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)?

Harmful algal blooms, sometimes referred to as “red tides,” are mostly caused by single celled algae called phytoplankton (Fig. 1). Many harmful algae, however, are not red. Further, not all reddish blooms are harmful. 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 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.

Harmful algal blooms 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. All U.S. coastal states are now adversely affected by HABs (Fig. 3).

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

What Are the Impacts of HABs?

- *Acute human health impacts*: Effects of algal toxin exposure can range from neurological impairment to gastrointestinal 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.
- *Acute animal health impacts*: Massive fish kills are perhaps 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 beginning to be understood. Impacts from this type of exposure 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, seagrasses, and bottom-dwelling organisms.
- *Socioeconomic impacts:* HAB events can be costly. A 2006 study showed economic impacts from a subset of HAB events in U.S. marine waters averaged $82 million/year. Just one major HAB event can cost local coastal economies tens of millions of dollars, translating to a much larger nationwide impact. For examples from individual events, see http://www.cop.noaa.gov/stressors/extremeevents/hab/current/HAB_Econ.html.

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 improving HAB monitoring by establishing partnerships between Federal, state, tribal, and local managers and HAB researchers, by developing new HAB sensors, and by including HABs as a priority in coastal observing systems.
- *Event Response:* NOAA provides assistance when needed during HAB and marine mammal mortality events.
- *Prediction:* NOAA funds the development and implementation of systems to regionally predict HABs. Currently, weekly HAB forecasts are provided for the Florida red tide in the eastern Gulf of Mexico. Prototypes are currently underway for the Great Lakes, Gulf of Maine, Washington State, and western Gulf of Mexico (http://tidesandcurrents.noaa.gov/hab/).

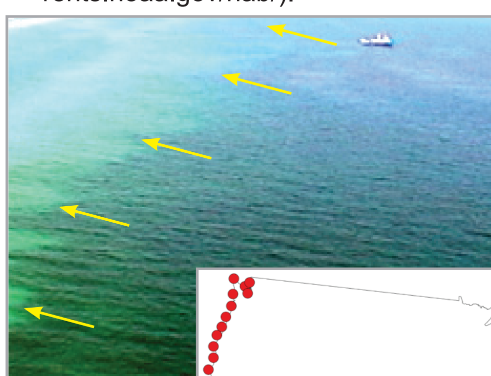


Fig.2. Massive HAB in the Gulf of Mexico moving from offshore toward the beach (upper left corner). Arrows indicate the leading edge of the bloom (NOAA).

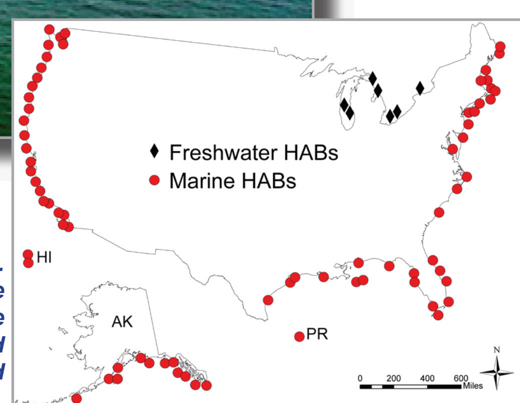


Fig. 3. Locations where HABs have been observed along the United States coastline.

Examples of Recent Accomplishments in NOAA HAB Research

Harmful Algal Bloom Forecasting

NOAA and its partners use satellite remote sensing data to support an ecological forecast system for HABs in the Gulf of Mexico (Fig. 4). This useful forecasting system detects and monitors the location of HABs in coastal waters on a twice-weekly basis and issues public forecasts to help determine where and when blooms will impact beaches. HAB forecast bulletins are provided to local, state, and Federal resource managers via the web.

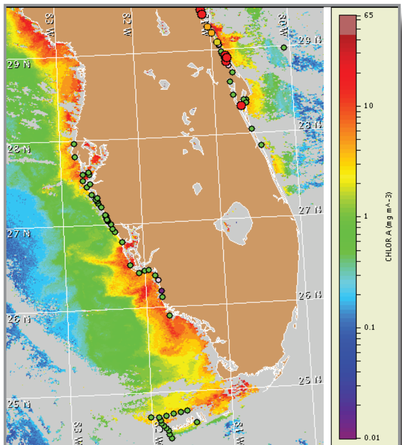
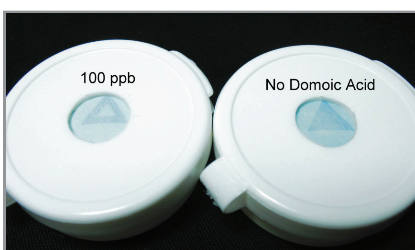


Fig. 4. A combination of satellite imagery (left), wind data, field samples, public health data, in situ currents, and an ecological model are used to determine HAB location and extent and to forecast the transport and likely impacts at the beach over several days. In this figure, green dots indicate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

Algal Toxin Test Kit

One of the algal toxins with great impact on shellfish harvesting is domoic acid. Harmful algae in the genus *Pseudo-nitzschia* produce this toxin that accumulates up the food chain. 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.

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



First Annual Gulf of Maine HAB Prediction

In 2008, NOAA-funded researchers made the first-ever seasonal prediction of a severe outbreak of toxic *Alexandrium*, the New England red tide organism, based on a model developed through 10 years of NOAA funding. Blooms began when seed-like cysts present in bottom sediments hatched; the abundance of cysts in the fall of 2007 was extraordinarily high, leading to the 2008 prediction. Early warning allowed managers to plan and focus monitoring resources. Shellfish harvesting was closed for extended periods. Weekly forecasts were used to allow precise opening of shellfish harvesting, minimizing economic impacts while protecting public health.

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 (Fig. 6). Many organisms are susceptible to HAB poisoning during fetal development, leading to reproductive failure or neurological disease later in life. Investigations of wildlife mortality indicate the presence of HAB toxins in regions and in species previously not known to be affected. This raises awareness of unexpected risks of HABs to humans.

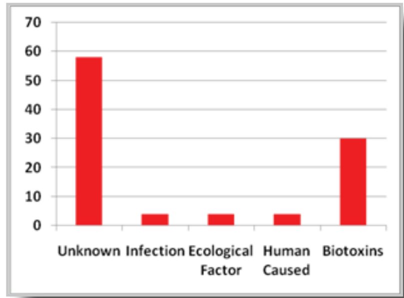


Fig. 6. Causes of unusual marine mammal mortality events from 1998-2008 by percent; biotoxins = algal toxins (NOAA).

In-water, Automated Detection of HAB Species and Toxins

NOAA and collaborators have achieved the first simultaneous detection of a HAB species and its toxin using an autonomous, underwater sensor called the Environmental Sample Processor (ESP, Fig. 7). The ESP uses molecular-based technology for the highly specific, near real-time detection of *Pseudo-nitzschia* and toxin domoic acid produced by this species. When deployed as part of an ocean observing system, the ESP provides data needed to drive forecasting models for toxic blooms, helping coastal managers reduce the impacts of HABs on marine resources and human health.

Fig. 7. Deployment of an environmental sample processor (ESP), a device used for near real-time detection of one HAB species (Monterey Bay Aquarium Research Institute).

NOAA Leads the implementation of the Harmful Algal Bloom and Hypoxia Research Act, providing leadership through interagency science advisory committees, assessments, and plans. NOAA's HAB research aims to prevent, control, and mitigate HABs and their impacts in U.S. coastal waters. Efforts are executed through centers that conduct intramural research, guide sponsored research, and catalyze partnerships. The results are world-class research, monitoring, and technology/outreach products with a strong emphasis on application and transitioning of key products to operation.

For more information see:

http://tidesandcurrents.noaa.gov/hab/

http://www.cop.noaa.gov/stressors/extremeevents/hab/current/noaaHab.html

http://www.ocean.us/what_is_ioos