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Report to Congressional Committees

October 2016

ENVIRONMENTAL PROTECTION

Information on Federal Agencies' Expenditures and Coordination Related to Harmful Algae

GAO-17-119

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GAO Highlights

Highlights of GAO-17-119, a report to congressional committees

Why GAO Did This Study

Harmful algal blooms are an environmental problem in all 50 states, according to EPA. While algae are essential to the ecosystem, providing food for all types of animals, these blooms can produce toxins that hurt the environment and local economies. Specifically, they can cause human illness or death from the consumption of seafood or water contaminated by toxic algae; harm aquatic and other animal species through neurological or liver damage or severe oxygen depletion; and hurt the seafood industry, recreation, and tourism. Harmful algal blooms occur naturally, but their prevalence, frequency, and severity are increasing—and this increase is influenced by climate, pollution, and human activities such as agriculture and wastewater, according to an interagency working group report.

The Drinking Water Protection Act included a provision for GAO to review federally funded activities related to harmful algal blooms. This report examines (1) how much federal agencies expended on these activities from fiscal years 2013 through 2015 and (2) how federal agencies coordinate their activities with each other and with nonfederal stakeholders. GAO collected information from federal agencies by using a questionnaire and interviewing agency officials.

GAO provided a draft of this report to the Departments of Agriculture, Commerce, Defense, Health and Human Services, and the Interior; EPA; NASA; and the Executive Office of the President for comment. Most of the agencies provided technical comments, which were incorporated as appropriate.

View GAO-17-119. For more information, contact J. Alfredo Gómez at (202) 512-3841 or gomezj@gao.gov.

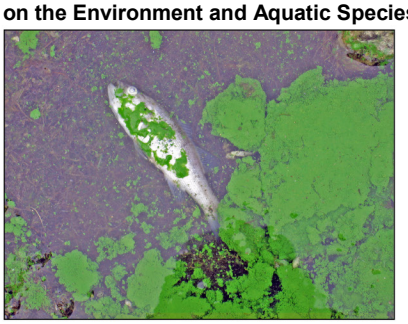
What GAO Found

Twelve federal agencies reported expending an estimated total of roughly $101 million from fiscal years 2013 through 2015 to fund various research, monitoring, and other activities related to harmful algae—overgrowths of algae that can create toxic "blooms" in marine or freshwater environments. The agencies provided a mix of actual and estimated expenditure data and used different methods for collecting the data, making comparisons among agencies, and a federal total, inexact. Based on the data, the 5 agencies with the largest expenditures related to harmful algal blooms for this period—totaling roughly $86 million—were the National Oceanic and Atmospheric Administration, $39.4 million; National Science Foundation (NSF), $15.4 million; Environmental Protection Agency (EPA), $14.5 million; U.S. Geological Survey, $9 million; and the National Institute of Environmental Health Sciences (NIEHS), $8 million. According to agency officials, these 5 agencies funded efforts to research and analyze harmful algal blooms; forecast, monitor, and respond to their occurrence; and investigate human and ecological health effects. In addition, other agencies expended millions of dollars funding activities to address harmful algae. For example, from fiscal years 2013 through 2015, the National Aeronautics and Space Administration reported expending nearly $2 million on research to improve the detection of algal blooms using satellite imagery.

Federal officials reported that their agencies coordinate in a variety of ways with each other and with nonfederal stakeholders to share information, expertise, and opportunities for collaboration on activities to address harmful algae. For example, since 2014, an interagency working group has been the primary, government-wide mechanism through which federal agencies coordinate such activities, develop plans for future work, and identify any gaps in federal activities and capabilities. In addition, federal officials reported that agencies participate in numerous groups, task forces, and other coordination efforts led by federal agencies, states, international organizations, or academics. Furthermore, federal officials reported a number of interagency partnerships directly related to their harmful algae work, such as NIEHS' and NSF's collaboration since 2005 to jointly fund research projects.

Harmful Algal Blooms Can Have Toxic Effects on the Environment and Aquatic Species

An algal bloom appears on the water's surface at Assateague Island National Seashore, Maryland.



A cyanobacteria (also called blue-green algae) bloom on Binder Lake, Iowa, caused a fish kill.

Sources: Eric Vance, Environmental Protection Agency (left); Jennifer L. Graham, U.S. Geological Survey (right). | GAO-17-119

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Abbreviations

AVM	avian vacuolar myelinopathy
BOEM	Bureau of Ocean Energy Management
CDC	Centers for Disease Control and Prevention
CEQ	Council on Environmental Quality
CSP	Conservation Stewardship Program
CWA	Clean Water Act
CyAN	Cyanobacteria Assessment Network
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FDA	Food and Drug Administration
FWS	U.S. Fish and Wildlife Service
GLRI	Great Lakes Restoration Initiative
HAB	harmful algal bloom
HABHRCA	Harmful Algal Bloom and Hypoxia Research and Control Act
ICES	International Council for the Exploration of the Sea
IJC	International Joint Commission
IOOS	Integrated Ocean Observing System
IPHAB	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization's Intergovernmental Panel on Harmful Algal Blooms
ISSC	Interstate Shellfish Sanitation Conference
IWG-HABHRCA	Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act
NASA	National Aeronautics and Space Administration
Navy	Department of the Navy
NCCOS	National Centers for Coastal Ocean Science
NIEHS	National Institute of Environmental Health Sciences
NIFA	National Institute of Food and Agriculture

NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRL	Naval Research Laboratory
NSF	National Science Foundation
OHHABS	One Health Harmful Algal Bloom System
ORD	Office of Research and Development
OSTP	Office of Science and Technology Policy
OW	Office of Water
PHSA	Public Health Service Act
SBIR	Small Business Innovation Research Grants
SDWA	Safe Drinking Water Act
SERVIR	Mesoamerican Regional Visualization and Monitoring System
STTR	Small Business Technology Transfer
USACE	U.S. Army Corps of Engineers
USDA	Department of Agriculture
USGS	U.S. Geological Survey

U.S. GOVERNMENT ACCOUNTABILITY OFFICE

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October 14, 2016

The Honorable James M. Inhofe
Chairman
The Honorable Barbara Boxer
Ranking Member
Committee on Environment and Public Works
United States Senate

The Honorable Fred Upton
Chairman
The Honorable Frank Pallone
Ranking Member
Committee on Energy and Commerce
House of Representatives

Harmful algal blooms (HAB)—overgrowths of algae in marine or freshwater environments, like the one that began in May 2016 in Lake Okeechobee, Florida's largest lake—are an environmental problem in all 50 states, according to the Environmental Protection Agency (EPA). While algae are essential to the ecosystem, providing food for all types of animals, HABs can produce toxins, and even non-toxic blooms can hurt the environment and local economies. Specifically, HABs can cause human illness or death from consumption of seafood or water contaminated by toxic algae; harm aquatic and other animal species through neurological or liver damage or severe oxygen depletion (hypoxia);[1] and hurt the seafood industry, recreation, and tourism. While HABs and hypoxia can occur naturally, their prevalence, frequency, and severity are increasing—and this increase is influenced by climate, pollution, and human activities such as agriculture and wastewater, which can produce runoff laden with excess nutrients, according to a report by

[1]While the focus of this report is HABs, we frequently refer to hypoxia throughout this report because HABs and hypoxia are, at times, interrelated. According to EPA's website, hypoxia can be caused by a variety of factors, including excess nutrients, primarily nitrogen and phosphorus, which promote algal growth. As dead algae decompose, oxygen is consumed in the process, resulting in low levels of oxygen in the water.

the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act (IWG-HABHRCA).[2]

HAB outbreaks in the United States with significant environmental and economic effects include blue-green algae (cyanobacteria) in the Great Lakes, "red tide" on the Gulf of Mexico coast, and "brown tide" in the mid-Atlantic states.[3] According to the National Oceanic and Atmospheric Administration (NOAA) and EPA websites, marine and freshwater HABs cause millions of dollars per year in economic losses in the United States. HABs reduce tourism, close beaches, and decrease the catch from both recreational and commercial fisheries, among other impacts. In the summer of 2015, NOAA pronounced a bloom from central California to Alaska to be the largest and most severe marine HAB recorded along the West Coast in at least 15 years. This HAB event resulted in massive economic losses because of closures of recreational and commercial shellfish harvesting areas in three states. For instance, shellfish managers shortened or closed the razor-clam season in parts of California, Oregon, and Washington, and closed the southern Washington coast to Dungeness crab fishing—the largest-ever shutdown of that state's multi-million-dollar industry.[4] In addition, elevated levels of a potent neurotoxin, domoic acid, caused by this HAB event were the

[2]For example, the incidence of hypoxia globally has increased tenfold over the past 50 years, and by almost thirtyfold in the United States since 1960. See *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report* (Washington, D.C.: Feb. 11, 2016), a report to Congress produced by the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act.

[3]"Red tide" is a colloquial term often used to describe HABs in marine coastal areas; however, the term is misleading since algal blooms can be a wide variety of colors, and growth of algae is unrelated to the tides. As a result, scientists prefer the term "harmful algal bloom" as a more appropriate descriptor for overgrowths of algae that can cause human, environmental, or economic harm. To the human eye, algal blooms can appear greenish, brown, reddish-orange, or golden, depending upon the algal species, the aquatic ecosystem, and the concentration of the organisms. However, many blooms discolor the water but are not harmful, and other blooms of highly toxic cells cause problems at low, and essentially invisible, cell concentrations.

[4]NOAA officials reported in July 2016 that the agency is working to quantify the economic losses related to this bloom; the initial estimate for losses in tourism-related spending related to the lost razor clam harvest is $22.7 million.

highest ever reported for anchovies, mussels, and crabs, exceeding regulatory limits by 10 times or more.[5]

In 2011, a then-record bloom of toxin-producing *Microcystis* in Lake Erie—a source of tourism and recreation for Ohio and Michigan, and Toledo's primary drinking water supply—caused an estimated economic impact of roughly $71 million in lost property values, tourism, recreation, and water treatment.[6] Three years later, another *Microcystis* bloom in Lake Erie disrupted the municipal water system, causing about 500,000 Toledo residents to be advised not to drink their tap water for 4 days and incurring an estimated $65 million in economic losses.[7]

The Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) is the key law regarding federal HAB activities.[8] HABHRCA designates roles and responsibilities for federal agencies to maintain and enhance marine and freshwater HAB programs, conduct research, develop and submit to Congress various reports, and carry out coordination and other functions through an interagency working group. The IWG-HABHRCA, established in October 2014 to carry out several activities under the law, consists of the following 14 federal agencies:

[5]According to NOAA's website, certain types of algae produce domoic acid, which can accumulate in shellfish and fish without apparent ill effects, but in humans, very high doses of the toxin can cause death, and lower doses can cause permanent brain damage (short-term memory loss).

[6]Cyanobacteria, including *Microcystis* species—bacteria that produce a class of toxins known as microcystins—typically occur in freshwaters, although they have also appeared in marine waters. Cyanobacteria can produce two groups of toxins: neurotoxins, such as anatoxin-a, which can cause neurological damage, and peptide hepatotoxins, such as microcystins, which can cause serious damage to the liver.

[7]The estimated economic losses caused by the 2011 and 2014 Lake Erie HABs were prepared for the International Joint Commission, an international organization created by the Boundary Waters Treaty, signed by Canada and the United States in 1909. See *Economic Benefits of Reducing Harmful Algal Blooms in Lake Erie*, M. Bingham, S. K. Sinha, and F. Lupi, Environmental Consulting & Technology, Inc. (Gainesville, Fla.: October 2015).

[8]Pub. L. No. 105-383, Title VI, 112 Stat. 3448 (1998), as amended; 33 U.S.C. § 4001 et seq.

- NOAA;
- EPA;
- Department of Agriculture's (USDA) National Institute of Food and Agriculture (NIFA) and Natural Resources Conservation Service (NRCS);[9]
- Department of the Interior's Bureau of Ocean Energy Management (BOEM), National Park Service (NPS), and U.S. Geological Survey (USGS);
- Department of Defense's Department of the Navy (Navy) and U.S. Army Corps of Engineers (USACE);
- Department of Health and Human Services' Centers for Disease Control and Prevention (CDC), Food and Drug Administration (FDA), and National Institutes of Health's National Institute of Environmental Health Sciences (NIEHS);
- National Science Foundation (NSF); and
- National Aeronautics and Space Administration (NASA).

NOAA and EPA are designated by HABHRCA as having primary responsibility for administering a national HAB and hypoxia program for marine and freshwater bodies, respectively.[10] Because federal agencies do not generally receive appropriations dedicated specifically for HAB-related activities, the extent and nature of their HAB-related expenditures are not readily available to Congress or the general public.

The Drinking Water Protection Act includes a provision for us to review federally funded HAB-related activities and to report within 90 days.[11] We provided you with preliminary information on November 6, 2015. This report provides additional information on (1) how much federal agencies expended on activities related to marine and freshwater HABs, and the

[9]In addition, officials from USDA's Agricultural Research Service and Forest Service reported that their agencies have participated in the IWG-HABHRCA and have conducted HAB-related activities in the past, but these expenditures occurred prior to fiscal year 2013.

[10]33 U.S.C. § 4002(d), (h). NOAA has responsibility for the HAB and hypoxia program for the Great Lakes. See 33 U.S.C. § 4002(f)(2), (h).

[11]Pub. L. No. 114-45, § 2(b), 129 Stat. 473 (2015).

types of activities funded, from fiscal years 2013 through 2015; and (2) how federal agencies coordinate their HAB-related activities with each other and with nonfederal stakeholders.

For both objectives, we reviewed HAB-related laws; federal agencies' reports on HABs; our prior work on ocean acidification, the Great Lakes, water quality, climate change, and interagency collaboration (a list of related products is included at the end of this report); and other relevant documents. To identify how much federal agencies expended on activities related to marine and freshwater HABs for fiscal years 2013 through 2015, we conducted interviews and collected information from agency officials; and we identified 17 agencies that have conducted research, monitoring, response, or other HAB-related activities for this period.[12] These agencies include the 14 participating in the interagency working group, plus 3 additional agencies: the Department of the Interior's Fish and Wildlife Service (FWS) and the Executive Office of the President's Council on Environmental Quality (CEQ) and Office of Science and Technology Policy (OSTP).

To identify the types of activities the agencies funded in relation to marine and freshwater HABs, we conducted interviews with and requested data from the 17 relevant agencies on their HAB-related expenditures in fiscal years 2013, 2014, and 2015.[13] To gather expenditure data, we developed and distributed a questionnaire that asked the 17 agencies to identify their HAB-related research, monitoring, or other activities at the program and project levels. To assess the accuracy and completeness of the expenditure data and to learn of any data limitations, we conducted a

[12]Based on our review of documents, interviews with federal agencies, and the agencies' written responses to a questionnaire that, in part, asked them to identify other relevant agencies, we identified 17 agencies that conducted HAB-related activities in fiscal years 2013 through 2015. We started with NOAA and EPA officials because of their lead roles, as designated by HABHRCA, in administering a national HAB and hypoxia program for marine and freshwater bodies, respectively; and we interviewed and collected information from additional agencies as they were identified by other agencies.

[13]In cases where expenditure data were not available, we used obligated funding data, which contributes to an inexact, federal total. Obligated funds refer, in part, to a definite commitment that creates a legal liability of the government for the payment of goods and services ordered or received. An agency incurs an obligation, for example, when it places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another.

data reliability assessment through written questions and follow-up interviews, as necessary, with agency officials. Our questions asked for officials to specify if the associated activities were single-purpose in addressing HABs only, or if they addressed multiple purposes including HABs.[14] Of the 17 agencies we contacted, 12 provided HAB-related expenditure data for fiscal years 2013 through 2015, which we determined were sufficiently reliable for the purpose of producing a rough estimate of federal HAB-related expenditures and are presented in this report.[15]

Even with the efforts we made to ensure the reliability of the data, each of the agencies had its own methods for collecting HAB-related expenditure data. For example, some agencies collected data from their databases using key word searches, while other agencies relied on subject matter experts to identify HAB-related activities and submit expenditure data. Some agencies provided actual expenditure data, whereas other agencies provided estimated expenditure data or obligated funding data. In addition, we asked agencies to identify whether their HAB-related activities were (1) single-purpose in addressing HABs only, (2) multi-purpose including HABs, or (3) a mixture of both. The lack of a standardized approach to collecting HAB-related expenditures across the agencies means that any comparisons among agencies and any

[14]Our data reliability questions asked agency officials to identify whether their HAB-related activities were (1) single-purpose in addressing HABs only, (2) multi-purpose including HABs, or (3) a mixture of both. To provide a rough, estimated total for federal HAB-related expenditures, we excluded one agency—NRCS—that provided solely multi-purpose HAB-related expenditures for fiscal years 2013 through 2015. Specifically, NRCS provided expenditures that funded multi-purpose initiatives designed to improve the water quality of areas where HABs and hypoxia are of critical concern, but the agency does not directly track HAB expenditures. More information on NRCS' multi-purpose expenditure data is included in app. II.

[15]There are five agencies that we did not present in table 1 but that are involved in HAB-related activities. For example, CEQ and OSTP are entities within the Executive Office of the President whose overall budgets are relatively small. According to CEQ and OSTP officials, their agencies do not track staff time spent on specific HAB-related activities, thus they reported that their agencies could not provide expenditure data. In addition, two agencies—BOEM and FWS—provided data that we determined were not sufficiently reliable for our purposes, therefore those agencies' expenditure data are not presented in this report. Finally, we excluded NRCS, which provided solely multi-purpose HAB-related expenditure data, because NRCS officials told us they provided a generous estimate for initiatives that target water quality, including HABs, and we believed it could skew the overall federal agencies' estimated total.

estimated federal total are inexact. In addition, our questionnaire asked the agencies for information on (1) their key activities regarding HABs; (2) the purposes of these activities; (3) the specific statutory provisions authorizing these activities; and (4) the funding mechanisms used, such as grants or contracts.

To determine how federal agencies coordinate their HAB-related activities with each other and with nonfederal stakeholders, we collected and analyzed information from the agencies through interviews and our questionnaire on (1) their participation with each other and nonfederal stakeholders in interagency working groups or other mechanisms to share information and coordinate on HABs research, monitoring, or other activities;[16] (2) efforts taken by federal agencies to minimize duplication; and (3) gaps, if any, in federal HAB-related activities. Among other things, we also reviewed the official notes from a nongeneralizable sample of 21 IWG-HABHRCA twice-monthly meetings, starting from the group's creation in October 2014 through July 2016. In addition, through our correspondence with federal agencies and our own web searches, we identified agencies' publicly accessible websites describing HABs and HAB-related activities. See appendix I for more information on our scope and methodology.

We conducted this performance audit from September 2015 to October 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

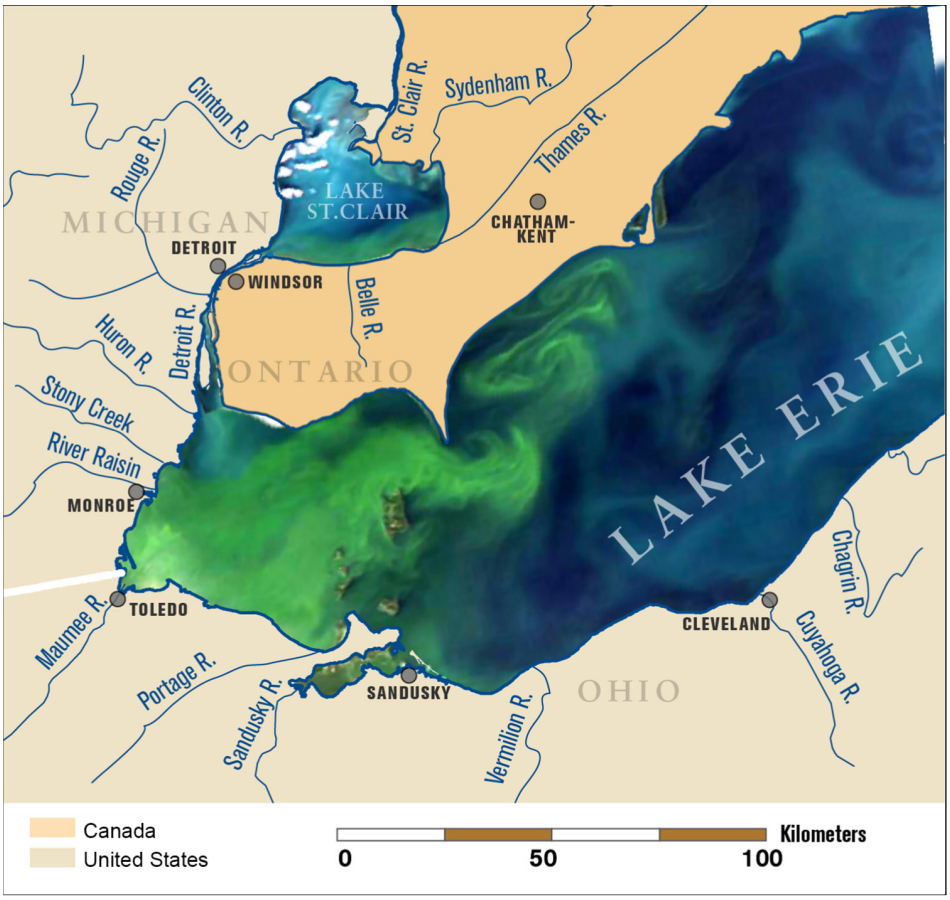
[16]For the purpose of this report, we define coordination as any joint activity by two or more organizations that is intended to produce more public value than could be produced when the organizations act alone. We use the term "coordination" broadly to include interagency activities that others have variously defined as "collaboration," "cooperation," "integration," or "networking." We have done so since there are no commonly accepted definitions for these terms, and we are unable to make definitive distinctions between these different types of interagency activities. See GAO, *Results-Oriented Government: Practices That Can Help Enhance and Sustain Collaboration among Federal Agencies*, GAO-06-15 (Washington, D.C.: Oct. 21, 2005).

Background

Algae are natural components of marine and freshwater flora, performing many roles that are vital for the health of ecosystems. Most algae are not harmful, and the proliferation of algae generally provides the energy source to fuel food webs. However, when certain conditions are favorable, algae can rapidly multiply, causing "blooms" and increasing the risk of toxin contamination of water. When algae bloom in significant numbers and produce toxic or harmful effects, such events are termed HABs. The risk is especially great for blooms caused by some species of cyanobacteria, historically known as blue-green algae, which typically occur in freshwater but may also appear in marine environments. Cyanobacterial HABs are of special concern because of their potential impacts on drinking and recreational waters. Toxins produced by cyanobacteria (cyanotoxins) can cause allergic and respiratory issues, attack the liver and kidneys, or affect the nervous system in mammals, including humans. Cyanobacterial HABs can also cause detrimental effects on aquatic ecosystems. High biomass blooms, whether of toxic or nontoxic species, can accumulate as thick scums and mats, which decompose, causing excessive oxygen consumption—which, in turn, leads to an increased mortality rate in local fish, shellfish, invertebrate, and plant populations because of hypoxia. Cyanobacterial HABs may also adversely affect some types of flora and fauna because they cause decreased light penetration. Figure 1 shows a satellite image of the then-record-setting cyanobacterial HAB in Lake Erie in September 2011 (an even larger Lake Erie HAB set a new algal biomass record in 2015), overlaid on a map of the lake's tributaries. This image shows the algal bloom (in green) covering the entire western basin and beginning to expand into the central basin of Lake Erie, where it continued to grow until October 2011.[17]

[17]Michalak, A.M., et al., "Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions," *Proceedings of the National Academy of Sciences* (Washington, D.C.: Apr. 16, 2013).

Figure 1: Satellite Image of a Harmful Algal Bloom in Lake Erie in 2011



Source: Prepared by Michigan Sea Grant for Michalak, A.M., et al. (2013). | GAO-17-119

Marine HABs and Health Impacts

Coastal waters of the United States are subject to most of the major HAB impacts and poisoning syndromes. Marine HAB impacts on animals and plant life include fish kills, shellfish mortalities, widespread marine mammal mortalities, and loss of submerged vegetation.[18] Specifically, some types of harmful algae produce potent toxins that cause illness or death in humans and marine organisms—fish, seabirds, manatees, sea

[18]Submerged vegetation, such as seagrasses, provides habitat, food, and shelter to aquatic species; it may also stabilize sediments and help maintain water clarity.

lions, turtles, and dolphins are some commonly affected animals. Other types of harmful algae are nontoxic to humans but cause harm to fish and invertebrates by damaging or clogging their gills or by forming such large blooms that the death, and subsequent decay, of the algae lead to hypoxia in the bottom waters of marine environments, forcing animals to either leave the area or die. Birds can also get sick by eating algae, drinking contaminated water, or eating contaminated fish or shellfish.

Exposure to marine HAB toxins can occur through direct contact by swimming (dermal exposure); breathing in aerosolized toxins (toxins in water turned into tiny airborne droplets or mist); or eating toxin-contaminated seafood, including shellfish and finfish. Impacts on human health through contaminated seafood include amnesic shellfish poisoning, ciguatera fish poisoning, diarrhetic shellfish poisoning, neurotoxic shellfish poisoning, and paralytic shellfish poisoning—illnesses that have been reported in the United States. Two major groups of marine algae—diatoms and dinoflagellates—produce HAB toxins that cause these syndromes. According to NOAA's website, the toxins that cause these syndromes have been found in U.S. marine waters, and these syndromes have adverse human health impacts, as follows:

- **Amnesic shellfish poisoning**, which is caused by several species of *Pseudo-nitzschia* that produce the toxin domoic acid, produces gastrointestinal and neurological effects. Mild cases arise within 24 hours of consumption of contaminated shellfish. Symptoms include nausea, vomiting, diarrhea, and abdominal cramps. In more severe cases, neurological symptoms occur, which include headaches, hallucinations, confusion, short-term memory loss, respiratory difficulty, seizures, coma, and, in extreme cases, death. These toxic species have been found on the Pacific Northwest coast from Canada

to mid-California and the Atlantic northeast coast of Canada, as well as the Gulf of Mexico.[19]

- **Ciguatera fish poisoning** is the most common seafood-toxin illness reported in the world, and certain algal species have caused this syndrome in many tropical and subtropical regions with coral reefs in the United States, including Caribbean and Pacific Islands, Florida, and the Gulf of Mexico.[20] Ciguatoxins are transferred through the food chain from small toxic algae to large fish, such as grouper, and produce gastrointestinal, neurological, and cardiovascular symptoms that usually begin developing within 12 to 24 hours of eating contaminated fish. Gastrointestinal symptoms include diarrhea, abdominal pain, nausea, and vomiting occur, and neurological symptoms include numbness and tingling of hands and feet, dizziness, altered hot/cold perception, muscle aches, and low heart rates and blood pressure. In extreme cases, death occurs through respiratory failure.
- **Diarrhetic shellfish poisoning** is a gastrointestinal illness that has been reported worldwide. Symptoms usually occur within 30 minutes to a few hours after consumption of contaminated shellfish. Symptoms include diarrhea, nausea, vomiting, and abdominal pain. A full recovery is expected within 3 days, regardless of medical treatment, but long-term exposure may promote tumor growth in the digestive system. Various species of *Dinophysis* and their related toxins, which

[19]According to representatives from the U.S. National Office for Harmful Algal Blooms, amnesic shellfish poisoning toxin (domoic acid) occurrences have also been documented along the southern coast of California and confirmed in the northeastern United States, including Long Island, Maine, and locations near Cape Cod, Massachusetts. The U.S. National Office for Harmful Algal Blooms, located at Woods Hole Oceanographic Institution, is funded by NOAA's Center for Sponsored Coastal Ocean Research and supports the agency's national program for HABs research. Specifically, the Center for Sponsored Coastal Ocean established the U. S. National Office for Harmful Algal Blooms to provide critical coordination and technical support capabilities that enhance the nation's ability to respond to and manage the growing threat posed by HABs. It also provides liaison with the scientific community and related programs nationally and internationally.

[20]According to U.S. National Office for Harmful Algal Blooms representatives, ciguatera fish poisoning is endemic to the Hawaiian Islands; there have been clinical cases of the syndrome reported, as well as the detection of ciguatoxins in fish.

cause this syndrome, have been found along the Texas Gulf coast and the Chesapeake Bay.[21]

- **Neurotoxic shellfish poisoning** produces gastrointestinal and neurological symptoms within 3 to 6 hours of ingestion of contaminated shellfish. Milder cases may include symptoms of headaches, diarrhea, and muscle/joint pain and commonly occur when beachgoers are exposed to toxic aerosols produced by wave action. Symptoms include irritation of the throat and upper respiratory tract, causing asthma-like effects. More severe effects are altered perceptions of hot and cold, difficulty breathing, or double vision. Neurotoxic shellfish poisoning is caused by *Karenia brevis*, a toxic dinoflagellate found in the Gulf of Mexico and the east coast of Florida. *Karenia brevis* "red tides" are typically characterized by patches of discolored water, dead or dying fish, and toxic aerosols.
- **Paralytic shellfish poisoning** symptoms include tingling sensations or numbness, headaches, fever, rash, dizziness, and gastrointestinal illness. In severe cases, symptoms include muscular paralysis, respiratory difficulty, and choking sensation. Despite the severity of this toxin, victims generally begin to recover within 12 to 24 hours of intoxication. In some severe cases, victims may die from paralysis and respiratory failure. A number of species of the dinoflagellate *Alexandrium*, which produce a group of toxins (called saxitoxins) responsible for paralytic shellfish poisoning, have been observed along the northeast and west coasts of North America, including Alaska. Another species associated with this syndrome, *Pyrodinium bahamense*, has also been found in Florida. The United States has reported persistent problems with cases of this syndrome since the mid-1960s.

Each of these syndromes is caused by different species of toxic algae that occur in various coastal waters of the United States and the world. According to the U.S. National Office for Harmful Algal Blooms' website, there are virtually no human populations that are free of risk, in part because of an increase in interstate and international transport of seafood. CDC officials stated that records of these syndromes are incomplete because their diagnosis is difficult, physicians might not

[21]According to U.S. National Office for Harmful Algal Blooms representatives, *Dinophysis* and diarrhetic shellfish poisoning toxins have also been detected in coastal waters of the Pacific Northwest (particularly Puget Sound), Long Island and Cape Cod.

always report cases to their health departments, and reporting to CDC is voluntary; however, CDC estimates that 15,910 cases of ciguatera fish poisoning occur in the United States annually. According to NOAA officials, the recent emergence of diarrhetic shellfish poisoning in U.S. waters, the massive domoic acid-producing bloom on the West Coast in 2015, and the rapid expansion of cyanobacterial blooms in freshwater indicate that HABs are an increasing threat in the United States. However, FDA officials stated that controls are in place to prevent contaminated seafood from entering interstate commerce.

Beyond human health threats, NOAA officials noted, marine HABs can have other deleterious impacts. For example, massive fish kills drive away tourists, require costly beach cleanup, and impact fisheries management. Some HABs kill or weaken young stages of shellfish, damaging shellfish aquaculture and impairing shellfish restoration. Furthermore, NOAA officials stated, water discoloration and accumulation of algae on beaches affects tourism and property values. Many of these effects can have serious economic impacts on communities in coastal areas that depend on marine resources for their livelihoods.

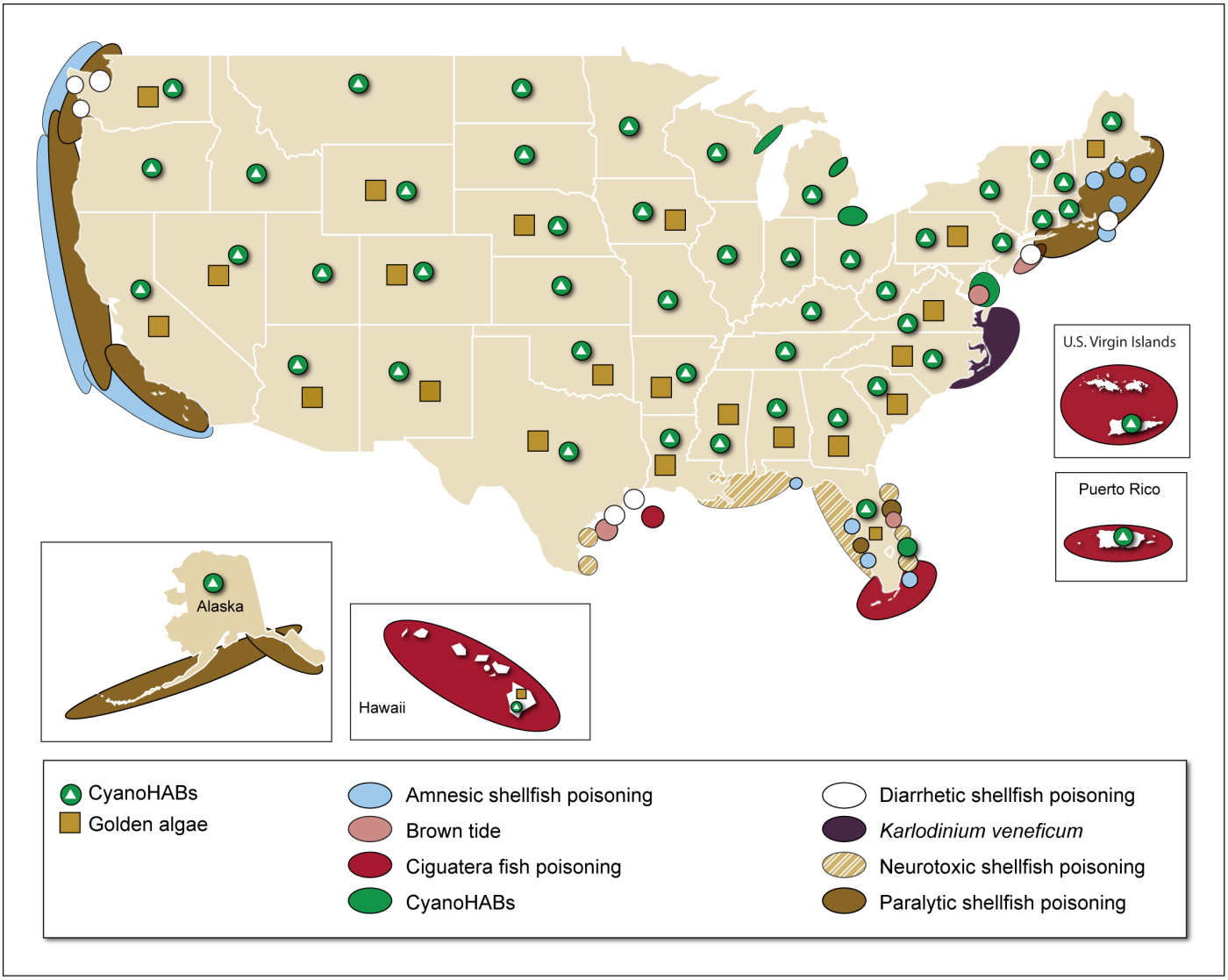
HAB Occurrences in the United States

HABs have occurred in all 50 states in the past decade in marine waters, freshwaters, or both. According to the U.S. National Office for Harmful Algal Blooms' website, all 50 states have been affected by cyanobacterial HABs, typically in many different lakes, rivers, streams, reservoirs, and other freshwater sources. In addition, 23 states have been affected by "golden algae" blooms caused by *Prymnesium parvum*. Furthermore, the dinoflagellate *Karlodinium veneficum* blooms along the mid-Atlantic coast; and brown tides caused by the rapid population growth of a minute alga, *Aureococcus anophagefferens*, have decimated multiple fisheries and seagrass beds in mid-Atlantic estuaries for three decades.[22] A

[22]According to the U.S. National Office for Harmful Algal Blooms' website, *Prymnesium parvum*, commonly referred to as golden algae, is one of the most problematic HAB toxins in the United States and has caused fish kills in Texas annually since 2001. Similarly, *Karlodinium veneficum* has been associated with toxic activity ever since its discovery in the 1950s, with significant fish kills in Maryland. Brown tides can also negatively affect shellfish (such as clams, oysters, and scallops) and submerged vegetation, and have been found along the Atlantic seaboard, including Maryland, New Jersey, New York, and Rhode Island. Another brown tide species, *Aureoumbra lagunensis*, has caused massive blooms and ecosystem impacts in Texas and Florida, according to representatives from the U.S. National Office for Harmful Algal Blooms.

generalized map appears in figure 2, depicting marine and freshwater HAB occurrences—as well as locations where HAB poisoning syndromes affecting human health have been reported, or where the associated toxins have been detected in fish and shellfish tissue extracts or marine algae samples—in the United States from 2006 through 2015.

Figure 2: Generalized Map Depicting Harmful Algal Blooms (HAB) and Related Poisoning Syndromes and Toxin Occurrences in the United States, 2006-2015



Source: U.S. National Office for Harmful Algal Blooms. | GAO-17-119

Notes: Because it is not practical to indicate the location of each cyanobacterial or golden algae bloom, each state experiencing these blooms is indicated by a single green circle, gold square, or both. Green ovals denote widespread cyanoHAB problems. In addition, this generalized map depicts the various HAB poisoning syndromes and toxins that have occurred in specific areas. Colored dots or ovals indicate locations where the incidence of a particular syndrome has been reported, or where the related toxins have been detected in fish and shellfish tissue extracts, marine algae, or both.

HAB Causes and Human Influence

HABs were recorded as early as the 16th century, according to NOAA's website, but human activities seem to play a role in the increased occurrence of some blooms. In general, HAB growth is enhanced when environmental conditions are optimal for a given species. These conditions may include natural phenomena, such as unusually high water temperatures; extreme weather events, such as hurricanes, floods, or drought; or sluggish water circulation that allows biomass to accumulate. One way that human activities may contribute to HABs is by supplying nutrients to aquatic ecosystems at a rate that "overfeeds" the algae that exist naturally. These nutrients (mainly nitrogen, phosphorus, and carbon) can originate as runoff from lawns and farmland or wastewater discharges from municipalities and industry. Human activity may also influence HABs through ecosystem disturbances such as water flow modifications or the introduction of new species.

Twelve Federal Agencies Reported Expending Roughly $101 Million from Fiscal Years 2013 through 2015 on Various HAB-Related Activities

Twelve federal agencies expended an estimated total of roughly $101 million from fiscal years 2013 through 2015 to fund various HAB-related activities—such as research and analysis, forecasting, surveillance and monitoring, outreach, and response—according to data reported by the agencies.[23] Based on the data, the 5 agencies with the largest HAB-related expenditures for this period—totaling roughly $86 million—were NOAA ($39.4 million), NSF ($15.4 million), EPA ($14.5 million), USGS ($9.0 million), and NIEHS ($8.0 million). According to agency officials, these 5 agencies provided internal and external funding for research on and analysis of HABs; forecasting, monitoring, outreach and response efforts; and investigations of human and ecological health effects, as follows:

- NOAA developed and provided capabilities to predict, detect, monitor, and respond to marine and Great Lakes HAB events. NOAA

[23]As previously noted, each of the agencies had its own methods for collecting HAB-related expenditure data, and therefore comparisons among agencies, and any estimate of federal expenditures for HAB-related activities, are inexact. For example, some agencies collected data from their databases using key word searches, while other agencies relied on subject matter experts. In addition to the 12 agencies whose expenditure data we determined were reliable for our purposes, officials from 2 agencies (CEQ and OSTP) reported that their agencies could not provide HAB-related expenditure data, and 2 agencies (BOEM and FWS) provided expenditure data that we determined were not sufficiently reliable for our purposes.

competitively funded additional research on HAB ecology, monitoring, prediction, mitigation, and control.

- NSF funded HAB-specific and broader research that contributed to the understanding of algal blooms. It also funded workshops and activities that built and facilitated international collaboration on HAB-related research.
- EPA funded internal research on HABs and their toxins, focused on four main areas: water quality, human and ecological health effects, monitoring and analytical methods, and drinking water treatment. It performed outreach to other federal agencies, state agencies, and academia regarding HAB-related activities.
- USGS developed laboratory analysis and field testing to detect and quantify HABs, researched causal factors, and developed early warning systems for HABs.
- NIEHS supported peer-reviewed research grants to develop approaches to enhance prediction of HAB events and understand the effects of HAB toxins on human health.

In addition, other agencies—such as FDA, CDC, and NASA—expended millions of dollars funding activities to address HABs, associated with their respective missions. For example, from fiscal years 2013 through 2015, NASA reported expending nearly $2 million on basic and applied research to use satellite imagery to improve the detection of algal blooms.

Table 1 provides the estimated HAB-related expenditures for the 12 agencies that provided expenditure data for fiscal years 2013 through 2015.[24] The agencies reported actual or estimated expenditure data, or a mix of both; and a few agencies also provided some obligated funding

[24]Expenditure data for CEQ, OSTP, BOEM, FWS, and NRCS are not included. CEQ and OSTP officials reported that their agencies do not track staff time dedicated toward specific HAB-related activities, and thus they could not provide expenditure data. BOEM and FWS provided expenditure data that we determined were not sufficiently reliable for our purposes. In addition, we excluded NRCS' reported expenditure data from table 1 because NRCS officials told us that their estimated total of $208 million was a generous estimate for initiatives that target water quality, including HABs, and we believed it could skew the overall federal agencies' estimated total.

data.[25] Four agencies—NASA, NIEHS, NSF, and USGS—provided actual expenditures. NIFA officials provided estimated expenditures and reported that the identified NIFA funding does not include multi-purpose capacity awards that relate, in part, to HABs.[26] Other agencies, such as NOAA, Navy, USACE, CDC, FDA, NPS, and EPA, provided mostly actual expenditures but also included some estimated HAB-related expenditures. For example, the identified EPA funding does not include multi-purpose nutrient reduction projects, nutrient monitoring, phytoplankton community monitoring, or assessment of nutrient reduction projects intended, in part, to support reductions in HABs.[27] A few other agencies—CDC, NIEHS, and NSF—also provided some obligated funding data for a portion of their HAB-related activities for fiscal years 2013 through 2015.

[25]In addition, agency officials identified which HAB-related activities were single-purpose in addressing HABs only or a mixture of single- and multi-purpose including HABs. Five agencies—EPA, NIEHS, NIFA, NOAA, and USGS—provided single-purpose expenditure data. Seven agencies—CDC, FDA, NASA, the Navy, NPS, NSF, and USACE—provided a mixture of both single- and multi-purpose expenditure data. One agency—NRCS—provided solely multi-purpose HAB-related expenditures and is only presented in app. II.

[26]According to NIFA officials, capacity programs are supported by federal formula funding, which in some cases, must be matched with state funding to support research in agriculture, food, nutrition, and related fields at the nation's land grant institutions. The funding is not delivered by project but is provided to the eligible institution as one award. As these awards are for projects that are subsets of larger awards, agency officials could not provide award amounts for the HAB-related portions of those awards during the time frame of our review.

[27]According to EPA officials, since 2010, hundreds of millions of dollars have been allocated for a wide array of projects intended to reduce the loading of nutrients—which can fuel HABs—into the Great Lakes. However, the agency could not provide expenditure amounts for the HAB-related portions of those projects during the time frame of our review. In addition, agency officials stated that 2 of EPA's 10 regional offices did not fund HAB-related programs from fiscal years 2013 through 2015.

Table 1: Twelve Federal Agencies' Reported Actual and Estimated Expenditures for Activities Related to Harmful Algal Blooms (HAB), Fiscal Years 2013-2015

Amounts in dollars

	FY 2013	FY 2014	FY 2015	Total
Department of Agriculture				
National Institute of Food and Agriculture[a,b]	200,000	144,000	49,968	**393,968**
Department of Commerce				
National Oceanic and Atmospheric Administration[b,c]	9,761,470	13,995,227	15,692,169	**39,448,866**
Department of Defense				
Department of the Navy[c,d]	343,000	353,000	353,000	**1,049,000**
U.S. Army Corps of Engineers[c,d]	300,000	543,000	862,000	**1,705,000**
Department of Health and Human Services				
Centers for Disease Control and Prevention[c,d,e]	566,828	524,004	573,776	**1,664,608**
Food and Drug Administration[c,d]	2,081,000	2,681,326	2,621,973	**7,384,299**
National Institute of Environmental Health Sciences[b,e,f]	1,894,603	3,319,453	2,777,289	**7,991,345**
Department of the Interior				
National Park Service[c,d]	50,000	50,000	12,945	**112,945**
U.S. Geological Survey[b,f]	2,320,959	2,656,096	4,063,156	**9,040,211**
Environmental Protection Agency[b,c]	3,233,825	5,589,751	5,680,373	**14,503,950**
National Aeronautics and Space Administration[d,f]	344,003	230,545	1,418,915	**1,993,463**
National Science Foundation[d,e,f]	4,670,692	5,002,257	5,693,891	**15,366,840**
Estimated total	**25,766,380**	**35,088,659**	**39,799,455**	**100,654,494**

Legend: FY = fiscal year.

Source: GAO analysis of agencies' responses to GAO questionnaire. | GAO-17-119

Notes: The data in this table were provided by the agencies and reflect their annual expenditures to address HABs for fiscal years 2013 through 2015. In some cases, the agencies provided estimated expenditure or obligated funding data for their HAB-related activities. Each of the agencies had its own methods for collecting HAB-related expenditure data. For example, some agencies collected data from their databases using key word searches, while other agencies relied on subject matter experts. Given these different methods, any federal total should be regarded as a rough estimate, and any comparisons among agencies' expenditures should be regarded as inexact.

[a]Agency provided an estimate for annual expenditures in fiscal years 2013 through 2015.

[b]Agencies provided single-purpose expenditures.

[c]Agencies provided a mixture of actual and estimated expenditures.

[d]Agencies provided a mixture of both single- and multi-purpose expenditure data.

[e]Agencies provided obligated expenditures.

[f]Agencies provided actual expenditures.

As previously discussed, we identified 17 agencies that have conducted research, monitoring, or other HAB-related activities in fiscal years 2013 through 2015. Table 2 provides 17 agencies' key activities related to

HABs, consistent with their missions and expertise, in fiscal years 2013 through 2015.

Table 2: Seventeen Federal Agencies' Reported Key Activities Related to Harmful Algal Blooms (HAB), Fiscal Years 2013-2015

Department or agency	Component agency	Key HAB-related activities
Department of Agriculture (USDA)[a]	National Institute of Food and Agriculture	Supported projects focusing on agriculture and food safety; most of this work related to the impacts of HABs on aquaculture and ecology.
	Natural Resources Conservation Service	Managed specific initiatives designed to improve the water quality of areas where HABs and hypoxia are of critical concern, but did not directly track HABs as a resource concern.
Department of Commerce	National Oceanic and Atmospheric Administration	Acted as the lead federal agency on HABs occurring in ocean and coastal waters and the Great Lakes, co-chaired the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act (IWG-HABHRCA), and administered the National Harmful Algal Bloom and Hypoxia program. Developed and operationalized HAB forecasts, as well as tools for HAB and toxin detection and monitoring. Conducted research and development to address gaps in understanding, detection, prevention, mitigation, and control. To complement intramural research, provided extramural, competitive funding to organizations outside the federal sector. Routinely provided advice on HABs to federal, state, and local governments.
Department of Defense	Department of the Navy	Executed and promoted the science and technology programs of the Navy and the Marine Corps. Conducted a broad program of scientific research, technology, and advanced development.
	U.S. Army Corps of Engineers (USACE)	Conducted research on HABs and other aquatic invasive species, managed efforts to reduce negative impacts to wildlife, and completed HAB response plans for USACE projects.
Department of Health and Human Services	Centers for Disease Control and Prevention	Addressed public health issues and conducted health surveillance—the systematic collection, analysis, and interpretation of health data—to understand and prevent HABs. Provided laboratory support for public health responses to HAB-related toxins and developed and applied unique laboratory tests that help identify people exposed to certain toxins from marine and freshwater HABs.
	Food and Drug Administration	Conducted its own activities and supported activities conducted by others (e.g., universities, science laboratories, research institutions, and contractors) aimed at understanding, preventing, and detecting toxins that affect the food supply, primarily focused on seafood safety.
	National Institute of Environmental Health Sciences	Supported research on (1) the health effects associated with exposure to HAB toxins and (2) efforts that reduce human exposure to HAB toxins.
Department of the Interior	Bureau of Ocean Energy Management	Prepared for and participated in monthly IWG-HABHRCA meetings.
	National Park Service	Responded to outbreaks of HABs within national park units and investigated the effects on human and animal health, such as the 2009 red tide outbreak at Padre Island National Seashore in Texas, which resulted in deaths of marine life, wildlife, and domestic animals.
	U.S. Fish and Wildlife Service	Provided technical assistance and support to state, local, and federal agencies to address HAB events.

Department or agency	Component agency	Key HAB-related activities
	U.S. Geological Survey	Focused on (1) developing analytical laboratory and field methods to detect and quantify blooms, associated toxins, and taste-and-odor compounds; (2) understanding causal factors; and (3) developing early warning systems for potentially harmful blooms.
Environmental Protection Agency		Co-chaired the IWG-HABHRCA and chaired the Great Lakes Interagency Task Force. Developed policy and guidelines; conducted research; provided technical support and assistance through grants and other agreements; educated the public; and created partnerships with environmental agencies, academia, tribes, municipal water suppliers, nongovernmental organizations, and other federal agencies on HABs.
Executive Office of the President	Council on Environmental Quality	Coordinated federal environmental efforts and worked closely with agencies and other White House offices in developing environmental policies and initiatives. Served as a co-chair of the National Ocean Council.
	Office of Science and Technology Policy	Responsible for the overall policy direction and coordination of federal government-wide research and related funding on HABs and their impacts on public health. Served as a co-chair of the National Ocean Council.
National Aeronautics and Space Administration		Conducted basic and applied research using satellite imagery and improved the detection and forecasting of algal blooms.
National Science Foundation		Funded the discovery, learning, innovation, and research infrastructure to boost U.S. leadership in all aspects of science, technology, engineering, and mathematics research and education. Funded HAB-related research, education, community planning workshops, and activities that facilitated international collaborations.

Sources: GAO interviews with federal agency officials and agencies' responses to GAO questionnaire. | GAO-17-119

Note: This information on agency activities for HABs is not necessarily comprehensive; it is intended to illustrate key activities of each agency as they relate to HABs. In addition, while the scope of this information is limited to fiscal years 2013 through 2015, these activities may be ongoing.

[a]USDA's Agricultural Research Service officials stated that the agency conducted general research on controlling nutrient losses from agricultural lands (i.e., nitrogen and phosphorus) that can cause HABs. In addition, Forest Service officials stated that the agency's primary focus has been investigating the impacts of climate-induced stresses on water quality and quantity—and that it has conducted limited research examining items such as the taxonomic diversity of cyanobacteria in deserts, algal community response to changes in hydrology in boreal peatlands, and impact of invasive species on water quality. Officials from these two agencies reported having no HAB-related expenditures after fiscal year 2013.

Appendix II provides more detailed information on federal agencies' key HAB-related activities, expenditures, and specific statutory provisions authorizing such activities.

Federal Agencies Reported Coordinating HAB-Related Activities in a Variety of Ways

Federal officials reported that their agencies coordinate in a variety of ways with each other and with state, international, and academic stakeholders to share information, expertise, and opportunities for collaboration on HAB-related activities. Federal officials also reported that part of the purpose of this coordination is to reduce unnecessary duplication and to leverage resources. Since 2014, the IWG-HABHRCA has been the primary, government-wide mechanism though which federal agencies coordinate their activities, develop plans for future work, and identify remaining gaps related to federal HAB activities and capabilities.[28] In addition, federal agencies participate in numerous groups, task forces, and other coordination efforts led by federal agencies, states, international organizations, or academics (see table 3 for examples of these efforts). Furthermore, federal officials reported a number of partnerships between two or more federal agencies (federal interagency partnerships) directly related to their HAB work in recent years. For example, NIEHS and NSF have collaborated and provided joint funding for some HAB-related research projects since 2005.

Appendix III provides more detailed information on federal agencies' HAB-related coordination.

[28]Since November 2015, the IWG-HABHRCA and EPA released reports to Congress that, in part, identified remaining gaps related to federal HAB activities and capabilities. These gaps encompass research, forecasting, surveillance and monitoring, outreach, and response. See *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report* (Washington, D.C.: Feb. 11, 2016), a report to Congress produced by the IWG-HABHRCA. Also see Environmental Protection Agency, *Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water* (Washington, D.C.: November 2015), submitted to Congress to meet the requirements of the Drinking Water Protection Act (Pub. L. No. 114-45).

Table 3: Examples of Harmful Algal Blooms (HAB)-Related Coordination Efforts Led by Federal, State, International, and Academic Stakeholders

Coordination effort	Description
Federal-led efforts	
Great Lakes Interagency Task Force	Chaired by the Environmental Protection Agency (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, 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), a federal-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, multi-year action plans that identify goals, objectives, measurable ecological targets, and specific actions for five GLRI focus areas.
Inland HAB Discussion Group	Led by EPA, the U.S. Geological Survey (USGS), and the Centers for Disease Control and Prevention (CDC) 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.
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 to 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 co-chaired by the National Oceanic and Atmospheric Administration (NOAA) and EPA.
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.
National Ocean Council	A cabinet-level body that oversees the implementation of the National Ocean Policy, the council released a plan in April 2013 that described specific actions—including four actions related to HABs—for federal agencies to take to address key challenges.
One Health Harmful Algal Bloom System (OHHABS)	CDC collaborates with other federal agencies—such as EPA, USGS, NOAA, and the Food and Drug Administration (FDA)—and many state governments on OHHABS, an electronic system that is accessible to health departments and their designated animal health and environmental health partners for voluntary reporting of HAB events and associated cases of human and animal illness.
State-led efforts	
Interstate Shellfish Sanitation Conference (ISSC)	The ISSC was formed in 1982 to foster and promote shellfish sanitation through the cooperation of state and federal control agencies, the shellfish industry, and the academic community. According to FDA officials, cooperative partners in the ISSC include FDA, NOAA, EPA, CDC, state agencies, industry, tribes, and other nations. Agency officials stated that FDA's efforts to ensure the safety and sanitation of bivalve mollusks in interstate commerce includes attention to HAB toxins and involvement with the ISSC's National Shellfish Sanitation Program, which determines the methods that states are allowed to use for regulatory purposes.
Ohio Lake Erie Phosphorus Task Force II	In 2012, the Ohio Environmental Protection Agency, in partnership with other Ohio agencies, reconvened the Ohio Lake Erie Phosphorus Task Force as a Phase II effort to reduce phosphorous loading and associated HABs in Lake Erie and surrounding watersheds. As members of this task force or its subcommittees, NOAA, EPA, and other federal agencies contributed relevant information and expertise.

Coordination effort	Description
International efforts	
Great Lakes HABs Collaboratory	Beginning in late 2015, the Great Lakes Commission and Great Lakes scientists in the United States and Canada launched this 2-year effort. The overall goal is to create a collective laboratory ("collaboratory") to enable science-based information-sharing among scientists, as well as between scientists and federal, state, and local decision-makers working on HABs in the Great Lakes. Its initial focus will be three priority watersheds.
International Council for the Exploration of the Sea (ICES)	ICES is an intergovernmental organization whose main objective is to increase the scientific knowledge of the marine environment and its living resources and to use this knowledge to provide unbiased, non-political advice to authorities. A NOAA official and an academic representative currently serve as the U.S. delegates to this organization. To address HABs specifically, the Working Group on HAB Dynamics serves as a forum to review and discuss HAB events and to provide advice and updates on the state of HABs on an annual basis. This working group also facilitates interaction among scientists working in diverse areas of HAB science and monitoring, and provides a forum for discussing various approaches to HAB research.
International Joint Commission (IJC)	The IJC an international organization created by the Boundary Waters Treaty, signed by Canada and the United States in 1909. Its Great Lakes Water Quality Board, Great Lakes Science Advisory Board, and Health Professionals Advisory Board periodically address and coordinate research related to HABs in the Great Lakes.
Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization's Intergovernmental Panel on Harmful Algal Blooms (IPHAB)	IPHAB aims to foster effective management of, and scientific research on, HABs to understand their causes, predict their occurrences, and mitigate their effects. IPHAB meets every other April and generates a 2-year work plan that must be endorsed by the Intergovernmental Oceanographic Commission the following June. IPHAB typically addresses topics of broad interest where global coordination will accelerate the science needed to support the management of HABs.
Academic-led effort	
National HAB Committee	Co-chaired by two researchers, this committee was established to provide a collective voice for the academic, management, and stakeholder communities. Its mission is to facilitate coordination and communication of HAB activities at a national level. The committee communicates these activities through the U.S. National Office for Harmful Algal Blooms, biennial National HAB Conferences, and listservs and websites.

Source: Agencies' responses to GAO questionnaire. | GAO-17-119

Most of the federal agencies within the scope of this review maintain information on their public websites regarding HABs and HAB-related research, monitoring, and other activities.[29] Agency officials reported that they maintain such information on their websites to coordinate with each other and with nonfederal stakeholders on their HAB-related activities, reduce duplication, and raise public awareness, among other purposes. For example, EPA has compiled information on freshwater cyanobacterial

[29]The IWG-HABHRCA is exploring the possibility of creating a central, government-wide portal for information on HABs and hypoxia, according to NOAA officials.

HABs, including causes and prevention, detection, health and ecological effects, control and treatment, research by EPA and other federal agencies, new policies and regulations for toxins produced by cyanobacteria (cyanotoxins) at the state and international levels, and guidelines and recommendations.[30]

Appendix IV provides more detailed information on federal agencies' HAB-related websites.

Agency Comments

We provided a draft of this report to the Departments of Agriculture, Commerce, Defense, Health and Human Services, and the Interior; EPA; NASA; NSF; and the Executive Office of the President for review and comment. None of the agencies provided formal, written comments, but all except USDA and Navy provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees; the Secretaries of Agriculture, Commerce, Defense, Health and Human Services, and the Interior; the Administrators of EPA and NASA; the Director of NSF; the Chief of Staff, Executive Office of the President; and other interested parties. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or gomezj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last

[30]As of August 2016, this website was accessible at https://www.epa.gov/nutrient-policy-data/cyanohabs.

page of this report. GAO staff who contributed to this report are listed in appendix V.

J. Alfredo Gómez
Director, Natural Resources and Environment

Appendix I: Objectives, Scope and Methodology

This report examines (1) how much federal agencies expended on activities related to marine and freshwater harmful algal blooms (HAB), and the types of activities funded, from fiscal years 2013 through 2015; and (2) how federal agencies have coordinated their HAB-related activities with each other and with nonfederal stakeholders.

For both objectives, we reviewed HAB-related laws; federal agencies' reports on HABs; our prior work on ocean acidification, the Great Lakes, water quality, climate change, and interagency collaboration (a list of related products is included at the end of this report); and other relevant documents.

To identify how much federal agencies expended on activities related to marine and freshwater HABs, and the types of activities funded, for fiscal years 2013, 2014, and 2015, we conducted interviews with and requested data from officials from the 17 relevant agencies on their HAB-related expenditures for this period, and we found that 12 agencies' expenditure data were relevant and sufficiently reliable for the purpose of producing a rough estimate of federal HAB-related expenditures.[1] We started with National Oceanic and Atmospheric Administration (NOAA) and Environmental Protection Agency (EPA) officials because of their lead roles, as designated by the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA), in administering a national HAB and hypoxia program for marine and freshwater bodies, respectively; and we interviewed and collected information from additional agencies as they were identified by other agencies. An interagency working group (IWG-HABHRCA), established to implement aspects of the law, consists of the following federal agencies:

- NOAA;
- EPA;

[1]In cases where expenditures were not available, we used obligated funding data, which contributes to an inexact estimate of the federal total. Obligated funds refer, in part, to a definite commitment that creates a legal liability of the government for the payment of goods and services ordered or received. An agency incurs an obligation, for example, when it places an order, signs a contract, awards a grant, purchases a service, or takes other actions that require the government to make payments to the public or from one government account to another.

- Department of Agriculture's (USDA) National Institute of Food and Agriculture and Natural Resources Conservation Service (NRCS);[2]
- Department of the Interior's Bureau of Ocean Energy Management (BOEM), National Park Service, and U.S. Geological Survey;
- Department of Defense's Department of the Navy (Navy) and U.S. Army Corps of Engineers;
- Department of Health and Human Services' Centers for Disease Control and Prevention, Food and Drug Administration, and National Institutes of Health's National Institute of Environmental Health Sciences;
- National Science Foundation (NSF); and
- National Aeronautics and Space Administration.

In addition to these 14 agencies that participate in the interagency working group, we identified 3 additional agencies, based on our interviews, as having HAB-related expenditures in fiscal years 2013 through 2015: the Department of the Interior's Fish and Wildlife Service and the Executive Office of the President's Council on Environmental Quality (CEQ) and Office of Science and Technology Policy (OSTP). To gather expenditure data, we developed and distributed a questionnaire that asked the agencies to identify their HAB-related research, monitoring, or other activities. We asked the agencies to provide expenditure data for these activities at the program and project levels. To assess the accuracy and completeness of the expenditure data and to learn of the agencies' definitions of HAB-related activities and any data limitations, we conducted a data reliability assessment through written questions and follow-up interviews, as necessary, with agency officials. Our questions asked officials to specify if the associated activities were single-purpose in addressing HABs only, or if they addressed multiple

[2]In addition, officials from USDA's Agricultural Research Service and Forest Service reported that their agencies have participated in the IWG-HABHRCA and have conducted HAB-related activities in the past, but these expenditures occurred prior to fiscal year 2013.

purposes including HABs.[3] Of the 17 agencies we contacted, 12 provided HAB-related expenditure data for fiscal years 2013 through 2015, which we determined were sufficiently reliable for our purposes and are presented in this report.[4] For informational purposes, we present more detailed tables in appendix II for each of the agencies' HAB-related expenditures, but we did not independently verify these amounts.

Even with the efforts we made to ensure the reliability of the data, each of the agencies had its own method for collecting HAB-related expenditure data, and therefore the numbers presented for each agency may differ compared to a scenario in which a single, standardized method was used. For this reason, comparisons of HAB-related expenditures from one agency to another are inexact. For example, agencies such as NOAA and NSF each utilized a database to track actual expenditures or obligated funding for HAB-related activities, whereas agencies such as Navy relied on subject matter experts or staff estimates. Some agencies provided actual expenditure data, while other agencies provided estimated expenditure data or obligated funding data.

In addition, we asked agencies to identify whether their HAB-related activities were (1) single-purpose in addressing HABs only, (2) multi-purpose including HABs, or (3) a mixture of both. While we believe the

[3]Our data reliability questions asked agency officials to identify whether their HAB-related activities were (1) single-purpose in addressing HABs only, (2) multi-purpose including HABs, or (3) a mixture of both. To provide a rough, estimated total for federal HAB-related expenditures, we excluded one agency—NRCS—that provided solely multi-purpose HAB-related expenditures for fiscal years 2013 through 2015. Specifically, NRCS provided expenditures that funded multi-purpose initiatives designed to improve the water quality of areas where HABs and hypoxia are of critical concern, but the agency does not directly track HAB expenditures. More information on NRCS' multi-purpose expenditure data is included in app. II.

[4]There are five agencies that we did not present in table 1 but that are involved in HAB-related activities. For example, CEQ and OSTP are entities within the Executive Office of the President whose overall budgets are relatively small. According to CEQ and OSTP officials, their agencies do not track staff time dedicated toward specific HAB-related activities, thus they reported that their agencies could not provide expenditure data. In addition, two agencies—BOEM and FWS—provided data that we determined were not sufficiently reliable for our purposes; therefore, those agencies' expenditure data are not presented in this report. Finally, we excluded from table 1 NRCS, which provided solely multi-purpose HAB-related expenditure data, because NRCS officials told us that it was a generous estimate that target water quality, including HABs, and we believed it would skew the overall federal agencies' estimated total.

data are sufficiently reliable for the purpose of producing a rough estimate of HAB-related expenditures, the lack of a standardized approach to collecting HAB-related expenditures means that any federal total should be regarded as a rough estimate, and any comparisons among agencies' expenditures should be regarded as inexact. In addition, our questionnaire asked the agencies for information on (1) their agencies' key activities regarding HABs; (2) the purposes of these activities; (3) the specific statutory provisions authorizing these activities; and (4) the funding mechanisms used, such as grants, contracts, or interagency agreements.

To determine how federal agencies coordinate their HAB-related activities with each other and with nonfederal stakeholders, we collected and analyzed information from the agencies through interviews and our questionnaire on (1) their participation with each other and nonfederal stakeholders in interagency working groups or other mechanisms to share information and coordinate on HABs research, monitoring, or other activities;[5] (2) efforts taken by federal agencies to minimize duplication; and (3) gaps, if any, in federal HAB-related activities. As warranted, we sent the agencies follow-up requests for clarification or elaboration. We also received and reviewed the official notes from a nongeneralizable sample of 21 IWG-HABHRCA twice-monthly meetings, starting from the group's creation in October 2014 through July 2016. In addition, we attended, in person or by phone, the following events to observe federal agencies' efforts to coordinate HAB-related activities with each other and other stakeholders:

- Biennial conference of HAB experts and researchers, "Eighth Symposium on Harmful Algae in the U.S.," led by HAB researchers from the Southern California Coastal Water Research Project and University of Southern California; the conference was held in November 2015 and attended by more than 250 federal and state

[5]For the purpose of this report, we define coordination as any joint activity by two or more organizations that is intended to produce more public value than could be produced when the organizations act alone. We use the term "coordination" broadly to include interagency activities that others have variously defined as "collaboration," "cooperation," "integration," or "networking." We have done so since there are no commonly accepted definitions for these terms, and we are unable to make definitive distinctions between these different types of interagency activities.

officials, academic researchers, non-profit organization representatives, and industry representatives;

- A nongeneralizable sample of five IWG-HABHRCA twice-monthly meetings from February through July 2016, based on our availability; and
- Three webinars focused on HABs and hypoxia in the Great Lakes, two of which were organized by the IWG-HABHRCA in February 2016 and one of which was organized by the Inland HAB Discussion Group in March 2016.

In addition, through our correspondence with federal agencies and our own web searches, we identified agencies' publicly accessible websites describing HABs and HAB-related activities. We conducted a general web search, and searched each of the agencies' websites, using the terms "algae blooms" and "algal blooms." Based on the search results, we identified websites that were broad or national in scope and that appeared to be maintained by the agency on an ongoing basis (as opposed to being a one-time news release or document). We then asked each of the agencies to review our results for their particular agency, to verify that we had identified the appropriate websites and to refer us to any additional HAB-related websites (maintained by the agency) that met our criteria.

We conducted this performance audit from September 2015 to October 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Federal Agencies' Key Harmful Algal Bloom-Related Activities, Expenditures, and Authority

Appendix II includes additional information for federal agencies that reported expenditures for activities related to harmful algal blooms (HAB) from fiscal years 2013 through 2015 and specific statutory provisions authorizing such activities. We present detailed tables for each of the agencies' HAB-related expenditures for informational purposes, but we did not independently verify these amounts.

(1) Centers for Disease Control and Prevention (CDC)

Agency's Mission and Key HAB-Related Activities

According to agency officials, for more than 40 years, CDC has provided epidemiology and surveillance support to states and other partners, enabling them to take public health action to address non-infectious water-related concerns. In the late 1990s, CDC began to address public health issues associated with HABs. In the past several years, CDC has been involved with a number of HAB-related activities, including the following:

- collaborating with the National Oceanic and Atmospheric Administration (NOAA) to engage citizen scientists to identify and report freshwater HAB events;
- collaborating with NOAA to improve a module to forecast cyanobacterial blooms;
- providing technical assistance and expert guidance to states that experience HABs;
- convening a workgroup to identify surveillance indicators and measures for bloom events and public health consequences;
- developing health surveillance definitions for reporting HAB-related human cases of illnesses, animal cases of illness, and HAB events;
- creating the One Health Harmful Algal Bloom System, a nationally available, online system for health agencies and their animal and environmental health agency partners to report HAB-related illnesses in animals and people, and the environmental conditions associated with the HABs;
- providing resources to state health departments to build capacity for HAB-related illness surveillance; and

- creating a CDC website about HAB-associated illnesses (http://www.cdc.gov/habs/).

In addition, the agency's Division of Laboratory Sciences provides laboratory support for public health responses to chemical threat agents. For example, this division provides assistance to state and local laboratories responding to regional events by identifying people exposed to certain toxins from marine and freshwater HABs.

HAB-Related Expenditures

According to agency-provided expenditures from fiscal years 2013 through 2015, CDC expended a total of roughly $1.7 million on public health surveillance, waterborne disease prevention, and health promotion, as follows:

- $566,828 in fiscal year 2013,
- $524,004 in fiscal year 2014, and
- $573,776 in fiscal year 2015.[1]

For CDC's expenditures, see table 4.

Legal Authority to Address HABs

According to agency officials, CDC's authority to address HABs is provided under the Public Health Service Act (PHSA), and some activities receive funding from the Environmental Protection Agency (EPA).

- Sections 301(a) and 317(k)(2) of the PHSA, as amended, authorize public health activities research and other activities and authorize grants to states and other entities for public health purposes.
- EPA's Great Lakes Restoration Initiative (GLRI) provides annual funding to CDC's National Center for Emerging and Zoonotic Infectious Diseases through an interagency agreement. One purpose of the center is to build waterborne disease prevention capacity in the Great Lakes states to inform and evaluate GLRI activities. This includes systematic detection and descriptions of HABs and associated human and animal health effects and environmental impacts. The National Center for Emerging and Zoonotic Infectious Diseases works closely with subject matter experts in CDC's National Center for Environmental Health to address three main efforts: (1)

[1]The total numbers for fiscal years 2013 through 2015 do not add to $1.7 million because of rounding.

rebuilding and launching of public health surveillance for HABs, (2) state waterborne disease prevention capacity-building, and (3) health promotion. Through partnering with other federal agencies, CDC aims to connect these data to better describe the occurrence and health consequences of HABs.

Table 4: Centers for Disease Control and Prevention (CDC) Harmful Algal Bloom (HAB)-Related Programs and Expenditures, Fiscal Years 2013- 2015

Amounts in dollars

Initiatives/ programs	Purpose	Funding mechanism /recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Public health surveillance for HABs	Develops HAB surveillance (direct costs for information technology development and a HAB coordinator)	Contract[c]	Public Health Service Act (PHSA). § 301	197,000	201,958	75,000	**473,958**
State waterborne disease prevention capacity-building	Provides Council of State and Territorial Epidemiologists fellowship and project support	Cooperative agreements[d]	PHSA. § 301	369,828	322,046	498, 776	**1,190,650**
Health promotion	Expands HAB-related information and health promotion materials	Contract[e]	PHSA. § 301	n/a	n/a	n/a	**n/a**
CDC total				**566,828**	**524,004**	**573,776**	**1,664,608**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of CDC expenditure data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by CDC officials.

[b]According to CDC officials, these amounts reflect actual, estimated, and obligated expenditures. CDC officials reported that the expended funds were received from the Great Lakes Restoration Initiative. The CDC-identified HAB-related initiatives and programs are a mixture of single- and multi-purpose. We did not independently verify these amounts.

[c]Public health surveillance for HABs funding recipients are private companies and CDC.

[d]State waterborne disease prevention capacity-building funding recipients are the Council of State and Territorial Epidemiologists, which administers the council's Applied Epidemiology fellowship, and CDC's Epidemiology and Laboratory Capacity program, which funds state capacity-building work.

[e]Health promotion funding recipients are a private company and CDC. The agency indirectly provides funding to staff and information technology development that, according to CDC officials, cannot be broken down into HAB-related and non-HAB-related expenditures.

(2) Environmental Protection Agency (EPA)

Agency's Mission and Key HAB-Related Activities

According to agency officials, EPA's mission is to protect human health and the environment. To accomplish this mission, the agency develops relevant policy and guidelines, conducts research, provides assistance through grants and other agreements, educates the public, and creates partnerships. EPA's Office of Water (OW), Office of Research and Development (ORD), and EPA regions, as well as the Gulf of Mexico Program Office and the Great Lakes National Program Office, have been working together to protect public health from HABs, including toxin-producing cyanobacteria. From fiscal years 2013 through 2015, EPA's research on HABs and their toxins focused on four main areas:

- *Water quality research:* Explores the interrelationships among nutrient inputs, temperature effects, land use, and runoff and how these parameters affect the timing, distribution, and magnitude of HABs and toxin production.
- *Human and ecological health effects research:* Provides information on human exposure to HAB toxins (e.g., dermal vs. ingestion) and food-chain bioaccumulation and allergenic aspects of toxins produced by cyanobacteria (cyanotoxins). ORD continues to develop and optimize analytical procedures for measuring HAB toxins in drinking and source waters, including the qualitative and quantitative analysis of microcystin toxins, which are also being examined for toxicity levels.
- *Monitoring/analytical methods research:* Includes small-scale monitoring, such as surface water and real-time water quality monitoring, to large-scale monitoring using satellite imagery. The ultimate objective for monitoring research is to provide communities and utilities with early warning detection methods to better manage consequences from HABs.
- *Drinking water treatment research:* Provides results on optimizing drinking water treatment strategies and timely response to HAB events, such as the Toledo, Ohio, incident in August 2014 caused by a toxic bloom in Lake Erie.

HAB-Related Expenditures

According to agency-provided expenditure data from fiscal years 2013 through 2015, EPA expended a total of roughly $14.5 million on HAB-related activities across various research efforts, as follows:

- $3.2 million in fiscal year 2013,
- $5.6 million in fiscal year 2014, and
- $5.7 million in fiscal year 2015.[2]

For specific HAB-related expenditures, see table 5, highlighting activities by OW, the regions, and ORD.

Legal Authority to Address HABs

According to agency officials, EPA's authority to address HABs is provided by three statutes and as a part of annual appropriations for the Great Lakes Restoration Initiative (GLRI).[3]

- The Safe Drinking Water Act (SDWA) has a goal of ensuring that public drinking water is safe and requires EPA to establish legally enforceable standards for public water systems to limit the levels of specific contaminants that can adversely affect public health. Under the SDWA, EPA is proposing in its 4th Candidate Contaminant List and its 4th Unregulated Contaminant Monitoring Rule the evaluation and monitoring of several cyanotoxins that may be present in drinking water systems.
- The Drinking Water Protection Act (Pub. L. No. 114-45), enacted on August 7, 2015, amended the SDWA in 2015 by adding Section 1459, which directs EPA to develop and submit a strategic plan for assessing and managing risks associated with algal toxins in drinking water provided by public water systems. The act requires the strategic plan to include steps and timelines to assess human health effects and to identify a list of algal toxins, health advisories, treatment

[2]EPA officials reported that this funding does not include EPA's nutrient reduction projects, nutrient monitoring, phytoplankton community monitoring, or assessment of nutrient reduction projects intended to support reductions in HABs—which have collectively cost hundreds of millions of dollars since fiscal year 2010.

[3]The Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014 assigned EPA primary responsibility for administering the freshwater aspects of the HAB program, except for the Great Lakes. The amendments require EPA, through an interagency task force, to conduct research on the ecology and impacts of freshwater HABs and to forecast, monitor, and respond to freshwater HABs in lakes, rivers, estuaries (including their tributaries), and reservoirs.

options, analytical and monitoring approaches, causes of HABs, source water protection, and collaboration and outreach.[4]

- The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into waters of the United States and for regulating quality standards for surface waters. Under the CWA, EPA has implemented pollution control programs and has reviewed, approved, or promulgated water quality standards to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Section 303(d) of the CWA requires states to identify those waters that are not meeting applicable water quality standards (impaired waters or impairments) and for which the state must establish Total Maximum Daily Loads for pollutants.
- Some states have identified algal toxins and cyanobacteria hepatotoxic microcystins as causing recreational use impairments for source water on the most recent 303(d) list, and Total Maximum Daily Loads have been approved to address impairments to aquatic life, recreation, and subsistence fishing uses caused by cyanotoxins. Section 426 of Pub. L. No. 114-113, enacted in December 2015, formally established the GLRI to carry out programs and projects for Great Lakes protection and restoration.[5] GLRI action plans outline such activities for the GLRI, which include implementation of activities to reduce nutrient and sediment loadings such as voluntary agricultural practices; tracking; voluntary, incentive-based, and regulatory approaches to reduce nutrient losses; education; and other implementation of watershed management and green infrastructure projects. GLRI partners will also assess the extent to which HABs are affected by various factors and the relationship between algal blooms and hypoxia. In addition, in 1972, the United States and Canada signed the Great Lakes Water Quality Agreement to restore, protect, and enhance the water quality of the Great Lakes to promote the ecological health of the Great Lakes Basin. The countries signed another Great Lakes Water Quality Agreement in 1978, which was

[4]To meet these requirements, EPA released *Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water* in November 2015.

[5]Congress first made funds available for the GLRI in fiscal year 2010. In fiscal years 2010, 2012, 2014, and 2015, Congress did not provide appropriations for GLRI purposes. Instead, in those fiscal years, Congress provided EPA with transfer authority, up to a maximum amount, to undertake GLRI programs and projects. However, in fiscal years 2011 and 2013, Congress did provide EPA with specific appropriations for GLRI purposes.

amended several times. For example, most recently, in 2012, the nations added provisions to the agreement to address the effects of climate change, among other things.

Table 5: Environmental Protection Agency (EPA) Harmful Algal Bloom (HAB)-Related Research Programs and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Offices/ Regions	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Office of Water (OW)							
Office of Science and Technology	OW is responsible for developing policies and guidelines to support the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA). OW supports the needs of the states and local agencies by creating partnerships and facilitating outreach and communication to protect public health in both surface water and drinking water systems.	Interagency agreements, contract[c]	SDWA. §§ 1412(b)(1)(B) and (b)(1)(F); CWA. § 304(b)	306,436	202,905	30,450	**539,791**
Office of Wetlands, Oceans, and Watersheds	See OW purpose above.	Grants, contracts, interagency agreement[d]	CWA. §§ 104 and 106; 40 C.F.R. parts 130 and 131	55,500	610,000	610,500	**1,276,000**
Office of Ground Water and Drinking Water	See OW purpose above.	Contract[e]	SDWA. §§ 1412(b)(1)(B) and 1459	26,200	261,600	513,800	**801,600**
Subtotal				**388,136**	**1,074,505**	**1,154,750**	**2,617,391**
Regions							
Region 1	The regions support the needs of the states and local agencies by creating partnerships and facilitating outreach and communication to protect public health in both surface water and drinking water systems.	Loan[f]	CWA. Sec. 305(b)	n/a	3,740	11,740	**15,480**
Region 3	See region purpose above.	Grant[g]	CWA. § 117	220,000	220,000	220,000	**660,000**

Offices/ Regions	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Region 4 and Gulf of Mexico Program Office	See region purpose above.	Cooperative agreement[h]	40 C.F.R. parts 30 and 31[i]	n/a	n/a	n/a	**n/a**
Region 5 and Great Lakes National Program Office[j]	See region purpose above.	Contracts, grants, interagency agreement, cooperative agreement[k]	Annex 4 of the Great Lakes Water Quality Agreement; CWA. § 104(b)(2),(3); annual EPA appropriations acts[l]	1,730,741	2,468,163	2,153,611	**6,352,516**
Region 7	See region purpose above.	Purchase card[m]	CWA. § 104	3,500	3,500	11,425	**18,425**
Region 8	See region purpose above.	Contract[n]	CWA. § 304(b)	n/a	n/a	26,316	**26,316**
Region 9	See region purpose above.	Supplies, contract, technical assistance, and grant[o]	CWA. §§ 106, 305(b), 319; SDWA.	165,000	915,000	537,700	**1,617,700**
Region 10	See region purpose above.	Grant, cooperative agreement[p]	Indian Environmental General Assistance Program Act of 1991; CWA. § 320(g)	124,929	106,660	288,392	**519,981**
Subtotal				**2,244,170**	**3,717,063**	**3,249,184**	**9,210,418**
Office of Research and Development (ORD)							
ORD	ORD is the scientific research arm of EPA and supports six research programs that identify the most pressing environmental health research needs. ORD coordinates and gets input from EPA program offices, the regions, partners, and stakeholders for the development of the research programs.	Contract[q]	SDWA. §§ 1412(b)(1)(B) and 1442(a)(1); Harmful Algal Bloom and Hypoxia Research and Control Act, especially 42 U.S.C. § 4002(h); CWA. §§ 104(a)(1), (5), and (6)	601,519	798,183	1,276,439	**2,676,141**
Subtotal				**601,519**	**798,183**	**1,276,439**	**2,676,141**
EPA total				**3,233,825**	**5,589,751**	**5,680,373**	**14,503,950**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of EPA data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by EPA officials.

[b]According to EPA officials, these amounts reflect actual expenditures. The EPA-identified HAB-related research programs are single-purpose. We did not independently verify these amounts. In addition, agency officials stated that 2 of EPA's 10 regional offices did not fund HAB-related programs from fiscal years 2013 through 2015.

[c]Office of Science and Technology funding recipients are national laboratories, a private entity, and a research institution.

[d]Office of Wetlands, Oceans, and Watersheds funding recipients are states, tribes, a federal agency, and a nonprofit organization.

[e]Office of Ground Water and Drinking Water funding recipients are private entities, a university, and science laboratories.

[f]Region 1 funding recipients are research staff members.

[g]Region 3 funding recipients are states.

[h]Region 4 funding recipient is a university.

[i]In December, 2014, EPA repealed 40 C.F.R. part 30 (Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and Other Nonprofit Organizations) and part 31 (Uniform Administrative Requirements for Grants and Agreements with States and Localities), and replaced them with 2 C.F.R. § 1500.1.

[j]The identified Great Lakes National Program Office funding does not include multi-purpose nutrient reduction projects, nutrient monitoring, phytoplankton community monitoring, or assessment of nutrient reduction projects intended, in part, to support reductions in HABs. According to EPA officials, since 2010, hundreds of millions of dollars have been allocated for a wide array of projects that will reduce the loading of nutrients—which can fuel HABs—to the Great Lakes. For example, more than 680 projects and $60 million of Great Lakes Restoration Initiative (GLRI) funds were invested in the Lake Erie Basin from 2010 through 2015 to reduce phosphorus, nutrient, and nonpoint source pollution and to support related science and monitoring work. The agency could not provide expenditure amounts for the HAB-related portions of those projects during the time frame of our review.

[k]Region 5 funding recipients are a private entity, federal and state agencies, and a regional planning commission.

[l]Congress first made funds available for the GLRI in fiscal year 2010. In fiscal years 2010, 2012, 2014, and 2015, Congress did not provide appropriations for GLRI purposes. Instead, in those fiscal years, Congress provided EPA with transfer authority, up to a maximum amount, to undertake GLRI programs and projects. However, in fiscal years 2011 and 2013, Congress did provide EPA with specific appropriations for GLRI purposes.

[m]Region 7 funding recipient is Region 7.

[n]Region 8 funding recipient is a private entity.

[o]Region 9 funding recipients are states, tribes, utility companies, and municipalities.

[p]Region 10 funding recipients are tribes and a university.

[q]ORD funding recipients are federal agencies, research institutions, a university, and an EPA program.

(3) Food and Drug Administration (FDA)

Agency's Mission and Key HAB-Related Activities

According to agency officials, FDA is responsible for protecting public health by ensuring that human and animal drugs are safe and effective; biological products do not threaten public health; there are reasonable

assurances that medical devices are safe and effective; food is safe, wholesome, sanitary, and properly labeled; cosmetics are safe and properly labeled; and the public health and safety is protected from products that emit radiation. FDA's Center for Food Safety and Applied Nutrition, in conjunction with the agency's field staff promotes and protects the public health by ensuring that the nation's food supply is safe, sanitary, wholesome, and properly labeled, and that cosmetic products are safe and properly labeled. FDA's role and expertise in conducting activities focused on toxin-producing cyanobacteria and algae and public health concerns related to HABs are mission relevant and focused on products regulated by the agency.

Center for Food Safety and Applied Nutrition regulates products that may be affected by harmful algae, their toxins, or both, including seafood, dietary supplements, and bottled water. Most of FDA's HAB activities focus on seafood, with fewer dedicated efforts on dietary supplements. To date, there have been no specific HAB activities focused on bottled water. FDA HAB-related activities include research program management, project management, domestic and international compliance and enforcement, regulation development and policy, emergency response and recovery, risk assessment, education and outreach, consumer education, postmarket monitoring and surveillance, domestic regulatory partnerships, international standards development, trade and partnerships, industry and academic collaboration, international collaboration and outreach, recalls, administrative activities, economic adulteration, and employee training. FDA awards small contracts to external entities in cases where it would be more cost-effective than the agency performing the work, FDA does not have the expertise or capability to conduct the work needed, or FDA can achieve more through collaboration and contributions to other's work.

HAB-Related Expenditures

According to agency-provided expenditures from fiscal years 2013 through 2015, FDA expended a total of roughly $7.4 million on internal and external activities, as follows:

- $2.1 million in fiscal year 2013,
- $2.7 million in fiscal year 2014, and
- $2.6 million in fiscal year 2015.

For FDA's expenditures, see table 6.

Legal Authority to Address HABs

According to agency officials, FDA's authority to address HABs and their toxins is provided under multiple statutes, including the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 et seq.); the Public Health Service Act (PHSA) (42 U.S.C. 243); and 21 C.F.R. part 123 (Fish and Fishery Products), specifically 21 C.F.R. § 123.6 (Seafood Hazard Analysis and Critical Control Point Plan) and 21 C.F.R. § 1240.60 (Molluscan Shellfish). Seafood Hazard Analysis and Critical Control Point is a preventive system of hazard control implemented by processors to help ensure the safety of their products and reduce the risk of illness for consumers. Seafood Hazard Analysis and Critical Control Point requires that processors identify and control for species- and process-specific hazards, which would include biotoxins produced by HABs.

FDA is designated by the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 (Pub. L. No. 105-383 § 603(a), 112 Stat. 3447, 3448) as one of the federal agencies that shall participate in an interagency task force on HABs and hypoxia to develop reports and assessments for Congress. The act was most recently amended in 2014 by Pub. L. No. 113-124, 128 Stat. 1379.

Table 6: Food and Drug Administration (FDA) Harmful Algal Bloom (HAB)-Related Activities and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Types of activities	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Intramural activities, including research	To identity hazardous sources and vectors for biotoxins that affect seafood safety; develop, optimize and validate a range of methods used to detect toxins in seafood environments; and develop policy, compliance, enforcement, risk assessment, education and outreach, and respond to potential illnesses.	Intramural[c]	Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 et seq.); the Public Health Service Act (PHSA) (42 U.S.C. 243); and 21 C.F.R. part 123 (Fish and Fishery Products) and 21 C.F.R. § 1240.60 (Molluscan Shellfish).	1,900,000	1,995,243	2,064,774	**5,960,017**
External activities	To support the maintenance of analytical equipment to ensure quality control of data generated from instruments, enhance education and outreach partnerships, support research collaborations, and fund student and post-doctoral participation in a national HAB conference.	Contracts, grant, interagency agreement[d]	Federal Food, Drug, and Cosmetic Act (21 U.S.C. 301 et seq.); the PHSA (42 U.S.C. 243); and 21 C.F.R. part 123 (Fish and Fishery Products), and 21 C.F.R. § 1240.60 (Molluscan Shellfish).	181,000	686,083	557,199	**1,424,282**
FDA total				**2,081,000**	**2,681,326**	**2,621,973**	**7,384,299**

Legend: FY = fiscal year.

Source: GAO analysis of FDA expenditure data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by FDA officials.

[b]According to FDA officials, these amounts reflect actual and estimated expenditures. The FDA-identified HAB-related activities are a mixture of single- and multi-purpose. We did not independently verify these amounts.

[c]Intramural activities, including research, funding recipients are FDA's Office of Regulatory Science, Office of Compliance, Office of Foods and Veterinary Medicine, Office of Regulatory Affairs, and the Office of Food Safety.

[d]External activities funding recipients are universities, a science symposium, a science laboratory, a research institution, and contractors.

(4) National Aeronautics and Space Administration (NASA)

Agency's Mission and Key HAB-Related Activities

According to agency officials, the purpose of NASA's Earth Science Division is to develop a scientific understanding of the Earth and its response to natural or human-induced changes, and to improve prediction of climate, weather, and natural hazards. A major component of NASA's Earth Science Division is a coordinated series of satellite and airborne missions for long-term global observations of the land surface, biosphere, solid earth, atmosphere, and oceans. This coordinated approach enables an improved understanding of the Earth as an integrated system.

NASA also supports Executive Order 13547 that established the National Ocean Policy, a policy for the stewardship of the ocean, coasts, and Great Lakes. NASA participates in many interagency working groups, including the Interagency Working Group on the Harmful Algal Blooms and Hypoxia Research and Control Act. NASA research supports the working group's scientific objectives when possible and relevant to the agency mission.

HAB-Related Expenditures

According to agency-provided expenditures from fiscal years 2013 through 2015, NASA expended a total of roughly $2.0 million on HAB-related activities across various monitoring efforts and research-related activities, as follows:

- $344,003 in fiscal year 2013,
- $230,545 in fiscal year 2014, and
- $1.4 million in fiscal year 2015.[6]

[6]The total numbers for fiscal years 2013 through 2015 do not add to $2.0 million because of rounding.

For specific HAB-related program expenditures, see table 7.

Legal Authority to Address HABs

According to agency officials, NASA's authority to address HABs is provided under the NASA Authorization Act, 51 U.S.C. §§ 20112 and 20113, which authorizes NASA's Earth science research. Table 7 includes specific HAB-related expenditures organized by program and project: (1) NASA Ocean Biology and Biogeochemistry, (2) NASA Health and Air Quality Applications, (3) SERVIR (an acronym for the Spanish words meaning Mesoamerican Regional Visualization and Monitoring System), (4) Digital Earth Virtual Environment Learning Outreach Project, (5) Applied Remote Sensing Training, (6) Research and Analysis, and (7) Center for the Advancement of Science in Space HAB research grant project.

Table 7: National Aeronautics and Space Administration (NASA) Harmful Algal Bloom (HAB)-Related Programs and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Programs/ projects	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
NASA Ocean Biology and Biogeochemistry	NASA's Ocean Biology and Biogeochemistry program focuses on describing, understanding, and predicting the biological, ecological, and biogeochemical regimes of the upper ocean, as determined by observation of aquatic optical properties using remote sensing data, including those from space, aircraft, and other suborbital platforms. The program has undertaken research regarding cyanobacteria and development of associated ocean color satellite data products for freshwater systems to develop an early warning indicator/data product for toxic and nuisance blooms.	Interagency agreement and Research and Technology Operating Plan[c]	NASA Authorization Act, 51 U.S.C. §§ 20112 and 20113	n/a	n/a	97,930	**97,930**
NASA Health and Air Quality Applications	The NASA Health and Air Quality Applications program encourages the use of Earth observations in air quality management and public health, particularly involving environmental health and infectious diseases. The program has undertaken projects that identify environmental thresholds that indicate the potential for cyanobacterial or *Karenia brevis* blooms to form or persist, and makes these data sets available to state and federal operational managers for HAB monitoring and characterization.	Interagency agreement, grant[d]	NASA Authorization Act, 51 U.S.C. §§ 20112 and 20113	318,485	n/a	330,935	**649,420**

Programs/ projects	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
SERVIR (an acronym for the Spanish words meaning Mesoamerican Regional Visualization and Monitoring System)	The NASA Capacity Building Program's SERVIR program is a NASA and U.S. Agency for International Development initiative that fosters applications of Earth observations and geospatial technologies to help developing countries assess environmental conditions and climate change to better inform their decision-making processes. SERVIR has provided HAB support in Latin America based on end user needs.	Cooperative agreement and contract[e]	NASA Authorization Act, 51 U.S.C. §§ 20112 and 20113	11,413	6,000	12,260	**29,673**
Digital Earth Virtual Environment Learning Outreach Project	From 2010 through 2015, this NASA Capacity Building Program has conducted feasibility projects that sought to build capacity for end users and partners to use NASA Earth observations to assist with decision-making and policy related to HABs. The projects sought to apply existing NASA products and published methods to help partners make better decisions, and make them easier and faster.	Cooperative agreement and contract[f]	NASA Authorization Act, 51 U.S.C. §§ 20112 and 20113	14,105	64,545	107,790	**186,440**
Applied Remote Sensing Training	This NASA Capacity Building Program offered its first water quality webinar in November and December 2014. This webinar covered remote sensing of Chlorophyll-a concentration from the Moderate Resolution Imaging Spectroradiometer, which is an indicator for HABs.	Cooperative agreement and contract[g]	NASA Authorization Act, 51 U.S.C. §§ 20112 and 20113	n/a	35,000	35,000	**70,000**

Programs/ projects	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Research and Analysis	The Earth Science Research and Analysis program enables advances in Earth system science by supporting analysis of data from NASA satellites and aircraft, as well as those of our international partners, and documents the program's results in peer-reviewed literature while sharing results with the broader public. The program has funded research to delineate the presence of harmful algal species, their concentration, and their movement in an augmented spatial and temporal resolution and under clouds.	Research and Technology Operating Plan[h]	NASA Authorization Act, 51 U.S.C. §§ 20112 and 20113	n/a	n/a	710,000	**710,000**
Center for the Advancement of Science in Space HAB research grant project	The International Space Station National Laboratory, managed by the Center for the Advancement of Science in Space, issued a grant to study HABs using the Hyperspectral Imager for the Costal Ocean instrument, which provides space-borne imaging that samples ocean coastal regions.	Grant[i]	NASA Authorization Act, 51 U.S.C. § 20113	n/a	125,000	125,000	**250,000**
NASA total				**344,003**	**230,545**	**1,418,915**	**1,993,463**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of NASA data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by NASA officials.

[b]According to NASA officials, these amounts reflect actual expenditures. The NASA-identified HAB-related programs and project are a mixture of single- and multi-purpose. We did not independently verify these amounts.

[c]NASA Ocean Biology and Biogeochemistry program funding recipients are federal agencies.

[d]NASA Health and Air Quality Applications program funding recipients are a federal agency and university.

[e]SERVIR program funding recipients are various university representatives and contractors.

[f]Digital Earth Virtual Environment Learning Outreach Project program funding recipients are various university representatives and contractors.

[g]Applied Remote Sensing Training program funding recipients are various university representatives and contractors.

[h]Research and Analysis program funding recipient is the NASA research center.

[i]Center for the Advancement of Science in Space HAB research grant project funding recipient is the Naval Research Laboratory.

(5) Department of the Navy (Navy)

Agency's Mission and Key HAB-Related Activities

According to agency officials, the Navy's mission is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. The Office of Naval Research coordinates, executes, and promotes the science and technology programs of both the Navy and the U.S. Marine Corps. The Naval Research Laboratory (NRL) is the corporate research laboratory for the Navy and Marine Corps and conducts a broad program of scientific research, technology, and advanced development. Some NRL research, capabilities, and techniques are useful when applied to other fields, including HAB and hypoxia research performed by other agencies, such as the National Oceanic and Atmospheric Administration, Environmental Protection Agency, and National Aeronautics and Space Administration. Thus, NRL provides expertise and experience to other agencies for a variety of research purposes, including HAB and hypoxia research.

HAB-Related Expenditures

According to agency-provided expenditures from fiscal years 2013 through 2015, Navy expended a total of roughly $1.0 million on HAB-related activities across various monitoring and research-related activities, as follows:

- $343,000 in fiscal year 2013,
- $353,000 in fiscal year 2014, and
- $353,000 in fiscal year 2015.[7]

For specific HAB-related program expenditures, see table 8.

Legal Authority to Address HABs

According to agency officials, Navy's authority to address HABs is provided under 10 U.S.C. § 5013, which authorizes the Secretary to be responsible for, and have the authority necessary to conduct, all affairs of the agency. In addition, 10 U.S.C. § 7921 authorizes the Secretary to

[7]The total numbers for fiscal years 2013 through 2015 do not add to $1.0 million because of rounding.

maximize the safety and effectiveness of all maritime vessels, aircraft, and members of the armed forces by means of (1) marine data collection, (2) numerical weather and ocean predictions, and (3) forecasting of hazardous weather and ocean conditions.

Table 8: Department of the Navy (Navy) Harmful Algal Bloom (HAB)-Related Projects and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Projects	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Internally funded projects							
Dinoflagellate identification and ecological modeling	Study of in situ and remotely sensed spectral optical properties to identify dinoflagellates through field sampling and improvement of remote sensing techniques. Dinoflagellate information has been incorporated into the Naval Research Laboratory's (NRL) ecological-circulation models for better understanding/prediction. This work supported improved understanding of ocean clarity, which is important operationally to the Navy. Some dinoflagellate species can contribute to HAB outbreaks.	Navy appropriation[c]	10 U.S.C. §§ 5013 and 7921	343,000	353,000	353,000	**1,049,000**
Projects funded by other federal agencies							
Improved characterization and quantification of hypoxia	The National Oceanic and Atmospheric Administration (NOAA), National Science Foundation, and Navy developed a research plan to utilize gliders to examine hypoxia in coastal regions, including the Gulf of Mexico. Agency gliders were eventually to be incorporated into a global observation network. Additional coordination would lead to improved data management, product development, and data/product delivery (NOAA's Integrated Ocean Observing System (IOOS) National Glider Network Plan). The product of this work was a white paper designed to focus multiagency efforts.	n/a[d]	n/a[e]	n/a	n/a	n/a	n/a

Projects	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Navy total				**343,000**	**353,000**	**353,000**	**1,049,000**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of Navy expenditure data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by Navy officials.

[b]According to Navy officials, these amounts reflect actual and estimated expenditures. The Navy-identified HAB-related projects are a mixture of single- and multi-purpose. We did not independently verify these amounts.

[c]Dinoflagellate identification and ecological modeling funding recipient is the NRL at the National Aeronautics and Space Administration's Stennis Space Center.

[d]According to Navy officials, the Navy did not provide nor receive funding for the improved characterization and quantification of hypoxia project.

[e]Agency did not provide legal authority.

(6) National Institute of Environmental Health Sciences (NIEHS)

Agency's Mission and Key HAB-Related Activities

According to agency officials, HABs are a primary focus of NIEHS-supported research activities in marine and freshwater environments. There are two overarching themes associated with the NIEHS HAB grants portfolio: (1) supporting research on the health effects associated with exposure to HAB toxins; and (2) supporting research that reduces human exposure to HAB toxins.

To accomplish this mission, NIEHS has solicited and funded grant applications in collaboration with the National Science Foundation, with a specific focus on marine and freshwater HABs. NIEHS has also supported peer-reviewed, unsolicited research grant applications to develop novel approaches to enhance prediction of HAB events and to better understand the adverse impacts on human health associated with exposures to HAB toxins. Additionally, NIEHS has supported research conferences that allow investigators to share published and unpublished research results, and has provided training opportunities for pre- and post-doctoral investigators to help advance this scientific field and develop the next generation of HAB investigators.

HAB-Related Expenditures

According to agency-provided expenditure data, NIEHS expended a total of roughly $8 million from fiscal years 2013 through 2015 on HAB-related projects and activities, as follows:

- $1.9 million in fiscal year 2013,
- $3.3 million in fiscal year 2014, and
- $2.8 million in fiscal year 2015.

Table 9 identifies specific HAB-related expenditures, organized by (1) toxicity, (2) detection, and (3) communication.

Legal Authority to Address HABs

According to agency officials, NIEHS' authority to address HABs is provided under a variety of statutes. Additional information on these statutes follows:

- The Public Health Service Act (PHSA), particularly Sections 301 (Public Health Research and Investigation),[8] 401 (NIEHS Organization and Authorities),[9] 437 (Research and Training),[10] and 463 (NIEHS Purpose),[11] authorizes the activities included in table 9.
- The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Reauthorization Act of 2011, Pub. L. No. 112-81, 15 U.S.C. 638, authorizes NIEHS to provide assistance for certain detection technology activities.
- The Harmful Algal Bloom and Hypoxia Research and Control Act, as amended, Pub. L. No. 105-83, 108-456, and 113-124, 33 U.S.C. 4001 et seq., authorizes NIEHS participation in the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Amendments Act, and other NIEHS interagency collaboration

[8]42 U.S.C. § 241.

[9]42 U.S.C. § 281.

[10]42 U.S.C. § 285d-2.

[11]42 U.S.C. § 285.

Table 9: National Institute of Environmental Health Sciences (NIEHS) Harmful Algal Blooms (HAB)-Related Activities and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Types of activities	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Toxicity	A primary purpose of NIEHS research on HABs is to utilize multidisciplinary approaches to • enhance understanding of the adverse consequences to human health from exposure to HAB toxins, • identify mechanisms of toxicities, • determine toxin exposure routes, • use animal models to study health effects, and • perform studies in human cohorts.	Grant[c]	Public Health Service Act (PHSA), particularly §§ 301, 401, 437, and 463	1,262,531	2,386,571	2,240,801	**5,889,903**
Detection	The second focus is to support research of novel strategies aimed at preventing HAB toxin exposures by • developing state-of-the-art sensing approaches for prediction and forecasting of HAB events, • improving detection of HAB toxin-producing microorganisms, • identifying new HAB-producing species, • improving understanding of the geophysical conditions that are favorable or conducive to initiating HAB events, and • developing translational approaches.	Grant[d]	PHSA, particularly §§ 301, 401, 437, and 463; SBIR and STTR Reauthorization Act of 2011, Pub. L. No.112-81, 15 U.S.C 638	632,072	932,882	528,488	**2,093,442**
Communication	A third focus of the NIEHS is to ensure dissemination and communication of research results through support of research conferences.	Grant[e]	PHSA, particularly §§ 301, 401, 437, and 463	n/a	n/a	8,000	**8,000**
NIEHS total				**1,894,603**	**3,319,453**	**2,777,289**	**7,991,345**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures); SBIR = Small Business Innovation and Research; STTR = Small Business Technology Transfer.

Source: GAO analysis of NIEHS data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by NIEHS officials.

[b]According to the NIEHS officials, these amounts reflect actual and obligated expenditures. The NIEHS-identified HAB-related activities are single-purpose. We did not independently verify these amounts.

[c]Toxicity activity recipients of the grants are universities.

[d]Detection activity recipients of the grants are universities, a private entity, and a research institution.

[e]Communication activity grant recipient is a research conference.

(7) National Institute of Food and Agriculture (NIFA)

Agency's Mission and Key HAB-Related Activities

According to agency officials, NIFA is the extramural funding agency for the Department of Agriculture (USDA) and provides leadership and funding for programs that advance agriculture-related sciences. Since the Food, Conservation, and Energy Act of 2008 directed its creation, NIFA has taken strides toward enhancing the impact of food, agriculture, natural resources, and human sciences on environment and human health. NIFA applies an integrated approach to ensure that groundbreaking discoveries in agriculture-related sciences and technologies reach the people who can put them into practice. NIFA invests in and supports initiatives that ensure the long-term viability of agriculture. The agency does not conduct research internally, but provides funding for research, extension, and education activities through competitive grants program and capacity programs.

In terms of human health and HABs, NIFA sponsors work that supports agriculturally relevant projects and the agency's human health areas focus on food safety. Most of NIFA's related work focuses on the impacts of HABs on aquaculture and ecology-related HABs research. NIFA provides funds to eligible institutions through competitive grants, capacity grants, and noncompetitive grants and agreements.

HAB-Related Expenditures

According to agency-provided expenditures from fiscal years 2013 through 2015, NIFA expended a total of roughly $393,968 on initiatives that focus on the impacts of HABs on aquaculture and ecology related research, as follows:

- $200,000 in fiscal year 2013,

- $144,000 in fiscal year 2014, and
- $49,968 in fiscal year 2015.[12]

For NIFA's expenditures, see table 10.

Legal Authority to Address HABs

According to agency officials, NIFA's authority to address HABs is provided under a variety of statutes, as follows:

- 7 U.S.C. 301 authorizes tribal research grants that support agricultural research addressing high-priority concerns of tribal, national, or multistate significance. Grants support investigative and analytical studies in the food and agricultural sciences. Funds are awarded on a competitive basis.
- Section 7406 of the Food, Conservation, and Energy Act of 2008 (Pub. L. No. 110-246) amended section 2(b) of the Competitive, Special, and Facilities Research Grant Act as amended (7 U.S.C. 450i(b)) to authorize the Secretary of Agriculture to make competitive grants to promote research in food, agriculture, and related areas. Under that authority, USDA established the Agriculture and Food Research Initiative as a competitive grant program to provide funding for fundamental and applied research, education, and extension to address food and agricultural sciences.
- Competitive, Special, and Facilities Research Grant Act, as amended and codified at 7 U.S.C. 450i(c), authorizes the Secretary of Agriculture to make grants, for periods not to exceed 3 years, for special emphasis awards to facilitate or expand promising food and agricultural research, extension, or education programs.

[12]NIFA officials reported that this funding does not include multi-purpose capacity awards that relate, in part, to HABs. According to agency officials, capacity programs are supported by federal formula funding, which in some cases, must be matched with state funding to support research in agriculture, food, nutrition, and related fields at the nation's land grant institutions. The funding is not delivered by project, but is provided to an eligible institution as one award. As these projects are subsets of larger awards, agency officials could not provide award amounts for the HAB-related portions of those awards within the time frame of our review.

Table 10: National Institute of Food and Agriculture (NIFA) Harmful Algal Bloom (HAB)-Related Initiatives and Programs and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Initiatives/ programs	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Tribal Colleges Research Grants Program	To determine the seasonal variation of algicidal bacteria in Northern Puget Sound and relationship with HABs.	Grants[c]	7 U.S.C. § 450i(c) and 16 U.S.C. § 582a-8	200,000	n/a	n/a	**200,000**
Post-doctoral fellowships	To evaluate impacts of HABs on shellfish aquaculture and sustainable mitigation strategies.	Agriculture and Food Research Initiative[d]	7 U.S.C. §§ 450i(b) and (c); 16 U.S.C. § 582a-8	n/a	144,000	n/a	**144,000**
Water for Agriculture Challenge Area	To launch a symposium series entitled the 2015 Healthy Soils for Healthy Waves dedicated to whole systems management practices for agricultural lands that affect the nation's waters.	Agriculture and Food Research Initiative[e]	7 U.S.C. § 450i(b) and (c); 16 U.S.C. § 582a-8	n/a	n/a	49,968	**49,968**
NIFA total				**200,000**	**144,000**	**49,968**	**393,968**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of NIFA expenditure data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by NIFA officials.

[b]According to NIFA officials, these amounts reflect estimated expenditures. The NIFA-identified HAB-related initiatives and programs are single-purpose. We did not independently verify these amounts.

[c]Tribal Colleges Research Grants Program funding recipient is a college.

[d]Post-doctoral fellowships funding recipient is a university.

[e]Water for Agriculture Challenge Area funding recipient is a university.

(8) National Oceanic and Atmospheric Administration (NOAA)

Agency Mission and Key HAB-Related Activities

According to agency officials, NOAA's mission is to understand and predict climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources. The Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014 designates NOAA as the lead federal agency in addressing HABs occurring in ocean

and coastal waters and the Great Lakes. NOAA programs improve the understanding of HABs and their impacts and develop tools for HAB and toxin detection, forecasting, and response. NOAA addresses the continuum from research to operations through a mix of in-house expertise and competitive awards to partners in academia, industry, and state and local governments.

HAB-Related Expenditures

According to agency officials, from fiscal years 2013 through 2015, NOAA expended a total of roughly $39.4 million on HAB-related activities across various extramural and intramural programs, as follows:

- $9.8 million in fiscal year 2013,
- $14.0 million in fiscal year 2014, and
- $15.7 million in fiscal year 2015.[13]

For specific HAB-related program expenditures, see table 11.

Legal Authority to Address HABs

According to agency officials, NOAA's authority to address HABs is provided under a variety of statutes, including HABHRCA, the National Sea Grant College Program Act, and the Integrated Coastal and Ocean Observation System Act of 2009. Table 11 includes NOAA HAB-related expenditures organized by (1) intramural HAB expenditures supporting HABHRCA for HAB forecasting, detection, and event response; (2) program management, coordination, and ship time; (3) HABHRCA-named competitive research on monitoring, response, prevention, control, and mitigation; and (4) other competitive research programs (e.g., those administered by the National Sea Grant College Program and the Integrated Coastal and Ocean Observation System Program). Additional information on these statutes follows.[14]

[13]The total numbers for fiscal years 2013 through 2015 do not add to $39.4 million because of rounding. These numbers differ from those reported to Congress in NOAA's "HABHRCA Spending 2010-2015" table, which includes hypoxia work.

[14]The Marine Mammal Protection Act mandates that NOAA establish unusual mortality event working groups, among other things, to investigate the likely causes of marine mammal deaths. In response, NOAA has developed surveillance capabilities that identify algal toxin exposure in marine wildlife populations. NOAA monitors stranded and dead mammals for domoic acid (the toxin responsible for amnesic shellfish poisoning), saxitoxin (the most potent toxin of the paralytic shellfish toxins), and the toxins responsible for diarrhetic shellfish poisoning.

- HABHRCA recognizes NOAA as the lead federal agency on HABs occurring in ocean and coastal waters and the Great Lakes.
- The National Sea Grant College Program Act specifically included "university research on the biology, prevention, and forecasting of harmful algal blooms" within its authorization of appropriations for NOAA competitive grants through fiscal year 2014. HAB-related research is conducted by Sea Grant College-funded scientists, as described in table 11.
- The Integrated Coastal and Ocean Observation System Act of 2009 authorizes NOAA, other federal agencies, and nonfederal partners to provide coastal and ocean observations, technologies, and data management and communication systems. These can help address HABs.

Table 11: National Oceanic and Atmospheric Administration (NOAA) Harmful Algal Bloom (HAB)-Related Programs and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Programs	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Intramural HAB expenditures supporting HABHRCA							
Harmful Algal Bloom Forecasting	HAB forecasts alert coastal managers to blooms before they cause serious damage. Short-term (once or twice weekly) forecasts identify which blooms are potentially harmful, where they are, how big they are, and where they are likely headed. Longer-term, seasonal forecasts predict the severity of HABs for the bloom season in a particular region.	Internal base funding[c]	Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA), § 603, as amended in 2004; HABHRCA, §§ 603A (f)(2), (f)(3), and (h)(1)(b), added in 2014	1,100,000	1,391,600	1,437,100	**3,928,700**
HAB detection, toxicity, and early warning	Detection: Develop fast, accurate and cost-effective identification protocols that are used by coastal and public health managers to protect lives and livelihoods. Toxicity: Work with managers to incorporate information on how algae and toxin distributions and concentrations vary during a bloom event into predictive models. Early warning: Provides health officials, environmental managers and water treatment facility operators with information to focus their testing to guide beach and shellfish bed closures or water treatment in a more appropriate time frame.	Internal base funding[d]	HABHRCA, § 603, as amended in 2004; HABHRCA, §§ 603A (f)(2), (f)(3) and (h)(1)(b), added in 2014	2,000,001[e]	2,305,017[e]	2,555,463	**6,560,481[e]**
Harmful Algal Bloom Event Response Program	NOAA responds to HAB events by coordinating access to technology and expertise, assisting with detection and identification of HABs and toxins, and ensuring proper scientific documentation to add to the HAB knowledge base.	Internal base funding[f]	HABHRCA, § 603, as amended in 2004; HABHRCA, § 603A (f)(2), as added in 2014	261,620	258,368	369,785	**889,773**
Subtotal				**3,361,621**	**3,954,985**	**4,062,348**	**11,378,954**

Programs	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Program management, coordination, and ship time							
Program management, coordination, ship time	NOAA leads or co-leads coordination of the interagency working group and other regional, national, and international HAB efforts and groups. This also includes grants management and administration, program management, ship time, and support to the National HAB Office. Efforts are spread across forecasting, detection, control, mitigation, and event response.	Internal base funding[g]	HABHRCA	1,777,997	1,727,997	1,415,000	**4,920,994**
Subtotal				**1,777,997**	**1,727,997**	**1,415,000**	**4,920,994**
HABHRCA-named National Ocean Service (NOS) competitive research programs[h]							
Ecology and Oceanography of Harmful Algal Blooms	A national, competitive research funding program with two broad goals: to develop information and tools, predictive models and forecasts, and prevention strategies to aid managers in coastal environments, including the Great Lakes, and to learn how toxins are transferred across and up the food chain, including biosynthesis and metabolism of toxins, and assess the impacts of toxins on higher trophic levels.	Administered by the National Centers for Coastal Ocean Science (NCCOS) as cooperative agreements[i]	HABHRCA, § 603, amended in 2004; HABHRCA, § 603A, added in 2014	1,755,000	2,405,000	2,970,000	**7,130,000**
Monitoring and Event Response for Harmful Algal Blooms	The program builds capacity along our coasts for enhanced HAB monitoring and response. This helps NOAA and state partners identify when beaches, shellfisheries, and marine animals are at risk from harmful algae, and to make informed decisions that protect public health and safeguard our coastal economies.	Administered by NCCOS as cooperative agreements[j]	HABHRCA, § 603, as amended in 2004; HABHRCA, § 603A, added in 2014	1,328,000	1,661,00	1,286,000	**4,275,000**

Programs	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Prevention, Control and Mitigation of Harmful Algal Blooms	The program funds research to move promising HAB technologies from development to demonstration, and finally to application, culminating in widespread use. The program also funds socioeconomic research, assessing societal impacts of HAB events at local scales, the impact of HAB events on coastal economies, and the costs and benefits of mitigation strategies to aid managers in devising cost-effective management strategies.	Administered by NCCOS as cooperative agreements[k]	HABHRCA, § 603 as amended in 2004; HABHRCA, § 603A added in 2014	603,000	853,000	677,000	**2,133,000**
Harmful Algal Bloom Event Response Program	NOAA provides supplemental financial support for investigating a unique event. In partnership with the U.S. National Office for Harmful Algal Blooms, modest funding is available from NOAA to help defray costs of immediate mobilization of sampling, supplies, and analytical services.	Administered through Cooperative Institute for the North Atlantic Region, a NOAA cooperative institute[l]	HABHRCA, § 603, as amended in 2004; HABHRCA, § 603A (f)(2), (f)(3) and (h)(1)(b), added in 2014	18,159	20,540	13,282	**51,981**
Subtotal				**3,704,159**	**4,939,540**	**4,946,282**	**13,589,981**
Other competitive research programs							
Sea Grant College Program	The HAB research projects funded by Sea Grant College Program are typically small (under $100,000 per year) hypothesis-driven research and tool development (including monitoring tool development). They complement and often leverage projects funded through NOS HAB programs. In line with the program's mission, Sea Grant College's extension funding provides stakeholder engagement and community outreach and education on HAB issues.	Administered by Sea Grant College as grant[m]	HABHRCA, § 603, as amended in 2004; Sea Grant College Act § 212(a)	503,693	1,379,705	1,523,539	**3,406,937**

Programs	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Coastal Storms Program	The Coastal Storms Program is a national effort to make communities safer by reducing negative impacts of coastal storms. Sea Grant College administered the Great Lakes funds for this program in FY 2015, focusing on nutrient reductions in response to the extensive HAB in Lake Erie.	NOS funds administered by Sea Grant College as a grant[n]	HABHRCA, § 603, as amended in 2004; Sea Grant College Act § 212(a)	n/a	n/a	1,080,000	**1,080,000**
Integrated Ocean Observing System Research Program	The program provides coastal and ocean observations, technologies, and data management and communication systems that can help address HABs.	Administered by Integrated Ocean Observing System (IOOS) as a cooperative agreement[o]	Integrated Coastal and Ocean Observation Act of 2009	414,000	1,993,000	2,665,000	**5,072,000**
Subtotal				**917,693**	**3,372,705**	**5,268,539**	**9,558,937**
NOAA total				**9,761,470**	**13,995,227**	**15,692,169**	**39,448,866**

Legend: FY = fiscal year; HABHRCA = Harmful Algal Bloom and Hypoxia Research and Control Act; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of NOAA data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by NOAA officials.

[b]According to NOAA officials, these amounts reflect actual and estimated expenditures. The NOAA-identified HAB-related programs are a mixture of single- and multi-purpose. We did not independently verify these amounts.

[c]Harmful Algal Bloom Forecasting receives internal funding and partners with universities, research institutions, science laboratories, federal agencies, and state agencies.

[d]HAB detection, toxicity, and early warning receives internal funding and partners with federal agencies, universities, NOAA science centers, state agencies, research institutions, scientific research committees, science laboratories, private entities, and tribes.

[e]Indicates estimated amounts were included in total.

[f]Harmful Algal Bloom Event Response Program receives internal funding and partners with states governments, state agencies, research institutions, federal agencies, NOAA science centers, universities, tribes, and marine sanctuaries.

[g]Program management, coordination, ship time receives internal funding.

[h]According to NOAA, the HABHRCA-named NOS competitive research is funded by the Competitive Research Programs, Projects, and Activities within NOS. The intramural HAB expenditures supporting HABHRCA; program management, coordination, and ship time; and other competitive research are funded separately.

[i]Ecology and Oceanography of Harmful Algal Blooms recipients of the NCCOS-administered cooperative agreements are universities, research institutions, state agencies, science laboratories, and NOAA science centers.

[j]Monitoring and Event Response for Harmful Algal Blooms recipients of the NCCOS-administered cooperative agreements are universities, research institutions, science laboratories, federal agencies, tribes, private entities, and NOAA science centers.

[k]Prevention, Control and Mitigation of Harmful Algal Blooms recipients of the NCCOS-administered cooperative agreements are universities, research institutions, science laboratories, and state agencies.

[l]Harmful Algal Bloom Event Response Program recipients of the NCCOS-administered cooperative agreements are universities, science laboratories, research institutions, state agencies, private entities, federal agencies, NOAA science centers, tribes, and marine sanctuaries.

[m]Sea Grant College recipients of the Sea Grant College-administered grants are universities and research institutes.

[n]Coastal Storms Program recipients of the Sea Grant College-administered funds are universities and research institutes.

[o]IOOS recipients of the IOOS-administered cooperative agreements are federal government agencies, research institutes, NOAA science centers, universities, observation systems, and science laboratories.

(9) National Park Service (NPS)

Agency's Mission and Key HAB-Related Activities

According to agency officials, NPS responds to HAB events that have an impact on human or animal health, at the request of park units. The agency's response efforts are limited to identifying hazards; consulting on management strategies; arranging for diagnostic testing of specimens; and connecting the park unit with additional public health resources, such as state health departments and the Environmental Protection Agency. The agency's response activities are intended to assist park managers in developing appropriate partnerships and effectively preventing and addressing HABs on-site; communicating agency-wide strategies; understanding the severity of the problem; and implementing management strategies that minimize the risk to aquatic life, the public, and employees. In addition, NPS is developing a website to assist parks with HAB response activities, update staff on the current scientific understanding of HABs, and allow the agency to track HABs within park units. NPS officials reported that the website should be completed and available to the public by the end of calendar year 2016.

HAB-Related Expenditures

According to agency-provided expenditures from fiscal years 2013 through 2015, NPS expended a total of roughly $112,945 on website development, identifying HAB concentrations, and performing disease outbreak investigations, as follows:

- $50,000 in fiscal year 2013,
- $50,000 in fiscal year 2014, and

- $12,945 in fiscal year 2015.

For NPS' expenditures, see table 12.

Legal Authority to Address HABs

According to agency officials, NPS' authority to address HABs is provided under the National Park Service Organic Act, as amended, 54 U.S.C. § 100101(a); Title II of the National Parks Omnibus Management Act of 1998, 54 U.S.C. §§ 100701-100706; and NPS Management Policies.

- The National Park Service Organic Act, as amended, 54 U.S.C. § 100101(a), authorizes the agency to conserve and provide for the enjoyment of the scenery, natural and historical objects, and wildlife in national park system units in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.
- Title II of the National Parks Omnibus Management Act of 1998, 54 U.S.C. §§ 100701-100706, authorizes the agency to enter into cooperative agreements with colleges and universities, including land grant schools, in partnership with other federal and state agencies to conduct research, monitor and take inventory of long-term trends in the condition of national park resources, make parks available for scientific study, and integrate study results into management decisions.
- NPS Management Policies (2006), section 4.6.3, states that the agency will "work with appropriate governmental bodies to obtain the highest possible standards available under the Clean Water Act for the protection for park waters; take all necessary actions to maintain or restore the quality of surface waters and ground waters within the parks, consistent with the Clean Water Act and all other applicable federal, state, and local laws and regulations; and enter into agreements with other agencies and governing bodies, as appropriate, to secure their cooperation in maintaining or restoring the quality of park water resources."

Table 12: National Park Service (NPS) Harmful Algal Bloom (HAB)-Related Initiatives and Programs and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Initiatives/ programs	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY2014	FY 2015	Total
Natural Resource Stewardship and Science Directorate / Water Resources Division							
Development of an informational website	Of the 413 NPS units, there are 88 units that are considered ocean, coastal, or Great Lake parks, in addition to other park units that have extensive surface water bodies. HABs have the potential to affect all of these park units, and it is therefore important to prepare for these events and preserve park resources. NPS is developing a website to maintain a public health and ecological HAB events reporting system. The website will also provide a point of contact for park managers to partner with local, state, and federal health and environmental agencies that can provide park personnel with technical assistance for managing HAB events.	Cooperative agreements[c]	NPS Management Policies (2006), section 4.6.3	n/a	n/a	6,945	**6,945**
Identify concentrations	The initiative identifies HAB concentrations to protect public health at three park units in Michigan—Isle Royale National Park and Pictured Rocks and Sleeping Bear Dunes National Lakeshores—through the U.S. Geological Survey (USGS)/NPS Water Quality Partnership Program.	Internal funds[d]	54 U.S.C. §§ 100701-100706	50,000	50,0000	n/a	**100,000**
Subtotal				**50,000**	**50,000**	**6,945**	**106,945**
Visitor and Resource Protection Directorate / Office of Public Health							
Lake Mead National Recreation Area disease outbreak investigations	Staff members perform NPS disease outbreak investigations and respond to HAB incidents.	Base funding[e]	54 U.S.C. § 100101	n/a	n/a	6,000	**6,000**
Subtotal				**n/a**	**n/a**	**6,000**	**6,000**
NPS total				**50,000**	**50,000**	**12,945**	**112,945**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of NPS expenditure data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by NPS officials.

[b]According to NPS officials, these amounts reflect actual and estimated expenditures. The NPS-identified HAB-related initiatives and programs are a mixture of single- and multi-purpose. We did not independently verify these amounts.

[c]Development of an informational website funding recipients are staff members.

[d]NPS receives USGS scientific expertise through the USGS/NPS Water Quality Partnership Program.

[e]Lake Mead National Recreation Area disease outbreak investigations funding recipients are the Office of Public Health and Natural Resource Stewardship and Science Directorate staff members.

(10) Natural Resources Conservation Service (NRCS)

Agency's Mission and Key HAB-Related Activities

According to agency officials, NRCS is an agency within the Department of Agriculture with a mission of improving the health of our nation's natural resources while sustaining and enhancing the productivity of American agriculture. The agency provides voluntary assistance through partnerships with private landowners, managers, and communities to protect, restore, and enhance the lands and waters upon which people and the environment depend. NRCS provides two broad categories of conservation assistance—financial and technical.

NRCS offers financial and technical assistance through several programs to help agricultural producers make and maintain conservation improvements on their land. The Conservation Stewardship Program encourages eligible agricultural producers to address natural resource concerns and improve and conserve the quality and condition of natural resources, such as soil and water. The Environmental Quality Incentives Program provides technical and financial assistance to help eligible agricultural producers implement conservation practices that sustain food production while addressing soil, water, and air quality natural resources concerns, among other things. NRCS also works with partners to leverage additional conservation assistance for agricultural producers and landowners in priority conservation areas.

Although NRCS does not directly track HABs as a resource concern or track HAB-related activities through its financial management systems, the agency does have specific, multi-purpose initiatives designed to improve the water quality of areas where HABs and hypoxia are of critical concern, such as within the Gulf of Mexico. These initiatives address

other resource concerns such as improving wildlife habitats, soil health and erosion, air quality, and limited water availability. Thus, the expenditure amounts included in table 13 fund assistance programs to improve water quality, which includes but is not limited to HABs.

HAB-Related Expenditures

According to agency-provided expenditures from fiscal years 2013 through 2015, NRCS expended a total of roughly $208 million on various, multi-purpose conservation assistance programs to improve water quality, which includes but is not limited to HABs, as follows:

- $57 million in fiscal year 2013,
- $66 million in fiscal year 2014, and
- $85 million in fiscal year 2015.

For NRCS' multi-purpose expenditures to improve water quality, see table 13.

Legal Authority to Address HABs

According to agency officials, NRCS' authority to offer financial and technical assistance to producers to address water quality issues, such as HABs, is provided under the Food, Conservation, and Energy Act, which authorizes and reauthorizes NRCS' voluntary conservation programs. Table 13 includes multi-purpose expenditures to improve water quality, including HABs, organized by the following agency initiatives: (1) Chesapeake Bay Watershed Initiative, (2) Gulf of Mexico Initiative, (3) National Water Quality Initiative, (4) Bay Delta Initiative, (5) Illinois River/Eucha-Spavinaw Watersheds Initiative, and (6) Mississippi River Basin Healthy Watersheds Initiative.

Table 13: Natural Resources Conservation Service's (NRCS) Harmful Algal Bloom (HAB)-Related Initiatives and Programs and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Initiatives/ programs	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Chesapeake Bay Watershed Initiative							
Environmental Quality Incentives Program (EQIP)	To provide technical and financial assistance to help producers implement conservation practices that sustain food production while addressing soil, water, and air quality natural resources concerns, among other things.	Contract[c]	16 U.S.C § 3839aa-2	16,398,194	16,938,095	26,027,053	**59,363,342**
Conservation Stewardship Program (CSP)	To encourage producers to address primary resource concerns and improve the quality and condition of natural resources, such as soil and water quality, among other things, in a comprehensive way.	Contract[d]	16 U.S.C. § 3838e	8,899,520	11,473,762	8,785,044	**29,158,326**
Subtotal				**25,297,714**	**28,411,857**	**34,812,097**	**88,521,668**
Gulf of Mexico Initiative							
EQIP	See EQIP purpose above.	Contract[c]	16 U.S.C § 3839aa-2	1,732,926	1,408,192	1,386,131	**4,527,249**
Subtotal				**1,732,926**	**1,408,192**	**1,386,131**	**4,527,249**
National Water Quality Initiative							
EQIP	See EQIP purpose above.	Contract[c]	16 U.S.C § 3839aa-2	13,705,212	20,139,892	23,578,347	**57,423,451**
Subtotal				**13,705,212**	**20,139,892**	**23,578,347**	**57,423,451**
Bay Delta Initiative							
EQIP	See EQIP purpose above.	Contract[c]	16 U.S.C § 3839aa-2	10,027,327	10,852,623	15,162,298	**36,042,248**
CSP	See CSP purpose above.	Contract[d]	16 U.S.C. § 3838e	1,551,781	2,441,284	1,174,305	**5,167,370**
Subtotal				**11,579,108**	**13,293,907**	**16,336,603**	**41,209,618**
Illinois River/Eucha-Spavinaw Watersheds Initiative							
EQIP	See EQIP purpose above.	Contract[c]	16 U.S.C § 3839aa-2	4,282,551	3,083,076	2,500,844	**9,866,471**
Subtotal				**4,282,551**	**3,083,076**	**2,500,844**	**9,866,471**
Mississippi River Basin Healthy Watersheds Initiative							
EQIP	See EQIP purpose above.	Contract[c]	16 U.S.C § 3839aa-2	68,994	39,069	6,182,470	**6,290,533**

Initiatives/ programs	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Regional Conservation Partnership Program	To use existing NRCS programs to further conservation, restoration, and sustainable use of soil, water, and wildlife resources through eligible partners, such as state and local governments; tribes; and producer associations, groups, and cooperatives.	Contract[e]	16 U.S.C. § 3871	n/a	n/a	76,296	**76,296**
Subtotal				**68,994**	**39,069**	**6,258,766**	**6,366,829**
NRCS total				**56,666,505**	**66,375,993**	**84,872,788**	**207,915,286**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of NRCS expenditure data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by NRCS officials.

[b]According to NRCS officials, these amounts reflect estimated expenditures. The NRCS-identified HAB-related initiatives and programs are multi-purpose. We did not independently verify these amounts.

[c]EQIP funding recipients are agricultural producers who voluntarily participate in the program.

[d]CSP funding recipients are agricultural producers who voluntarily participate in the program.

[e]Regional Conservation Partnership Program funding recipients are agricultural producers who voluntarily participate in the program.

(11) National Science Foundation (NSF)

Agency's Mission and Key HAB-Related Activities

According to agency officials, the NSF is responsible for advancing science and engineering in the United States across a broad and expanding spectrum of disciplines. NSF's mission is to promote the progress of science; to advance the national health, prosperity and welfare; to secure the national defense; and other purposes. To achieve its mission, NSF funds discovery, learning, innovation, and research infrastructure to boost U.S. leadership in all aspects of science, technology, engineering, and mathematics research and education. NSF investments span all scientific and engineering disciplines. While NSF does not have a specifically mandated area of research, NSF-supported activities may include: research focused on HABs such as the Oceans and Human Health Initiative; research that may have a broader scope than HABs but contributes to the understanding of HABs; education and community planning activities (workshops) related to HABs; activities that

build and facilitate international collaboration; and infrastructure that may have multiple uses, including supporting activities focused on HABs.

HAB-Related Expenditures

According to agency-provided expenditures from fiscal years 2013 through 2015, NSF expended a total of roughly $15.4 million on HAB-related activities across various monitoring and research-related activities, as follows:

- $4.7 million in fiscal year 2013,
- $5.0 million in fiscal year 2014, and
- $5.7 million in fiscal year 2015.

For specific HAB-related program expenditures, see table 14.

Legal Authority to Address HABs

According to agency officials, NSF's authority to address HABs is provided under the National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq. Table 14 includes specific HAB-related expenditures organized by NSF organizations: (1) NSF-wide investments; (2) Directorate for Geosciences; (3) Directorate for Biological Sciences; (4) Directorate for Engineering; and (5) Office of International Science and Engineering.

Table 14: National Science Foundation (NSF) Harmful Algal Bloom (HAB)-Related Programs and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Organizations/ programs[a]	Purpose	Funding mechanism/ recipients	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
NSF-wide investments							
Science, Engineering, and Education for Sustainability	The program's mission is to advance science, engineering, and education to inform the actions needed by society for environmental and economic sustainability and human well-being.	Standard grant[d]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	800,000	786,428	n/a	**1,586,428**
Research Experiences for Undergraduates	This activity supports active research participation by undergraduate students in any of the areas of research funded by NSF.	Continuing and standard grants[e]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	n/a	417,379	470,209	**887,588**
Subtotal				**800,000**	**1,203,807**	**470,209**	**2,474,016**

Organizations/ programs[a]	Purpose	Funding mechanism/ recipients	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
Directorate for Geosciences							
Biological Oceanography Program	The Biological Oceanography Program supports research in marine ecology, broadly defined as relationships among aquatic organisms and their interactions with ocean or Great Lakes environments. Projects submitted to the program for consideration are often interdisciplinary efforts.	Continuing grant[f]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	40,000	40,000	165,586	**245,586**
Oceans and Human Health	NSF and the National Institute of Health's National Institute of Environmental Health Sciences jointly fund research on marine-related health issues through the Centers for Oceans and Human Health and through individual research projects focusing on oceans and human health, as well as the Great Lakes and human health.	Continuing grant[g]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	2,075,657	2,122,367	1,895,658	**6,093,682**
Hydrologic Sciences Program	The Hydrologic Sciences Program focuses on the fluxes of water in the environment that constitute the water cycle, as well as the mass and energy transport function of the water cycle. The program supports the study of processes from rainfall to runoff to infiltration and streamflow; evaporation and transpiration; the flow of water in soils and aquifers; and the transport of suspended, dissolved, and colloidal components. The program also funds research on how water interacts with the landscape and the ecosystem, as well as how the water cycle and physical, chemical, and biological processes are altered by land use and climate.	Continuing grant[h]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	165,818	n/a	n/a	**165,818**
Subtotal				**2,281,475**	**2,162,367**	**2,061,244**	**6,505,086**

Organizations/ programs[a]	Purpose	Funding mechanism/ recipients	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
Directorate for Biological Sciences							
Long-Term Ecological Research Program	To address ecological questions that cannot be resolved with short-term observations or experiments, NSF established the Long-Term Ecological Research Program in 1980. Two components differentiate the program's research from projects supported by other NSF programs: (1) the research is located at specific sites chosen to represent major ecosystem types or natural biomes, and (2) it emphasizes the study of ecological phenomena over long periods of time based on data collected in five core areas. Long-term studies are essential to achieving an integrated understanding of how populations, communities, and other components of ecosystems interact, as well as to test ecological theory. Ongoing research at program sites must test ecological theories and significantly advance understanding of the long-term dynamics of populations, communities, and ecosystems. It often integrates multiple disciplines and, through cross-site interactions, examines patterns or processes over broad spatial scales.	Continuing grant[i]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	1,280,000	1,280,000	2,088,453	**4,648,653**

Organizations/ programs[a]	Purpose	Funding mechanism/ recipients	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
Ecosystem Studies Program	The Ecosystem Studies Program supports investigations of ecosystem structure and function across a diversity of spatial and temporal scales to advance understanding of (1) material and energy fluxes and transformations within and among ecosystems; (2) roles and relationships of ecosystem components in whole-system structure and function; (3) ecosystem dynamics, resilience, and trajectories of change through time; and (4) linkages among ecosystems in space and time.	Standard grant[j]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	197,568	n/a	n/a	**197,568**
Division of Biological Infrastructure's General Thematic Program	The Division of Biological Infrastructure empowers biological discovery by investing in the development and enhancement of biological research resources, human capital, and biology centers and other mid- to large-scale infrastructure. These investments support advances in all areas of biological research.	Standard grant[k]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	111,649	n/a	n/a	**111,649**
Subtotal				**1,589,217**	**1,280,000**	**2,088,453**	**4,957,670**

Organizations/ programs[a]	Purpose	Funding mechanism/ recipients	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
Directorate for Engineering							
Environmental Engineering	The goal of the Environmental Engineering program is to encourage transformative research which applies scientific and engineering principles to avoid or minimize solid, liquid, and gaseous discharges, resulting from human activities on land, inland and coastal waters, and air, while promoting resource and energy conservation and recovery. The program also fosters cutting-edge scientific research for identifying, evaluating, and monitoring the waste assimilative capacity of the natural environment and for removing or reducing contaminants from polluted air, water, and soils. Any proposal investigating sensors, materials, or devices that does not integrate these products with an environmental engineering activity or area of research may be returned without review. Major areas of interest include enhancing the availability of high-quality water supplies and addressing the fate and transport of contaminants of emerging concern in air, water, and soils.	Standard grant[l]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	n/a	298,488	68,874	**367,362**

Organizations/ programs[a]	Purpose	Funding mechanism/ recipients	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
Directorate for Engineering							
Partnerships for Innovation	The Partnerships for Innovation's Building Innovation Capacity program supports academic-industry partnerships that are led by an interdisciplinary academic research team collaborating with at least one industry partner. In this program, there is an emphasis on the quality, composition, and participation of the partners, including the appropriate contributions for each role. These partnerships focus on the integration of technologies into a specified human-centered service system with the potential to achieve transformational change by improving an existing service system or by spurring the creation of an entirely new smart service system. The selected service system should function as a test bed.	Standard grant[m]	National Science Foundation Act of 1950 as amended, 42 U.S.C. § 1861 et seq.	n/a	n/a	1,000,000	**1,000,000**
Subtotal				**n/a**	**298,488**	**1,068,874**	**1,367,362**
Office of International Science and Engineering							
Catalyzing New International Collaborations	The Catalyzing New International Collaborations program supports the participation of U.S.-based researchers and students in activities intended to catalyze new international research collaborations.	Standard grant[n]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	n/a	57,595	n/a	57,595

Organizations/ programs[a]	Purpose	Funding mechanism/ recipients	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
Office of International Science and Engineering	An Eastern Asia and Pacific Summer Institutes for U.S. Graduate Students award provides U.S. graduate students in science, engineering, and education: (1) firsthand research experiences in Australia, China, Japan, Korea, New Zealand, Singapore, or Taiwan; (2) an introduction to the science, science policy, and scientific infrastructure of the respective location; and (3) an orientation to the society, culture, and language. It is expected that these awards will help students initiate professional relationships to enable future collaboration with foreign counterparts. The award includes participation in the Pre-Departure Orientation, a summer stipend of $5,000, and a round-trip airplane ticket to the host location. Partner agencies pay in-country living expenses during the summer sessions.	Fellowship[o]	National Science Foundation Act of 1950, as amended, 42 U.S.C. § 1861 et seq.	n/a	n/a	5,111	**5,111**
Subtotal				**n/a**	**57,595**	**5,111**	**62,706**
NSF total				**4,670,692**	**5,002,257**	**5,693,891**	**15,366,840**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of NSF expenditure data and other information. | GAO-17-119

[a]According to NSF officials, the NSF organizations and programs are not specifically HAB focused, but include HAB-related activities as a subset of projects.

[b]Legal authority to address HABs is based on information reported by NSF.

[c]According to NSF officials, these amounts reflect actual and obligated expenditures. The NSF-identified HAB-related programs are a mixture of single- and multi-purpose. We did not independently verify these amounts.

[d]Science, Engineering, and Education for Sustainability funding recipients are universities.

[e]Research Experiences for Undergraduates funding recipients include universities.

[f]Biological Oceanography program funding recipient is a scientific committee.

[g]Oceans and Human Health funding recipients include research institutions and universities.

[h]Hydrologic Sciences program funding recipients are universities.

[i]Long-Term Ecological Research program funding recipient is a university.

[j]Ecosystem Studies program funding recipient is a university.

[k]Division of Biological Infrastructure's General Thematic program funding recipients are a science laboratory and consortium.

[l]Environmental Engineering funding recipients are universities.

[m]Partnerships for Innovation funding recipient is a research institution.

[n]Catalyzing New International Collaborations funding recipient is a university.

[o]Office of International Science and Engineering funded an individual recipient.

(12) U.S. Army Corps of Engineers (USACE)

Agency's Mission and Key HAB-Related Activities

According to agency officials, USACE operates and manages more than 300 water projects, which include public recreation and environmental stewardship responsibilities on 12 million acres, including more than 4 million acres in aquatic systems. USACE conducts research on HABs and other aquatic invasive species under two, directly funded research programs: the Aquatic Plant Control Research Program and the Aquatic Nuisance Species Research Program. These research programs aim to (1) provide science-based guidance on developing or using new technologies for managing, preventing, and monitoring aquatic invasive species; (2) improve the efficacy and diversity of available management options; (3) reduce the impacts of aquatic invasive species on federally listed (threatened and endangered) species; (4) reduce operations and maintenance costs associated with aquatic invasive species management; and (5) develop solutions regarding these species based on field needs.

Additionally, USACE makes efforts to reduce negative impacts on wildlife resources, most notably bald eagles. The agency noted that the increase of hydrilla—an invasive plant—has been an ongoing issue for all aquatic habitat resource-based agencies. Avian vacuolar myelinopathy (AVM), a disease produced by a toxin that comes from cyanobacteria, attacks birds' nervous system and has been linked to hydrilla. The highest concentrations of cyanobacteria that produce AVM are found on hydrilla, which is increasing in acres at lakes and reservoirs throughout the southeastern and south central United States, but the toxin-producing algae also persist on other native, submerged plants. This problem has been most evident to USACE at lakes and reservoirs in its Southeast and Southwest Divisions. Since 1998, 84 bald eagle deaths are suspected to have been caused by AVM at J. Strom Thurmond Lake bordering Georgia and South Carolina. Additional funds have been directed toward removing hydrilla at these USACE projects where AVM has been confirmed to reduce AVM-related mortalities.

HAB-Related Expenditures

According to agency officials, from fiscal years 2013 through 2015, USACE expended a total of roughly $1.7 million on HAB-related activities across various response efforts and research and technology-related activities, as follows:

- $300,000 in fiscal year 2013,
- $543,000 in fiscal year 2014, and
- $862,000 in fiscal year 2015.

For specific HAB-related program expenditures, see table 15.

Legal Authority to Address HABs

According to agency officials, the following statutes authorize USACE to address HABs:

- The River and Harbor Act of 1958, section 104, as amended, authorized the Aquatic Plant Control Research Program, which is the research component of the Aquatic Plant Control program.
- The Non-Indigenous Aquatic Nuisance Prevention & Control Act of 1990 authorized the Aquatic Nuisance Species Research Program, and the National Invasive Species Act of 1996 reauthorized the program.

Table 15: U.S. Army Corps of Engineers (USACE) Harmful Algal Bloom (HAB)-Related Activities and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Types of activities	Purpose	Funding mechanism/ recipients	Authority[a]	Expenditures[b]			
				FY 2013	FY 2014	FY 2015	Total
Management and response activities related to HABs	Activities provide and fund staff at multi-purpose projects responding to HABs at public beaches or other public access areas.	Internal funding[c]	River and Harbor Act of 1958, § 104, as amended	300,000	500,000	600,000	**1,400,000**
Research and technology transfer activities	Activities provide science-based guidance on developing or using new technologies for managing, preventing, and monitoring aquatic invasive species; improve the efficacy and diversity of available management options; reduce the impacts of aquatic invasive species on federally listed (threatened and endangered) species; reduce operations and maintenance costs associated with aquatic invasive species management; and develop solutions regarding these species based on field need.	Internal funding[d]	River and Harbor Act of 1958, § 104, as amended; Non-Indigenous Aquatic Nuisance Prevention & Control Act of 1990; and reauthorization by National Invasive Species Act of 1996	n/a	43,000	262,000	**305,000**
USACE total				**300,000**	**543,000**	**862,000**	**1,705,000**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of USACE expenditure data and other information. | GAO-17-119

[a]Legal authority to address HABs is based on information reported by USACE officials.

[b]According to USACE officials, these amounts reflect actual expenditures. The USACE-identified HAB-related activities are a mixture of single- and multi-purpose. We did not independently verify these amounts.

[c]Management and response activity funding recipients are internal USACE personnel labor, supplies and materials, travel, and contracting services.

[d]Research and technology transfer activity funding recipients are a university and federal employee labor, supplies and materials, travel, and report editing and formatting services.

(13) U.S. Geological Survey (USGS)

Agency Mission and Key HAB-Related Activities

According to agency officials, USGS HAB science is focused on (1) developing analytical laboratory and field methods to detect and quantify blooms and associated toxins and taste-and-odor compounds; (2) understanding causal factors, environmental fate and transport of cyanotoxins, and ecological processes; and (3) developing early warning systems for potentially harmful blooms. Studies range in scale from individual water bodies to those that are regional or national in scope, and are conducted in collaboration with a variety of local, state, federal, and tribal partners.

HAB-Related Expenditures

According to agency-provided expenditure data from fiscal years 2013 through 2015, USGS expended a total of roughly $9 million on HAB-related activities across various monitoring and research-related activities, as follows:

- $2.3 million in fiscal year 2013,
- $2.7 million in fiscal year 2014, and
- $4.1 million in fiscal year 2015.[15]

For specific HAB-related program expenditures, organized by science centers, see table 16.

Legal Authority to Address HABs

According to agency officials, USGS' authority to address HABs is provided under a variety of statutes. Additional information on these statutes follows.

USGS is directed to classify the public lands and examine the geological structure, mineral resources, and products within and outside the national domain under the Organic Act of March 3, 1879, as amended, 43 U.S.C.

[15]The total numbers for fiscal years 2013 through 2015 do not add to $9 million because of rounding.

§ 31 et seq. The statute establishes the Office of the Director of the United States Geological Survey under the Department of the Interior.

The Consolidated and Further Continuing Appropriations Act, 2015, provides the USGS water resources mission area with funding for use in matching states', municipalities', and tribes' contributions to cooperative water efforts. The act authorizes USGS to use its appropriations "to perform surveys, investigations, and research covering topography, geology, hydrology, biology and mineral water resources of the United States, its territories and possessions."[16] Jointly funded programs (programs that may be matched up to 50 percent by federal dollars) are considered when the study is mutually advantageous to USGS and localities, states, and tribes. These cooperative, jointly funded programs are reviewed and renegotiated annually to ensure that they respond to the needs of localities, states, and tribes and to the USGS' national priorities. This authority appears in USGS' annual appropriations bill language, which states that "no part of this appropriation shall be used to pay more than one-half the cost of topographic mapping or water resources data collection and investigations carried on in cooperation with States and municipalities."

[16]Similar provisions appeared in USGS appropriations for fiscal years 2012 through 2014.

Table 16: U.S. Geological Survey (USGS) Harmful Algal Bloom (HAB)-Related Centers and Expenditures, Fiscal Years 2013-2015

Amounts in dollars

Science centers	Purpose	Funding mechanism/ recipients[a]	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
USGS Nebraska Water Science Center	Understand causal factors.	Cooperative agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	97,615	94,859	117,429	**309,903**
USGS Wetland and Aquatic Research Center	Conduct research on how HABs affect animals.	Salaries, reimbursable agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	n/a	12,500	**12,500**
USGS Texas Water Science Center	Identify cyanobacteria and associated compounds and develop an early warning system in a drinking-water supply reservoir.	Cooperative agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	100,000	100,000	100,000	**300,000**
USGS Indiana-Kentucky Water Science Center	Research and monitor bodies of water (e.g., lakes) in Kentucky.	Reimbursable agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	n/a	425,000	**425,000**
USGS Washington Water Science Center	Develop a water balance and nutrient budget in order to determine the amount and timing of nutrient delivery.	Cooperative agreement, reimbursable agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	95,400	n/a	n/a	**95,400**
USGS Louisiana offices of the Lower Mississippi Gulf Water Science Center (formerly the Louisiana Water Science Center)	Identify types of HABs-forming algae and associated compounds in bodies of water (e.g. lakes) in Louisiana.	Cooperative agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	133,185	201,337	144,300	**478,822**

Science centers	Purpose	Funding mechanism/ recipients[a]	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
USGS Kansas Water Science Center	Develop informational materials on USGS HAB research, develop new tools to better understand and predict HABs, and publish USGS HAB research in journal articles/reports.	Salary, travel, reimbursable agreement, contracts, equipment, supplies	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	613,841	590,144	873,881	**2,077,866**
USGS Ohio Water Science Center	Identify types of HAB-forming algae and associated compounds in bodies of water (e.g., lakes) in Ohio, understand causal factors and community interactions in the Great Lakes, and develop new tools to better understand and predict cyanobacterial HABs.	Staff, supplies, equipment, travel, reimbursable agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	108,000	337,479	**445,479**
USGS Columbia Environmental Research Center	Develop analytical laboratory and field methods to detect and quantify blooms and associated toxins and taste-and-odor compounds; conduct research on how HABs affect animals.	Research and analysis	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	81,103	58,965	285,138	**425,206**
USGS Great Lakes Science Center	Research and monitor bodies of water (e.g., lakes) across the Great Lakes and its sources of water, assessing potential health risks associated with exposure to certain types of algae and associated disease-causing organisms.	Mail, lab, sample processing, supplies (lab/field), equipment, salary, travel, wireless communication conference, printing and reproduction, student contracts, Great Lakes Restoration Initiative (GLRI)	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	56,937	193,694	339,524	**590,155**

Science centers	Purpose	Funding mechanism/ recipients[a]	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
USGS Illinois Water Science Center	Research and monitor bodies of water (e.g., lakes) in Illinois.	Cooperative agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	29,000	32,000	60,000	**121,000**
USGS Michigan Water Science Center	Document occurrence of HABs and toxins, work with the National Park Service (NPS) through the USGS/NPS Water Quality Partnership to determine baseline algal toxin concentrations on pre-determined NPS locations, and understand causal factors and community interactions in the Great Lakes.	GLRI, staff, supplies, equipment, travel	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	210,000	50,000	480,000	**740,000**
USGS Upper Midwest Environmental Sciences Center	Evaluate how gradients in environmental conditions influence ecological processes, such as secondary production.	GLRI, salary and operations	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	73,716	77,043	124,494	**275,253**
USGS Wyoming/Montana Water Science Center	Develop a water balance and nutrient budget in order to determine the amount and timing of nutrient delivery.	Cooperative agreement, reimbursable agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	700	725	1,300	**2,725**
USGS South Atlantic Water Science Center	Document occurrence of HABs and toxins in the southeastern United States.	Sampling efforts, cooperative agreement, research and analysis	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	284,219	127,235	100,800	**512,254**
Oklahoma Water Resources Research Institute	Research and monitor bodies of water (e.g., lakes) in Oklahoma.	Grant	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	25,000	n/a	n/a	**25,000**

Science centers	Purpose	Funding mechanism/ recipients[a]	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
Washington Water Resources Research Institute	Understand causal factors, and research and monitor bodies of water (e.g., lakes) in Washington.	Grant	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	27,478	n/a	**27,478**
North Dakota Water Resources Research Institute	Understand causal factors of HAB formation.	Grant	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	7,300	n/a	**7,300**
Georgia Water Resources Research Institute	Understand causal factors, and evaluate how gradients in environmental conditions influence ecological processes such as secondary production.	Grant	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	18,000	n/a	**18,000**
District of Columbia Water Resources Research Institute	Monitor urea concentrations and HAB productivity and physiology, and evaluate how gradients in environmental conditions influence ecological processes, such as secondary production.	Grant	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	12,466	15,000	n/a	**27,466**
Indiana Water Resources Research Institute	Develop new tools to better understand and predict cyanobacterial HABs.	Grant	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	n/a	15,000	**15,000**
Ohio Water Resources Research Institute	Develop new tools to better understand and predict cyanobacterial HABs.	Grant	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	n/a	24,455	**24,455**
Pennsylvania Water Resources Research Institute	Develop new tools to better understand and predict cyanobacterial HABs.	Grant	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	n/a	n/a	17,900	**17,900**

Science centers	Purpose	Funding mechanism/ recipients[a]	Authority[b]	Expenditures[c]			
				FY 2013	FY 2014	FY 2015	Total
USGS Oregon Water Science Center	Research and monitor bodies of water (e.g., lakes) across Oregon; conduct research on how HABs affect animals; assess potential health risks associated with exposure to certain types of algae and associated disease-causing organisms; develop new tools to better understand and predict cyanobacterial HABs; and evaluate how gradients in environmental conditions influence ecological processes, such as secondary production.	Reimbursable agreement, staff salary and expenses, contracts, cooperative agreement	Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. No. 113-235, 128 Stat. 2130, 2404 (2014)	507,776	954,316	603,956	**2,066,048**
USGS total				**2,320,959**	**2,656,096**	**4,063,156**	**9,040,211**

Legend: FY = fiscal year; n/a = not applicable (i.e., agency reported no expenditures).

Source: GAO analysis of USGS data and other information. | GAO-17-119

[a]Each science center is the funding recipient.

[b]Legal authority to address HABs is based on information reported by USGS officials. Similar provisions appeared in USGS appropriations for fiscal years 2012 through 2014. See Consolidated Appropriations Act, 2012, Pub. L. No. 112-74, 125 Stat. 786, 993 (2011); Consolidated and Further Continuing Appropriations Act, 2013, Pub. L. No. 113-6, § 1101(a)(3), 127 Stat. 198, 412 (2013); and Consolidated Appropriations Act, 2014, Pub. L. No. 113-76, 128 Stat. 5, 296 (2014).

[c]According to USGS officials, these amounts reflect actual expenditures. The USGS-identified HAB-related centers are single-purpose. We did not independently verify these amounts.

Appendix III: Federal Agencies' Harmful Algal Bloom-Related Coordination

Appendix III provides information on federal agencies' reported coordination related to harmful algal blooms (HAB).

Federal Agencies Reported Coordinating HAB-Related Activities in a Variety of Ways

Federal officials we interviewed reported that their agencies coordinate in a variety of ways with each other and with nonfederal stakeholders to share information, expertise, and opportunities for collaboration on HAB-related activities. Specifically, federal agencies reported participating in numerous groups, task forces, and other coordination efforts led by federal agencies, states, international organizations, or academics, as described below. Since 2014, the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act (IWG-HABHRCA) has been the primary, government-wide mechanism through which federal agencies coordinate their HAB-related activities, develop plans for future work, and identify remaining gaps related to federal HAB activities and capabilities. In addition, federal officials reported a number of partnerships between two or more federal agencies (federal interagency partnerships) directly related to their HAB work in recent years, of which we provide examples below.

Federal officials also reported that part of the purpose of this collaboration is to minimize duplication and to leverage resources in HAB research, monitoring, response, and other activities. For example, as part of their administrative reviews prior to awarding grants, the National Institute of Environmental Health Sciences (NIEHS) and the Centers for Disease Control and Prevention (CDC) review grant proposals to ensure that there is no overlap or duplication of effort with other federally funded research. In addition, Food and Drug Administration (FDA) officials reported that their agency assisted the U.S. Army Medical Research Institute of Infectious Diseases by expanding the use of a validated analytical method for detecting saxitoxin in seafood to identify the toxin's potential use as a threat agent. In this manner, FDA officials stated, the U.S. Army leveraged existing, federally funded resources to adapt a HAB toxin analytical method to enhance medical capabilities to detect such threat agents.

Groups, Task Forces, and Other HAB-Related Coordination Efforts

Federal-Led Efforts

Great Lakes Interagency Task Force

Chaired by the Environmental Protection Agency (EPA), the Great Lakes Interagency Task Force brings together 11 cabinet and other federal agency heads to coordinate the restoration of the Great Lakes. Created by a May 18, 2004, executive order, 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), a federal-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, multi-year action plans that identify goals, objectives, measurable ecological targets, and specific actions for five GLRI focus areas. EPA officials also stated that hundreds of millions of dollars have been allocated since 2010 for a wide array of projects intended to reduce nutrient loads in the Great Lakes—nutrients that can fuel HABs. For example, EPA officials reported that in response to the 2014 drinking water incident in Toledo, Ohio, nearly $12 million in GLRI funds was provided to federal and state agencies for projects intended to reduce and monitor HABs in the western basin of Lake Erie.

Inland HAB Discussion Group

Formed and facilitated by EPA, U.S. Geological Survey (USGS), and CDC, this informal discussion group shares information through free webinars (1 to 2 times per year) among federal, state, local, and industry stakeholders about HAB research, monitoring, human and ecological health risk assessment, education, and outreach. According to EPA's website, the group was created out of an expressed need by federal researchers and state agencies to bridge a communication gap with respect to inland HABs, and the group has been meeting periodically by conference call since May 2011.The group had its genesis from earlier efforts such as the International Symposium on Cyanobacteria Harmful Algal Blooms meeting sponsored by EPA in 2005, the Harmful Algal Blooms-Related Illness Surveillance System sponsored by CDC, and USGS efforts assisting states with sample collection and study design guidance.

IWG-HABHRCA

As the primary, government-wide mechanism for sharing information and coordinating HAB-related activities, this interagency working group was created after the 2014 reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) to convene relevant federal agencies to discuss HAB and hypoxia events and to develop related reports and assessments for Congress.[1] Co-chaired by the National Oceanic and Atmospheric Administration (NOAA) and EPA, the group meets twice per month to share information and coordinate HAB-related research, monitoring, and other activities. For example, the group convenes regularly scheduled briefings that aim to stimulate and enhance interagency collaboration on HABs, ranging from toxin testing to shellfish management. Between July 2015 and June 2016, several agencies (EPA, NOAA, FDA, U.S. Army Corps of Engineers, USGS, and CDC) made presentations on their HAB-related activities to the group. Furthermore, the group held a half-day meeting in October 2015 that focused, in part, on reducing duplication across the federal government.

This interagency working group is also responsible for developing reports to Congress mandated by HABHRCA's reauthorization in 2014 that collectively identify progress, plans for future work, and remaining gaps related to HABs and hypoxia.[2] To develop the first such report—*Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report*, released in February 2016—the IWG-HABHRCA coordinated with local, state, tribal, and federal government

[1]An earlier interagency task force, called the Interagency Working Group on HABs, Hypoxia, and Human Health, addressed the HABHRCA 2004 requirements for reports that specifically addressed marine and freshwater HAB and hypoxia management to be submitted to Congress. That task force fulfilled those requirements with five reports issued from 2007 through 2010 and then disbanded until the 2014 reauthorization of HABHRCA.

[2]The reports to Congress mandated by the HABHRCA amendments of 2014 are (1) HAB and Hypoxia Comprehensive Research Plan and Action Strategy (this report was released in February 2016; see below); (2) Report on the implementation of the HAB and Hypoxia Action Strategy (due 2 years after the Comprehensive Research Plan and Action Strategy was submitted to Congress); (3) Great Lakes Integrated Assessment for Harmful Algal Blooms and Hypoxia (this was incorporated into the HAB and Hypoxia Comprehensive Research Plan and Action Strategy, released in February 2016); (4) Great Lakes HAB and Hypoxia Plan (this report was under development as of July 2016); and (5) Biennial Progress Report on the Northern Gulf of Mexico Hypoxia (the first report was released in August 2015).

entities and consulted with stakeholders.[3] As part of this effort, the IWG-HABHRCA held a series of webinars in April 2015 focused on different U.S. geographic regions, which were designed to initiate conversation between federal representatives and stakeholders on HABs and hypoxia. Agenda topics included regional priorities for HABs research, needs for handling HAB and hypoxia events, and communication methods used to educate the public. The group held a similar series of webinars in February 2016 that were tailored to the Great Lakes to promote discussion and solicit stakeholder feedback.

To operate more efficiently, NOAA officials stated, the group also organized four subgroups to provide focus and expertise on key aspects of the HABHRCA-required reports to address specific issues related to HABs, hypoxia, the Great Lakes, and "engagement" (strategies, webinars, and other materials, such as informational documents). The group is overseen by the National Science and Technology Council's Subcommittee on Ocean Science and Technology, which is co-chaired by the Office of Science and Technology Policy, NOAA, and the National Science Foundation (NSF). The subcommittee is responsible for developing coordinated interagency strategies and advancing national ocean science and technology priorities, among other things.

Mississippi River/Gulf of Mexico Watershed Nutrient Task Force (Hypoxia Task Force)

Formally known as the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, the Hypoxia Task Force convenes federal agencies led by EPA, 12 states, and a national tribal representative to address hypoxia in the Mississippi River and the northern Gulf of Mexico. Specifically, a team of federal and university researchers and agricultural extension educators from the 12 states along the Mississippi and Ohio

[3]Since November 2015, the IWG-HABHRCA and EPA released reports to Congress that identified progress, plans for future work, and remaining gaps related to federal HAB activities and capabilities. These gaps encompass research, forecasting, surveillance and monitoring, outreach, and response. See *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report* (Washington, D.C.: Feb. 11, 2016), a report to Congress produced by the IWG-HABHRCA. Also see Environmental Protection Agency, *Algal Toxin Risk Assessment and Management Strategic Plan for Drinking Water* (Washington, D.C.: Nov. 2015), submitted to Congress to meet the requirements of the Drinking Water Protection Act (Pub. L. No. 114-45).

Rivers has partnered with the task force to increase efforts to manage complex natural resource management issues. The group is working to (1) expand and encourage the use of science-based nutrient management and other practices that help to reduce nutrient losses; (2) identify opportunities for states to share information; and (3) create a network of leaders, including farmers, who strategize about agricultural-based nutrient losses. According to EPA officials, in December 2014, the Hypoxia Task Force issued nutrient reduction strategies to target nutrients from all sources that flow into the Mississippi River and contribute to Gulf of Mexico hypoxia. EPA officials also stated that over 20 peer-reviewed publications describing the ecosystem mechanisms regulating nutrients and hypoxia in the northern Gulf of Mexico were published, and hypoxia modeling and monitoring workshops were conducted in 2011, 2012, and 2013. In August 2015, the Hypoxia Task Force released its first biennial report to Congress, as required by the HABHRCA amendments of 2014, to report on continued progress toward reducing nutrient loads to the northern Gulf of Mexico, summarize lessons learned in implementing nutrient reduction strategies, and describe any adjustments to its strategies for reducing Gulf hypoxia.[4]

National Ocean Council

A cabinet-level body that oversees the implementation of the National Ocean Policy, the council was established as a result of an executive order. In April 2013, the council released the National Ocean Policy Implementation Plan, which described specific actions—including four related to HABs—for federal agencies to take. These actions are intended to translate policy goals into on-the-ground changes to address key challenges, streamline federal operations, save taxpayer dollars, and promote economic growth. According to Natural Resources Conservation Service (NRCS) officials, the Water Quality and Sustainable Practices on Land subgroup of the council's Interagency Policy Committees reports on the status of 36 implementation plan action items, including the 4 actions related to HABs:[5]

[4]Environmental Protection Agency, *Mississippi River/Gulf of Mexico Watershed Nutrient Task Force: 2015 Report to Congress* (Washington, D.C.: August 2015).

[5]The year denotes the calendar year that the action item was planned for completion. The named agencies have responsibility for jointly completing the actions.

- 2014 – Develop, working with the seafood industry, new rapid-assessment methods to detect HAB toxins, petrochemicals, industrial and residential chemical contaminants, microbial contamination, and spoilage in seafood. (NOAA, FDA, and EPA were the designated implementing agencies.)
- 2014 – Improve infrastructure, including availability of standards and probes, shared-use facilities, monitoring platforms, and training, to develop the expertise necessary for state-of-the-art national capabilities for HAB monitoring and detection and improving accuracy of HAB forecasting. (NOAA, FDA, National Institute of Standards and Technology, and USGS were the designated implementing agencies.)
- 2014 – Provide more reliable models for HAB forecasts and coordinated training for state and local officials to improve regional capabilities for HAB monitoring, assessment, forecasting, and response. (NOAA and CDC were the designated implementing agencies.)
- 2015 – Develop and deploy rapid, field-based detection systems for various HAB-causing species and their toxins. (NOAA, FDA, and USGS were the designated implementing agencies.)

One Health Harmful Algal Bloom System (OHHABS)

CDC collaborates with federal agencies, such as EPA, USGS, NOAA, and FDA, and many state governments on OHHABS, an electronic system for voluntary reporting of HAB-related illnesses and events. Launched in June 2016, this surveillance system is accessible to health departments and their designated animal health and environmental health partners and collects data on HAB events and associated cases of human and animal illness. OHHABS is an example of CDC's "One Health" surveillance—an approach that recognizes that human, animal, and environmental health are interconnected, and that these three health communities can more effectively address many linked health challenges by working together.

State-Led Efforts[6]

Interstate Shellfish Sanitation Conference (ISSC)

The ISSC was formed in 1982 to foster and promote shellfish sanitation through the cooperation of state and federal control agencies, the shellfish industry, and the academic community. According to FDA officials, cooperative partners in the ISSC include FDA, NOAA, EPA, CDC, state agencies, industry, tribes, and other nations. To ensure the safety and sanitation of bivalve mollusks (e.g., oysters, clams, mussels, and scallops) in interstate commerce, proposals are submitted to the ISSC for adoption into the National Shellfish Sanitation Program. For example, FDA officials stated that the agency submits proposals on validated detection methods from the agency's HAB toxin projects for inclusion in the program; such methods must be adopted by the program in order for states to be allowed to use them for regulatory purposes. Additionally, this cooperative program adopted guidance levels for biotoxins that are acceptable in bivalve mollusks. FDA officials stated that having this arrangement enables the agency to expend its federal funds primarily on development and validation of methods for detecting HAB toxins in shellfish, while state programs focus on implementing those methods to monitor and make decisions about shellfish harvesting bans when necessary.

Ohio Lake Erie Phosphorus Task Force II

In 2012, the Ohio Environmental Protection Agency, in partnership with the Ohio Lake Erie Commission, the Ohio Department of Agriculture, and the Ohio Department of Natural Resources, reconvened the Ohio Lake Erie Phosphorus Task Force as a Phase II effort. The purpose of this task force's second phase was to reduce phosphorous loading and associated HABs in Lake Erie and surrounding watersheds by (1) developing reduction targets for total and dissolved reactive phosphorus that can be used to track future progress and (2) developing policy and management recommendations based upon new and emerging data and information. As members of this task force or its subcommittees, NOAA, EPA, and

[6]NOAA officials also reported that while only a few states have task forces dedicated specifically to HABs, NOAA scientists routinely provide advice to states on HABs. Standing groups to which NOAA contributes include the California Harmful Algal Bloom Monitoring and Alert Program, the Interstate Shellfish Sanitation Conference (ISSC), the Olympic Region Harmful Algal Blooms Partnership, and the Gulf of Mexico Alliance Water Resources Team.

other federal agencies (Agricultural Research Service, NRCS, and USGS) contributed relevant information and expertise. For example, a NOAA model showing the relationship between nutrient loads and the size and duration of a bloom were central to the task force's recommended nutrient load targets for the Maumee River watershed, a tributary to Lake Erie. Additionally, EPA officials stated that the agency provided $122,429 via a grant to the Ohio Environmental Protection Agency to reconvene this task force and build upon its 2010 report and to broaden participation to include agribusiness representatives and crop consultants.

International Efforts

Great Lakes HABs Collaboratory

Beginning in late 2015, the Great Lakes Commission and Great Lakes scientists from the United States and Canada (initially coordinated by USGS' Great Lakes Science Center) launched a 2-year effort to create a HABs Collaboratory.[7] The overall goal is to create a collective laboratory ("collaboratory") to enable science-based information-sharing among scientists, as well as between scientists and federal, state, and local decision-makers working on HABs in the Great Lakes.

The HABs Collaboratory partnership model builds on similar coordination efforts to address certain invasive species in the Great Lakes. Initially, the effort will focus on the three GLRI priority watersheds (Saginaw River/Bay, Maumee River/western basin of Lake Erie, and Lower Fox/Green Bay). HABs Collaboratory efforts will include (1) establishing the HABs Collaboratory by identifying and engaging the appropriate scientists and managers, (2) developing a common knowledge basis of current science and science needs, and (3) developing strategies for transmitting key scientific information to managers and for getting management feedback to support science-based decisions.

[7]The Great Lakes Commission is an interstate agency that promotes the use and conservation of water and related natural resources of the Great Lakes Basin and St. Lawrence River. Commission products and services focus on communication and education, information integration and reporting, facilitation and consensus-building, and policy coordination and advocacy.

Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization's Intergovernmental Panel on Harmful Algal Blooms (IPHAB)

IPHAB aims to foster effective management of, and scientific research on, HABs to understand their causes, predict their occurrences, and mitigate their effects. In 2015, IPHAB reviewed progress on harmful algae priorities and initiatives in partnership with other international organizations, such as the International Council for the Exploration of the Sea and the International Maritime Organization, according to NOAA officials. IPHAB meets every other April and generates a 2-year work plan that must be endorsed by the Intergovernmental Oceanographic Commission the following June, NOAA officials stated, and IPHAB typically addresses topics of broad interest where global coordination will accelerate the science needed to support the management of HABs. According to officials from NOAA—which chaired the panel from 2010 to 2014 and leads the U.S. delegation to IPHAB—these collaborative efforts include the following:

- rapid progress on HAB detection method development and technology transfer;
- synthesizing information on the likely impacts of climate change on HAB distributions and impacts;
- collaboration on improving HAB forecasting capabilities;
- identification of HAB threats to finfish aquaculture;
- coordination of international testing standards to support international commerce in fish and shellfish;
- documentation of HAB taxonomy online to serve as a global resource for identification of HAB species; and
- forging connections with health and food organizations (e.g., the World Health Organization and the Food and Agriculture Organization of the United Nations) to better address the impacts of HABs on human health and food security.

International Council for the Exploration of the Sea (ICES)

ICES is an intergovernmental organization whose main objective is to increase the scientific knowledge of the marine environment and its living resources and to use this knowledge to provide unbiased, non-political advice to authorities. According to NOAA officials, the United States has been a member of ICES since 1912 and, in recent years, has strengthened its leadership role, particularly in the advisory committees on marine pollution and on fisheries management, to direct the organization's work toward issues and concerns of U.S. interest. NOAA officials also reported that U.S. representatives participate in many of the ICES advisory and standing committees. Each ICES member country has two delegates, NOAA officials stated, and the current U.S. delegates are from NOAA's Northeast Fisheries Science Center and from academia.

According to ICES' website, the organization considers both how human activities affect marine ecosystems and how ecosystems affect human activities. In this manner, ICES aims to ensure that best-available science is accessible for decision-makers to make informed choices about the sustainable use of the marine environment and ecosystems. To achieve this objective, ICES prioritizes, organizes, delivers, and disseminates research needed to fill gaps in marine knowledge related to ecological, political, societal, and economic issues. ICES delivers scientific publications, information, and management advice requested by member countries and international organizations and commissions.

To address HABs specifically, the Working Group on HAB Dynamics serves as a forum for ICES and the Intergovernmental Oceanographic Commission to review and discuss HAB events and to provide advice and updates on the state of HABs annually, according to NOAA officials. This working group also facilitates interaction among scientists working in diverse areas of HAB science and monitoring and provides a forum for discussing various approaches to HAB research. Serving as a liaison to the working group on behalf of NOAA, agency officials stated, the U.S. National Office for Harmful Algal Blooms interacts with federal and academic colleagues to compile annual reports of HAB events in the United States and to update decadal maps for all U.S. HAB events.

International Joint Commission (IJC)

The IJC is an international organization created by the Boundary Waters Treaty, signed by Canada and the United States in 1909. According to NOAA officials, the IJC has set up more than 20 boards, made up of

experts from the United States and Canada, to help it carry out its responsibilities; the Great Lakes Water Quality Board, Great Lakes Science Advisory Board, and Health Professionals Advisory Board periodically address and coordinate research related to HABs in the Great Lakes. For example, NOAA serves on the Great Lakes Science Advisory Board and provides advice on HAB and hypoxia research, which the IJC uses to identify needs and recommendations for water quality work in the Great Lakes region. In turn, NOAA uses IJC recommendations to inform the agency's goals, products, and services.

Academic-Led Effort

National HAB Committee

Established to provide a collective voice for the academic, management, and stakeholder communities, this committee's mission is to facilitate coordination and communication of HAB activities at a national level. Its activities include:

- fostering communication between all components of the HAB community and communicate these activities through the U.S. National Office for Harmful Algal Blooms (located at Woods Hole Oceanographic Institution), biennial National HAB Conferences (most recently held in November 2015), and listservs and websites;
- responding to requests from Congress or federal and state entities for information or guidance on HAB issues; and
- raising the visibility and understanding of HAB issues nationally.

Co-chaired by researchers from an academic institution and a non-profit marine research institution, the committee's formal and ex-officio members include NOAA, EPA, CDC, FDA, NIEHS, NSF, and USGS. The committee was formed after the need for better coordination within the HAB research and management communities—and for enhanced communication with federal agencies—was identified in *Harmful Algal Research and Response: A National Environmental Science Strategy 2005-2015*,[8] a report published in 2005 with support from NOAA's National Centers for Coastal Ocean Science.

[8]Ramsdell, J.S., D.M. Anderson, and P.M. Glibert (Eds.), Ecological Society of America, *Harmful Algal Research and Response: A National Environmental Science Strategy 2005–2015* (Washington, D.C., 2005).

Federal Interagency Partnerships

Through our interviews with agency officials and their written responses to our questionnaire, we identified a number of partnerships between two or more federal agencies directly related to their HAB work in recent years.[9] This list is not comprehensive but is intended to illustrate examples of federal interagency, HAB-related partnerships beyond the coordination efforts discussed above. Additional examples of such partnerships are identified in the IWG-HABHRCA report to Congress, Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report.

Cyanobacteria Assessment Network (CyAN) Project

EPA leads this multi-federal agency project with USGS, NASA, and NOAA to use remote-sensing ocean color satellite data to develop an early warning system to protect the environment and human health. A collaborative effort officially launched in October 2015, of CyAN's is to support the environmental management and public use of U.S. lakes and estuaries by providing the ability to detect and quantify algal blooms and related water quality using satellite data records. Specifically, NOAA officials stated, NOAA currently uses remote sensing and modeling to monitor and forecast HABs in larger bodies of water, such as Lake Erie and along ocean coasts. CyAN aims to expand these monitoring and detection capabilities to provide data that the federal partners can use to improve HAB monitoring products and extend them to smaller lakes and reservoirs throughout the United States. In this manner, NOAA and EPA officials added, the partnership is building on, rather than reinventing, HAB detection techniques developed by NOAA and applying those techniques to other freshwater systems. In 2015, according to the CyAN Project's website, the agencies began using ocean color satellite data to help develop an early warning indicator for algal blooms in freshwater systems and an information distribution system for expedient public health advisories. The project will initially focus on selected states—, including Ohio, Florida, California, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island—for the first year, and then will expand to all 48 continental states.

EPA and NIEHS

According to NIEHS officials, the two agencies meet periodically to exchange information and coordinate research efforts on human health

[9]Based on the information we received from the agencies, these partnerships have involved only federal agencies, but we did not independently evaluate whether the partnerships may have also involved nonfederal stakeholders.

effects of cyanotoxins. Prior discussions have focused on toxicology research needs for microcystins, cylindrospermopsin, and anatoxins that could be addressed by the National Toxicology Program, an interagency program based at NIEHS.

FDA and CDC

Beyond their collaboration on the working group focused on OHHABS, FDA officials reported that these two agencies have a regularly scheduled conference call to discuss foodborne HAB surveillance, specifically. This collaboration is aimed at sharing information and reporting events, ensuring consistency in case definitions, and eliminating duplication of effort.

Interagency Group on HABs Research

According to EPA officials, EPA, CDC, USGS, NOAA, and FDA share expertise and develop methods to detect HAB-associated toxins in biological specimens.

NIEHS and NSF

These two agencies collaborate and provide joint funding for some HAB-related research projects. According to NIEHS officials, this active and ongoing collaboration has been in effect since 2005 between NIEHS' Oceans and Human Health Program and NSF's Division of Ocean Sciences. For example, NIEHS officials stated, the two agencies collaborated in supporting eight HAB-related projects whose grantees were conducting research on health effects of HABs as well as research on developing novel strategies for forecasting HAB events, as of March 2016. NIEHS officials also stated that there are clear boundaries in terms of what each agency supports in each grant that corresponds to the two agencies' different missions. This collaboration, in NIEHS officials' view, fosters the transdisciplinary approaches of these grants and addresses questions that cut across the specific areas of research that each agency typically supports.

USGS and National Park Service

USGS has assisted the National Park Service with collecting and testing water samples and ensuring that appropriate and necessary research is conducted within national park units to inform protection of wildlife and human health. For example, from 2012 to 2013, USGS collected samples from 4 Lake Michigan beach sites at Sleeping Bear Dunes National Lakeshore and from 16 inland lakes across three national park units in Michigan and detected microcystins at several sites. The results of this study provided baseline information to park managers and scientists about the occurrence, types, and levels of algal toxins that had not previously been observed.

Appendix IV: Federal Agencies' Harmful Algal Bloom-Related Websites

Most of the federal agencies within the scope of this review maintain information on their public websites regarding harmful algal blooms (HAB) and related research, monitoring, and other activities.[1] Agency officials reported that they maintain such information on their websites to coordinate with each other and nonfederal stakeholders on their HAB-related activities, reduce duplication, and raise public awareness, among other purposes. Through our correspondence with federal agencies and our own web searches, we identified the following publicly accessible websites describing HABs and HAB-related activities, organized by the agencies maintaining them:[2]

Centers for Disease Control and Prevention (CDC)

HAB-Associated Illness (http://www.cdc.gov/habs/): Provides a brief description and links to frequently asked questions; illness and symptoms; sources of exposure and risk factors; factors that promote HAB growth; how to stay healthy and prevent illness; publications, data, and statistics; health promotion materials; and One Health Harmful Algal Bloom System (OHHABS), an electronic system for voluntary reporting of HAB events and associated cases of human and animal illness.

Technical Assistance in State and Local Response to HABs (http://www.cdc.gov/nceh/hsb/cwh/technical_hab.htm): Briefly describes that public health representatives may consult and receive technical assistance from CDC to develop their responses to HAB events, and provides recent examples of such assistance given to state and federal agencies.

Department of the Navy (Navy)

Commercial Space-Borne Hyperspectral HAB Products (http://www7333.nrlssc.navy.mil/view_project.php?project=ruhul_algal_bloom): Briefly describes and provides images from the Naval Research Laboratory's work using space-borne sensors to develop more reliable detection, quantification, and identification of HABs to help mitigate health risk and economic damages. Navy describes these sensors as ideal tools for HAB detection because of their spatial coverage and low cost.

[1]As of August 2016, there is no central, government-wide portal for information on federal HAB-related activities, but according to National Oceanic and Atmospheric Administration officials, the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act is exploring the possibility of creating one for HABs and hypoxia.

[2]The websites cited were accessible as of August 2016.

Environmental Protection Agency (EPA)

Cyanobacterial HABs (https://www.epa.gov/nutrient-policy-data/cyanohabs): Contains links to information on what freshwater cyanobacterial HABs are, causes and prevention, detection, health and ecological effects, control and treatment, research by EPA and other federal agencies, news, policies and regulations for toxins produced by cyanobacteria (cyanotoxins) at the state and international levels, and guidelines and recommendations.

Epidemiology & Health Effects of Cyanobacteria (https://www.epa.gov/water-research/epidemiology-health-effects-cyanobacteria): Briefly describes EPA research on (1) drinking water treatment safety; (2) characterizing cyanobacterial toxins; (3) determining toxigenic properties; (4) cyanobacteria, nutrients, and land use; (5) disease outbreaks related to toxic algal blooms; and (6) development and application of a fiber optic array system for detection and enumeration of potentially toxic cyanobacteria.

Inland HAB Discussion Group (https://www.epa.gov/nutrient-policy-data/inland-hab-discussion-group): Describes the group and provides links to webinars dating back to October 2012 and contact information for CDC, U.S. Geological Survey (USGS), and EPA.

Nutrient Pollution – HABs (https://www.epa.gov/nutrientpollution/harmful-algal-blooms): Contains links for more information on causes, effects, "what you can do to help" (volunteer to monitor waterbodies), preventing nutrient pollution (in your home, yard, community, and classroom), webinars, videos, and national and state resources.

Executive Office of the President

National Ocean Council (https://www.whitehouse.gov/administration/eop/oceans): Provides information on the council and the National Ocean Policy; the National Ocean Policy Implementation Plan to address challenges facing the ocean, our coasts, and the Great Lakes (including four action items related to HABs); the final recommendations of the Interagency Ocean Policy Task Force; and marine planning, a science-based tool that regions can use to address specific ocean management challenges and advance their economic development and conservation objectives.

Subcommittee on Ocean Science and Technology (https://www.whitehouse.gov/administration/eop/ostp/nstc/oceans): Briefly describes the subcommittee's purpose and provides links to documents and reports, such as the *Harmful Algal Blooms and Hypoxia*

Comprehensive Research Plan and Action Strategy: An Interagency Report to Congress in February 2016; a scientific assessment of hypoxia in U.S. coastal waters from 2010; older scientific assessments of marine and freshwater HABs from 2008; a HAB management and response assessment and plan from 2008; and a national assessment of efforts to predict and respond to HABs in U.S. waters from 2007. As previously stated, the subcommittee oversees the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act (IWG-HABHRCA) and is co-chaired by the Office of Science and Technology Policy, the National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF).

Food and Drug Administration (FDA)

Bad Bug Book (http://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/): Provides current information about the major known agents, including HAB toxins, that cause foodborne illness. Each chapter in the book is about a pathogen—a bacterium, virus, or parasite—or a natural toxin that can contaminate food and cause illness. The book contains scientific and technical information about the major pathogens that cause these kinds of illnesses. A separate "consumer box" in each chapter provides non-technical information about what can make a person sick and, more important, how to prevent illness. The second edition of the Bad Bug Book was published in 2012 by FDA's Center for Food Safety and Applied Nutrition.

Seafood (http://www.fda.gov/Food/PopularTopics/ucm341987.htm): Provides access to content about seafood, including fish and shellfish, from across the Food section of fda.gov. Grouped according to target audiences, these links include access to up-to-date consumer information and advice, guidance documents, regulation, and science and research content. Some information accessible on this page relates to, but may not be specific to, HAB toxins.

National Aeronautics and Space Administration (NASA)

Citizen Scientists Track Algal Blooms (https://re.grc.nasa.gov/citizen-scientists-track-algal-blooms/): Encourages general aviation pilots, functioning as citizen scientists, to help develop an early warning system to alert communities of ensuing algal blooms along the coastline. Provides an opportunity for pilots to obtain high-resolution aerial images and videos as they fly over potentially affected waterways.

National Institute of Environmental Health Sciences (NIEHS)

Database of Environmental Health Science Research Funded by NIEHS (http://tools.niehs.nih.gov/portfolio/index.cfm/): Allows users to search for research funded by NIEHS using key words (e.g., algal bloom). The site also lists some active HAB research grantees, and provides links to their published research findings, through the "Search By Topic" option under the "Oceans and Human Health Centers" row in the "Center And Center-Like Programs" table. Other HAB research grantees can be identified using a keyword search.

HABs (http://www.niehs.nih.gov/health/topics/agents/algal-blooms/index.cfm): Briefly describes what HABs are, why HABs occur, how people are exposed, health effects, and other impacts. Also provides information on NIEHS efforts to (1) study potential long-term health effects of low-dose exposure to HAB toxins, (2) develop rapid detection of HABs to help state officials protect public health with minimal economic impacts to fisheries and recreational areas, (3) improve prediction, and (4) study a compound produced by certain HABs that can help to remove mucus from the lungs and may have potential as a treatment for cystic fibrosis.

Oceans and Human Health (http://www.niehs.nih.gov/research/supported/centers/oceans/index.cfm): Briefly describes how oceans can affect human health in many ways, such as by eating toxin-contaminated seafood, swimming in or drinking toxin-contaminated water, and breathing airborne HAB toxins; NIEHS and NSF jointly funded research on marine-related health issues, including techniques for more accurate and earlier detection of HABs; and other relevant NIEHS efforts. The site also provides links to program highlights and publications.

National Park Service

Oceans – Water Quality (https://www.nps.gov/subjects/oceans/water-quality.htm): Briefly describes various threats to water quality, including plastics, solid waste, chemical waste, toxic waste, HABs, disease, oil spills, and noise.

Natural Resources Conservation Service (NRCS)

Great Lakes Restoration Initiative (http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/home/?cid=nrcsdev11_023903): Briefly describes, among other things, that (1) the Great Lakes Restoration Initiative (GLRI) was launched in 2010 with NRCS as one of a number of federal agency partners; (2) GLRI helps NRCS accelerate conservation efforts on private lands located in targeted watersheds throughout the Great Lakes region by working with farmers and landowners to combat invasive species, protect watersheds and shorelines from non-point source pollution, and restore wetlands and

other habitat areas; (3) the lakes suffer from pollution—caused by urban runoff and sprawl, sewage disposal, agriculture, industry, and other sources—that damages the aquatic ecosystems and poses risks to human health; and (4) algal blooms in Lake Erie have underscored the importance of continued conservation efforts.

NOAA

Great Lakes HABs and Hypoxia (http://www.glerl.noaa.gov/res/HABs_and_Hypoxia/): Allows access to NOAA's Great Lakes Environmental Research Laboratory resources, such as Water Quality and Monitoring Data from field monitoring and continuous, real-time observations in western Lake Erie and two other lakes; Lake Erie HAB Bulletins—which provide biweekly forecasts—dating back to July 2009; near-real-time information on the presence of microcystin in western Lake Erie; hyperspectral and satellite images;[3] and an experimental "Western Lake Erie HAB Tracker," a tool that combines remote sensing, monitoring, and modeling to produce daily 5-day forecasts of bloom transport and concentration. The site also provides links to frequently asked questions, publications, a HAB photo gallery, and a Hypoxia Warning System that is under development to provide information to drinking water managers in the central Lake Erie basin.

Integrated Ocean Observing System (IOOS) – HABs and Hypoxia (https://ioos.noaa.gov/project/ott-habs-hypoxia/): Describes IOOS' Ocean Technology Transition Project awards related to HABs and hypoxia. IOOS' Ocean Technology Transition Project works with scientists and industry to make operational technologies to monitor ocean conditions that can affect human health. IOOS has funded four such projects in support of HAB and hypoxia detection and monitoring.

National Centers for Coastal Ocean Science (NCCOS) – Harmful Algal Blooms (https://coastalscience.noaa.gov/research/habs/default):

[3]NOAA's Great Lakes Environmental Research Laboratory and the University of Michigan's Cooperative Institute for Limnology and Ecosystems Research began a weekly airborne campaign in 2015 to assist in improvements to HAB forecasting by capturing images of HABs in western Lake Erie. The flyovers are done in collaboration with researchers at NASA that have been flying their own airborne imaging sensor. Airborne images are hyperspectral, meaning they contain many more (e.g. hundreds of) bands of discrete wavelengths than a typical spaceborne satellite and a broader visible range than the human eye can see.

Provides an overview of HABs and links to NOAA's NCCOS research programs (Ecology and Oceanography; Monitoring and Event Response; and Prevention, Control, and Mitigation), forecasting, HABHRCA, sensors, marine biotoxin impacts, rapid response, and other related topics.

National Ocean Service – Harmful Algal Blooms (http://oceanservice.noaa.gov/hazards/hab/): Provides links to NOAA's forecast for red tide in Florida, a West Coast HAB update, HAB forecast bulletins, research, "ecoforecasting" services, and additional information.

NCCOS – Our Research Projects (https://coastalscience.noaa.gov/projects): Allows access to NCCOS' research projects; users can search by title, a project's primary contact(s), keyword or phrase in the project's description, research area (including HABs), or regional area.

NCCOS – Phytoplankton Monitoring Network (https://products.coastalscience.noaa.gov/pmn/): Promotes a better understanding of HABs through volunteer monitoring, provides resources for current and prospective volunteers, and allows volunteers to submit new data and view historical data.[4]

NOAA Harmful Algal Bloom Operational Forecast System (http://tidesandcurrents.noaa.gov/hab/overview.html): Houses NOAA's HAB operational forecast system, which aims to assist HAB mitigation through early detection and forecasting in the Gulf of Mexico; and provides links to local beach condition reports in Florida and Texas, bulletins, health information, and other resources.

Northwest Fisheries Science Center – HAB Research Partnerships (https://www.nwfsc.noaa.gov/hab/research/research_partnerships/): Provides information on the SoundToxins partnership, a phytoplankton

[4]Phytoplankton are microscopic, photosynthetic organisms, such as microalgae and cyanobacteria, that produce much of the world's oxygen. As reported in the IWG-HABHRCA report to Congress, *Harmful Algal Blooms and Hypoxia Comprehensive Research Plan and Action Strategy: An Interagency Report* (Washington, D.C.: Feb. 11, 2016), NOAA staff train citizen volunteers in the Phytoplankton Monitoring Network on sampling techniques and identification methods for over 50 phytoplankton types, including 10 that are potentially toxin-producing. At the time of the report, 250 sites in 22 states and U.S. territories—including schools, universities, civic groups, and state and federal agencies—were collecting phytoplankton and environmental data. The report also states that since the inception of the program in 2001, more than 275 algal blooms and 15 toxic events had been reported by network volunteers.

and toxin monitoring program that provides early warning for HABs in Puget Sound; a Pacific Northwest HAB forecasting bulletin; and the Olympic Region Harmful Algal Blooms Partnership.

Northwest Fisheries Science Center – Wildlife Algal-Toxin Research and Response Network for the U.S. West Coast (https://www.nwfsc.noaa.gov/research/divisions/efs/warrnwest/): Hosts a West Coast-wide surveillance program that monitors for domoic acid, saxitoxin, and the toxins responsible for diarrhetic shellfish poisoning. The sampling network consists of federal, state, public, private, and academic partners and the major marine mammal stranding networks.

NSF

Award Search Database (http://www.nsf.gov/awardsearch/): Provides access to a searchable database of award abstracts for all NSF-funded research projects, dating back to 1989. The database is searchable using key terms (such as algal bloom), title, abstract, names, institutions, programs, and other information associated with an award.

U.S. Army Corps of Engineers (USACE)

Aquatic Nuisance Species Research Program (https://el.erdc.dren.mil/ansrp/ansrp.html): Provides USACE managers and operational personnel with information on aquatic nuisance species, including basic life history and ecological information, risk assessment tools, preventative strategies, and cost-effective and environmentally sound management options. The program is an expansion of USACE's Zebra Mussel Research Program and provides information not only on zebra mussels, but on all aquatic nuisance species fauna, including HAB species. The program's main objective is to conduct interdisciplinary research on the prevention, control, and management of aquatic nuisance species that affect USACE projects and public facilities. Reports from research conducted on HAB species can be found in the website's Technology Transfer section.

Louisville District (http://www.lrl.usace.army.mil/Missions/Civil-Works/Water-Information/HABs/): Provides contact information for reporting signs of a potential HAB in Kentucky, Indiana, Ohio, and the Ohio River; and information on HAB conditions, cyanobacteria threshold values, what HABs are, and what causes them to form.

USGS

BioData – Aquatic Bioassessment Data for the Nation (https://aquatic.biodata.usgs.gov/landing.action): Provides an online database of biological community and physical habitat ("bioassessment") data, which includes information on the occurrence of algal species,

collected by USGS scientists in stream ecosystems across the nation. The database contains data from over 15,000 fish, aquatic macroinvertebrate, and algae community samples as part of USGS' mission to describe and understand the Earth.

Cyanobacterial Blooms: Tastes, Odors, and Toxins (http://ks.water.usgs.gov/cyanobacteria): Provides information from USGS' Kansas Water Science Center on water-related research lecture series, current study areas, and relevant publications dating back to 2002.

Drinking Water Exposure to Chemical and Pathogenic Contaminants: Algal Toxins and Water Quality (http://health.usgs.gov/dw_contaminants/algal_toxins.html): Provides an overall description and links to algal toxin studies, fact sheets, USGS algal-related studies, methods, and protocols.

USGS Publications Warehouse (https://pubs.er.usgs.gov): Provides access to over 130,000 publications written by USGS scientists over the past century (including those on algal blooms and toxins), and is searchable using key terms.

Water Quality Portal (http://www.waterqualitydata.us/): Integrates data, including HAB and hypoxia data, collected by over 400 state, federal, tribal, and local agencies for this cooperative effort by USGS, EPA, and the National Water Quality Monitoring Council.

Appendix V: Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

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