What is a harmful algal bloom (HAB) and why do they form?

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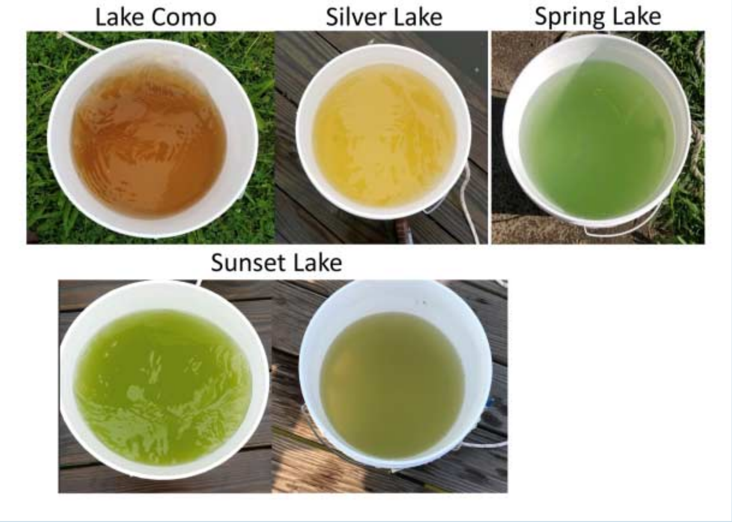
Anyone paying attention to New Jersey's lakes and coastal waters, especially if you live near them, has probably heard the term "harmful algal bloom" (HAB), and that has likely been linked to less-than-desirable consequences about access to, and the safety of, the waterbody. Here I aim to give the scientific context of what an HAB is and how it differs from business as usual for aquatic ecosystems, particularly lakes.

Harmful algal blooms are mostly formed by phytoplankton – an essential and taxonomically diverse group of photosynthetic microorganisms that grow in the water columns of lakes, estuaries and the ocean. Phytoplankton use sunlight and inorganic building blocks including carbon, nitrogen and phosphorous to build more of themselves. In doing so, phytoplankton release oxygen as a byproduct, exemplifying the phrase: "one person's trash is another's treasure," as approximately half of the oxygen we breathe comes from phytoplankton.

Phytoplankton are considered "primary producers" because of their ability to transform inorganic building blocks into food energy for the rest of ecosystem. In many aquatic ecosystems, and most of the time, phytoplankton play an important role in biogeochemical cycling, feeding a diverse array of primary consumers such as bacteria, zooplankton, and larval and juvenile fish, not to mention you and me when we eat fish. For phytoplankton this is business as usual!

Harmful algal blooms are caused by a small subset of the approximately 25,000 species of phytoplankton known to exist. Within any given aquatic ecosystem there can be tens to hundreds of common species cycling with seasonal changes in environmental conditions like sunlight, nutrient availability, water temperature, water



Samples of water collected from several Monmouth County Lakes in 2019 column structure and succession of grazer communities. Anthropogenic activity, such as climate change and eutrophication, have also changed environmental conditions in and around aquatic ecosystems. It is the consensus among the scientific community studying HABs that excess nutrient loading and anthropogenic climate change have increased the frequency and magnitude of HABs globally and will continue to do so if these factors go unchecked.

The colorful culprit – cyanobacteria

In lake ecosystems, the phytoplankton responsible for most HAB events are a type of photosynthetic bacteria known as cyanobacteria, or sometimes called "blue-green algae" in older literature. Cyanobacteria are Earth's oldest oxygen-producing photosynthetic organisms. They were responsible for the oxygenation of Earth's atmosphere about 2.3 billion years ago, and are ancestors of chloroplasts inside the cells of all eukaryotic plants and algae.

There are approximately 2,000 species of cyanobacteria representing a wide array of morphologies, ecological strategies and metabolic abilities. Certain cyanobacteria have gas-filled cavities called vacuoles that make them positively buoyant, driving surface accumulations known as "scums." Some use specialized cells to "fix" atmospheric N_2 into reduced N forms (a capability that is not common among phytoplankton) that they and other primary producers can use to grow. Others can produce specialized cells called akinetes that allow overwintering until good growth conditions return. These form-function adaptations are key to cyanobacterial success in different environments.

How cyanobacteria cause harm

Cyanobacteria produce potent toxins that can affect the liver and nervous system, making them dangerous to have blooming in our lakes. Cyanotoxins can contaminate drinking water to adversely affect humans, pets and wildlife through contact with or ingestion of contaminated lake water. For instance, the cyano-bacterium Microcystis aeruginosa can produce the potent hepatotoxin, micro-cystin, which is perhaps the most commonly-encountered cyanotoxin issue in lakes.

Other common cyanotoxins include cylindrospermopsin (hepatotoxin), anatoxin-a (neurotoxin), and saxitoxin (neurotoxin). Within a given population of cyanobacteria, a mix of toxic and nontoxic strains of the same species have typically been observed, reflecting the presence or absence (respectively) of the genes necessary to synthesize toxin. Among toxic strains, environmental conditions like nutrient levels and temperature can "turn on" toxin biosynthesis genes, or drive enrichment of toxic strains in mixed populations.

The list of cyanotoxins continues to grow in quite unexpected ways. A wildlife disease called vacuolar myelinopathy, responsible for bald eagle deaths in the Southeast, was recently traced back to cyanobacteria producing a novel cyanotoxin (aetokthonotoxin) growing on an invasive plant (Hydrilla verticillata). While we cannot tell just by looking (even under the microscope) whether cyanobacteria are producing toxins or not, the risk from known and emerging cyanotoxins warrants attention by environmental managers and concerned citizens.

The phytoplankton community of our lakes, estuaries and coastal ocean are taxonomically diverse and an important part of the ecosystem. When we see a HAB, we are looking at an accumulation of a subset of a species from within a potential pool of hundreds of species. Understanding how environmental conditions favor HAB species is critical to forecasting, adapting to and mitigating HABs.

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