State of the Science FACT SHEET

Harmful Algal Blooms

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION • UNITED STATES DEPARTMENT OF COMMERCE

What Are Harmful Algal Blooms (HABs)?

HABs are mostly caused by single celled algae a type of phytoplankton (Fig. 1). Phytoplankton are abundant in marine and freshwater ecosystems and are an essential component of marine and aquatic food webs. Harmful algae are a small subset of species that sometimes negatively affect human, animal, and ecosystem health and coastal resources through the production of potent chemical toxins (algal toxins) or the build-up of excess biomass. Sometimes referred to as "red tides," HABs can also be brown, green, purple, or no color at all. Further, not all discolored water is harmful.

HABs occur in fresh and marine waters all over the world and can be expansive, covering many square miles (Fig. 2). The frequency and distribution of HABs and their impacts have increased considerably in recent years, both in the United States and globally. Almost all U.S. coastal states are now adversely affected by HABs (Fig. 3).

Fig. 1. Massive blooms of the microscopic, single celled harmful alga, Karenia brevis occur along the west Florida coast almost every year and sporadically in Texas and throughout the Gulf of Mexico. (NOAA)

What Are the Impacts of HABs?

- *Acute human health impacts*: Effects of algal toxin expo- sure can range from neurological impairment to gastro- intestinal distress to respiratory irritation, in some cases resulting in severe illness and even death. Eating shellfish and fish contaminated by algal toxins is most often the cause of HAB-associated illness in humans. In addition drinking water supplies have been disrupted both in the US and abroad by algal toxins.
- *Acute animal health impacts*: Massive fish kills are per- haps the most commonly observed impact of HABs on wildlife, but algal toxins also have been associated with deaths of whales, sea lions, dolphins, manatees, sea turtles, birds, and invertebrates. Freshwater HABs have caused the death of domestic animals and livestock.
- *Chronic health impacts*: The effects of chronic or repeated, low-level HAB toxin exposure on health, reproductive failure, and behavior of humans and wildlife are only be- ginning to be understood. Impacts from this type of expo- sure could be significant on protected and endangered species.
- *Environmental impacts*: HABs can degrade ecosystem health by forming large and dense blooms. These blooms alter habitat quality through overgrowth, shading, oxygen depletion, or accumulation on beaches. Adverse effects are seen in degraded corals, sea grasses, and bottom- dwelling organisms.
- *Economic impacts:* HAB events can be costly. Although the national cost from 1987 to 2000 was conservatively estimated to be $100M/year, events are sporadic and one major HAB event can be locally quite costly. For example, estimated losses to tourism for seven coastal counties for three months in Florida in1974 were estimated at $71 M. During the historic 2005 bloom Maine shellfish harvesters experienced a $7.2M loss during the summer tourist season. In 2011, Lake Erie experienced its second largest bloom on record, which was estimated to have a $71 M impact to the region.

NOAA HAB Research and Response

NOAA's goal is to provide tools to prevent, control, or mitigate the occurrence of HABs and their impacts.

- *Research*: NOAA's HAB activities include research on HAB cell and toxin detection; bloom ecology and dynamics leading to predictive models and forecasts; HAB impacts on marine resources, human health, and coastal economies; and new strategies for HAB prevention and control. NOAA supports internal research programs and funds academic and nongovernmental research as well.
- *Monitoring*: NOAA is developing new technology and establishing partnerships between federal, state, tribal, and local managers and HAB researchers in order to improve HAB detection for resource monitoring programs and add HAB detection to ocean observing systems.
- *Event Response*: NOAA provides assistance with toxin and cell identification and funding for field investigations when needed during HAB and marine mammal mortality events.
- *Prediction*: The NOAA HAB Operational Forecasting System provides regional HAB forecasts, like weather forecasts. Currently, forecasts are provided for the eastern and western Gulf of Mexico and demonstration projects are underway for Lake Erie and Gulf of Maine. Forecasts are in development for California, Washington, and the Chesapeake Bay.

Fig. 2. Massive HAB in the Gulf of Mexico moving toward the beach (upper left corner). Arrows indicate the leading edge of the bloom.

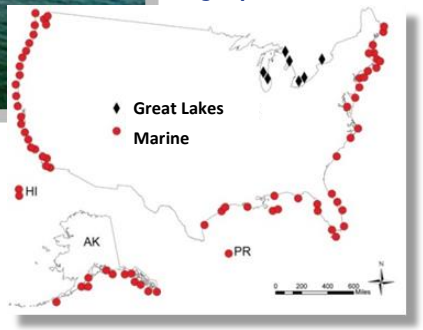

Fig. 3. Locations where HABs have been observed along the United States coastline and Great Lakes. Inland freshwater HABs occur in all states.

Examples of Recent Accomplishments in NOAA HAB Research

Harmful Algal Bloom Forecasting NOAA and its partners use satellite remote sensing data to support a system for forecasting HABs in the Gulf of Mexico (Fig. 4). This forecasting system detects and monitors the location of HABs in coastal waters on a twice-weekly basis and issues public forecasts to help indicate where and when blooms will impact beaches. HAB forecast bulletins are distributed directly to resource managers and the public (HABOFS). Weekly, summer forecasts are now available for Lake Erie blooms.

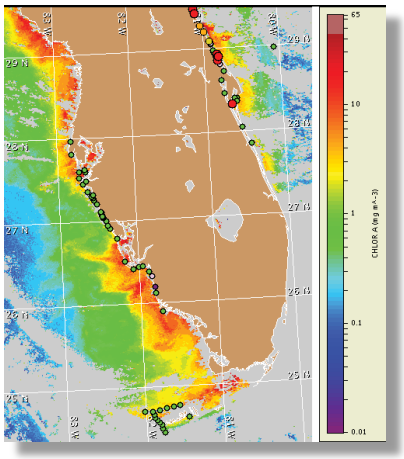

Fig. 4. A combination of satellite imagery (left, providing an estimate of all algae near the surface), wind data, field samples, public health data, in situ currents, and an ecological model are used to determine HAB location and extent and to forecast the transport and likely impacts at the beach over several days. In this figure, green dots indicate HAB field samples with low abundance and red dots indicate samples with high abundance of HAB cells.

Algal Toxin Test Kit Harmful algae in the genus *Pseudo-nitzschia* produce domoic acid, a toxin that accumulates in marine food chains. Humans are exposed to domoic acid through consumption of tainted shellfish or crabs. NOAA researchers have partnered with private industry to develop a test kit to detect domoic acid in razor clams (Fig. 5). Razor clams are an important food source for many coastal residents in the Pacific Northwest and provide income for Native Americans. The rapid, simple, and inexpensive test allows frequent monitoring of shellfish to determine if they are safe to harvest and is commercially available.

Fig. 5. Domoic acid test kits provide a rapid, cost-effective way to monitor shellfish toxicity. (NOAA/ Mercury Science, Inc.)

Algal Bloom Monitoring and Forecasting in the Gulf of Maine Research has been supported by NOAA for more than a decade to develop seasonal and weekly forecasts for the recurring Spring and Summer toxic red tides (*Alexandrium* spp) in the Gulf of Maine. This research has allowed NOAA and its partners to provide a seasonal red tide outlook since 2008 based upon a sophisticated mathematical model that takes into account the abundance of seed-like cysts overwintering on the seafloor and environmental conditions. This helps State and local shellfish managers as well as the shellfish industry prepare for the upcoming season to minimize impacts on human health and the coastal economy. Weekly forecasts in conjunction with state-of-the-art monitoring tools provide additional information for decisions for management decisions. NOAA is currently in the process of transitioning these new forecasting tools to operational status.

Understanding HAB Impacts on Wildlife More than a decade of NOAA marine algal toxins research has revealed the widespread involvement of HABs in marine animal mortality events. Chronic exposure to algal toxins is pervasive and increasing globally. NOAA research has discovered a novel toxin-specific antibody response to domoic acid, an algal toxin that affects humans and marine mammals (Fig. 6). This leads the way for diagnostic tests for exposure to domoic acid and informs health and management decisions.

Fig. 6. The diagnostic test for exposure to domoic acid was first tested in Sea Lions which are frequent victims of domoic acid poisoning caused by algal toxins. (National Marine Fisheries Service)

In-water, Automated Detection of Multiple HAB Species and Toxins NOAA and collaborators are developing a new class of ocean sensors that remotely detect HAB species and toxins. Two are now commercially available - the Environmental Sample Processor (ESP) and Imaging Flow Cytobot. The ESP (Fig. 7) robotically collects water samples, concentrates microorganisms, analyzes the samples for organisms of interest or their associated toxins, and transmits results to scientists and managers ashore. The IFC is an automated underwater microscope that uses a laser-based system to detect algae and takes photos for species identification in real time, enabling continuous monitoring of algal communities and alerts of rising levels of toxic algae. NOAA and partners have proven these sensors capable of providing data for forecasting toxic blooms and to help mitigate HAB impacts on human health, marine resources, and coastal economies.

Fig. 7. Deployment of an Environmental Sample Processor in the Gulf of Maine for near–real time monitoring of Alexandrium and paralytic shellfish toxins. (Woods Hole Oceanographic Institution)

NOAA Leads Implementation of the 2014 Reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act, through interagency coordination, assessments, research prioritization and planning, and intramural and competitive sponsored research with partners. The results are world-class research, monitoring, and technology/outreach with a strong emphasis on application and transitioning of key products where they will serve to protect coastal communities and economies.

For more information see:
HABHRCA: http://coastalscience.noaa.gov/research/habs/habhrca
NCCOS HAB Research & Response: http://coastalscience.noaa.gov/research/habs
HABOFS: http://tidesandcurrents.noaa.gov/hab/development.html
Lake Erie HABs: http://www.glerl.noaa.gov/res/HABs_and_Hypoxia/
Northwest Fisheries Science Center HABs & Biotoxins: http://www.nwfsc.noaa.gov/hab/habs_toxins/