Deep Hole Sampling Procedure

In-lake data was collected by the Polk County Land and Water Resources Department one time in July, August, and September 2024. Data was collected at 3 sites on Balsam Lake: Main Basin (493056), Boston Bay (10029967), and Little Balsam (493057). Dissolved oxygen, temperature, conductivity, specific conductance, and pH were recorded at meter increments with a YSI ProDSS multiparameter digital water quality meter. Secchi depth was recorded with a secchi disk. Surface samples were collected with a 2-meter composite sampler and analyzed at the Wisconsin State Laboratory of Hygiene for total phosphorus and chlorophyll a. Bottom samples were collected with a van dorn sampler and analyzed at the Wisconsin State Laboratory of Hygiene for total phosphorus and iron. Data was entered into the WDNR SWIMS database.

Balsam Lake Sampling Sites

N
W E
S

POLK COUNTY, WI

0 0.25 0.5 1 Miles

Sampling Sites

- Main Basin
- Boston Bay - Kemoh Park
- Little Balsam

Dissolved Oxygen

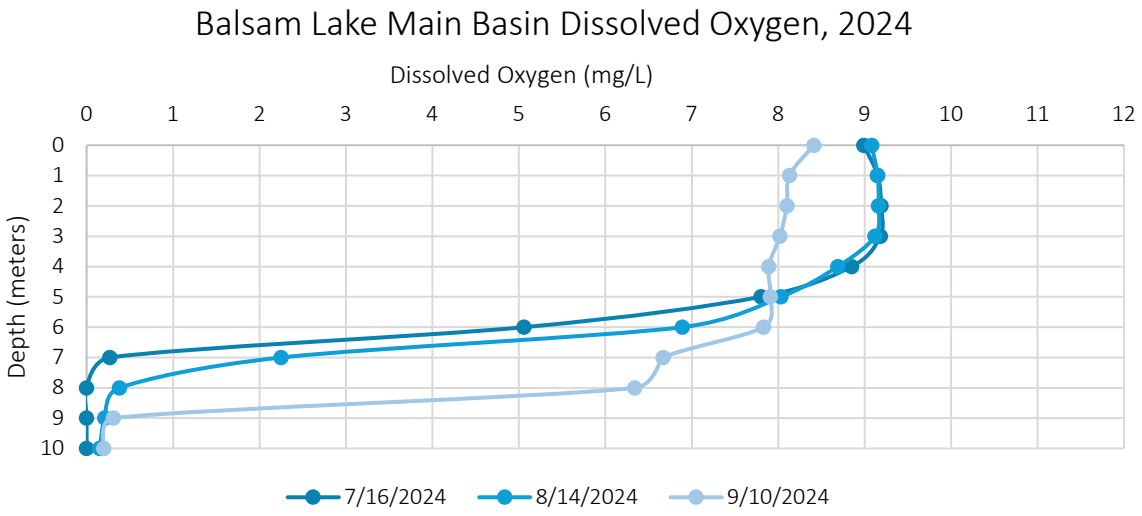
Oxygen is required by aquatic organisms for survival. The amount of oxygen dissolved in water depends on temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering a lake.

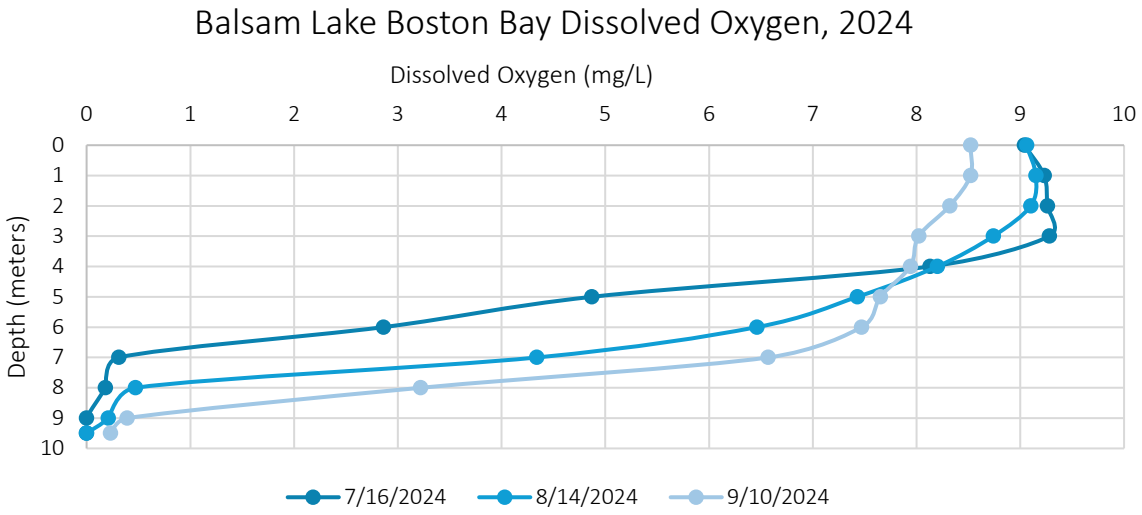
Plants produce oxygen in a process called photosynthesis. Since photosynthesis requires light, oxygen production occurs during the daylight hours at depths where sunlight can reach. During the sunlight hours, dissolved oxygen levels at a lake's surface may be quite high. Conversely, at night or early in the morning, dissolved oxygen values can be expected to be lower. Plants and animals use oxygen in a process called respiration.

It is not uncommon for oxygen depletion to occur in the hypolimnion (bottom waters of a lake) because mixing is unable to introduce oxygen to greater water depths, oxygen producing photosynthesis is not occurring, and the only reaction occurring is oxygen consuming respiration.

A water quality standard for dissolved oxygen based on the minimum amount of oxygen required by fish for survival and growth in warm water lakes and streams is set at 5 mg/L. For cold water lakes supporting trout, the standard is set even higher at 7 mg/L.

The surface waters of all three basins were well oxygenated (above 8 mg/L) on all sampling dates with bottom oxygen levels dropping to zero. Dissolved oxygen remained above 5 mg/L to depths of approximately 6 meters in the Main Basin, 5 meters in Boston Bay, and 2 meters in Little Balsam.


Balsam Lake Main Basin Dissolved Oxygen, 2024
Dissolved Oxygen (mg/L)
0 1 2 3 4 5 6 7 8 9 10 11 12
Depth (meters)
0 1 2 3 4 5 6 7 8 9 10
7/16/2024
8/14/2024
9/10/2024


Balsam Lake Boston Bay Dissolved Oxygen, 2024
Dissolved Oxygen (mg/L)
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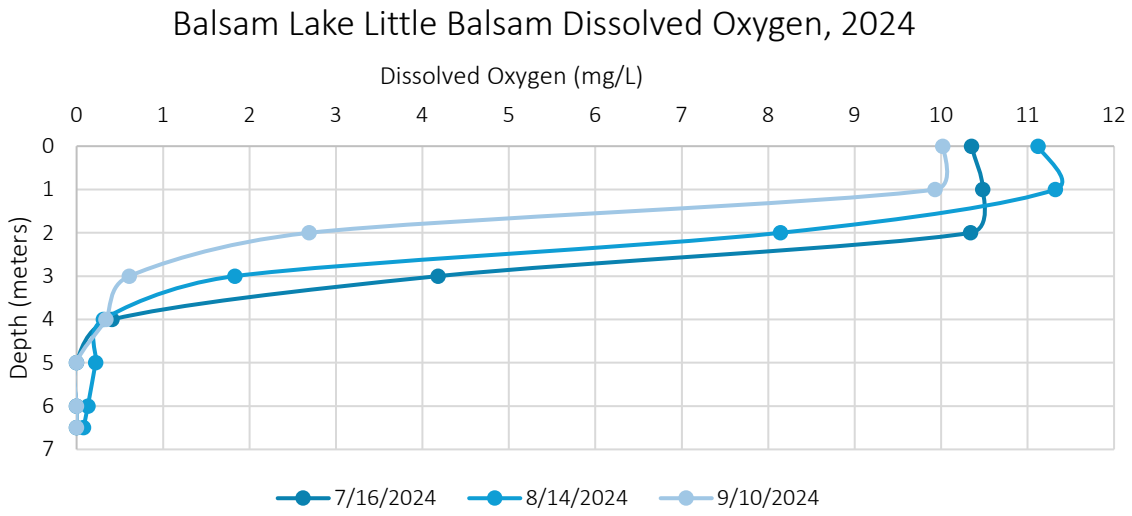
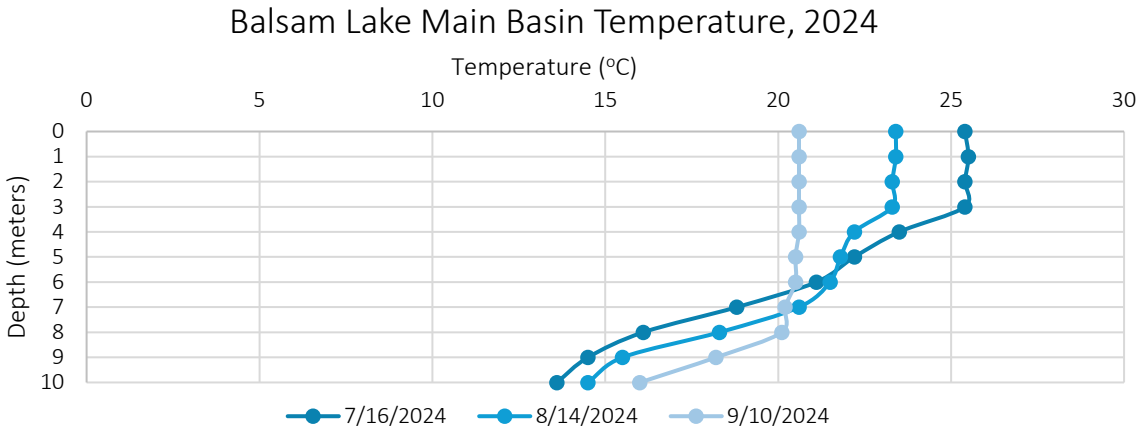
Depth (meters)
0 1 2 3 4 5 6 7 8 9 10
7/16/2024
8/14/2024
9/10/2024

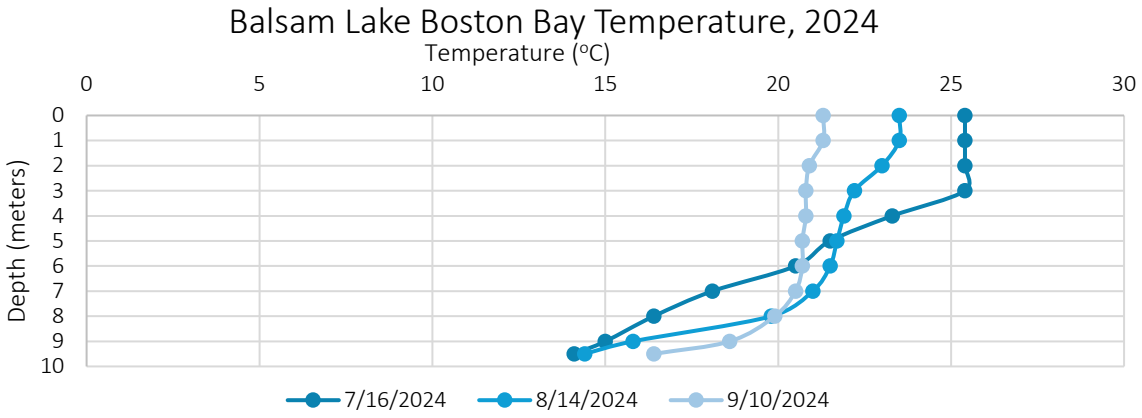

Balsam Lake Little Balsam Dissolved Oxygen, 2024
Dissolved Oxygen (mg/L)
0 1 2 3 4 5 6 7 8 9 10 11 12
Depth (meters)
0 1 2 3 4 5 6 7
7/16/2024
8/14/2024
9/10/2024

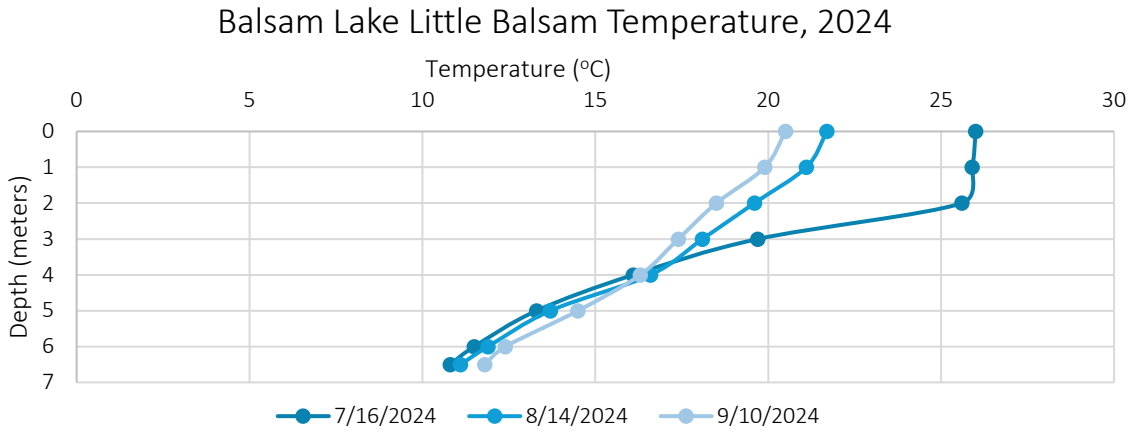
Temperature

The three basins of Balsam Lake stratified, or set up density dependent layers in July, August, and September. The epilimnion, or warmer surface layer, extended to the greatest depths in September in all three basins.

The surface temperature was greatest in July, followed by August, and September.





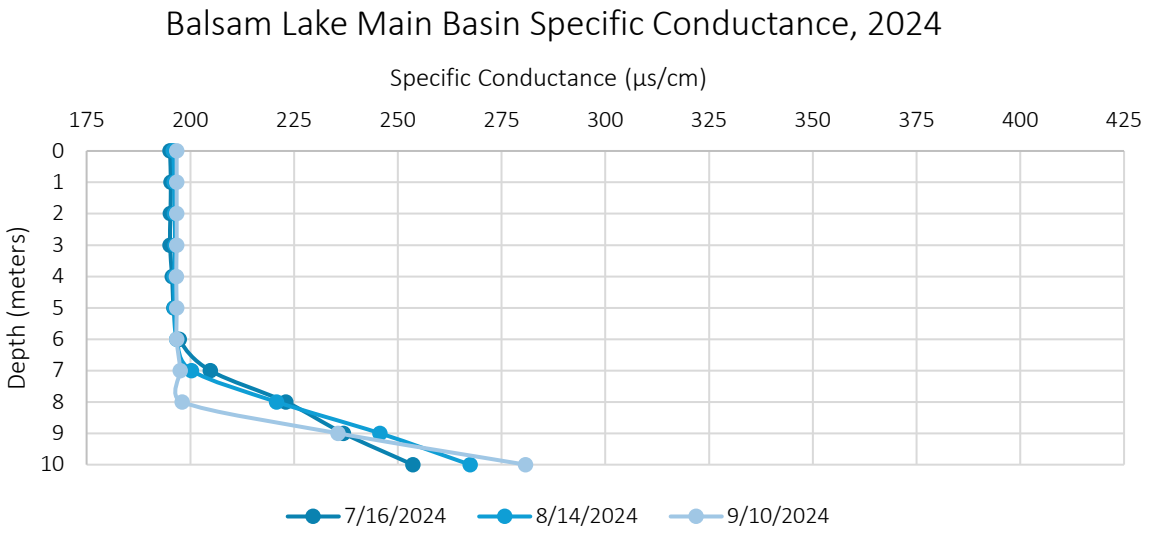


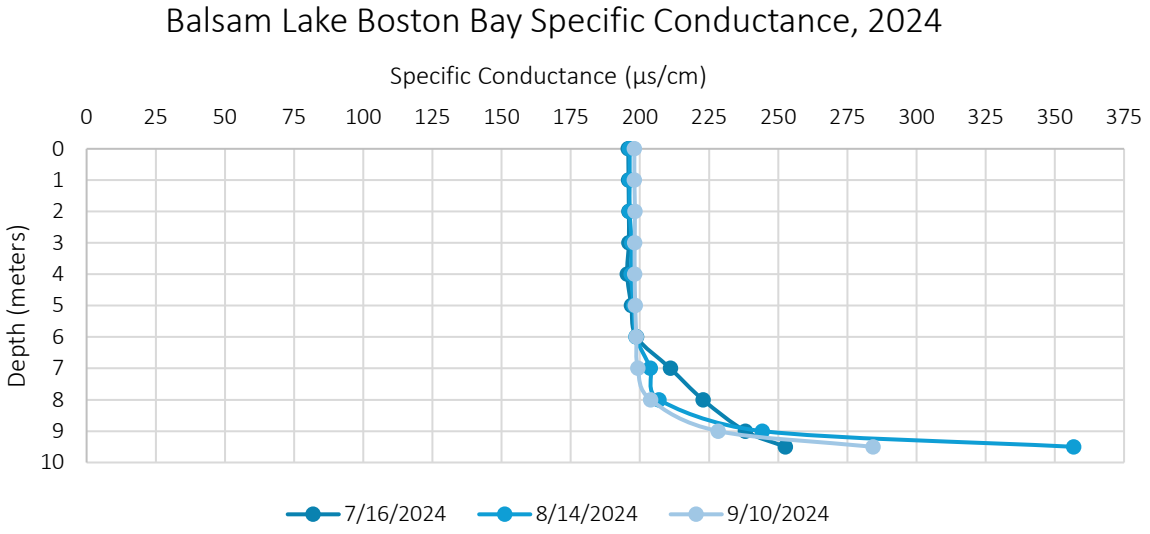
Specific Conductance (Conductivity)

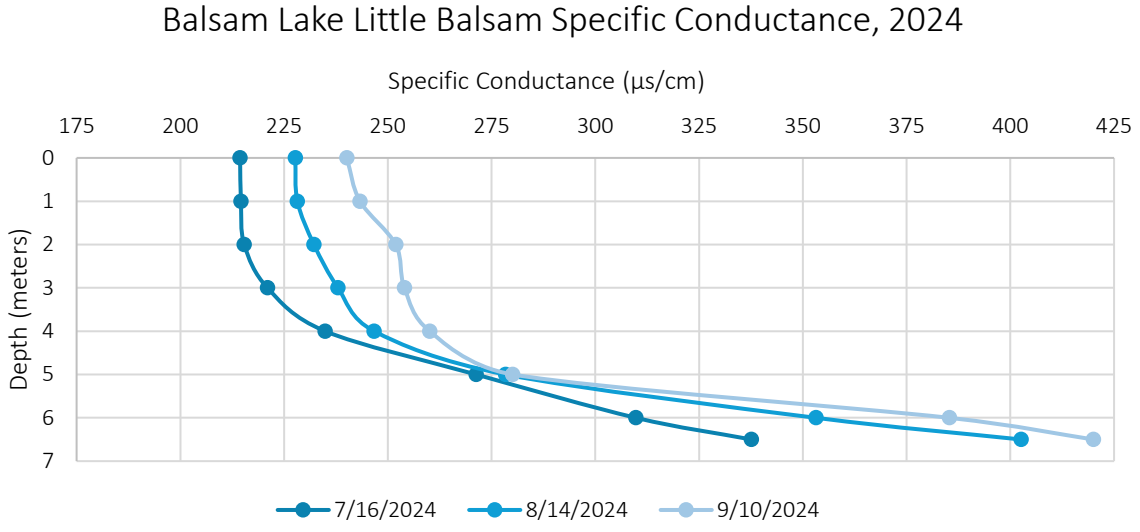
Conductivity measures the ability of water to conduct an electrical current and is an indicator of the concentration of total dissolved inorganic chemicals in the water. Values increase as the concentration of dissolved minerals in a lake increase. Since conductivity is temperature related, values are normalized at 25^{o}C and termed specific conductance.

When watersheds contain easily dissolved carbonate rocks, lakes are more likely to have higher conductivity. Watersheds that contain slow-to-dissolve rocks, such as granite, are more likely to have lower conductivity. Lakes with especially low conductivity are also more likely to be precipitation dominated (rather than groundwater or runoff dominated) because precipitation contains very little dissolved minerals.

Specific conductance values at the surface of all three basins were around 200 µS/cm. Values were greatest in Little Balsam as compared to the Main Basin and Boston Bay.


Balsam Lake Main Basin Specific Conductance, 2024
Specific Conductance (µs/cm)
175 200 225 250 275 300 325 350 375 400 425
Depth (meters)
0 1 2 3 4 5 6 7 8 9 10
7/16/2024
8/14/2024
9/10/2024


Balsam Lake Boston Bay Specific Conductance, 2024
Specific Conductance (µs/cm)
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375
Depth (meters)
0 1 2 3 4 5 6 7 8 9 10
7/16/2024
8/14/2024
9/10/2024

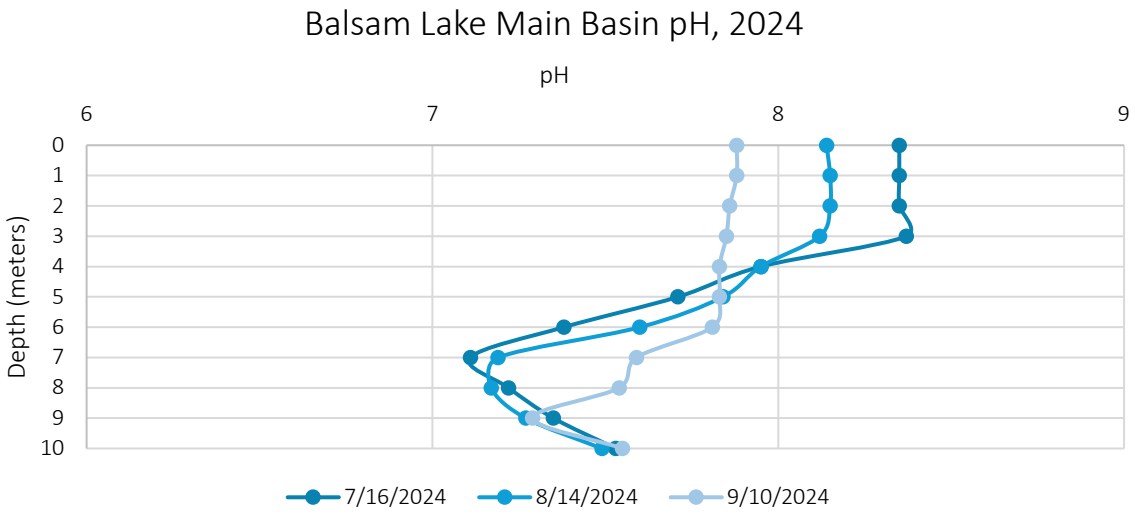

Balsam Lake Little Balsam Specific Conductance, 2024
Specific Conductance (µs/cm)
175 200 225 250 275 300 325 350 375 400 425
Depth (meters)
0 1 2 3 4 5 6 7
7/16/2024
8/14/2024
9/10/2024

pH

The pH is an indicator of acidity, with a value of seven being neutral. Values less than seven indicate acidic conditions and values greater than seven indicate alkaline conditions. A single pH unit change represents a tenfold change in acidity. For example, a lake with a pH of eight is ten times less acidic than a lake with a pH of seven. Across Wisconsin lakes, pH can range from 4.5 (acid bog lakes) to 8.4 (hard water, marl lakes).

Photosynthesis removes carbon dioxide from the water column which increases pH. As a result, pH generally increases during the day and decreases at night. Dense algae blooms can also cause pH levels to increase.

Surface pH values were around 8 in the Main Basin and Boston Bay. In Little Balsam surface pH values were higher at around 8.5.


Balsam Lake Main Basin pH, 2024
pH
6
7
8
9
0
1
2
3
4
5
6
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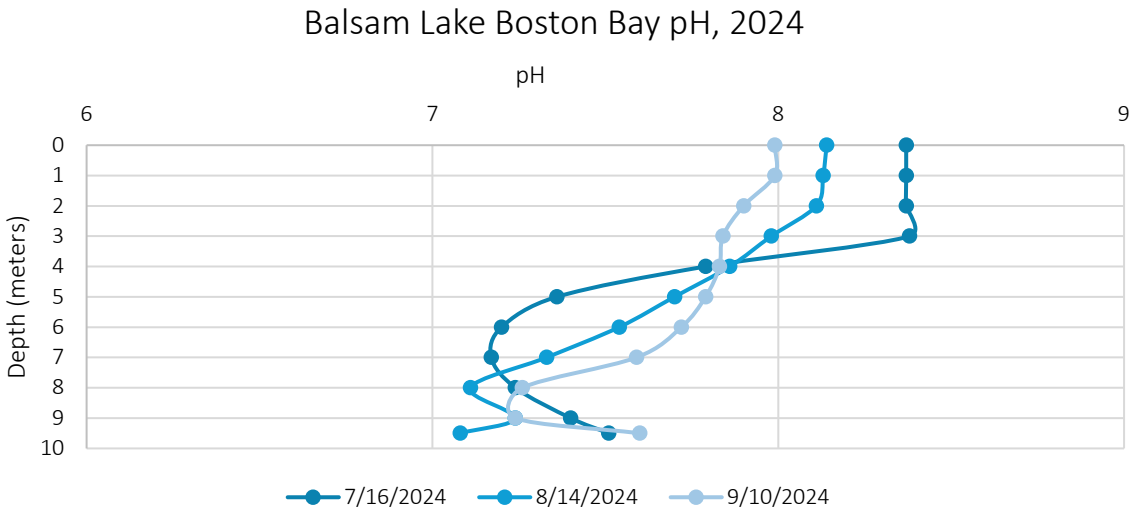
8
9
10
Depth (meters)
7/16/2024
8/14/2024
9/10/2024


Balsam Lake Boston Bay pH, 2024
pH
6
7
8
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0
1
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7
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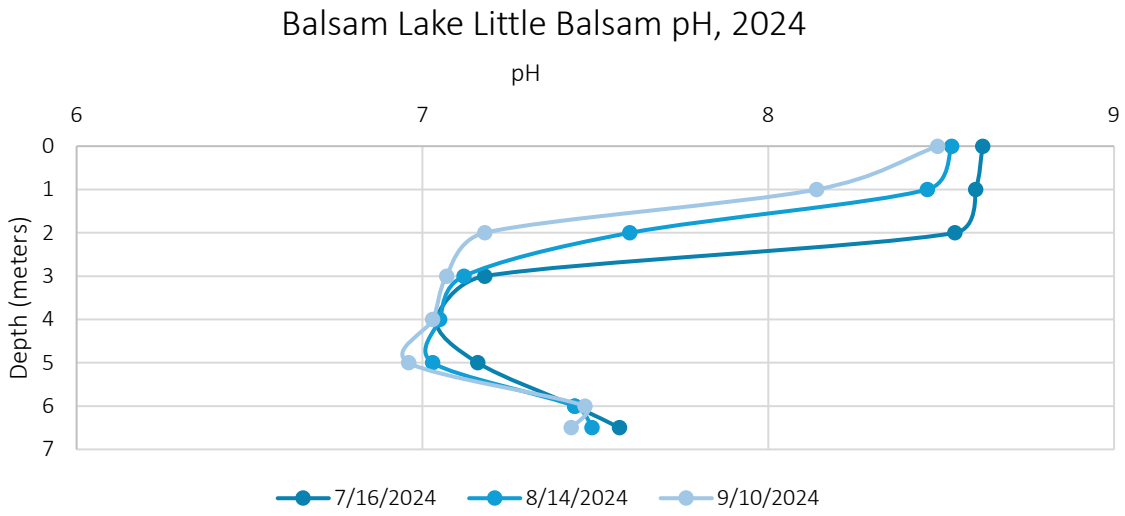
9
10
Depth (meters)
7/16/2024
8/14/2024
9/10/2024

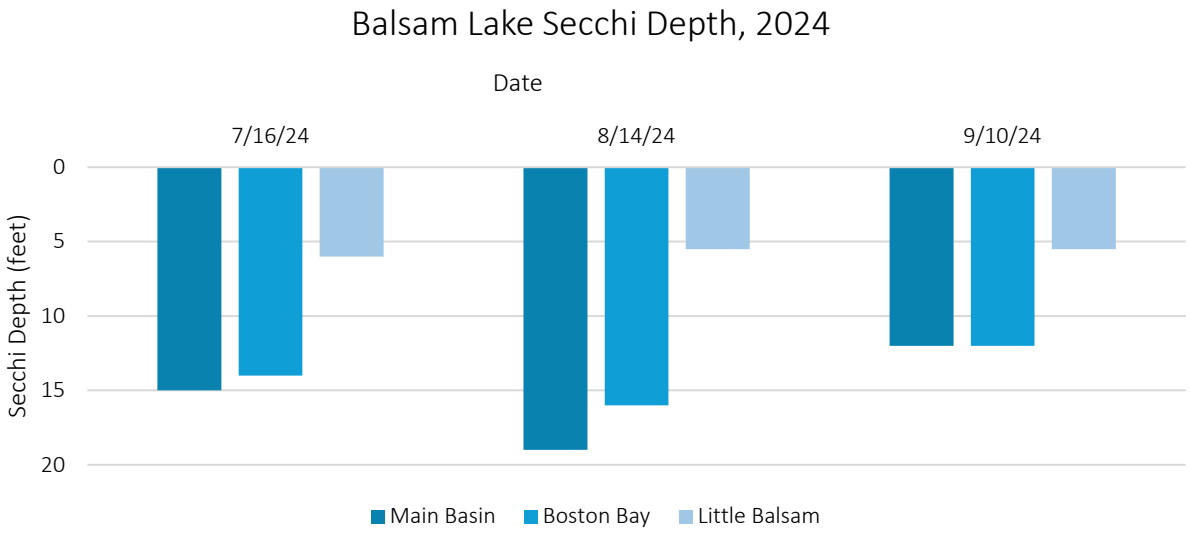

Balsam Lake Little Balsam pH, 2024
pH
6
7
8
9
0
1
2
3
4
5
6
7
Depth (meters)
7/16/2024
8/14/2024
9/10/2024

Secchi Depth

The depth light penetrates lakes is affected by suspended particles, dissolved pigments, and absorbance by water. Often the ability of light to penetrate the water column is determined by the abundance of algae or other photosynthetic organisms in a lake.

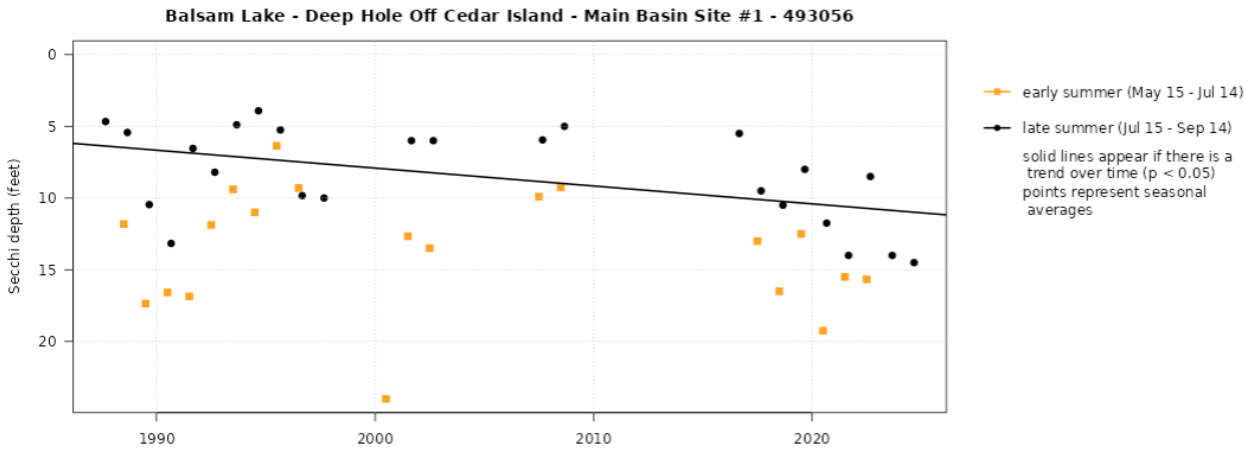
One method of measuring light penetration is with a secchi disk. A secchi disk is an eight-inch diameter round disk with alternating black and white quadrants that is used to provide an estimate of water clarity. The depth at which the secchi disk is just visible is defined as the secchi depth. A greater secchi depth indicates greater water clarity.

Summer average secchi depth in 2024 was 15.3 feet in the Main Basin, 14 feet in Boston Bay, and 5.7 feet in Little Balsam.



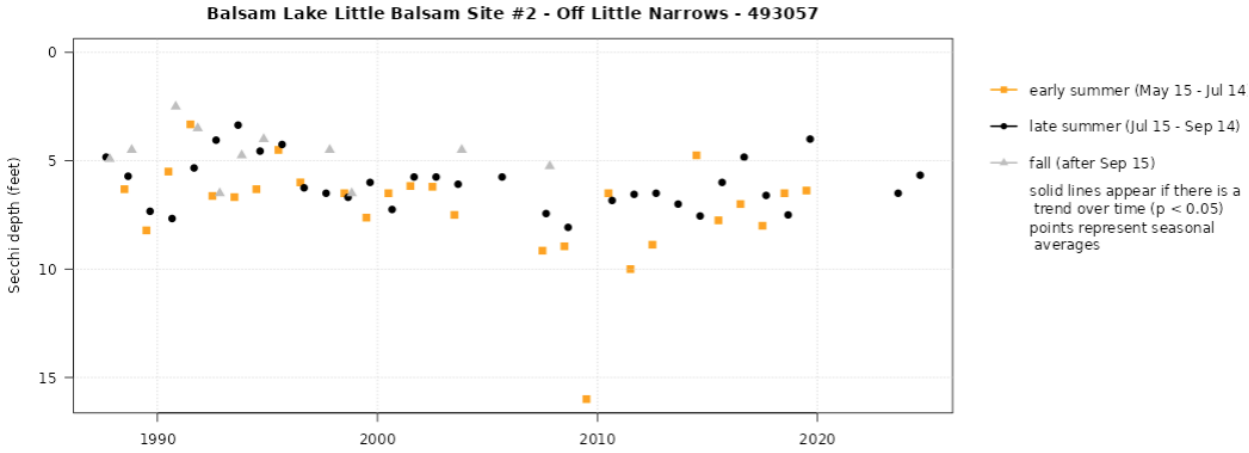
Late summer secchi depth in the Main Basin has increased significantly since 1987. Early summer secchi depth has also increased, although the change is not significant.

Trends in Secchi depth



A trend in increasing secchi depth is also seen in Little Balsam since 1987 although this change is not significant.

Trends in Secchi depth

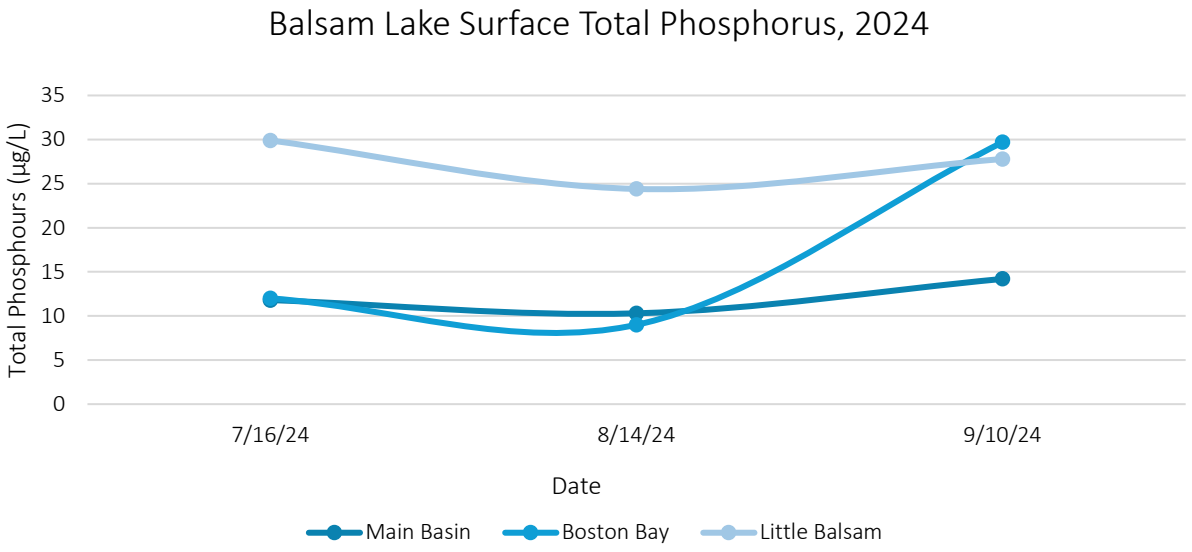


There is not enough data for Boston Bay to analyze trends in secchi depth.

Phosphorus

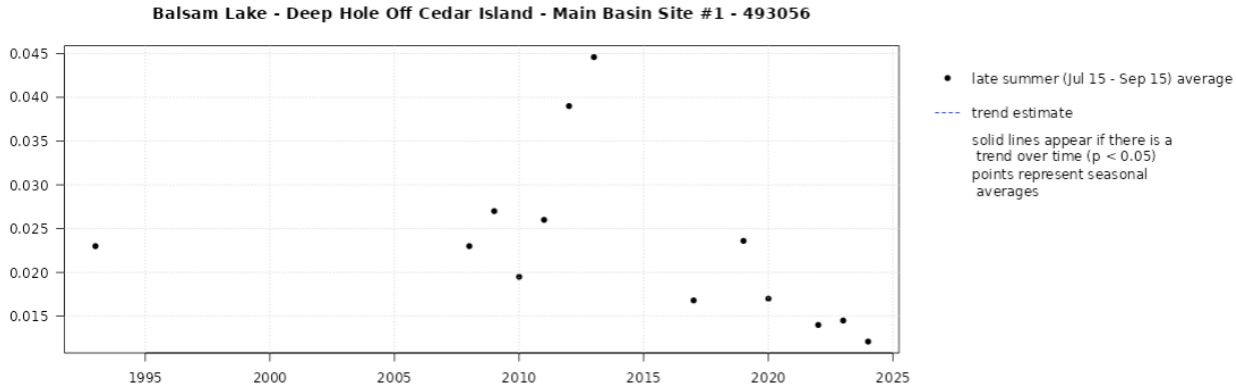
Phosphorus is an element present in lakes which is necessary for plant and algae growth. It occurs naturally in soil and rocks and in the atmosphere in the form of dust. Phosphorus can make its way into lakes through groundwater and human induced disturbances such as soil erosion. Additional sources of phosphorus inputs into a lake can include external sources such as fertilizer runoff from urban and agricultural settings and internal sources such as release from sediment at the bottom of a lake. Excessive amounts of phosphorus can lead to an overabundance of algae growth which can decrease water clarity in lakes.

Total phosphorus is a measure of all the phosphorus in a sample of water. In lakes, a healthy limit of total phosphorus is set at 20 µg/L. If a value is above the healthy limit, it is more likely that a lake could support nuisance algae blooms. Summer average total phosphorus in 2024 was 12.1 µg/L in the Main Basin, 16.9 µg/L in Boston Bay, and 27.4 µg/L in Little Balsam.



Late summer total phosphorus has decreased in the Main Basin since 1993, although the decrease is not significant.

Trends in total phosphorus

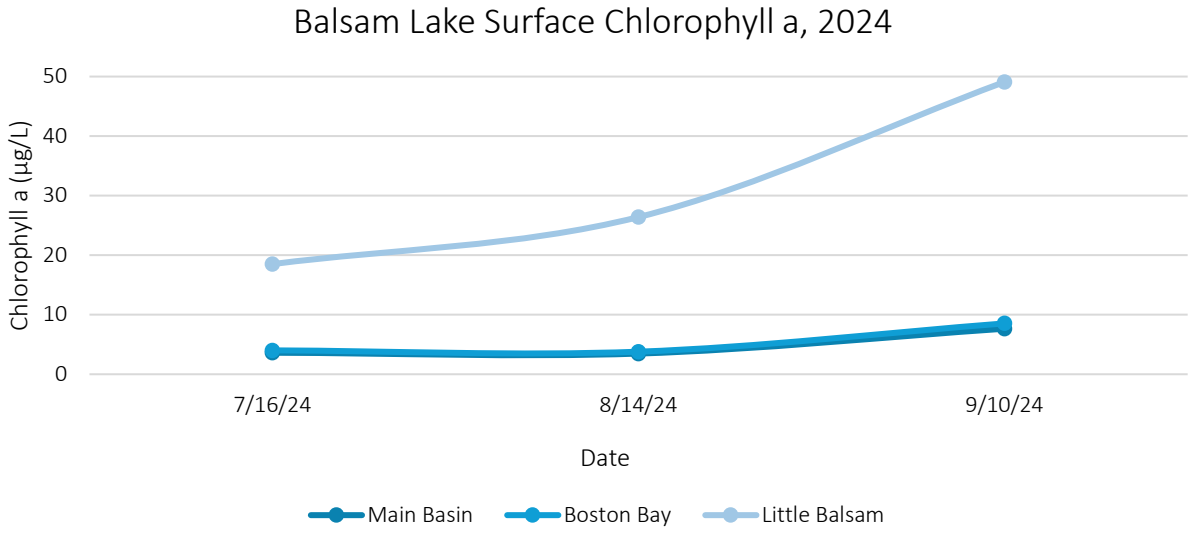


There is not enough data for Boston Bay or Little Balsam to analyze trends in total phosphorus.

Chlorophyll a

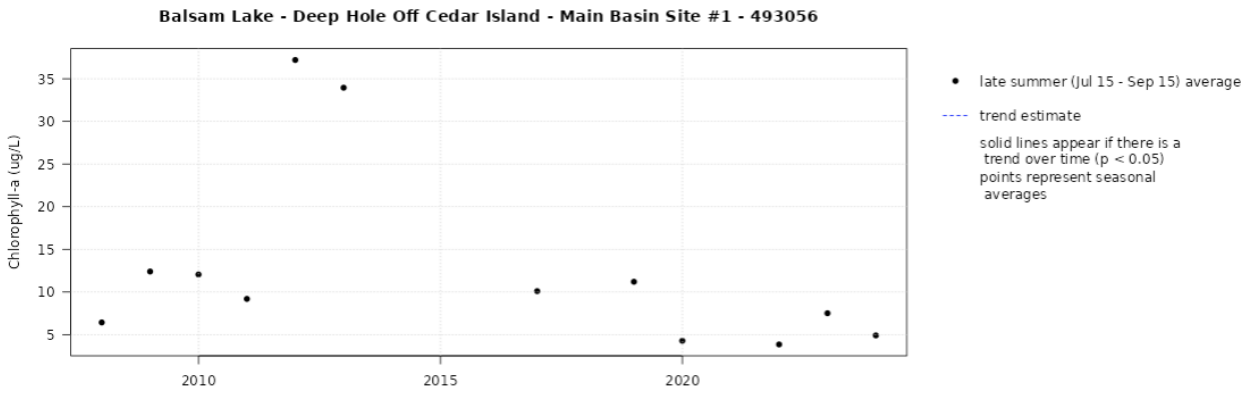
Chlorophyll a is a pigment in plants and algae that is necessary for photosynthesis and is an indicator of water quality in a lake. Chlorophyll a gives a general indication of the amount of algae growth in a lake, with greater values for chlorophyll a indicating greater amounts of algae. However, since chlorophyll a is present in sources other than algae— such as decaying plants— it does not serve as a direct indicator of algae biomass.

Chlorophyll a seems to have the greatest impact on water clarity when levels exceed 30 µg/L. Lakes which appear clear generally have chlorophyll a levels less than 15 µg/L. Summer average chlorophyll a in 2024 was 4.9 µg/L in the Main Basin, 5.4 µg/L in Boston Bay, and 31.3 µg/L in Little Balsam.



Late summer chlorophyll a has decreased in the Main Basin since 1993, although the decrease is not significant.

Trends in chlorophyll-α



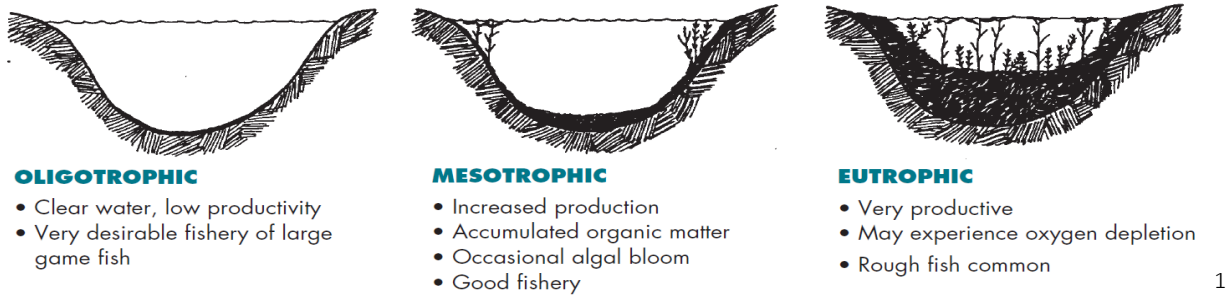
There is not enough data for Boston Bay or Little Balsam to analyze trends in chlorophyll a.

Trophic State Index

Lakes are divided into three categories based on their trophic state: oligotrophic, mesotrophic, and eutrophic. These categories reflect a lake's nutrient and clarity level and serve as an indicator of water quality. Each category is designed to serve as an overall interpretation of a lake's primary productivity.

Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms. These types of lakes are often low in nutrients and are unable to support large populations of fish. However, oligotrophic lakes can develop a food chain capable of supporting a desirable population of large game fish. Eutrophic lakes are generally high in nutrients and support many plants and animals. They are usually very productive and subject to frequent algae blooms. Eutrophic lakes often support large fish populations but are susceptible to oxygen depletion. Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

All lakes experience a natural aging process which causes a change from an oligotrophic to a eutrophic state. Human influences that introduce nutrients into a lake (agriculture, lawn fertilizers, and septic systems) can accelerate the process by which lakes age and become eutrophic.

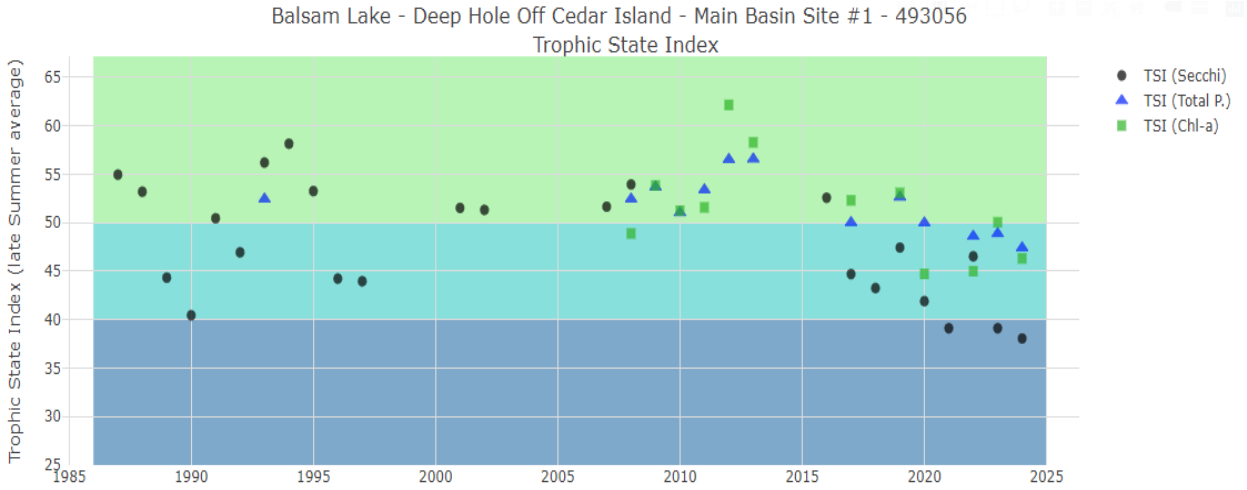


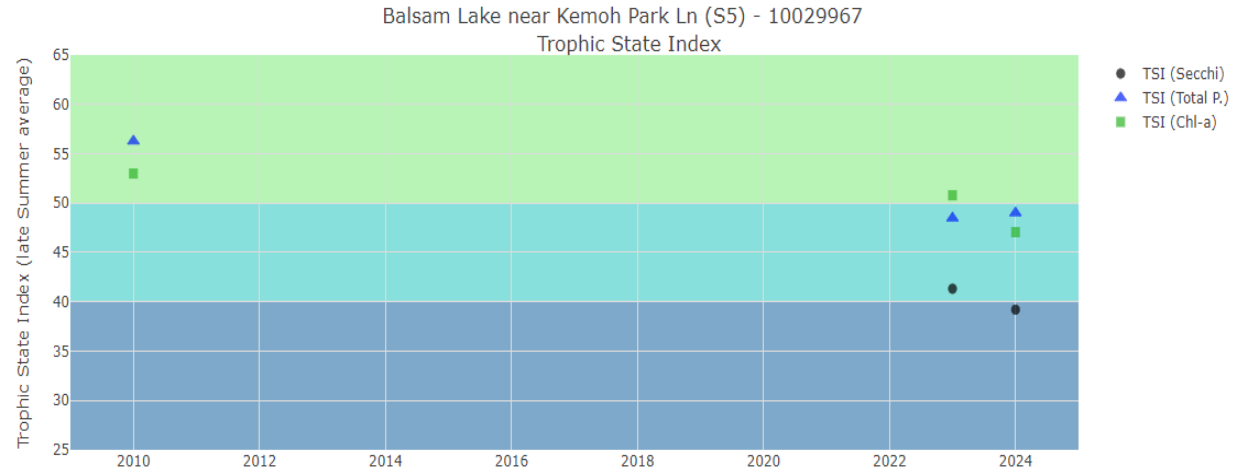
[1]

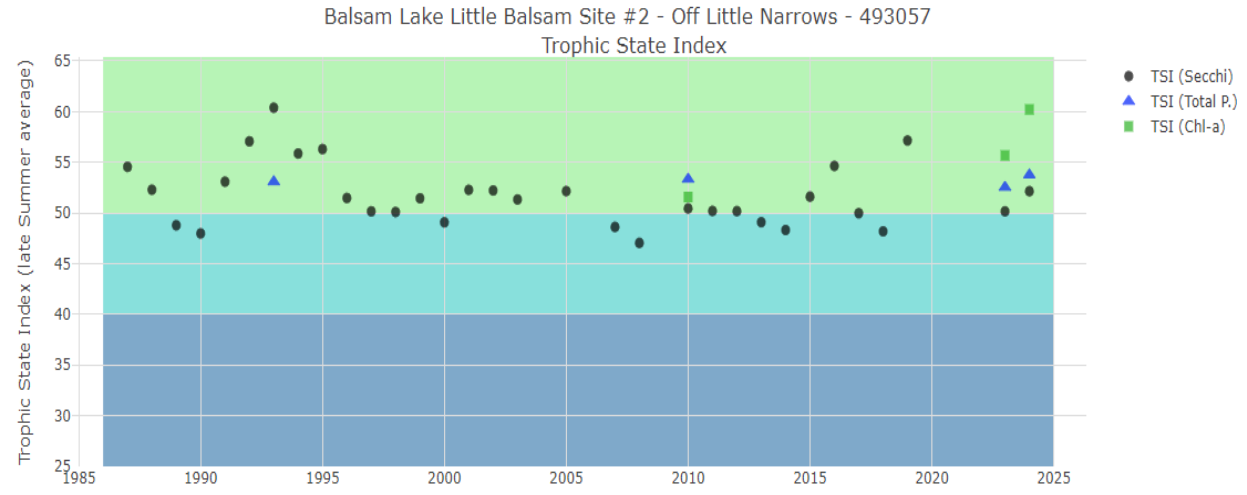
A common method of determining a lake's trophic state is to compare total phosphorus (important for algae growth), chlorophyll a (an indicator of the amount of algae present), and secchi disk readings (an indicator of water clarity). Although many factors influence these relationships, the link between total phosphorus, chlorophyll a, and secchi disk readings is the basis of comparison for the trophic state index (TSI).

[1] Figure from Understanding Lake Data (G3582), UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004.

Values for Trophic State Index generally fall within mesotrophic conditions in the Main Bain and Boston Bay. Values for Little Balsam indicate eutrophic conditions.







Bottom Chemistry

Bottom samples were analyzed for total phosphorus and iron. If oxygen is available in the hypolimnion, iron forms sediment particles that store phosphorus in the sediments. However, when lakes lose oxygen in the winter or when the hypolimnion becomes anoxic in the summer, these particles dissolve and phosphorus is redistributed throughout the water column with strong wind action or turnover events. This process is termed internal loading.

Summer average bottom total phosphorus in 2024 was 201 µg/L in the Main Basin, 76.4 µg/L in Boston Bay, and 285 µg/L in Little Balsam.

Summer average bottom iron in 2024 was 2.5 mg/L in the Main Basin, 0.7 mg/L in Boston Bay, and 19.3 mg/L in Little Balsam.

Bottom total phosphorus levels were elevated, indicating that phosphorus is being released from the bottom sediments in all three basins. However, because each basin is stratified (has set up density dependent layers) the phosphorus is primarily staying in the bottom waters where it is unavailable for algae growth.