The Influence of Aquatic Plants on Dissolved Oxygen

By Erin Bradshaw Settevendemio

There are four essential elements needed by living organisms on Earth: light, nutrients, water, and oxygen. For the foreseeable future, sunlight is in great supply, adding up to about 274 million gigawatt-years of energy per year. Nutrients are found in all living organisms as well as organic soils, and are continually recycled through our ecosystems. As most of us know, 70% of the earth is covered in water, supporting great masses of organisms across the globe. It seems odd, then, that oxygen is comparatively in such little supply. Our atmosphere is composed mostly of nitrogen, with oxygen constituting only 20% to support life on our planet. Furthermore, this is the availability of oxygen for *terrestrial* organisms; the amount of available oxygen in aquatic environments is approximately 13,500 times *less*, rarely exceeding 0.0015%, or 15 ppm. This dynamic has caused important influences on the evolutionary biology of aquatic organisms such as submersed aquatic plants and fish. For instance, submersed macrophytes lack the waxy cuticle layer commonly found in terrestrial species, facilitating the diffusion of gases across the plant epidermal layer; many fish species found in low dissolved (DO) environments are morphologically evolved for surface breathing or with lungs.

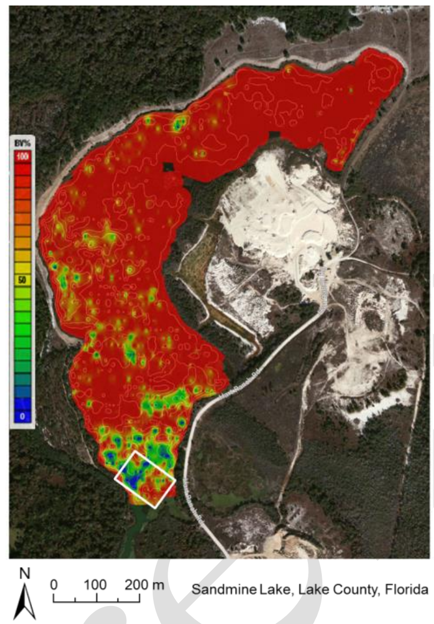
Factors That Influence Dissolved Oxygen

As major producers and consumers of DO, autotrophs have substantial influence over the biological community in our fresh waters. Autotrophs are organisms which use sunlight energy to produce sugars, proteins, and fibers. Examples of autotrophs in our aquatic environment include macrophytes, phytoplankton, and algae. During the process of photosynthesis, oxygen is a by-product that is released to the surrounding environment. However, in the absence of sunlight, these organisms switch gears and consume oxygen and release carbon dioxide as a by-product, resulting in a depletion of DO concentrations.

There are a number of other factors that influence DO concentrations in the aquatic environment. For instance, water circulation by wave action can increased DO, while stagnation can lower it. The benthic sediment type and organic layer build up can also lead to DO consumption by bacteria as dead and dying plants are broken down. Finally, DO is negatively correlated with temperature, which causes a decrease in DO as temperature increases. Combined with the natural daily fluctuation of DO caused by plants, these factors ultimately result in compounding effects. Impacts can be severe in late summer, lowering DO to levels unsuitable for many aquatic fauna such as fish and invertebrates (hypoxia: DO <2.0 ppm).

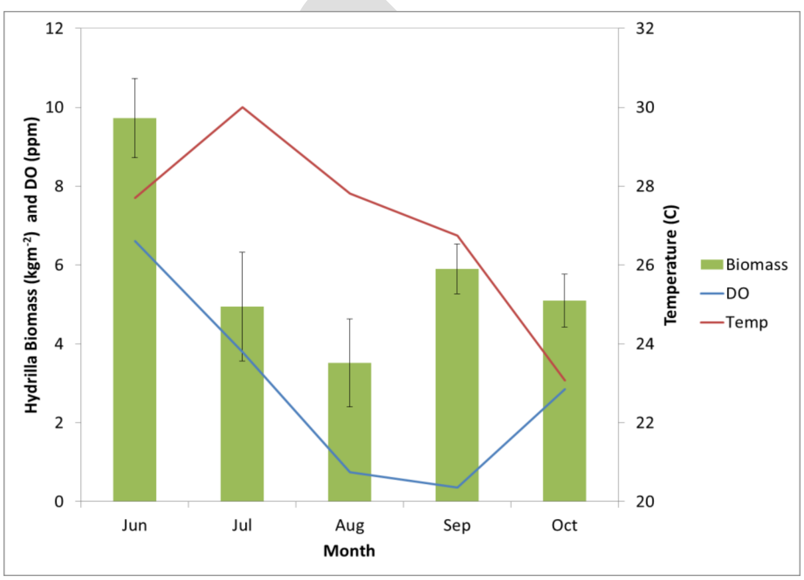
How Hydrilla Impacts Dissolved Oxygen

Hydrilla (*Hydrilla verticillata*) is a fast-growing, dense aquatic weed found extensively in Florida and throughout the United States. This species provides beneficial habitat for invertebrates and fish species, however it can also negatively impact water quality. Hydrilla exhibits high complexity due to abundant stemming and extreme branching at the surface. Dense stemming and a thick floating mat results in very limited water circulation. Additionally, the surface mat dramatically decreases sunlight transmission through the water column, limiting DO production via photosynthesis. In late summer when temperatures are high, these combined factors may result in hypoxic conditions.



Sandmine Lake is a man-made lake, former sandmine operation located in the Lake Norris Conservation Area. Its depth range s from 2-9 meters. Hydrilla coverage is substantial throughout the year, particularly when coupled with mild winters. This coverage map shows surface-matted hydrilla on Sandmine Lake during March 2012. The white box respresents the primary sampling area during that summer, from June-September.

In a study conducted on Sandmine Lake in Lake County, Florida, dissolved oxygen, temperature, and hydrilla density was monitored in dense hydrilla beds to evaluate how water quality is impacted by the growth of this aquatic weed during summer months. Although our hypothesis was confirmed and we did find complete hypoxia (hypoxia



extending through the entire water column) in dense hydrilla beds, we did not find a direct correlation with biomass density or temperature. Biomass was consistently very high throughout summer ($\geq$3.5 kgm^{-2} dry weight), and temperature peaked in July; yet, we did not see hypoxia until August and September. According to our hypothesis, we would have expected to see hypoxia in July when hydrilla density was high and temperature was at a maximum. However, hydrilla density was not significantly higher and temperature was actually lower in September than at the beginning of the summer season.

Hydrilla Isn't The Whole Story

These results suggest that other factors which influence DO may contribute significantly to the occurrence of hypoxia in dense hydrilla beds. By late summer, day length is decreasing and gradually limiting the time period in which the plants are able to produce oxygen, while increasing the time period of oxygen consumption. The decrease in day length also results in plant senescence; the increase in released nutrients from dying plants promotes filamentous algal blooms on top of dense hydrilla mats, which can also substantially influence dissolved oxygen concentrations.

Although we did see hypoxia in dense hydrilla beds, it was limited to a portion of the day and only at a certain time of year. We did not see fish kills during our sampling periods, even when severe hypoxia (DO <1.0 ppm) extended throughout the entire water column. Although fish kills do occur occasionally, it is usually by compounding factors such as overcast skies, increased water circulation due to wind, and turbidity, which combined with warm temperatures and nightly plant respiration can result in fish kill events. It is also clear that treatment with herbicides during late summer would be hazardous to fish communities, given the additional depletion in dissolved oxygen due to plant senescence.

Our results show that dissolved oxygen dynamics in dense hydrilla are not very different from other submersed aquatic macrophytes, including native species evaluated in other studies. Furthermore, macrophytes such as hydrilla or coontail (*Ceratophyllum demersum*) are probably of better habitat quality for aquatic fauna such as invertebrates and fish as compared with floating leaved species, which have lower complexity and can experience prolonged hypoxic events.

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