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Focal Points

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from the Woods Hole Oceanographic Institution

Harmful Algal Blooms (HABs) in the United States

Introduction

Harmful Algal Blooms (HABs) is a relatively new term used to describe a proliferation, or "bloom," of single-celled marine algae called phytoplankton. Once more commonly referred to as "red tides," these blooms occur when the algae photosynthesize and multiply. While there are thousands of phytoplankton species in

existence, only a few dozen are known to be toxic. However, because phytoplankton serve as the base of the marine food web, the impact of these blooms can be devastating for consumers throughout the food web and for other marine flora or fauna in the affected ecosystem. Even blooms of non-toxic species can spell disaster for marine animals since the

massive quantities of phytoplankton deplete the oxygen in the shallow waters where most phytoplankton blooms occur.

Recently, the world's coastal waters have experienced an increase in the number and type of HAB events. This is especially true in the United States, where virtually every coastal state is now threatened, in some cases by

more than one species (refer to map comparing known incidences of U.S. HABs, pre-1972 and present).

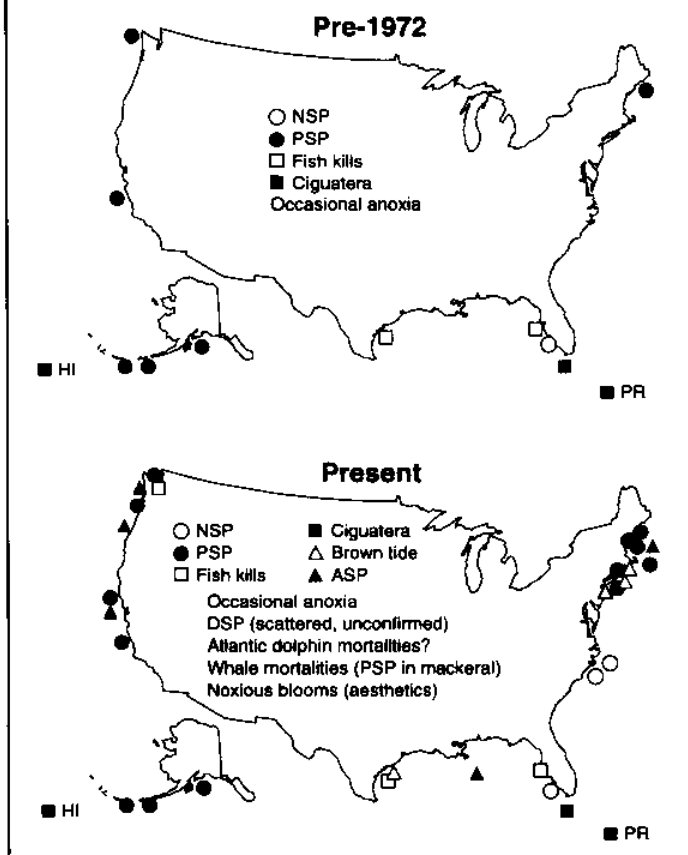
As to the causes of this trend, scientists say the jury is still out. Possibilities range from natural causes (species dispersal) to human-related causes (nutrient enrichment, shifts in global climate, or transport of algal species by ship ballast water).

Harmful Algal Blooms

Causative Species	Common Bloom Name	Toxin Produced	Region(s) Affected
<i>Gymnodinium breve</i> (dinoflagellate)	Neurotoxic Shellfish Poisoning (NSP) also, "Red Tide"	brevetoxins (neurotoxins)	Gulf of Mexico (West coast of FL, LA, MS, AL, and West TX) South Atlantic Bight
<i>Alexandrium</i> (several species) (dinoflagellate)	Paralytic Shellfish Poisoning (PSP)	—	East Coast (ME, NH, MA, also CT, NY) West Coast (CA, OR, WA, AK)
<i>Aureococcus anophagefferens</i> <i>Aureocoumbra lagunensis</i> (chrysophytes)	Brown Tide	—	Long Island, NY, TX (persistently) RI (Narragansett Bay) (occasionally) NJ (Barnegat Bay) (occasionally)
<i>Pseudo-nitzschia</i> (3 species) (diatom)	Amnesic Shellfish Poisoning (ASP)	domoic acid	Northeast U.S. (not quarantine levels) Gulf of Mexico Northwest U.S. (CA, OR, WA, AK)
<i>Pfiesteria piscicida</i> (dinoflagellate)	Fish Kills also, Human Illness (cognitive impairment, possibly skin rashes)	cxotoxins	East Coast (VA, FL, NC, DE, MD)
<i>Heterosigma</i> (raphidophyte flagellate)	Fish Kills	unknown, possibly ichthyotoxin, superoxide radicals, or hydrogen peroxide	Pacific Northwest
<i>Chaetoceros convolutus</i> <i>Chaetoceros concavicornis</i> (diatoms)	Fish Kills	no toxin, but long setae armed with short secondary spines	Pacific Northwest

Source: WHOI Sea Grant

U.S. Harmful Algal Blooms (HABs)



Source: National Office for Marine Biotoxins and Harmful Algal Blooms, WHOI

Marine Phytoplankton Known to Cause HABs in the U.S.

Scientists categorize blooms by species, toxins produced, and the effect that such toxins have on consumers, namely humans. A brief description of each is listed in the table on page 1.

Impacts of HABs

As evidenced by the table, the species of marine phytoplankton that cause HABs—and their effects—vary dramatically. While some are toxic only when concentrations reach high densities, others can be toxic at very low densities (only a few cells per liter). Whereas some blooms discolor the water (thus the terms “red tide”

and “brown tide”), others are undetectable by even highly sensitive satellite imagery techniques designed to pick up color differences.

While the bloom characteristics of HABs are highly variable, the effects of HABs generally fall into two major categories, public health and ecosystem effects and economic impacts.

• Public Health & Ecosystem Effects

- filter feeding shellfish (clams, mussels, oysters, scallops) may accumulate algal toxins by feeding on the toxic phytoplankton, sometimes at levels potentially lethal to humans or other consumers and may decrease

light penetration, an important consideration for many organisms;

- potential fish, shellfish, and bird kills, occasionally invertebrate and marine mammal kills;

- discoloration of water can be aesthetically unpleasant;

- toxins or other compounds released by the microalgae can kill marine fauna directly or result in low oxygen conditions as the bloom biomass decays (especially dangerous for aquaculture sites where fauna cannot easily escape); and

- blooms of seaweeds can be harmful to seagrass and coral reef ecosystems and the food webs that are dependent on those systems.

• Economic Impacts

- shellfish bed closures or quarantines, wild or farmed fish mortalities, loss of income due to closures and mortalities, and consumer fear of purchasing seafood are the most direct and costly economic impacts, but indirect impacts, such as fear of investing in aquaculture businesses, are also costly;

- lost marine recreational opportunities including tourism, fishing, shellfishing, swimming and sunbathing resulting from blooms, including dead fish or shellfish washing up on beaches, discolored water, noxious odors, and human respiratory problems caused by toxins released into the air;

- cost of maintaining monitoring and testing programs designed to detect algal toxins and costs associated with cleaning up fish or shellfish kills when they do occur; and

- medical costs and lost

productivity of workers poisoned by HAB toxins is a significant and recurring annual impact.

Overall, preliminary estimates of the overall impact of HAB outbreaks on the U.S. economy, taking the above factors into account, are over \$40 million per year, or nearly \$1 billion over a decade.

HAB Research Directions Now Underway

HAB research has been taking place for over two decades. One source of funding that has remained constant throughout the years—even before the term HAB existed—is the National Sea Grant College Program. Sea Grant’s research support, along with a recent influx of federal support from other NOAA agencies and NSF, has seen and will continue to see, better understanding of HABs. Unfortunately, due to the complexities of the individual species and the fact that identical species can behave differently region-to-region or under different environmental conditions, there remain many more questions than answers.

Sea Grant HAB research, to date, has focused primarily on the following:

- physiology and behavior of individual HAB species and toxins,
- causes of HABs, and
- predicting or detecting the occurrence of HABs and their toxins.

In 1995, a national, multi-agency research agenda was initiated to increase the understanding of impacts and population dynamics of HABs. The program, called ECOHAB (ECology and Oceanography of Harmful

Algal Blooms), is supported by the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF), the Environmental Protection Agency (EPA), and the Office of Naval Research (ONR), and is administered by NOAA's Coastal Ocean Program and the National Sea Grant College Program.

What Do We Know?

Research over the past few decades has yielded a number of important results with respect to HABs. These include:

- In the northeastern U.S., the dynamics of toxic dinoflagellate blooms have been well characterized, including the identification of a "source" or initiation zone where blooms begin that eventually impact hundreds of miles of coastline, and the documentation of a transport pathway for these blooms via a coastal current originating in the freshwater outflow of two rivers in western Maine.
- Discovery of toxic dinoflagellate cysts in areas of Connecticut and Long Island where paralytic shellfish poisoning (PSP) had never been recorded. When state agencies began monitoring these sites, PSP toxicity was detected, necessitating annual shellfish testing programs that continue to this day.
- Development of antibody and DNA "probes" that are being used to detect HAB species and their toxins in natural waters more rapidly and accurately than is possible with conventional techniques. For example, an antibody probe to the

brown tide chrysophyte *Aureococcus anophagefferens* is now used by all researchers conducting laboratory or field studies of this tiny, non-descript organism.

- Development of methods to utilize satellite imagery of coastal waters (through the NOAA Coastwatch Program) to follow HABs and the water masses with which they are associated.

- Research on a "phantom" dinoflagellate responsible for fish kills in laboratory aquaria in North Carolina led to the eventual discovery of *Pfiesteria piscicida* and related organisms, now known to be responsible for human illnesses, diseased fish, and massive fish kills in Florida, North Carolina, Delaware, Virginia, and Maryland.

- Field studies of toxic *Alexandrium* within Massachusetts Bay and waters to the immediate north provided critical information in the policy debate on the potential impact of Boston's sewage outfall relocation. Opponents to the outfall cited increases of blooms of toxic and noxious algae, and even increased mortality of the endangered right whale in their litigation to stop the outfall construction.

- Research on the factors regulating the recurrence of harmful "brown tides" in Long Island waters has identified a number of key factors, including the composition of the microzooplankton grazing community and the influence of the nature and composition of groundwater on brown tide growth and nutrition.

Where Do We Go From Here?

Three areas of HAB research that have gone largely unexplored, at least in the U.S., are now the focus of a NOAA initiative aimed at guiding federal, state, and local policy in dealing with the growing problem of HABs:

- management options for reducing the incidence of HABs,
- control of HABs, and
- reduction in economic and resource loss and human health risks association with HABs.

Support from Sea Grant and other funding sources is critical if researchers are to solve some of the many mysteries associated with HABs and to focus efforts on new areas such as those listed above. At the national level, a lot of attention has been given to the most recently discovered toxic dinoflagellate, *Pfiesteria piscicida*, (thus the term "*Pfiesteria* Hysteria"), but it is only one of many HABs that can have disastrous consequences for a region's economy, while threatening public health and safety.

As Donald Anderson, a Woods Hole Oceanographic Institution marine biologist and world-renowned expert on HABs, points out in a *Nature* Commentary: "One thing is certain—there is a growing global problem at a time when human reliance on the coastal zones for food, recreation and commerce is rapidly expanding." Today, more than ever before, research into HABs must continue.

For more information about the research or outreach projects profiled in *Focal Points*, contact WHOI Sea Grant at the address listed above.