Evaluation of Lake Owen Water Clarity

Interaction of lake layers and influence on algae growth

Lake Owen Association consulting scientists set out to answer some basic questions about Lake Owen water clarity in 2019. Their work was supported by donations of LOA board members and lake residents and a grant from the Wisconsin Department of Natural Resources. This summary provides an overview of lake science to help understand the study results. The full report is also available.[1] A second summary will address information about the watershed, sub-basins, and potential effects of development.

Lake Study Questions

Why is the water of Lake Owen so clear?

Does the phosphorus that builds up in the lake bottom reach to near the surface where algae can grow? If not, why not?

We know from a past study completed by Northland College that high levels of the nutrient phosphorus build up at the bottom of the lake. The Northland College study also confirmed that phosphorus is responsible for algae growth in Lake Owen.

The 2019 study took comprehensive measurements at various depths and locations in Lake Owen to better understand the source of high water clarity in Lake Owen. We measured the following:

- *Phosphorus:* the nutrient that triggers algae growth; bioavailable phosphorus is in a form that algae can consume,
- *Chlorophyll a:* a pigment which provides a measure of algae growth,
- *Temperature:* establishes layers of lake water based on density,
- *Dissolved oxygen:* when oxygen levels are low, phosphorus can be released from deep lake sediments,
- *Conductivity:* measures the amount of charged particles in the water including nutrients; conductivity changes can be an indication of mixing of lake layers,
- *Light or PAR (photosynthetic active radiation):* measures how deep there is adequate light for algae growth,

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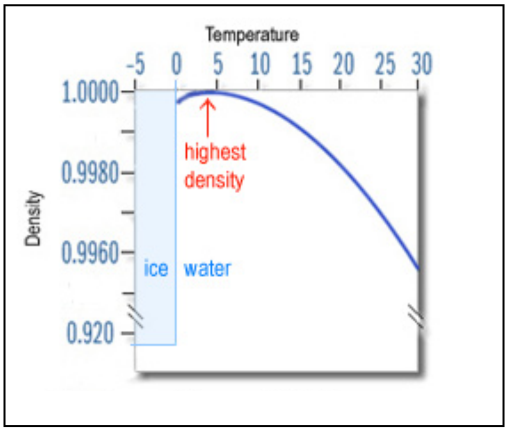
[1] *Evaluation of the water clarity: Interaction of epilimnion and metalimnion in regard to bioavailable phosphorus, chlorophyll, and zooplankton*. Lake Owen, Bayfield County, WI. Ecological Integrity Service and Harmony Environmental. 2019.

- *Zooplankton numbers:* these tiny animals eat algae, and their numbers might explain lack of algae when there is enough phosphorus for algae to grow, and
- *Secchi depth:* a measure of lake clarity. The Secchi depth indicates when the 7” black and white disk is no longer visible when lowered into the water.

To understand the answers to our lake study questions, a brief primer on lake science is in order.

Lake Science Primer: Stratification and Mixing[2]



Water Density

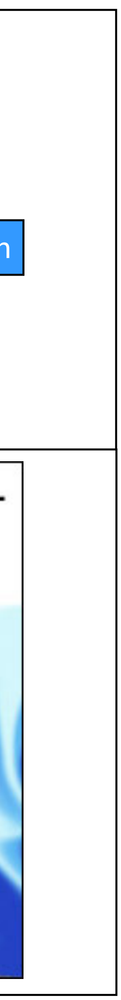
To understand lake stratification, we first must understand the relationship between water density and temperature. Water is unique in that it is denser as a liquid than a solid; therefore, ice floats. Water is most dense at 4 degrees Celsius (39 F). As water warms or cools it gets less dense. This has implications for a lake’s structure because the denser water is heavier and will be at the bottom of a lake while the less dense water is lighter and will generally be at the top of the lake.

Summer Stratification

In the summer, the sun heats the top layer of a lake, the **epilimnion**, which causes it to become less dense. The bottom layer of the lake, the **hypolimnion**, does not receive sunlight and therefore remains cold. Since the epilimnion is less dense, it floats on top of the hypolimnion and the two do not mix. The **metalimnion** is the dividing area between the top and bottom layers. The **thermocline** is the point of the metalimnion where there is maximum change in temperature.

In most lakes, the epilimnion is the only part of the lake where sunlight can penetrate, and it is where plants and algae grow. *Our study found that with Lake Owen’s clear water, light adequate for algae growth penetrates well into the metalimnion*. In the middle of the lake, the epilimnion is generally home to algae and zooplankton.

When algae and zooplankton die, they sink to the bottom of the lake. Invertebrates and microbes living in the benthos or lake sediments recycle and decompose this dead material and use up oxygen. Since the lake does not mix during the summer, the hypolimnion is cut off from the epilimnion and does not receive a fresh supply of oxygen. The hypolimnion also lacks oxygen because it is too deep for photosynthesis which occurs with plant and algae growth and releases oxygen. Therefore, the hypolimnion can become anoxic (void of oxygen) during the summer.



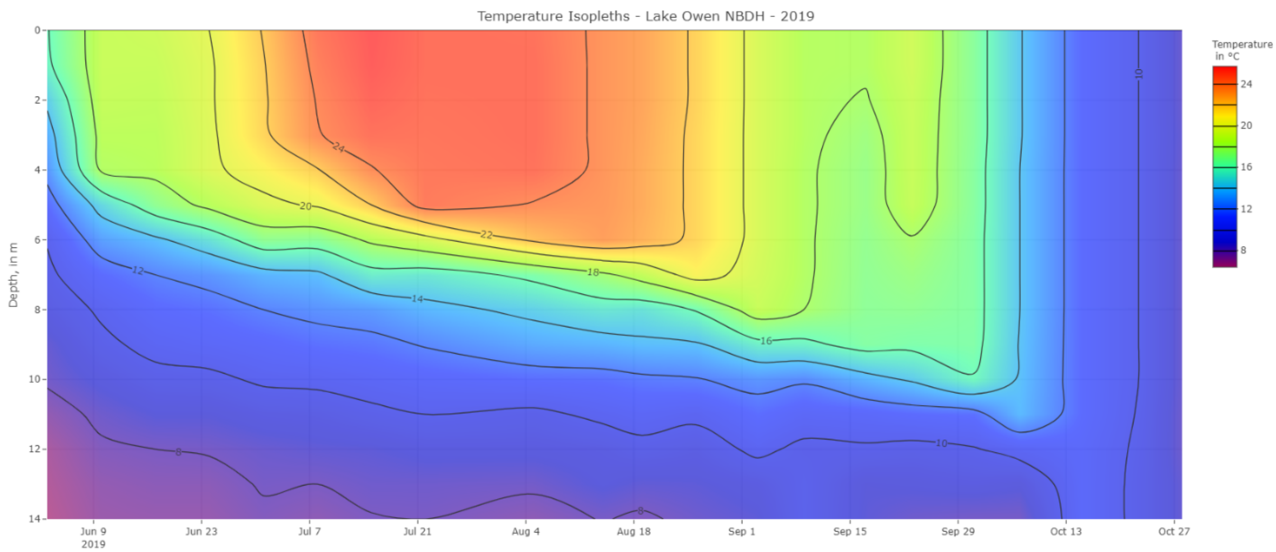
Fall Turnover

In the fall, the epilimnion cools off. As the water in the epilimnion cools, the density difference between the epilimnion and hypolimnion is not as great. The layers then become less stable, and are readily mixed by the wind. In addition, when the epilimnion cools it becomes denser and sinks to the hypolimnion, mixing the layers. This mixing allows oxygen and nutrients to be distributed across the water column.

[2] https://www.rmbel.info/primer/stratification-and-mixing/

Study Results

Lake Owen was strongly stratified into layers from June until mid to late October throughout the lake in depths 30 feet and greater. We know this from measuring dissolved oxygen, temperature, and conductivity at various depths from the lake surface to near the bottom. Recall that strong stratification means that phosphorus released from the lake bottom doesn't reach the surface where algae can grow.



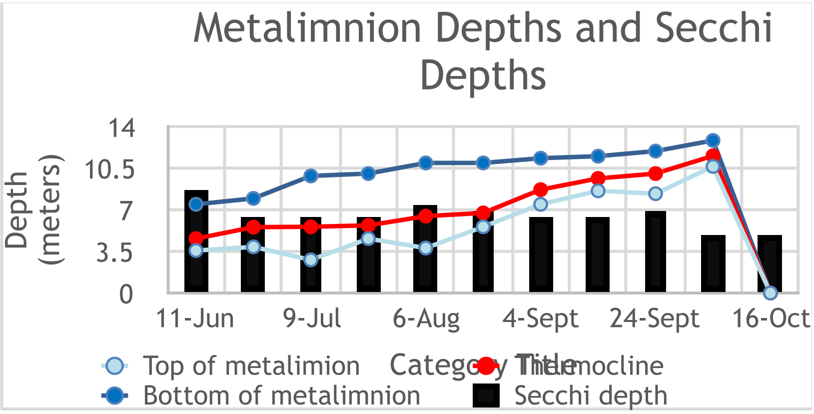
Temperatures in Lake Owen from the surface down to 14 meters from June through the end of October 2019

In fact, Lake Owen is not expected to mix until late October based on models that calculate susceptibility to mixing using water temperature (and therefore density) at various depths and other factors. A calculation known as Wedderburn's number indicates that even in high winds (up to 50 miles per hour 6 feet above the lake), the lake will not mix during the summer months.

When Lake Owen does mix in spring and fall, it does not mix completely, with excess phosphorus remaining in the bottom layer.

Increases in algae growth generally decrease water clarity. Lake Owen has high water clarity as measured by Secchi depth because there is little algae growth in the epilimnion throughout the growing season.

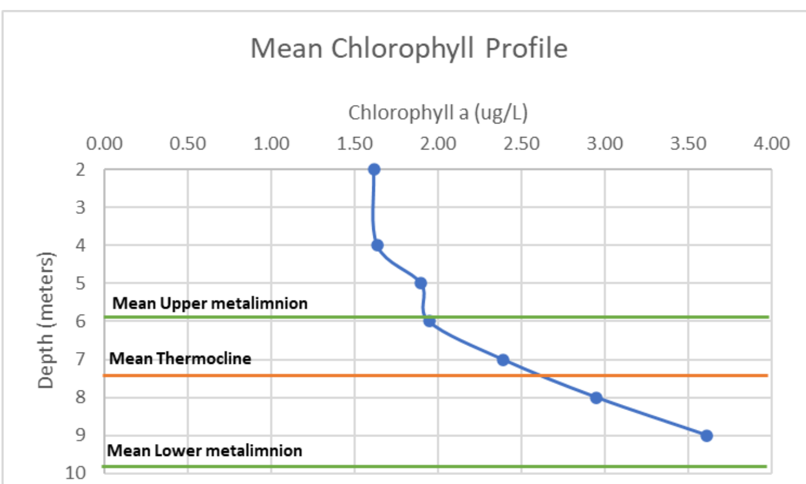
There appeared to be an external source of phosphorus into the epilimnion in June and July. An external source of phosphorus simply means that it came from outside of the lake. This external source could be pine pollen and/or runoff from a large rain event in late June. In fact, estimates of the potential pine pollen load account for the measured increase in phosphorus from May to June.



The thermocline is deep in Lake Owen, reaching 30 feet in August. The thermocline was deeper than the Secchi depth from late July to October.

Because of clear water, light penetrates very deeply in Lake Owen – well into the metalimnion and beyond. That light penetration allows plants and algae to grow deep in the water column.

Phosphorus in a form available for algae growth (bioavailable) is low most of the summer in the epilimnion limiting algae production. Algae production was highest in the metalimnion, likely due to more bioavailable phosphorus from diffusion from hypolimnion combined with available light.



More algae growth (as measured by chlorophyll) would have been expected based on the bioavailable phosphorus (SRP) present in June and July. This coupled with an increase in zooplankton as the summer progressed, suggests zooplankton were consuming algae and therefore reducing chlorophyll in the water.