RAW WATER/LAKES

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WHY CIRCULATE?
How to restore water quality, biodiversity and aesthetics to lakes, reservoirs and ponds

Long-distance circulation helps restore nutrient-rich waters for a healthy aquatic ecosystem by allowing "good" green algae to predominate over harmful algae blooms without the need for chemicals.

Every freshwater lake is a delicately balanced ecosystem. The most crucial part is the upper five to 10 feet, usually called the epilimnion, where sunlight penetrates and allows for photosynthetic production of algae cells from the carbon, nitrogen (N) and phosphorus (P) nutrients in the water. In a healthy lake, with "good" algae, that algae becomes food for zooplankton, which in turn become food for fish. The water stays clear and healthy as the nutrients flow all the way up the food chain into large happy fish.

Unfortunately, harmful blue-green algae blooms (HABs) have become all too common in freshwater lakes, ponds and reservoirs, including reservoirs that are sources of municipal drinking water. The most visible signs of HABs are surface scum—water that looks like pea soup or green paint, or which has bb-like algae particles visible in the water—and odors.

HABs usually occur in warm, stagnant, nutrient-rich water, typically in summer months. HABs usually consist of large-celled blue-green algae that can adjust their buoyancy, and can also bond together to increase their chances for survival. The surface scum they often form shades out and kills the good algae. HABs also can produce toxins that, if ingested, have severe health impacts to humans and pets.

Watershed protection, though laudable, has never reversed a HAB problem, because it addresses only a small part of the conditions that cause HABs. Another common solution for controlling HABs is to apply chemicals to kill algae, or else sequester the nutrients on the bottom of the lake. However, ongoing chemicals can be expensive, ineffective, and actually hurt the lake biology.

Recent research suggests a new paradigm for controlling HABs,

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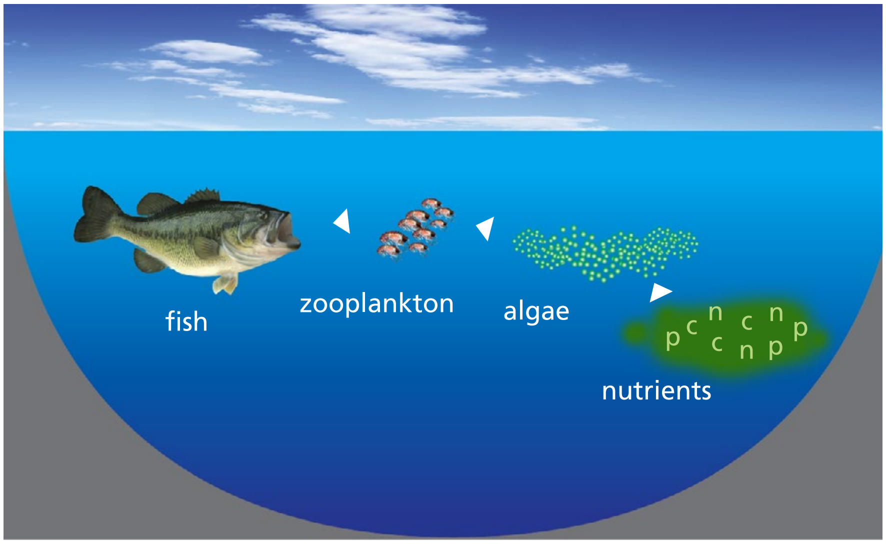


A healthy predator relationship maintains a pond's ecosystem. Green algae, the primary producers, convert nutrients into useable energy. They are consumed by zooplankton, which in turn are consumed by fish.

one that is chemical-free, easy to implement and effective. This new concept takes a holistic approach: If you create enough horizontal circulation in the photic zone—the upper six to 10 feet of the lake where photosynthesis occurs—the "good" green small-celled algae and diatoms will predominate all summer long, and the blue-green algae will never gain enough traction to form a HAB.

The algae battle: "good" green vs. toxic blooms

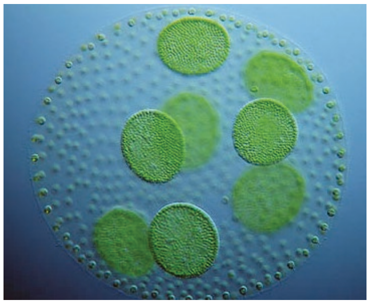
"Good" small-celled green algae, and small brown algae cells called diatoms, are integral to the aquatic food web. These algae are so small you cannot see them, but they put a pleasing tint in the water: green in summer and brown in cold seasons. Through photosynthesis, they capture energy from sunlight and convert nutrients—carbon, N and P—into useable energy for other living organisms. Their small size allows them to be eaten and cropped down by zooplankton, which in turn are eaten by fish. This prey-predator relationship is essential to a lake's health. A lake is healthy when "good" algae predominate, and will never bloom because grazing by the higher organisms—zooplankton—will never let algae levels get out of control. Consequently, the levels of algae, zooplankton, fish, dissolved oxygen and pH all stay within a normal and healthy range.

But "good" algae cannot adjust its buoyancy, and since it weighs more than water it is always slowly sinking. It relies on wind mixing of the upper water to bring it back up for light on a regular basis, and to expose it to a constant supply of nutrients. So in periods of little wind, "good" algae gradually sinks out of the photic zone (the depth to which the sun penetrates) at the top of the lake. That's where long distance horizontal circulation of the upper water comes in; the circulator pulls water and the good algae in from the level of the intake plate—typically set between seven and eight feet deep for example—and lifts it up and spreads it across the top of the pond. Putting the good algae back up in the top of the photic zone allows it to remain viable and dominate the lake all season.

Without circulation during periods of low wind, the good algae can sink too deep to receive sunlight. This leaves the upper water nutrient-rich with no organism that can uptake the nutrients there. Then the blue-green algae, which can adjust its buoyancy and form larger particles and/or surface scums and toxins, can rise to the top of the lake and capture virtually all nutrients in the upper water, and all of the sunlight hitting the lake, shading out and killing the good green algae and diatoms. The blue-green algae can also produce toxins, and the cells are generally too large for zooplankton to eat; thus, there is no control over how large the crop can become. This all leads to a full-blown HAB. The flow of nutrients up the food chain stops when blue green algae take over the lake. And once a HAB forms, usually it continues for the rest of the summer season.

The role of circulators in helping good green algae and diatoms

Good green algae and diatoms have two major advantages over blue-green algae: they start growing earlier in the season, and they reproduce many times faster than blue-green algae.



So, how do you give good green algae and diatoms a leg up, so to speak, so that they remain dominant all year? The answer lies in keeping them suspended in the water column. Wind mixing helps, but even lakes in very windy regions still have blue-green algae HABs. This is where solar-powered radial long distance circulators come into play. These machines, usually set to horizontally circulate just the upper six to eight feet of the lake, have been proven to keep the green algae and diatoms sufficiently suspended to remain viable and dominant in the lake throughout the season, regardless of how many nutrients are in the lake. With the good algae's fast reproduction and fast uptake of the nutrients, blue-green algae never gets enough traction to take over the lake and form a HAB.

Limitations of chemical and vertical mechanical methods as a solution

The science of lake management is relatively new and corresponds to the rapid increases in human population and associated nutrient enrichments of water bodies during the second half of the 20th Century. In some lakes, millions of dollars have been spent on a variety of solutions, but blue-green blooms persist.

One common approach to combatting HABs is to try to prevent the primary limiting nutrients from entering the lake, usually P and N, through better watershed management. But even though billions of dollars have been spent in the U.S. over the past 50 years on watershed management, reversing HABs is not usually successful using this method.

Another common approach to combatting HABs is to apply aquatic herbicides, such as copper sulfate or powdered hydrogen peroxide. These herbicides can give short-term relief from harmful blue-green algae—at a typical cost of $200 to $1000 per acre per year or more—but because they often kill non-targeted biota, including good algae and bacteria, usually a flood of nutrients is released that triggers another HAB several weeks later. In addition, copper chemicals lead to resistance and more copper being needed each year, plus the residue in the lake sediment causes long-term toxicity issues.

Another chemical approach has been to apply aluminum sulfate (alum) to try to sequester P in the sediment, but due to re-release, carp stirring the sediments, and new P inflow, alum has not controlled HABs either.

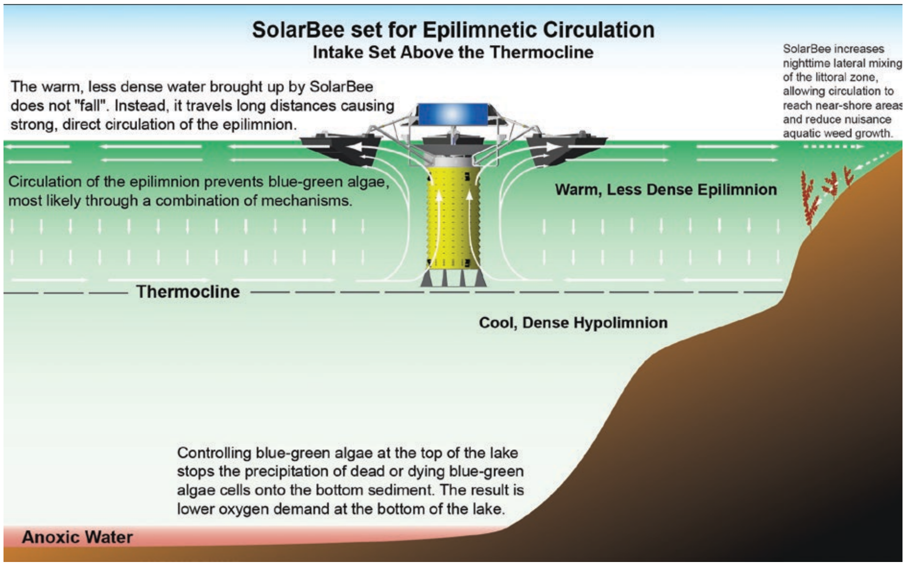
Vertical full-depth mixing devices, such as aeration bubblers and fountains have also proven to be ineffective at controlling HABs in all but the smallest ponds, plus they have high energy and maintenance costs. And sometimes they bring up P from the bottom to the top of the lake, making the HAB problems worse.

Gauging water-quality health

A lake must have sufficient levels of dissolved oxygen (DO) to support the food chain. DO is often measured in milligrams per liter (mg/l), with levels ranging from 0 mg/l (complete lack of oxygen) to 9 mg/l (the saturation point of water in typical summer temperatures).

The normal oxygen content in a healthy lake ranges from 6 to 9 mg/l, day or night, based on normal photosynthesis and respiration (breathing) of a modest-sized algae crop controlled by zooplankton. If a HAB occurs—where the algae is inedible and not being controlled by zooplankton—then the DO may range as high as 10-20 mg/l in the day, but drop to 0 to 4 mg/l at night or on cloudy days due to algal respiration (breathing).

When nutrients are being absorbed by small-celled edible algae and the predator relationship is in balance, the lake remains very healthy. But when blue-green algae take over, the presence of excessive nutrients makes the bloom that much larger. Then, eventually the bloom becomes light limited, and the blue-green algae can all die off at once. When that happens, the bacterial decomposition of the dead algae cell can use up all of the DO. That is why HABs are often accompanied by fish kills.



Horizontal lake circulation: throwing a life jacket to good green algae and diatoms

Water in lakes forms thin horizontal layers, much like each page of paper in a ream of copy paper. This water-layering allows a solar-powered circulator (with the intake plate set at eight feet, for example) to pull water from very long distances, extending toward the shorelines, and from all directions. The circulating machines draws water up and then pushes it out radially out across the surface in a thin layer. The constant lifting of the good green algae and diatoms from the eight-foot depth to the surface keeps them in the sunlight and constantly exposes them to new nutrients in a way that is much more viable all season long than wind mixing can. Each large machine can typically eliminate HABs in 35 acres. And in a large lake, due to the curvature of the earth, only three to four machines can be seen from any point on the lake.

The purpose of a circulator is not to add oxygen to a lake. That's the work of good green algae and diatoms. **The purpose of a circulator is to help the good green algae and diatoms survive and thrive all season, so that blue-green algae can not get enough nutrients or traction to form a HAB.** When the good algae survive, the levels of algae, zooplankton, fish, dissolved oxygen and pH will stay in balance all season, and the lake is free of HABs. The lake has much better water clarity, a "clear" indication that water quality has been restored.

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