NEWSLETTER OF THE LAKES OF MISSOURI VOLUNTEER PROGRAM

The Water Line

Volume 13 Number 1

Red Algae

If your lake takes on the rich, deep red color of wine in autumn, don't immediately run to the store for cheese and crackers. What you are witnessing is probably an algae bloom. *Planktothrix rubescens* (formerly known as *Oscillatoria rubescens*) is a species of blue-green algae (a.k.a. cyanobacteria) that can have a very distinctive red color. Additionally, the cells can attach end-to-end and may form filaments of several millimeters in length, making them easily visible to the naked eye. During winter this algae may even seep through fissures in the ice, creating colorful "flowers" across the lake's surface.

For much of the year *P. rubescens* resides near the metalimnion, that transition area between the warm epilimnion and the colder hypolimnion (see *Lake Stratification* in this issue). *P. rubescens* blooms are frequently reported in fall when lake temperatures cool and the water column starts mixing deeper. This change in lake thermal structure doesn't necessarily promote the bloom of *P. rubescens*, but rather moves the bloom from the metalimnion to the surface. The colorful algae become apparent once this metalimnion has mixed with the cooling surface layer of the lake.

Like many blue-greens, *P. rubescens* is capable of regulating its buoyancy, effectively moving itself up and down within the water column. When high in the water column they receive enough light to photosynthesize. During photosynthesis, they produce dense carbohydrates that eventually weigh the cells down, causing them to sink. Once in deeper water (sometimes the hypolimnion) where there isn't enough light to photosynthesize, *P. rubescens* will respire, using the carbohydrates for energy, thus lightening their load. A by-product of their respiration is the expansion of their "gas vacuoles". Eventually, with enough respiration, the gas vacuoles increase buoyancy enough to lift the algal cell back up in the water column.

P. rubescens has adapted to life in the summer metalimnion by tolerating cool temperatures and low light. The cool, dark and deep water of the hypolimnion tends to have more nutrients, thanks to settling particulates and the release of nutrients from the sediment (see "Phosphorus From Within" Fall 2006 Water Line). While in or near the hypolimnion, *P. rubescens* takes advantage of the higher nutrient levels by stocking up. Thanks to its tolerance of low-light conditions, *P. rubescens* has an advantage over the algae that are restricted to the epilimnion where nutrient concentrations are lower and competition is higher. Even during turnover, when the water column is mixed, this blue-green competes well under low-nutrient conditions. As a result, its presence in lakes with low nutrient concentrations can be prolonged, highlighting the contrast between the clear

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P. rubescens can create red “flower” patterns by seeping through fissures in ice-covered lakes.

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water state before turnover and the sudden, startling appearance of the red bloom.

P. rubescens is capable of producing two kinds of toxins; a neurotoxin (which affects the nervous system) and a hepatotoxin (which affects the liver). However, *P. rubescens* does not produce these toxins at all times. It is not well understood why P rubescens or and other blue-green algae sometimes produce toxins. To be safe, avoid swimming during any algae bloom, red or green.

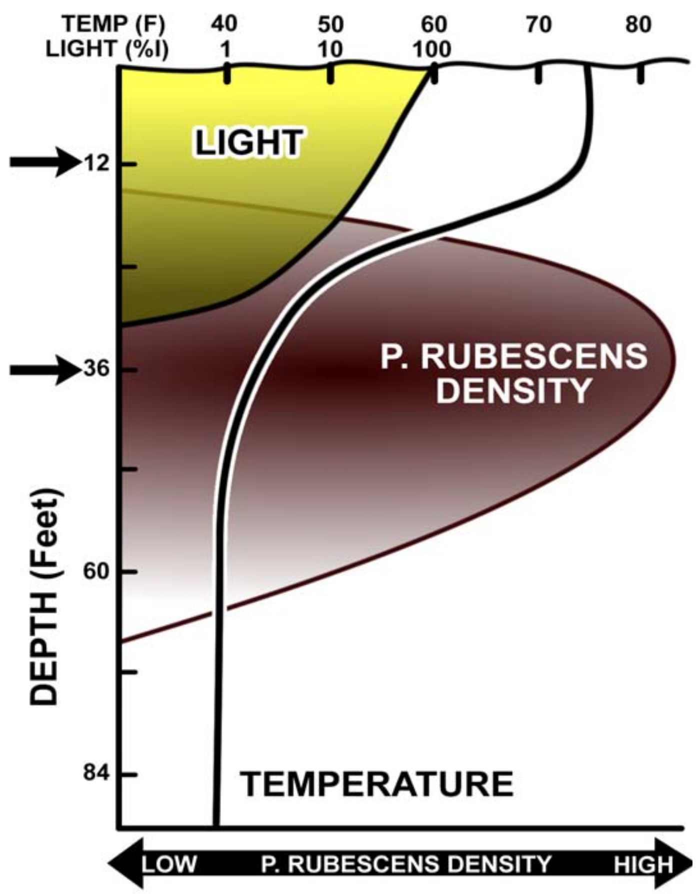
Blue-green algae are not technically algae at all, but rather bacteria that contain chlorophyll and have the ability to photosynthesize. Like all bacteria, blue-green algae (a.k.a. cyanobacteria) are *prokaryotes* and have no nucleus. Green algae are *eukaryotes*, with a nucleus and other organelles within their cell membranes. In photosynthesizing eukaryotes, the chlorophyll resides within organelles called chloroplasts.

Chloroplasts are interesting because they have their own DNA and replicate independently from the rest of the cell. It is believed that chloroplasts (and mitochondria) originated as cyanobacteria. Long ago, one cell enveloped another and rather than consuming it, assimilated it. The two cells mutually benefited in a process known as *endosymbiosis*, setting the stage for the myriad of life forms that would follow.

DENSITY OF P. RUBESCENS DURING STRATIFICATION

This graph shows three variables (temperature, light, and *P. rubescens*) as they relate to lake depth. The top and bottom of the graph represent the surface and bottom of the lake, respectively. The topmost arrow is at the Secchi depth, 12 feet. About 20% of the sun’s light penetrates to this depth. The temperature is the same as at the surface (about 74°F), and there is no red algae present.

At 36 feet (the second arrow), there is no sunlight, the temperature is much cooler (about 40°F) and the density of *P. rubescens* is the highest. This depth marks the bottom of the metalimnion, where there is likely access to a supply of dissolved phosphorus from the nutrient-rich hypolimnion.



Clarifying the Clean Water Act

The Clean Water Act (CWA) was enacted in 1972 to restore and protect our nation's waters. The CWA provides the statutory basis for protection of navigable waters. The term "navigable" has caused significant confusion and litigation in recent years. A bill currently being considered in Congress attempts to dispel this controversy.

Originally navigable waters were defined as: (1) all navigable waters of the United States, as defined in judicial decisions prior to the passage of the 1972 Amendments of the Federal Water Pollution Control Act, (FWPCA) (Pub. L. 92-500) also known as the Clean Water Act (CWA), and tributaries of such waters as; (2) interstate waters; (3) intrastate lakes, rivers, and streams which are utilized by interstate travelers for recreational or other purposes; and (4) intrastate lakes, rivers, and streams from which fish or shellfish are taken and sold in interstate commerce.

However, in 2002 the EPA revised the definition of navigable waters during promulgation of a new rule to include all waters that "could affect interstate or foreign commerce," tributaries to those waters and adjacent wetlands. This regulatory shift was soon met with legal challenges causing confusion about the scope of the CWA. The rule was vacated in 2008 when the Supreme Court found it to be arbitrary and without a valid legal explanation. The Court concluded that the CWA provides some federal jurisdiction but also limits federal regulation over non-navigable waters.

In April 2009, Senator Russ Feingold (D) of Wisconsin reintroduced the Clean Water Restoration Act, which first appeared in Congress in 2007. The bill attempts to clarify federal jurisdiction over streams, lakes, and wetlands of all sizes. On June 18, 2009 the bill received a favorable recommendation from the Committee on Environment and Public Works and will now be considered by the Senate.

Below is a summary of the proposed changes to the CWA written by the Congressional Research Service, a non-partisan arm of the Library of Congress. The summary and full text of the bill can be found at www.govtrack.us.

Clean Water Restoration Act - Amends the Federal Water Pollution Control Act (commonly known as the Clean Water Act) to replace the term "navigable waters" that are subject to such Act with the term "waters of the United States," defined to mean all waters subject to the ebb and flow of the tide, the territorial seas, and all interstate and intrastate waters and their tributaries, including lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, natural ponds, and all impoundments of the foregoing, to the fullest extent that these waters, or activities affecting them, are subject to the legislative power of Congress under the Constitution.

Declares that nothing in such Act affects the authority of the Secretary of the Army or the Administrator of the Environmental Protection Agency (EPA) under the provisions of the Clean Water Act related to discharges:

(1) composed entirely of return flows from irrigated agriculture;

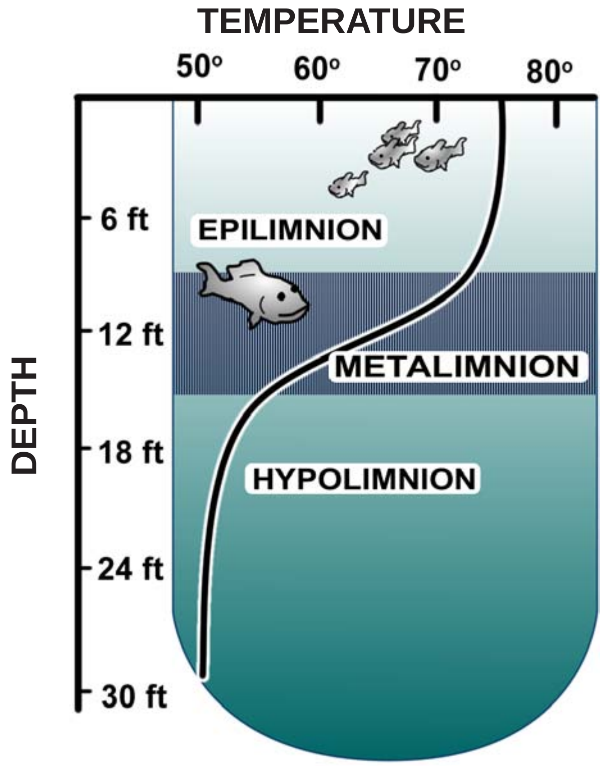
(2) of stormwater runoff from certain oil, gas, and mining operations composed entirely of flows from precipitation runoff conveyances, which are not contaminated by or in contact with specified materials;

(3) of dredged or fill materials resulting from normal farming, silviculture, and ranching activities, from upland soil and water conservation practices, or from activities with respect to which a state has an approved water quality regulatory program; or

(4) of dredged or fill materials for the maintenance of currently serviceable structures, the construction or maintenance of farm or stock ponds, irrigation ditches and maintenance of drainage ditches, or farm, forest, or temporary roads for moving mining equipment in accordance with best management practices, or the construction of temporary sedimentation basins on construction sites for which discharges do not include placement of fill material into the waters of the United States.

Amanda Sappington, Missouri Department of Natural Resources

Lake Stratification

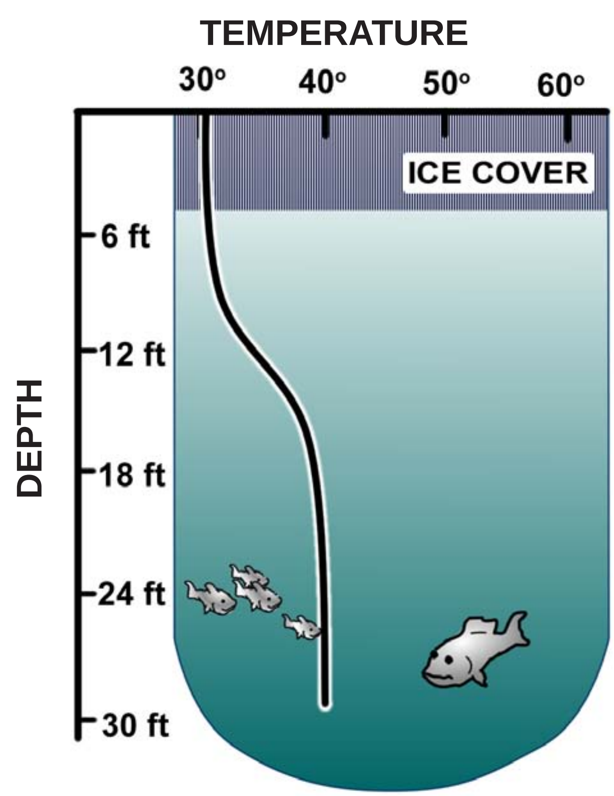


Many people, especially fisherman, have heard of "turnover," which occurs when lake water mixes from the surface to the bottom. Less well known is what is happening during the rest of the year. When a lake isn't "turning over" it becomes stratified.

A volume of water is heaviest at 4° Celsius (39.2° F), just above freezing. The same volume of water becomes lighter as it warms and rises to the surface, leaving the colder water at the bottom (except in winter—see below). As the sun continues to heat the water at the top, the difference in temperature (and density) between the top and bottom water becomes greater. Eventually there are 2 distinct layers, the epilimnion at the top and the hypolimnion at the bottom. Between these 2 layers is a third, less distinct, transition layer called the metalimnion. These layers generally hold until autumn, when the surface water cools.

Often in the summer, the hypolimnion will become depleted of oxygen. The bacteria responsible for decomposition consume the oxygen and access to atmospheric oxygen is cut off by stratification.

Water freezes from the top down



One would assume that if water becomes more dense as it gets colder, it should freeze from the bottom up. As explained earlier, however, water is most dense at 4° Celsius (or 39.2° F), which is warmer than freezing. So as water continues to cool from 4° C (39.2° F), it becomes less dense and rises to the top, leaving the slightly warmer water below.

At the surface, the cool water is exposed to freezing air temperatures and may eventually freeze. Once ice forms, the water beneath cannot be mixed by the wind.

When the ice melts in the spring, the entire water column will be at approximately 4° C for a brief time. The lake will mix thoroughly ("turnover") with just a bit of wind. A calm, warm day can heat the surface water and initiate the stratification process.

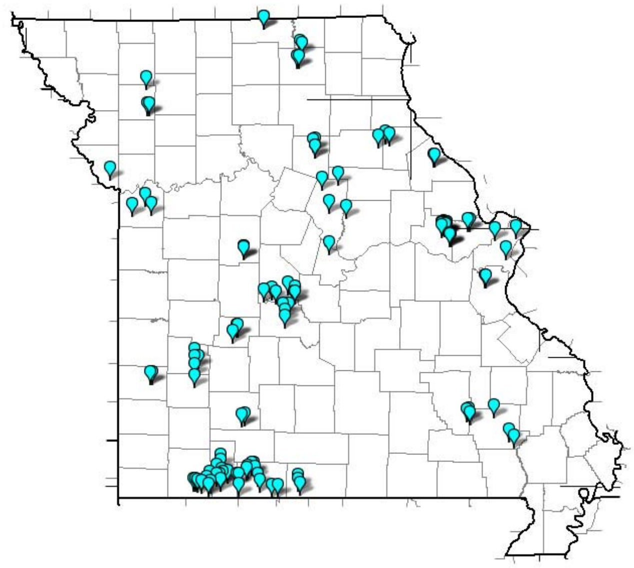
Stratification may also occur due to changes in salt content as well as temperature. Oceans, particularly in places where freshwater enters, may be stratified by salinity. The problems with Gulf Hypoxia may be attributed partially to the inability of the dense and salty bottom water to mix with the oxygen-rich, less salty water above.

LMVP in 2009

2009 Sampling Summary:

- 750 Samples Collected
- 57 Lakes
- 118 Sites
- 1300 Hours Worked
- 8200 Miles Driven
- 17 "Split Sample" Events

Sites Sampled in 2009



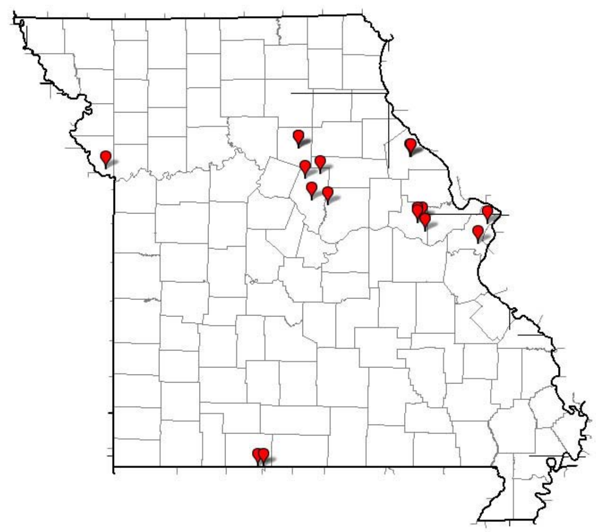
Split samples in 2009

University of Missouri staff collected 17 simultaneous samples with volunteers in 2009. This "Split Sampling" is a quality control check used to compare the results of MU collected data with those collected by volunteers. To date, there has been no significant difference detected.

Thanks to these volunteers for Split Sampling in 2009:

Herman Bauer, Geri Blakey, Georganne Bowman, Chad Ferguson, Bob Goulding, Mark and David Kuechenmeister, Armand Matthews, Vicky McAlister, David Murray, Carol Pollard, Marc Ramsey, Marion Traynor, Howard Webb, Dan Wollaeger

2009 Split Sample Locations



The graphs to the right show results of Split Samples (1998-2009).

Volunteer-collected samples are shown on the vertical axis, MU staff-collected samples are shown on the horizontal axis. The dotted line represents a perfect 1:1 relationship (R^2 = 1.00).