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To: Bay Lake Improvement Association

Subject: 2024 Bay Lake Annual Report

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INTRODUCTION

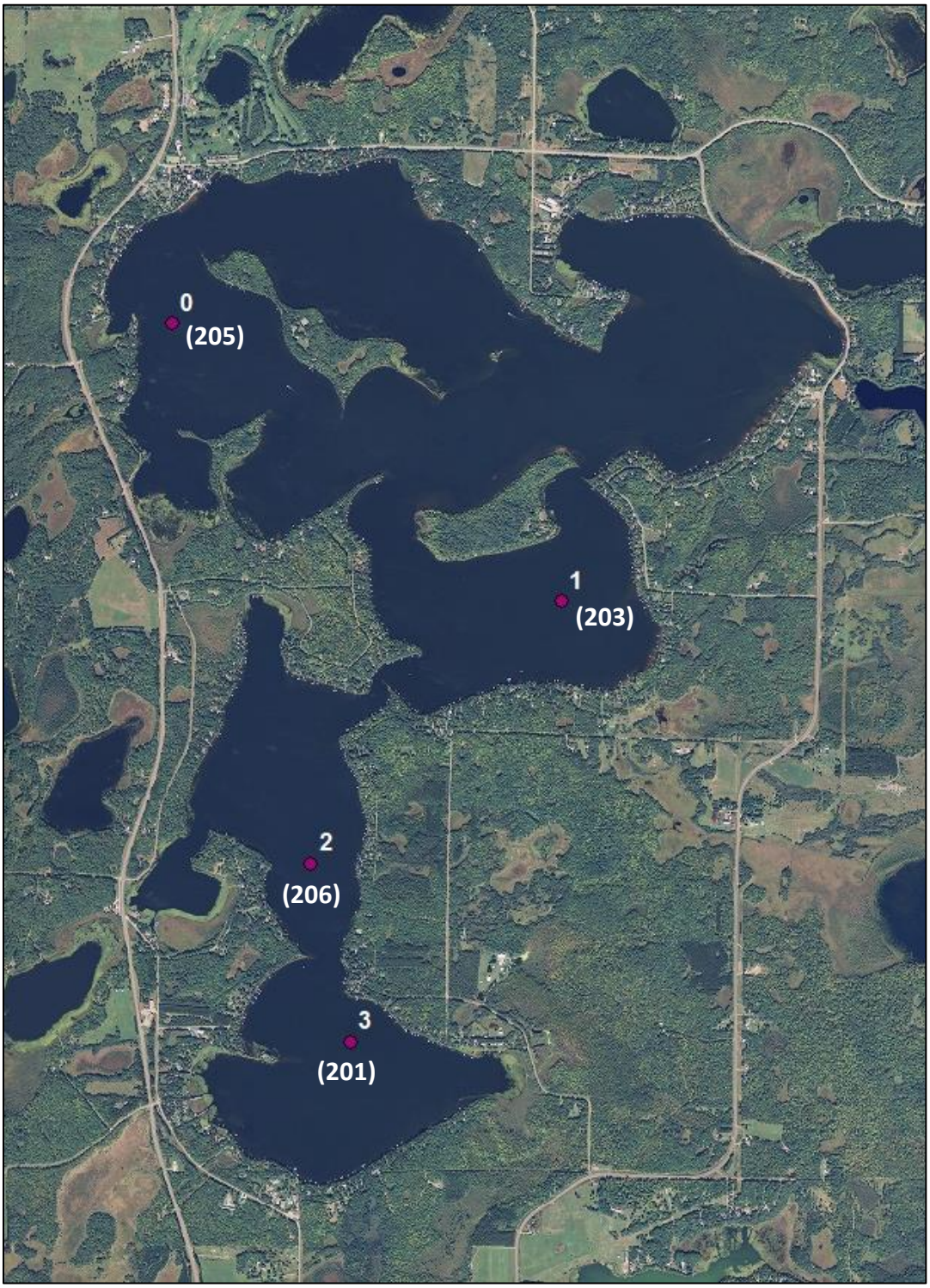
The Bay Lake Improvement Association has contracted A.W. Research Laboratories (AWRL) to conduct monthly Trophic Status Index (TSI) monitoring during the summer since 2014. In 2024, Sarah Fogderud of AWRL with the assistance of Gary Malek of the Bay Lake Improvement Association sampled four sites on Bay Lake monthly from May through September. Figure 1 on the following page displays the four sampling sites.

Water samples were collected using standard methods and were analyzed by AWRL's certified laboratory. A Hydrolab Quanta meter was used to collect a profile of temperature and dissolved oxygen at 10-foot intervals from the surface of the water to the lake bottom at each site.

The following report presents the 2024 and historical data collected for the Trophic Status Index Study and recommendations based on those results. The data collected by AWRL was supplemented with data from the Minnesota Pollution Control Agency's surface water database[1]. Raw sampling data is available in the Appendix of this report.

[1] MPCA surface water database: http://cf.pca.state.mn.us/water/watershedweb/wdip/waterunit.cfm?wid=18-0034-00&tab=Data

Figure 1: Sampling Locations



EXECUTIVE SUMMARY

Bay Lake has excellent water quality that is generally improving over time. Compared to typical water quality conditions of other lakes within the Northern Lakes and Forest Ecoregion of Minnesota, Bay Lake is of high quality and ranks among some of the best lakes in the ecoregion for the parameters measured. Table 1 below displays the typical range for lakes within the NLF Ecoregion alongside the average value measured at each site during the 2024 monitoring season. In 2024, Bay Lake was better than the expected range for all parameters measured.

Table 1: Ecoregion Comparison

Parameter	NLF Range	Site 205	Site 203	Site 206	Site 201
Phosphorus (µg/L)	14-27	9	9	9	9
Chlorophyll-a (µg/L)	< 10	2.0	2.1	1.7	1.8
Secchi Depth (feet)	7.8-15.1	17.2	17.6	16.1	16.7

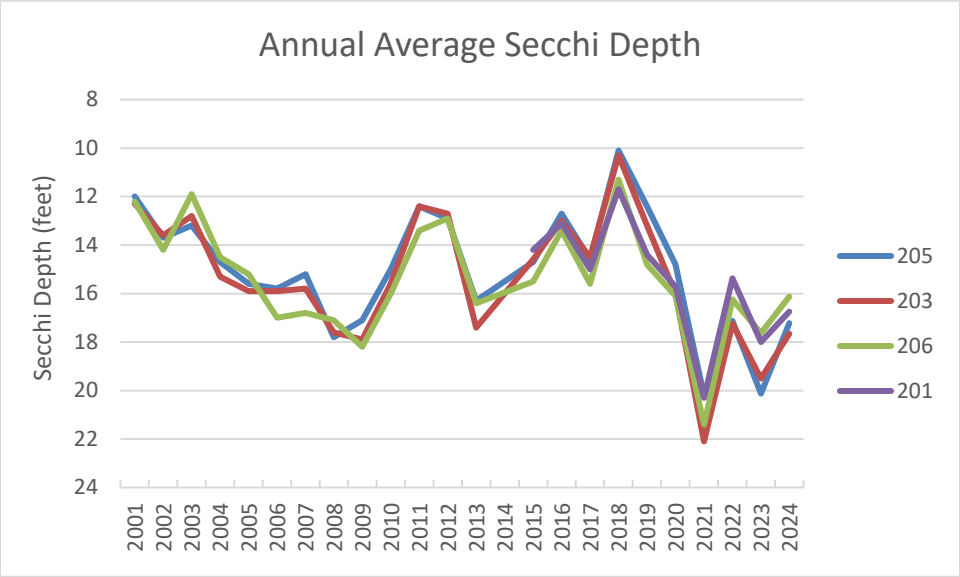
Table 2 below shows the results of a Mann-Kendall trend analysis of all monitoring data for the four sites on Bay Lake using a 95% confidence interval. This means that there is a 95% chance that the data are showing a true trend and only a 5% chance that the trend is a random result of the data. A result of "No trend" indicates that the data does not show an upward or downward trend over the time-period. For lakes, this is a good thing as we like to see stable water quality over time. The phosphorus in Bay Lake is stable over the past seven years, while Chlorophyll-a concentrations and Secchi depth have been generally improving.

Table 2: Trend Analysis by Site (2015-2024)

Site	Total Phosphorus	Chlorophyll-a	Secchi
205	Improving	Improving	Improving
203	No Trend	Improving	Improving
206	No Trend	Improving	Improving
201	Improving	Improving	Improving

Secchi depths have increased significantly since zebra mussels were first found in Bay Lake in 2018. Zebra mussels are filter feeders that remove large amounts of plankton from the water column. A single adult zebra mussel can filter up to 1 liter of water per day! As the zebra mussel population reaches the carrying capacity of the lake, they will die off often resulting in a reduction in water clarity. Figure 2 shows the annual average Secchi depth for each site for the past 2 decades on Bay Lake.

Figure 2: Annual Average Secchi Depth by Site, 2001-2024



With increasing water clarity, light can penetrate deeper into the water column. As a result, invasive plants can grow in more places throughout the lake, making efforts to monitor and control Eurasian water milfoil increasingly important. Starry stonewort, an invasive species of algae, should be a focus of AIS prevention efforts.

RECOMMENDATIONS

A.W. Research Laboratories recommends the following:

1. Continue annual TSI Monitoring with DO/Temp Profiles at each of the four monitoring sites on Bay Lake in 2024.
2. Increase education to residents regarding new AIS threats with special emphasis on starry stonewort. The University of Minnesota Extension's AIS Detectors[2] program would be a great opportunity to get some Bay Lake leaders trained in AIS identification and detection.
3. Encourage Pelican Lake residents to reduce runoff from their property. This is a significant source of phosphorus pollution and can be prevented by implementing shoreline best management practices such as buffer strips. Some possible ways to do this:
    a. Participate in the Minnesota Lakes and Rivers Advocates (MLR)'s "Lake Steward Program[3]". This is an excellent program open to all MLR member associations that

[2] AIS Detectors Website: https://maisrc.umn.edu/ais-detectors

[3] MLR Lake Steward Program:

https://mnlakesandrivers.org/lake-associations/lake-association-programs/lake-steward/

provides resources for educating lakeshore property owners about sustainable land management to protect water quality.

b. Provide financial/technical assistance to help property owners to install buffers and rain gardens to capture stormwater runoff.

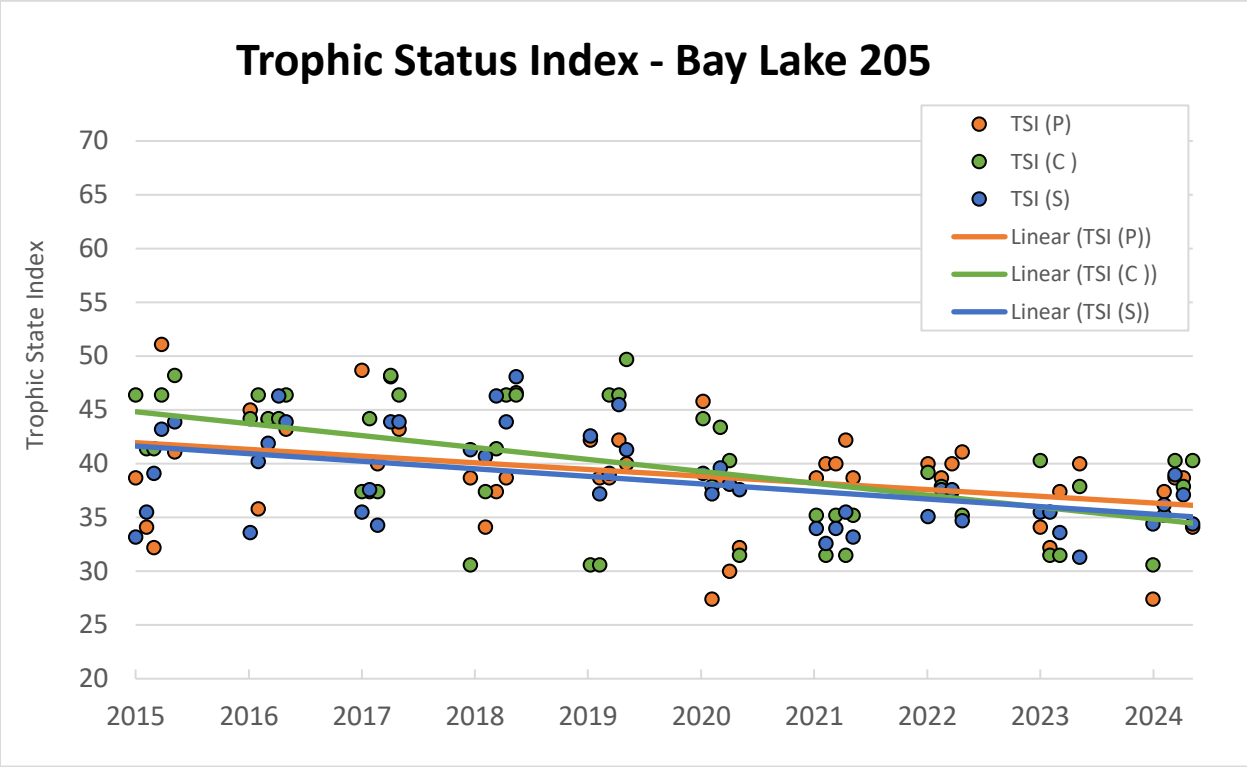
TSI RESULTS

The Carlson Trophic Status Index (TSI) is a tool used to summarize measurements of water quality into one index value. This value can be used to compare lakes in the same region or as a historical comparison of improvement/degradation over time. In many ways, the index can be viewed as a measure of the potential for algae growth.

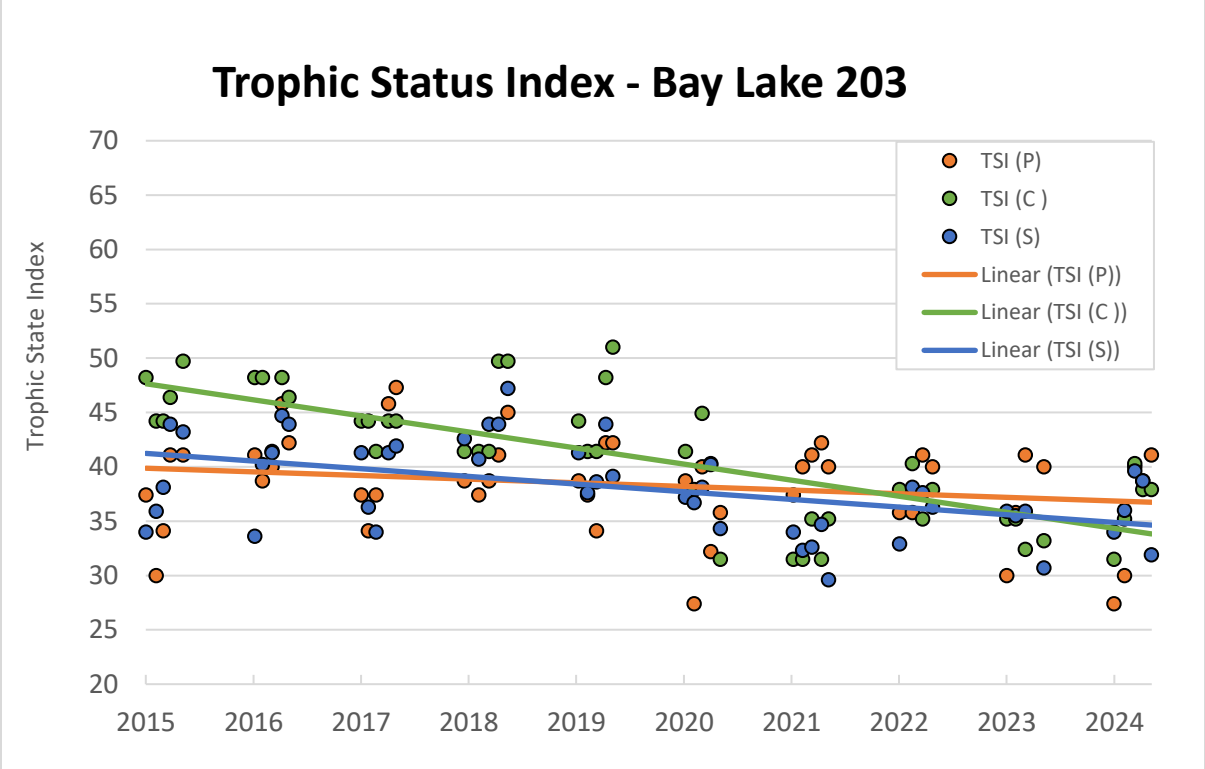
TSI is calculated using three measurements: total phosphorus, chlorophyll-a, and Secchi disk depth. Phosphorus is a requirement for plant growth. When phosphorus concentrations are high, large amounts of plant (including algae) growth can be supported. Phosphorus is most often the limiting factor, and therefore the most important factor to control to prevent overgrowth of plant and algae biomass. All green plants contain Chlorophyll-a, which allows Chlorophyll-a concentrations to be used as an estimate of overall plant/algae biomass. A Secchi Disk is a white metal disk used to measure the clarity or transparency of the water. The depth at which the disk is no longer visible is the Secchi Disk Reading.

The graphs on the following pages present the calculated TSI values for phosphorus, chlorophyll-a, and Secchi disk measurements. The average TSI is calculated by averaging the TSI values for phosphorus, chlorophyll-a, and Secchi disk for each sampling event, resulting in one summary TSI value for the site for each sampling event.

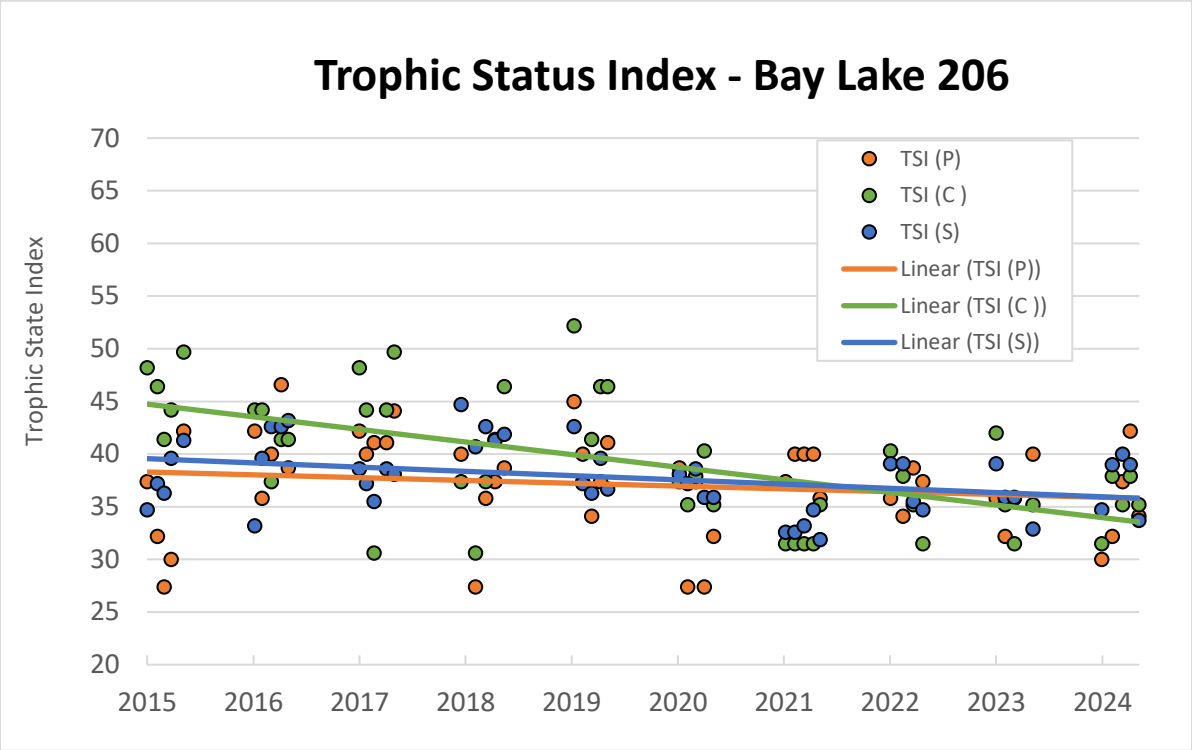
Graph 1: Site 205 TSI, 2015-2024



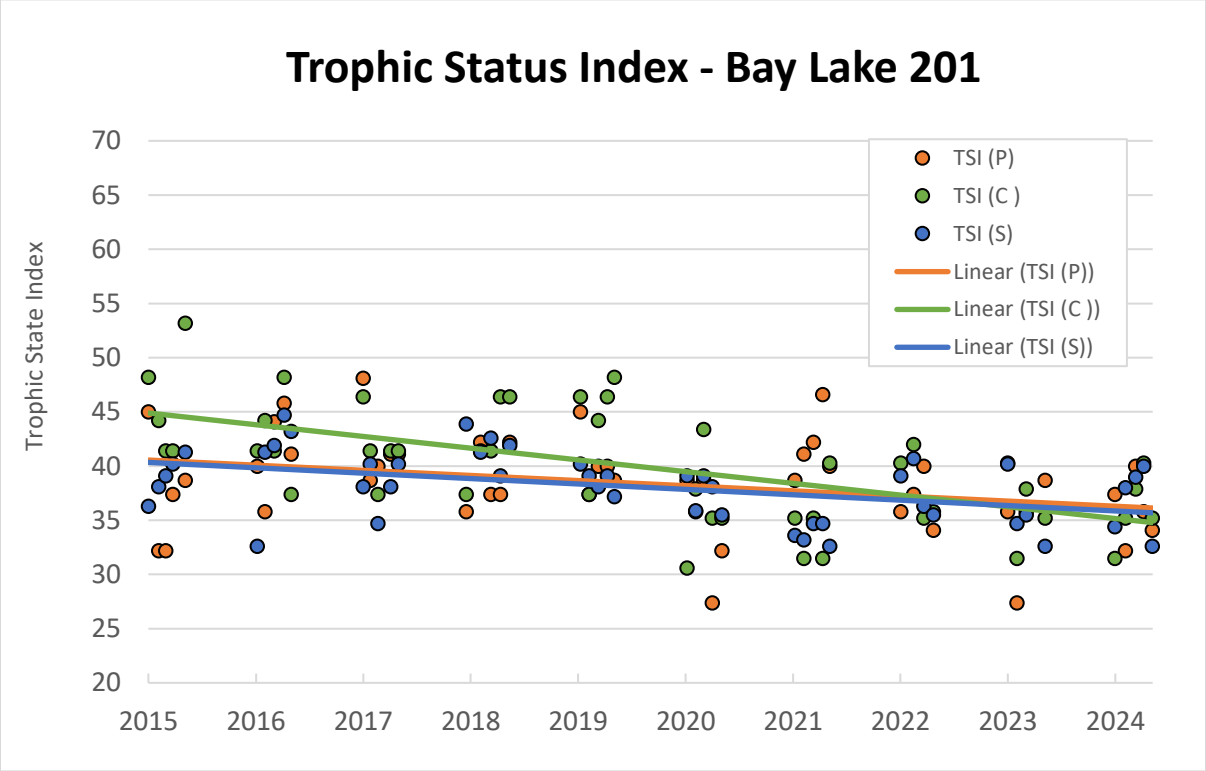
Graph 2: Site 203 TSI, 2015-2024



Graph 3: Site 206 TSI, 2015-2024



Graph 4: Site 201 TSI, 2015-2024

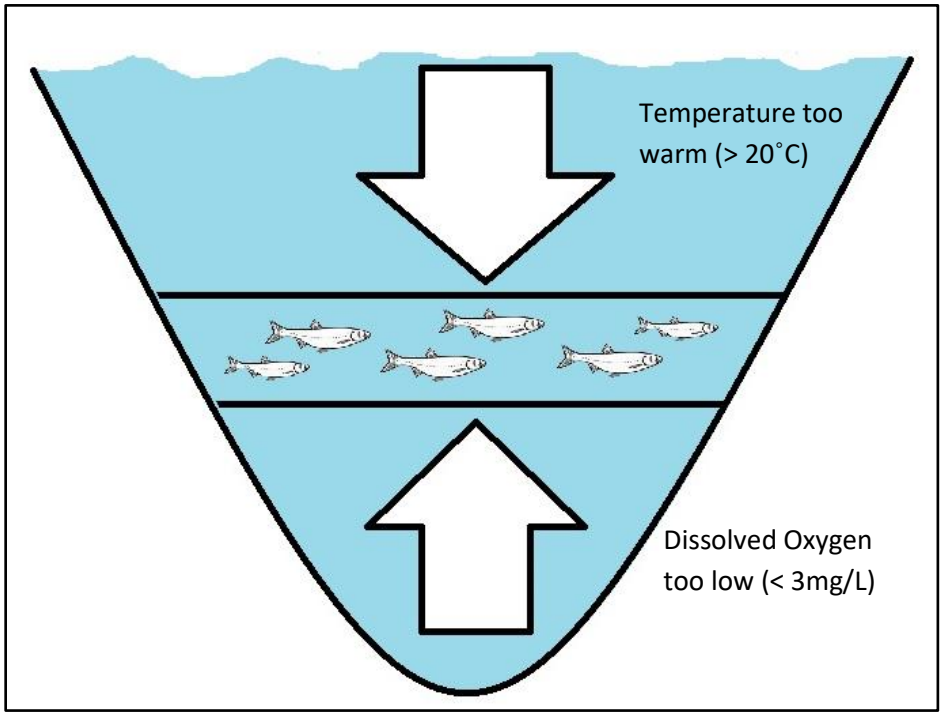


DISSOLVED OXYGEN AND TEMPERATURE PROFILES

The dissolved oxygen and water temperature were measured with a Hydrolab Quanta field meter. At each TSI site, measurements were taken at the surface and every 10 feet to the bottom.

At all four sites, we see oxygen depletion at lower depths and increased surface water temperatures that worsen throughout the summer months. This is a normal trend in many lakes, however as these conditions become more extreme it can put a squeeze on some species of fish leaving very little habitable water for them during the warmer months. Tullibee (cisco) are particularly sensitive to this late summer squeeze (Figure 2).

Figure 3: Temperature-Oxygen Squeeze Diagram

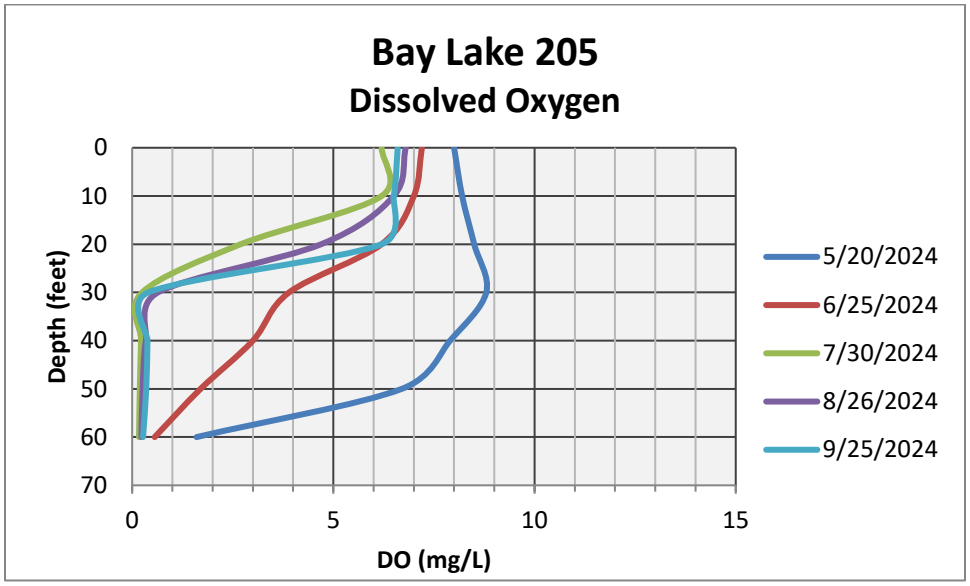


Graphs 5-12 show the dissolved oxygen and temperature profiles for each sampling date at each of the four sampling sites. Most fish require dissolved oxygen levels of 5-6 mg/L at a minimum to grow and thrive. Low oxygen conditions (levels less than 3 mg/L) are stressful for most aquatic organisms and when levels get much lower, they can cause fish kills.

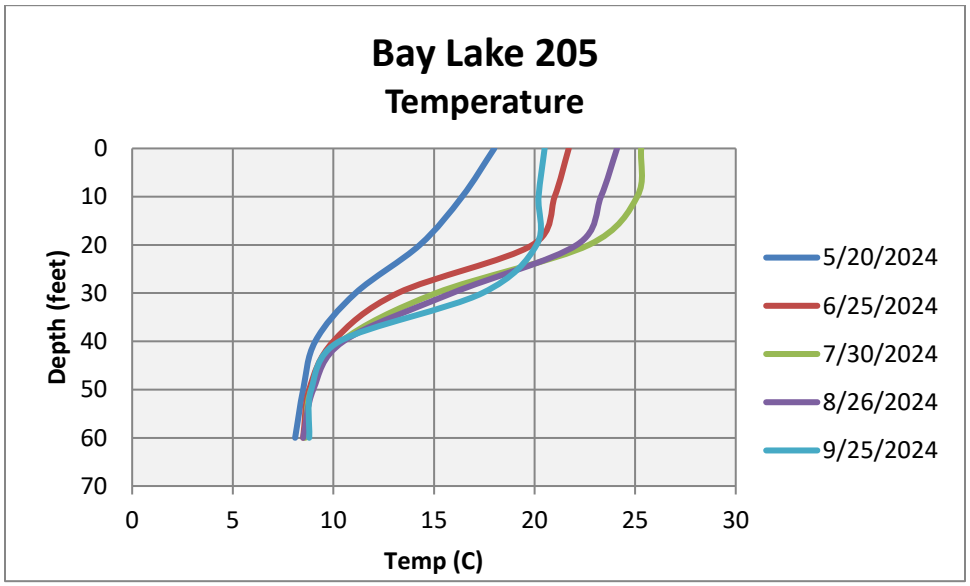
In 2024, we saw low oxygen conditions extending up to the 20-foot depth level in July, meaning that below 20 feet there was limited oxygen levels for fish. In August and September, the line moved lower to around 25 feet at all four sites. We also saw temperatures greater than 20˚C extending down to the 20 foot depth level in July, August, and September at all four sites. So in

July there was essentially no suitable habitat for cold water fish such as Tulibee (cisco), and in August and September there was just a 5 foot portion of the water column available.

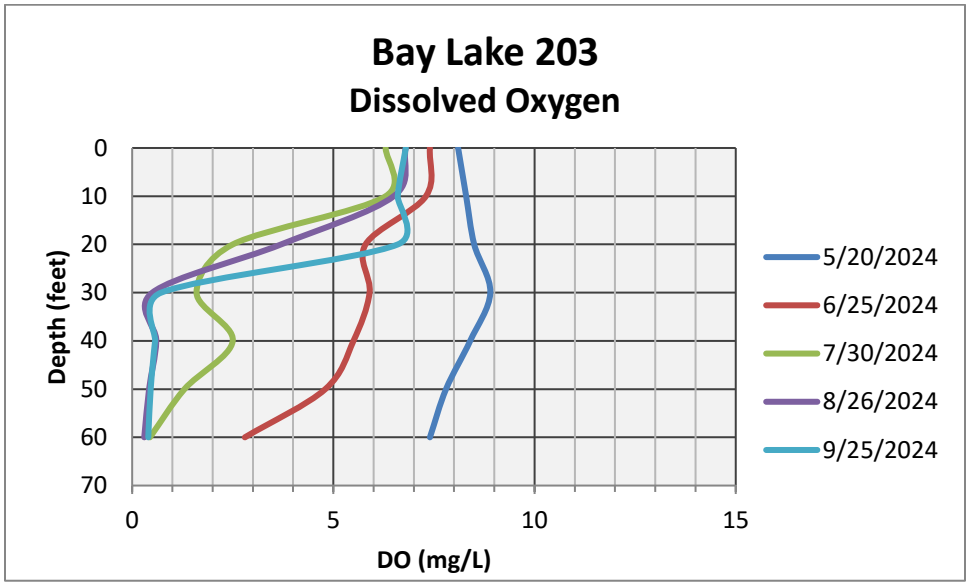
Graph 5: Site 205 Dissolved Oxygen Profile Series – 2024



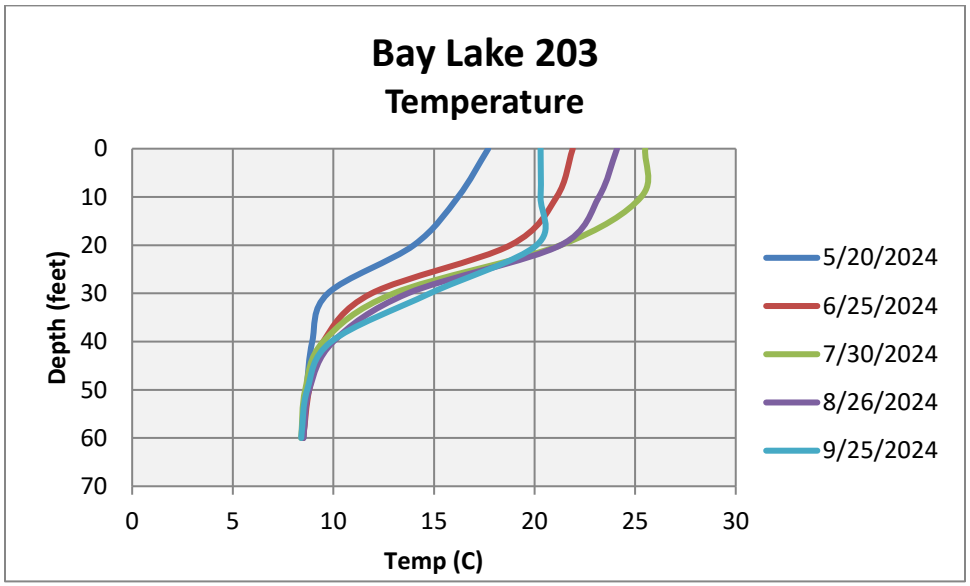
Graph 6: Site 205 Temperature Profile Series – 2024



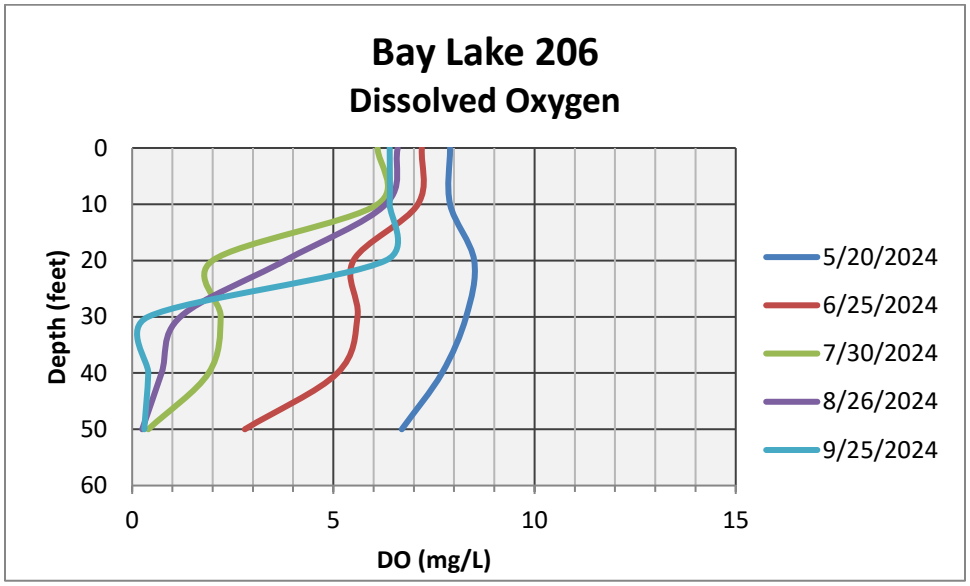
Graph 7: Site 203 Dissolved Oxygen Profile Series – 2024



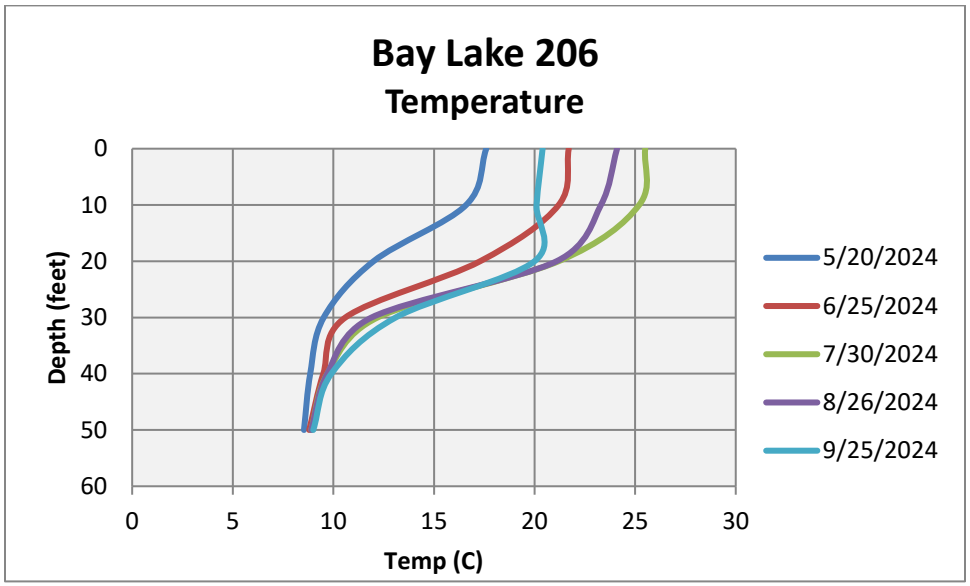
Graph 8: Site 203 Temperature Profile Series – 2024



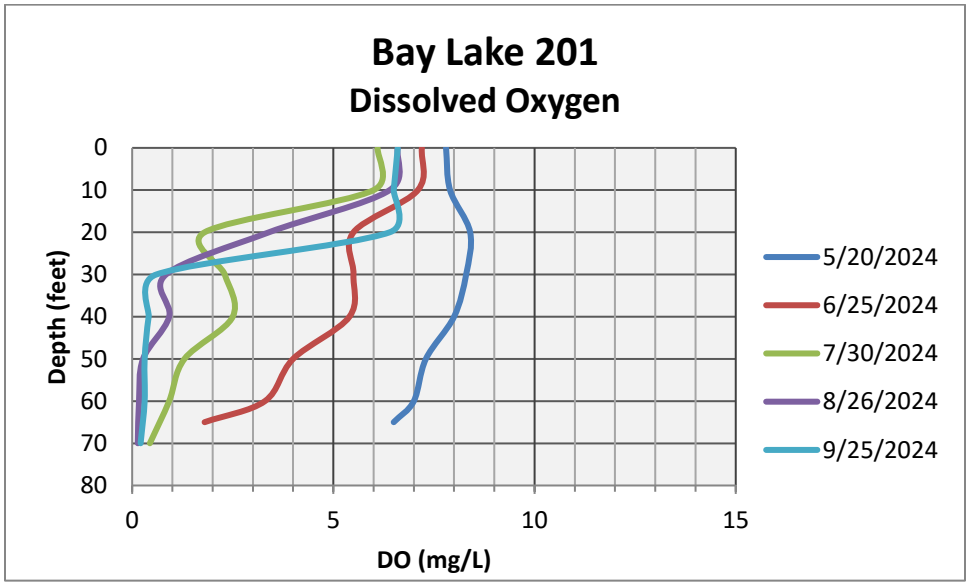
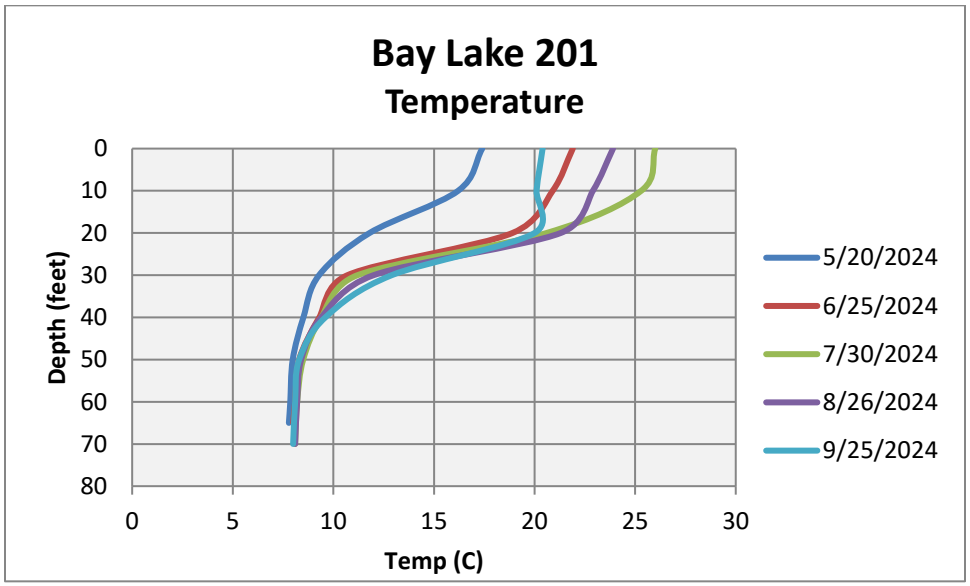
Graph 9: Site 206 Dissolved Oxygen Profile Series – 2024



Graph 10: Site 206 Temperature Profile Series – 2024



Graph 11: Site 201 Dissolved Oxygen Profile Series – 2024



Graph 12: Site 201 Temperature Profile Series – 2024