Lake Lingo: Cutting Through the Jargon

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Drain and water resources commissioners often deal with lakes and lake issues. Be it a statutory lake board, a legal lake level, a drain project or general discourse with a constituent, lakes are often a topic of discussion. This article provides background information on some of the technical language used to describe lakes and lake processes. Hopefully, this information will provide a better understanding of lakes, lake water quality, and some basic lake jargon.

Lake Trophic State

Limnology is the study of the physical, chemical, and biological characteristics of inland waters, a primary focus of which is the study of inland lakes. At last count, Michigan has 10,031 lakes five acres or greater in size, so there is plenty of fodder for limnological study in Michigan. Like most scientists, limnologists tend to classify things, and lakes are no exception. Lakes can be classified into three broad categories based on their *productivity* or ability to support plant and animal life. The three basic lake classifications are *oligotrophic*, *mesotrophic*, and *eutrophic*.

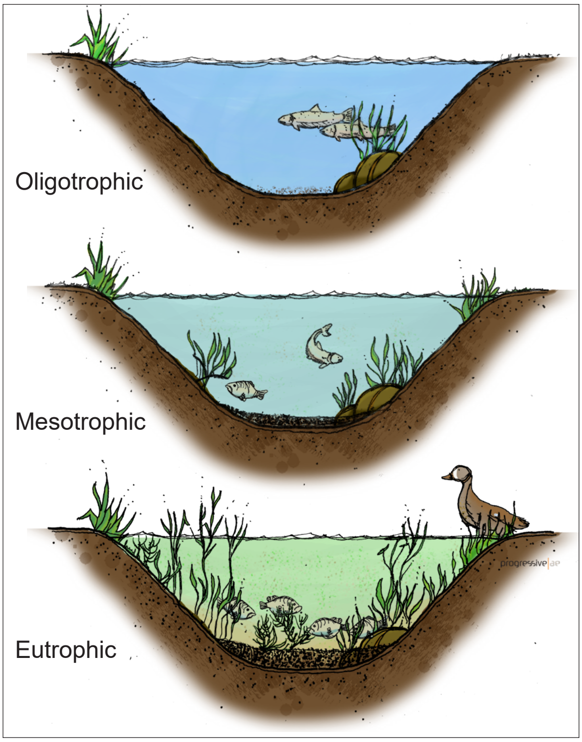
Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold water fish such as trout and whitefish.

Eutrophic lakes have poor clarity, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish such as bass and pike.

Lakes that fall between the two extremes of oligotrophic and eutrophic are called **mesotrophic** lakes.

Under natural conditions, most lakes will ultimately evolve to a eutrophic state as they gradually fill with sediment and organic matter transported to the lake from the surrounding watershed. As the lake becomes shallower, the process accelerates. When aquatic plants become abundant, the lake slowly begins to fill in as sediment and decaying plant matter accumulate on the lake bottom. Eventually, terrestrial plants become established and the lake is transformed to a marshland. The natural lake aging process can be greatly accelerated if excessive amounts of sediment and nutrients (which stimulate aquatic plant growth) enter the lake from the surrounding watershed. Because these added inputs are usually associated with human activity, this accelerated lake aging process is often referred to as *cultural eutrophication*.

The U.S. Geological Survey estimated that about 25% of Michigan lakes are oligotrophic, 52% are mesotrophic and 23% are eutrophic (Fuller and Taricska 2012). Examples of oligotrophic lakes include Glen Lake in Leelanau County, Torch Lake in Antrim County, Crystal Lake in Benzie County, and Higgins Lake in Roscommon County. Houghton Lake, the largest lake in Michigan, has both mesotrophic and eutrophic characteristics.



Lake trophic states.

Trophic State Indicators

Key parameters used to evaluate a lake's productivity or trophic state include total phosphorus, chlorophyll-*a*, and Secchi transparency.

Phosphorus is the nutrient that most often stimulates excessive growth of aquatic plants and causes premature lake aging. By measuring phosphorus levels, it is possible to gauge the overall health of a lake.

Chlorophyll-a is a pigment that imparts the green color to plants and algae. A rough estimate of the quantity of algae present in the water column can be made by measuring the amount of chlorophyll-*a* in the water column.

A *Secchi* disk is a round, black and white, 8-inch disk that is used to estimate water clarity. Generally, it has been found that plants can grow to a depth of about twice the Secchi disk transparency.

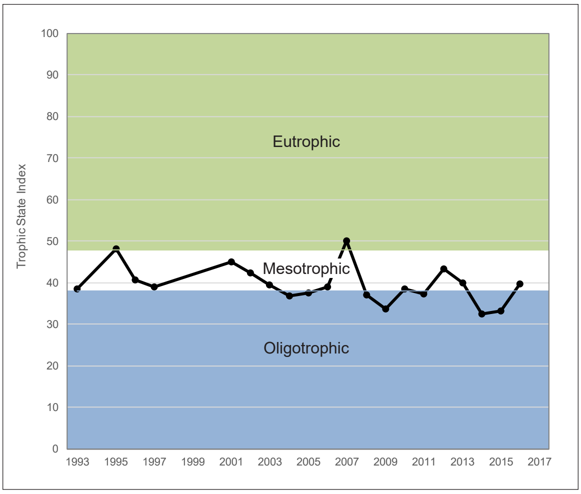
Generally, as phosphorus inputs to a lake increase, algae growth and chlorophyll-*a* increase and Secchi transparency decreases.

Carlson's Trophic State Index (TSI) was developed from mathematical relationships that allowed phosphorus, chlorophyll-*a*, and Secchi transparency readings to be converted to a numerical scale from 0 to 100, with increasing numbers indicating more productive lakes. The TSI can be used to determine the trophic state of Michigan lakes using values reported by USGS (Fuller and Taricska 2012) as follows:

Less than 38	Oligotrophic
38 to 48	Mesotrophic
Greater than 48	Eutrophic

Michigan's Cooperative Lakes Monitoring Program (CLMP) began in 1974 and is the second-longest running volunteer monitoring program in the country. Currently, as part of the program, data are collected annually from about 250 lakes, and are classified using Carlson's TSI.

To illustrate TSI, the chart below shows TSI values based on 20 years of data for Goguac Lake in Calhoun County, Michigan. The chart shows that Goguac Lake is mesotrophic, but it is also apparent that there is variability in the lake year to year. Because of the natural variability in most lakes, changes in lake water quality can be difficult to detect. In fact, it may take many years of regular sampling in a given lake to detect a statistically significant trend in water quality.



Goguac Lake trophic state index (TSI) 1993-2016, based on averages of spring phosphorus, and summer chlorophyll-*a* and Secchi transparency.

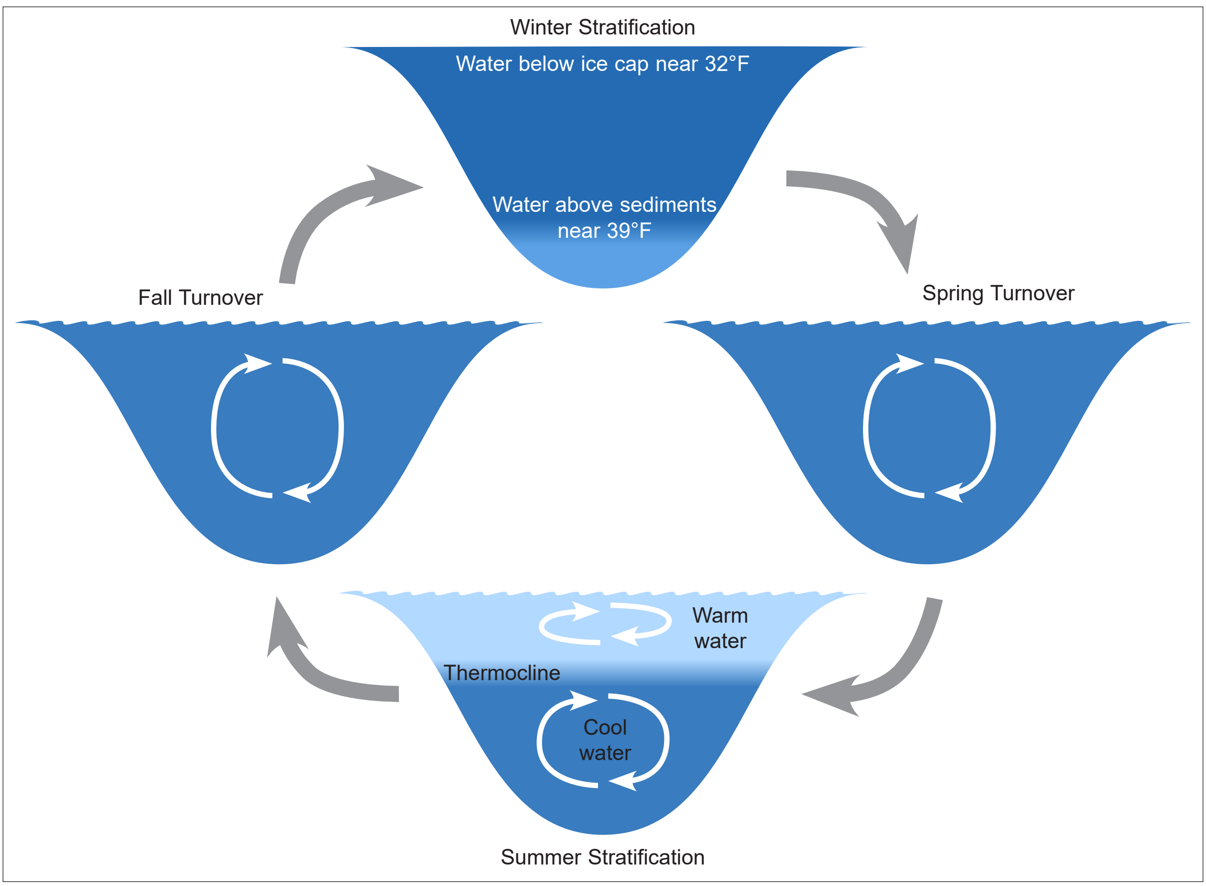
Temperature and Dissolved Oxygen

Other parameters that strongly influence lake water quality include temperature and dissolved oxygen. In fact, in terms of a lake's fishery, these are probably two of the most important measurements.

Temperature

Temperature is important in determining the type of organisms that may live in a lake. For example, trout prefer temperatures below 68°F. Temperature also determines how water mixes in a lake. As the ice cover breaks up on a lake in the spring, the water temperature becomes uniform from the surface to the bottom. This period is referred to as *spring turnover* because water mixes throughout the entire water column. As the surface waters warm, they are underlain by a colder, more dense layer of water. This process is called *thermal stratification*. In deeper lakes during summer there are three distinct layers. This is referred to as *summer stratification*.

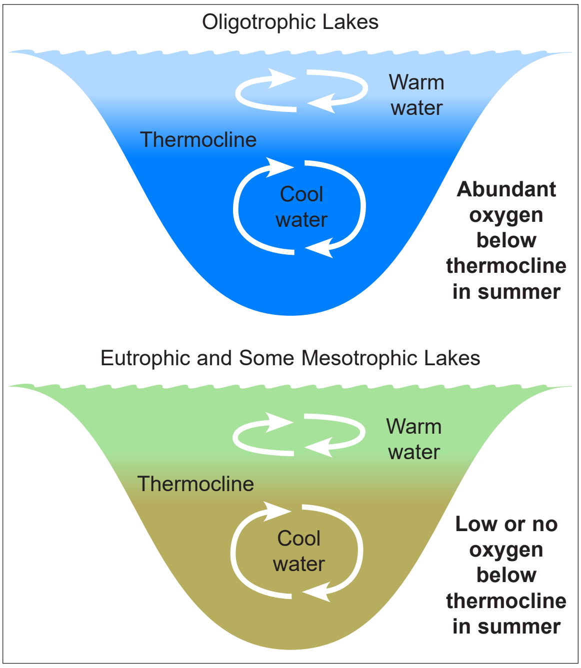
Once thermal stratification occurs, there is little mixing of the warm surface waters with the cooler bottom waters. The transition layer that separates these layers is referred to as the *thermocline*. The thermocline is characterized as the zone where temperature drops rapidly with depth. As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point that allows the lake to undergo complete mixing. This period is referred to as *fall turnover*. As the season progresses and ice begins to form on the lake, the lake may stratify again. However, during *winter stratification*, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is sometimes referred to as *inverse stratification* and occurs because water is most dense at a temperature of about 39°F. As the lake ice melts in the spring, these stratification cycles are repeated. Shallow lakes do not stratify. Lakes that are about 15 to 30 feet deep may stratify and destratify with storm events several times during the year.



Seasonal thermal stratification cycle.

Dissolved Oxygen

An important factor influencing lake water quality is the quantity of dissolved oxygen in the water column. The major inputs of dissolved oxygen to lakes are the atmosphere and photosynthetic activity by aquatic plants. An oxygen level of about 5 mg/L (milligrams per liter, or parts per million) is required to support warm-water fish. In lakes deep enough to exhibit thermal stratification, oxygen levels are often reduced or depleted below the thermocline once the lake has stratified. This is because deep water is cut off from plant photosynthesis and the atmosphere, and oxygen is consumed by bacteria that use oxygen as they decompose organic matter (plant and animal remains) at the bottom of the lake. Bottom-water oxygen depletion is a common occurrence in eutrophic and some mesotrophic lakes. Thus, eutrophic and most mesotrophic lakes cannot support cold-water fish because the cool, deep water (that the fish require to live) does not contain sufficient oxygen.



Trophic state and dissolved oxygen.

References

Fuller, L.M. and C.K. Taricska. 2012. Water-quality characteristics of Michigan's inland lakes, 2001–10: U.S. Geological Survey Scientific Investigations Report 2011–5233, 53 p., plus CD–ROM.