State of the Science FACT SHEET

Harmful Algal Blooms

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION • UNITED STATES DEPARTMENT OF COMMERCE

The marine and fresh waters of the United States are increasingly impacted by the growing environmental problem of harmful algal blooms (HABs), high densities of microscopic algae most noted for their production of potent toxins. HABs are known to occur in all 50 states. HABs can adversely affect human and animal health, and cause significant economic impacts to coastal communities, losses to aquaculture enterprises, and long-term ecosystem changes. While HABs are naturally occurring phenomena, they are increasing in frequency and duration, and geographically expanding due to human-influenced ecosystem changes such as excessive levels of nutrients and extreme weather events.

HABs have been reported in every U.S. state and their occurrence is on the rise. This map shows the types of HABs found in the U.S. and where they occur. Credit: NOAA

What are the Impacts of HABs?

Human health impacts: Effects of algal toxin exposure through eating seafood, drinking contaminated water, or recreation near contaminated air and water can range from neurological impairment, to gastrointestinal, respiratory distress, or eye irritation. In some cases, it even can result in severe or chronic illness or death.

Animal health impacts: Potent HAB toxins can kill or sicken fish, shellfish, marine mammals, birds, wildlife, livestock, and pets.

Economic impacts: HABs cost the U.S. economy millions of dollars each year. Most of these economic impacts are associated with public health, recreation, tourism, commercial fisheries, and monitoring and management efforts. For example, a 2015 West Coast HAB event resulted in $97.5 million in lost Dungeness crab landing revenue, while in Lake Erie, the economic cost of a severe HAB season has been estimated at $65-70 million.

HABs and Climate

As the climate continues to change, freshwater and marine environments are likely to experience shifts in precipitation and more extreme weather, higher temperatures, increased strengthening and duration of stratification and upwelling, and enhanced acidification. For example, the increase in forest fires in the coastal mountains of the U.S. West Coast has created conditions that foster HABs by changing the properties of the soil, allowing for more nutrient runoff after rain events. More research is necessary to understand climate and HAB relationships to improve models and forecasts.

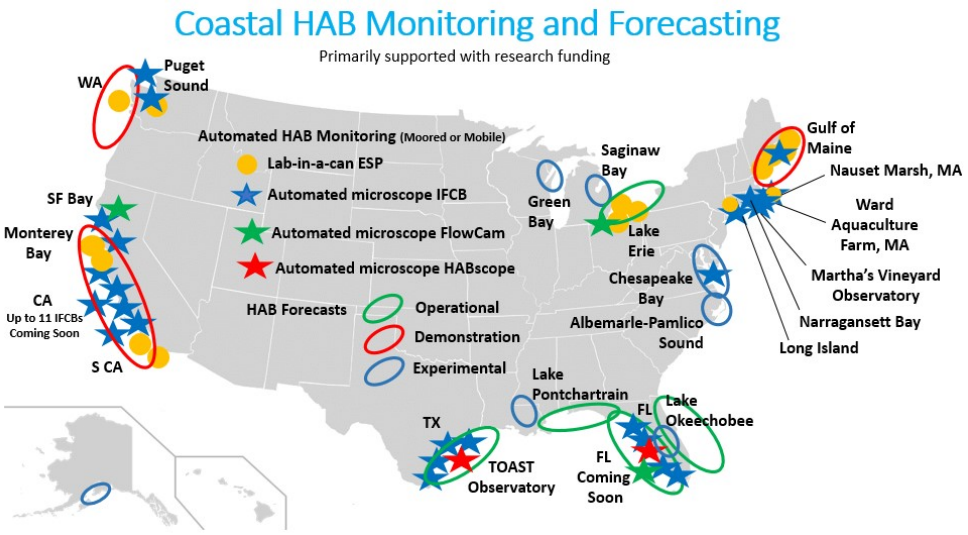
HAB and Hypoxia Research and Control Act

The Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2017 (HABHRCA) congressionally requires NOAA and EPA to advance the scientific understanding and ability to detect, monitor, assess, and predict HAB and hypoxia events in marine and freshwater in the U.S. NOAA co-leads the implementation of HABHRCA through interagency coordination, assessments, research prioritization and planning, and intramural and competitive sponsored research with partners. The results are collaborative world-class research, monitoring, technological advancements and outreach that help federal agencies most efficiently protect coastal communities.

NOAA's Research on HABs

NOAA works to provide the public and other entities with timely information on the occurrence of HABs, a deeper understanding of their causes and impacts, their toxins, and potential mitigation strategies, as well as ever improving forecasts that predict the likely intensity, timing, and trajectory of blooms. NOAA also builds capacity within states, tribes, the seafood industry, and other stakeholders, by providing access and training on proven detection technologies to ensure that trained and well- equipped personnel are able to mobilize quickly during HAB events.

Harmful algal bloom as seen from the research docks of The Ohio State University's Stone Laboratory on Gibraltar Island in Lake Erie. Credit: Jeff Reutter



Regions with HAB monitoring and forecasting. These efforts are supported primarily with research funding. Operational indicates a finalized system, process, product, service or tool; demonstration indicates a prototype; and experimental indicates under development. Credit: NOAA

Causes and Toxicity of HABs: NOAA conducts research to understand the causes and impacts of HABs and their toxins. This includes improved understanding of the factors controlling HAB growth and toxicity by focusing on harmful algal genetics, physiology, and toxin production. NOAA and partners are also investigating the trophic transfer of HAB toxins across marine food webs, and the impacts of these toxins on higher trophic levels.

HAB Monitoring and Toxin Detection: NOAA supports a wide range of monitoring and observing networks (ex. HABSOS, IOOS Regional Initiatives) many of which are a collaboration between internal NOAA and external partners. Observations and measurements of HAB species and toxins are key to supporting early warning and forecasting. NOAA and partners have developed new technologies to better monitor HABs and improve real-time sampling with Imaging FlowCytobot and toxin and genetic identification of algae with Environmental Sample Processor. The data collected by these technologies are useful in assessing bloom toxicity, identifying potential drivers of HAB growth and toxin production, and validating satellite observations and model outputs.

HAB Forecasting: NOAA and its partners use satellite remote sensing data, *in situ* observations, and numerical modeling to support a system for detecting, monitoring, and forecasting HABs across the US. Operational forecasts are provided for the eastern and western regions of the Gulf of Mexico and Lake Erie, demonstration forecasts are available for the Gulf of Maine, California, and the Pacific Northwest. Experimental forecasts are being developed for Alaska, Lake Okeechobee, and the Chesapeake Bay. By incorporating advances in observational science and modeling, it is possible to improve HAB forecasts. HAB forecasting products serve as decision-support tools and provide early warning of regional blooms for local coastal resource managers, public health officials, and research scientists.

HAB Prevention and Control: NOAA scientists and partners are working to eliminate or control HABs, in ways that are safe for people, wildlife, and the environment. For example, some naturally occurring marine bacteria can target and kill toxic algae. NOAA is also transitioning to large-scale operations environmentally sustainable technologies like nanobubble ozone technology (NBOT), which can eliminate harmful algae and their toxins. NBOT has also been successful in reducing or completely removing nitrogen and phosphorus from the water column. This research is in the process of being field tested.

Response and Readiness for HAB Events: NOAA provides analytical support and funding assistance during HAB and marine mammal mortality events. NOAA released approximately $111,360 in event response funds from July 2019 to March 2021 to assess and research ongoing HABs, toxin levels, impacts to marine animals, potential treatment methods for affected animals, and to support community toxin detection in response to a HAB event caused by warming waters.

Addressing HAB Impacts - Humans, Ecosystems and Economies: NOAA researchers have partnered with private industry to develop portable test devices to measure toxins in drinking water and harvested shellfish. NOAA empowers Native American tribes to establish laboratories that allow for quicker testing of samples for toxins in traditional and subsistence resources. NOAA also uses the power of citizen science to expand HAB forecasts and monitoring. Finally, NOAA is working to estimate the economic benefits of the HAB early warnings provided by forecasts.

Significance of NOAA HAB Research

NOAA's HAB research capabilities and assets, together with information collected by partners through state-led programs and other Federal agencies, enhance the understanding of the causes of HABs and how they respond to changing weather, ocean conditions, and other factors. Early warning of HABs provides health officials, environmental managers, and water treatment facility operators information to focus their testing to guide beach and shellfish bed closures or water treatment in a more appropriate timeframe; decrease costs for states, tribes, and local governments in monitoring and managing HABs and their impacts; and allow the seafood and tourism industries to minimize HAB impacts.