



SUMMARY OF HISTORICAL RESULTS

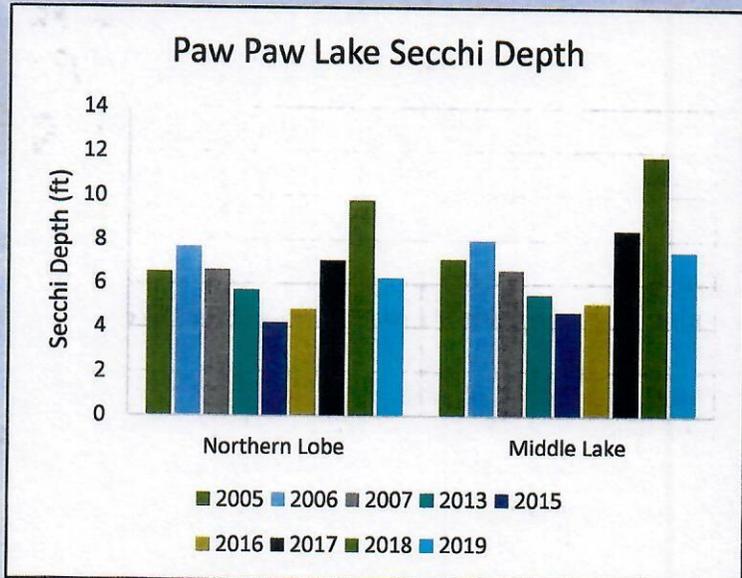
PAW PAW LAKE
BERRIEN COUNTY, MI
AUGUST 20, 2019



SECCHI DEPTH

Secchi depth is a measurement of water clarity. **The higher the Secchi depth, the higher the water clarity is.** Water clarity is often associated with “good” water quality. However, invasive species like zebra and quagga mussels can cause large increases in water clarity and allow for more light to hit the bottom of the lake, thus increasing the growth of aquatic plants. Therefore, a happy medium is desired for water clarity: not too clear to allow for excess growth of aquatic plants and not too cloudy so that the water appears dirty and does not allow for a productive, healthy lake.

In recent years, Paw Paw Lake has exhibited an overall healthy range of water clarity. Within the course of a year, clarity is typically highest during spring and mid-fall and lowest during the late summer months.



CRITERIA FOR COMPARISON – Michigan does not have a set water quality standard for Secchi Depth. However, Minnesota has a variety of water quality standards for Secchi Depths on different water bodies. The most applicable criteria are:

- ◆ Lakes and Reservoirs in North Central Hardwood Forest Ecoregion: **Not to be below 4.6 ft.**
- ◆ Lakes and Reservoirs in Western Corn Belt Plains and Northern Glaciated Plains Ecoregion: **Not to be below 3.0 ft.**

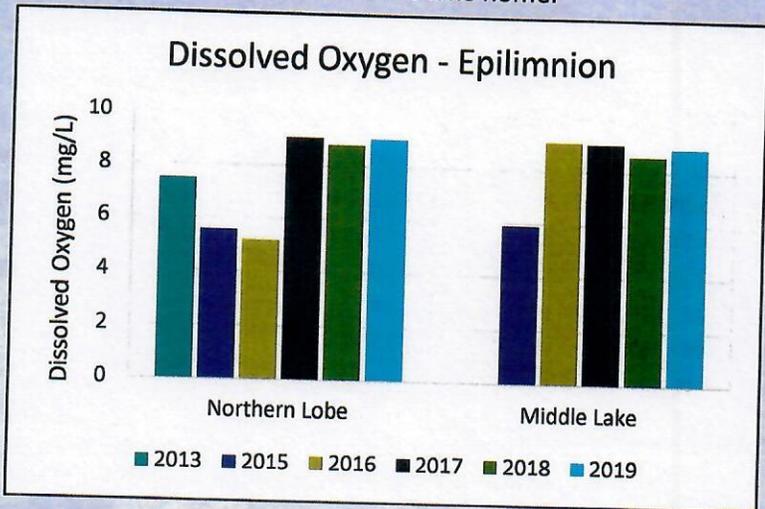
WHY DOES IT INCREASE AND DECREASE? –

- ◆ **Increase and Decrease in Secchi Depth** – An increase in Secchi depth is caused by the reduction of particulate matter suspended in the water column and reduction of algae blooms, phytoplankton and zooplankton. Conversely, a decrease in Secchi depth is due to an increase in particulate matter suspended in water, algae, phytoplankton and zooplankton. An increase in particulate matter can be caused by more runoff and boat traffic, and an increase in algae blooms, phytoplankton, and zooplankton can be due to excess nutrients in the water.
- ◆ **The increase in Secchi Depth during 2018 is likely a result of the decreased nutrient levels causing a less productive ecosystem than years past. This shift may also be linked to the presence of zebra mussels and the associated filter feeding.**

DISSOLVED OXYGEN (DO)

Dissolved oxygen is a measurement of **how much oxygen gas is dissolved in the water** and is typically measured in milligrams per liter (mg/L). It is important to have high enough dissolved oxygen concentrations within the water to support the aquatic wildlife that calls the lake home.

Dissolved oxygen can be reduced by excess algal growth, water that's too warm, and not enough wave action. Dissolved oxygen may be increased by more wave action, cooler temperatures, and non-invasive aquatic plants. The State of Michigan has developed water quality standards for dissolved oxygen. Paw Paw Lake is considered a "warm water fishery," as it is below the geographically designated line that extends horizontally from a point near Alma, Michigan that separates the cold water fisheries from the warm water fisheries. **The warm water fishery standard for dissolved oxygen is 5.0 mg/L.**



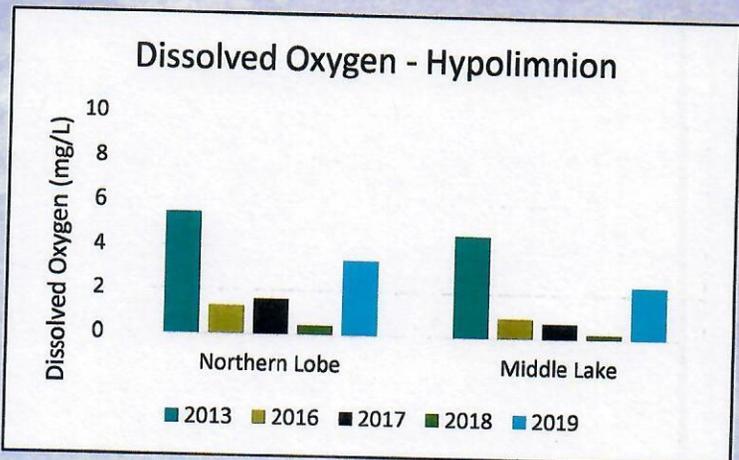
CRITERIA FOR COMPARISON –

MDEQ Rule 64 of Michigan Water Quality Standards (Part 4 of Act 451) –

- ◆ **Dissolved Oxygen (DO):**
5 mg/L

WHY DOES IT INCREASE AND DECREASE? –

- ◆ **Increase** – Dissolved oxygen increases due to more wave action, lower water temperatures, and more photosynthetic activity from aquatic plants and macrophytes.
- ◆ **Decrease** – Dissolved oxygen decreases due to the decay of organic material, such as aquatic plants and algae, the increase of oxygen demand from bacteria that use oxygen to respire and break down organic material, and warmer water temperatures.
- ◆ **The reduction in DO may be due to the above average temperatures in summer 2018.** Increases in water temperature hinder its ability to store oxygen and other gases.
- ◆ The bottom of Paw Paw Lake is anoxic, or lacking in oxygen once it is stratified in the summer. 2013 has elevated DO, as there was only one sample event for the year earlier in the season.

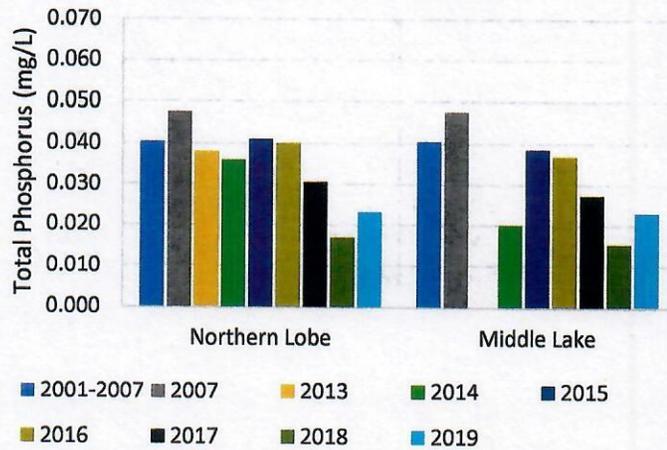


TOTAL PHOSPHORUS (TP)

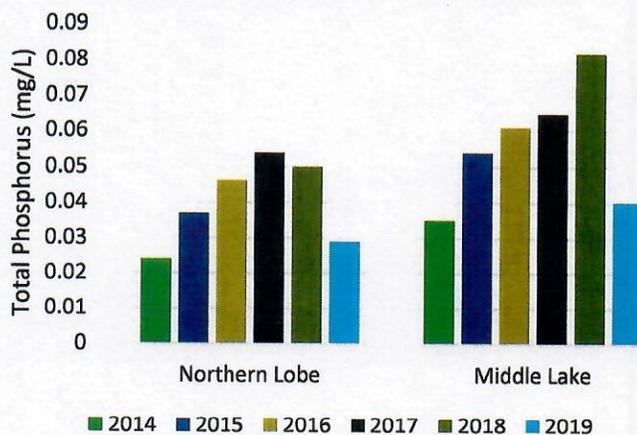
Phosphorus is an element that is a major component in all lifeforms, which includes everything from a human being to green algae. In fact, after calcium, phosphorus is the second most abundant mineral in the human body. Phosphorus can also be found in inorganic forms like in rocks. Therefore, as the name says, total phosphorus is the measurement of how much of all types of phosphorus (both organic and inorganic) are within the water, and is measured in milligrams per liter (mg/L). **Low TP concentrations that provide a balanced environment for aquatic wildlife are desired.**

The main concern regarding inland lakes and phosphorus is that if there is too much phosphorus within the water, it can lead to excess algal and plant growth. Excess algal growth can lead to reduced dissolved oxygen, reduced clarity, unpleasant odors/discolored water, and many more undesirable water quality issues. Excess aquatic plant growth can be an issue for motor boats, as propellers can get caught up in it. Phosphorus causes such a large impact on plant and algal growth because it is the limiting nutrient for plant and algal growth.

Total Phosphorus - Epilimnion



Total Phosphorus - Hypolimnion



CRITERIA FOR COMPARISON: Michigan does not have defined water quality standards for inland lakes, but is in the process of creating them. However, Wisconsin and Illinois both have water quality standards for total phosphorus:

- ◆ Wisconsin standard for drainage, stratified lakes: **0.030 mg/L**
- ◆ Illinois standard for a reservoir or lake with a surface area of >20 acres: **0.050 mg/L**

WHY DOES IT INCREASE AND DECREASE? –

- ◆ **Increase in Total Phosphorus** – An increase in total phosphorus may be due to an increase of external inputs of TP into the lake from lawns, soil erosion, or runoff from tributary drains. Additionally, phosphorus can be released from bottom sediments if dissolved oxygen is very low near the surface of the sediment and when temperature is elevated.

TOTAL PHOSPHORUS (TP), CONTINUED

- ◆ **Decrease in Total Phosphorus** – A decrease in TP can be due to the reduction in runoff and other external sources of TP. TP can also be reduced when dissolved oxygen levels are higher, and temperatures are lower near the surface of bottom sediment.
- ◆ **During 2018, TP levels dropped significantly from 2017.** Since zebra mussels have increased in population over the last two years, it is likely that they had influence in the reduction. When they filter feed, certain types of algae are removed, which uptake nutrients like phosphorus. Therefore, when they consume algae, they remove phosphorus from the water column and use it to build their bodies or eventually excrete it as waste.