2025 Sebago Lake Assessment

Portland Water District
Sebago Lake Watershed Monitoring Programs
Lake Monitoring

Presenting data from 1976 to 2025

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Introduction

Sebago Lake is the primary drinking water supply for nearly 200,000 people in 11 Greater Portland communities. Lake water was first delivered to Portland in 1869 from an intake in the southernmost part of the lake, known as Lower Bay. In 1908, the Portland Water District was chartered by the Maine Legislature to provide water services to the cities of Portland and South Portland. The water system has gradually expanded to include 11 cities and towns in Greater Portland. Since its inception, the District has been actively monitoring and protecting Sebago Lake.

In 1993, the District was granted a waiver to the filtration requirements of the federal Safe Drinking Water Act (SDWA) based in part on the purity of the water and the effectiveness of watershed protection efforts. This waiver agreement requires ongoing monitoring of lake water quality. The District maintains more than 10 monitoring and surveillance programs throughout the watershed and lake. In general, as one moves closer to the intakes, more samples are collected and tested for more parameters.

This report summarizes the results of the Lake Monitoring Program.

Methods

Lake profile sampling events occur once a month from May to November. Three deep stations at the maximum depths in Lower Bay, Big Bay, and Jordan Bay are monitored for total phosphorus, chlorophyll *a*, Secchi disk transparency, and dissolved oxygen/temperature profiles. Epilimnetic core samples are analyzed for chlorophyll *a* and total phosphorus concentrations. Secchi disk transparency is measured, and dissolved oxygen and temperatures are recorded every meter from the lake surface to the bottom. Data from the Lower Bay deep basin station are used in this assessment. The Lower Bay data set spans the longest available monitoring period for Sebago Lake.

Secchi Disk (SD)
Secchi disk transparency measurements are among the easiest, cheapest, and most recognizable lake water quality parameters. The disk represents a measure of water clarity. Things that interfere with transparency are: algae, silt, detritus, and color. Sebago Lake has essentially no color and has sufficient water volume in its deep basins that Secchi transparency can be considered a surrogate for algal productivity. Larger values indicate greater water transparency and, therefore, better water quality.

Total Phosphorus (TP)
Phosphorus is the least abundant nutrient in freshwater systems and is considered the limiting factor of biological productivity in Maine lakes. Phosphorus exists in numerous chemical forms, some of which are readily available to freshwater biota, and others are not. Simple dissolved phosphorus is readily absorbed by algae, while complex colloidal organic-bound phosphorus typically sinks to the bottom of a lake and becomes bound in the sediment under oxygen-saturated conditions. Total phosphorus is a measure of all molecular forms of phosphorus.

Chlorophyll a *(CHL)*
Chlorophyll *a* is the photosynthetic pigment found in algae. Measuring this green pigment is a surrogate for estimating total algal biomass in a lake. There are numerous methods to quantify the "greenness" of a lake.

The Portland Water District takes an epilimnetic core sample down to, but not including, the thermocline as determined by the temperature/dissolved oxygen profile. The sample is filtered through a 0.45 *um* glass fiber filter, preserved with $MgCO_3$, and frozen. Samples are ground with a Teflon glass tissue homogenizer and soaked in acetone for 4 hours. Samples are analyzed on a spectrophotometer using the trichromatic method.

Results and Discussion

There are numerous ways to assess and analyze trends in lake water quality data over time. Each way sheds new light on the lake system. This season, the decision was made to analyze Lower Bay by itself. The Lower Bay has the longest data record. We are also including some different statistical methods for analyzing the data.

Percent Annual Change
The percent annual change (PAC) indicates how much the key variables change, if at all, each year. PAC = (slope/mean value of variable) * 100. The slope is (x) for the best-fit regression line (y = mx+b) of the data. The mean value of the variable is simply the average of the entire data set. If the slope (x) of the line is not significant, the PAC becomes 0.

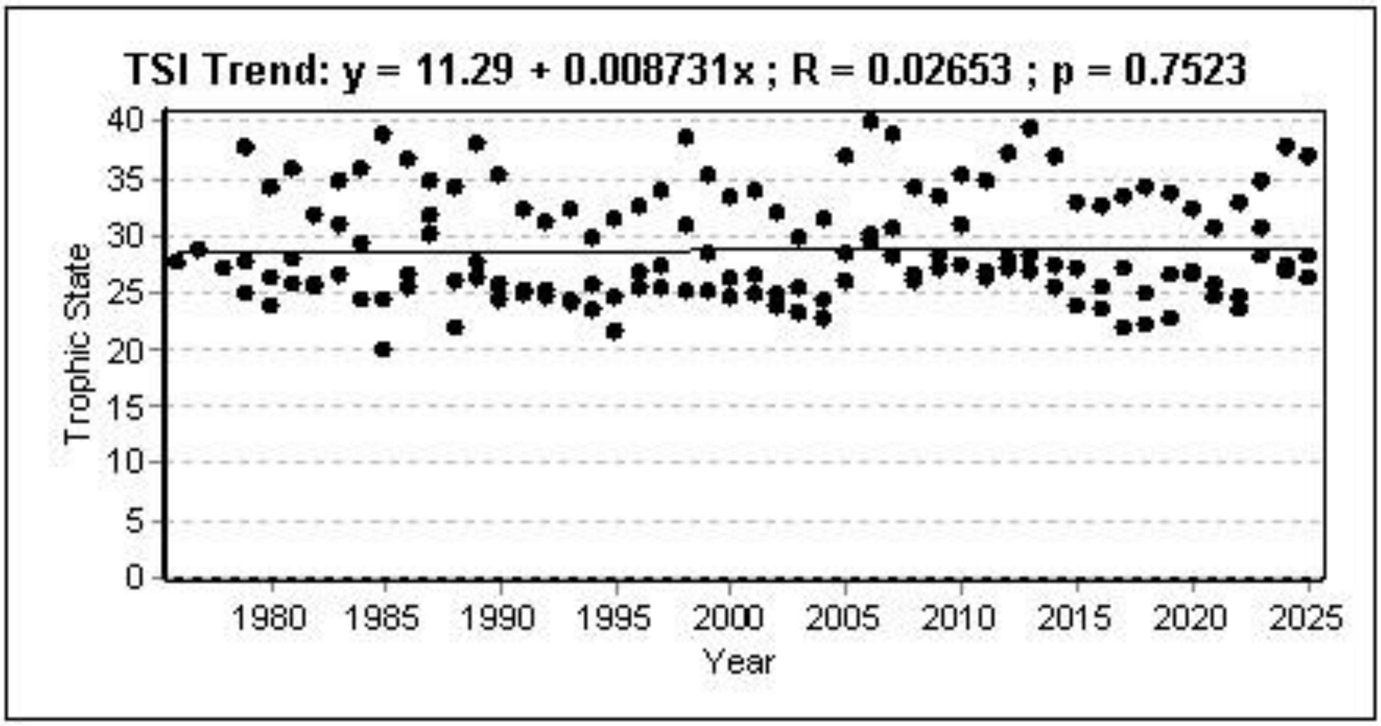
Trophic State Index
The Trophic State Index (TSI), a measure of a lake's relative "productivity," is calculated from Secchi disk, total phosphorus, and chlorophyll *a* measurements. The three TSI values are plotted on one graph (the y axis is the three individual TSI values), and the x axis is the year. A trend line is calculated for the TSI values, giving the rate of TSI change per year. Three independent water quality parameters plotted on a single graph provide greater accuracy than a single parameter alone. A p-value is calculated for the regression line fitted to the data. The p-value indicates the significance level of the regression line. A low p-value means there is a low probability that the line is due to random chance (e.g., if $p = 0.05$, then there is a 5% chance the trend is due to random chance).

Lower Bay Percent Annual Change and Trophic State Index

The SD, TP, CHL and HVOD show an average percent annual change of 0.0 % per year (p= 1.00) and a TSI change of 0.0 TSI units +/- 0.0 TSI units per year (p= 0.75). **This indicates no water quality change.**

Percent Annual Change (PAC)

Lake	Chla (mg/m3)	SD (m)	TP (mgP/m3)	TN (mg/m3)	HVOD (mg/m3/day)	Avg PAC	Std Err	P-Value
Change - Units Per Year	(0.00)	(0.00)	(0.01)		(-0.12)			
Average Over Period	(1.47)	(10.46)	(4.41)		(18.78)			
Percent Annual Change (%/Year)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.00**



SUMMARY:

PAC = 0.00 ± 0.00 % per year
P-Value = 1.00

TSI Value = 28.77 ± 0.38 TSI units
TSI Trend = 0.01 ± 0.03 TSI units per year
P-Value = 0.7523

ASSESSMENT:

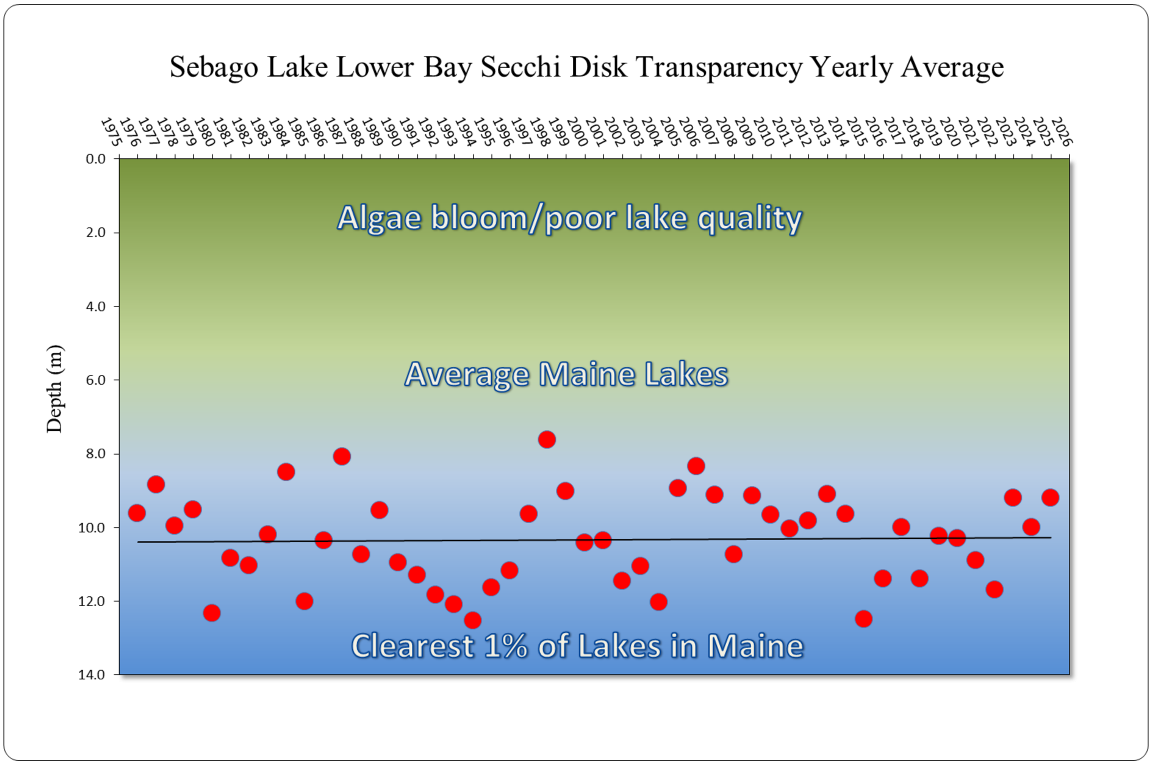
No Change

The guide used in the PAC average P-Value evaluation is

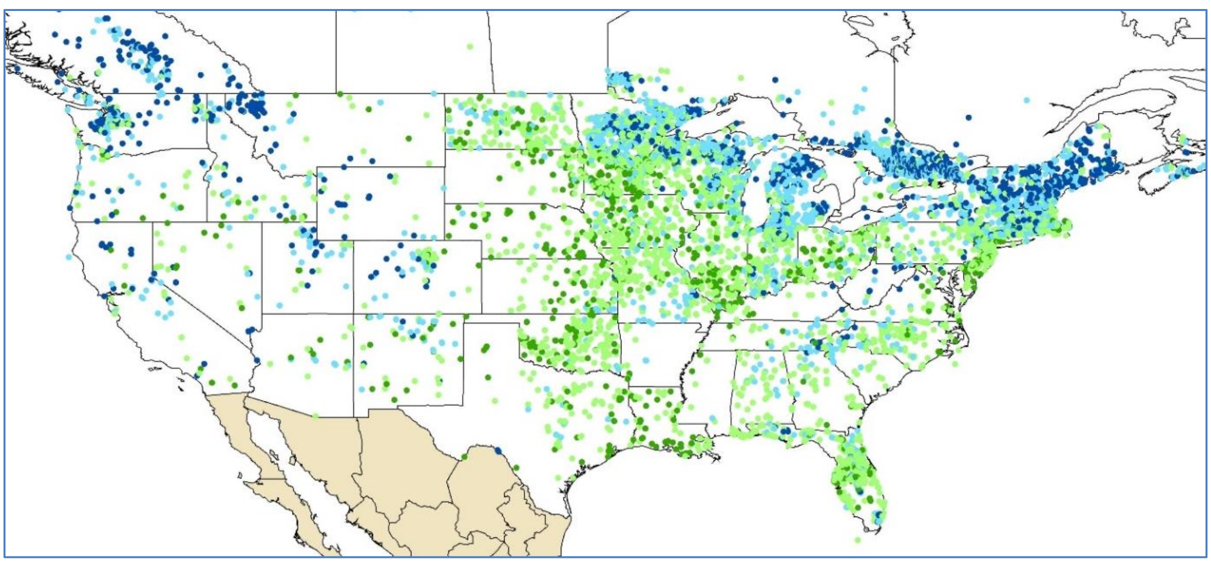
P-Value Range	Interpretation
P ≤ 0.1	Definite Change
0.1 < P ≤ 0.2	Probable Change
0.2 < P ≤ 0.3	Possible Change
0.3 < P	No Change

Lower Bay Transparency

The average Secchi Disk Transparency in Lower Bay since 1976 is 10.3 meters. The linear regression trend since 1976 shows no statistical change. Sebago Lake is consistently one of the clearest lakes in Maine.

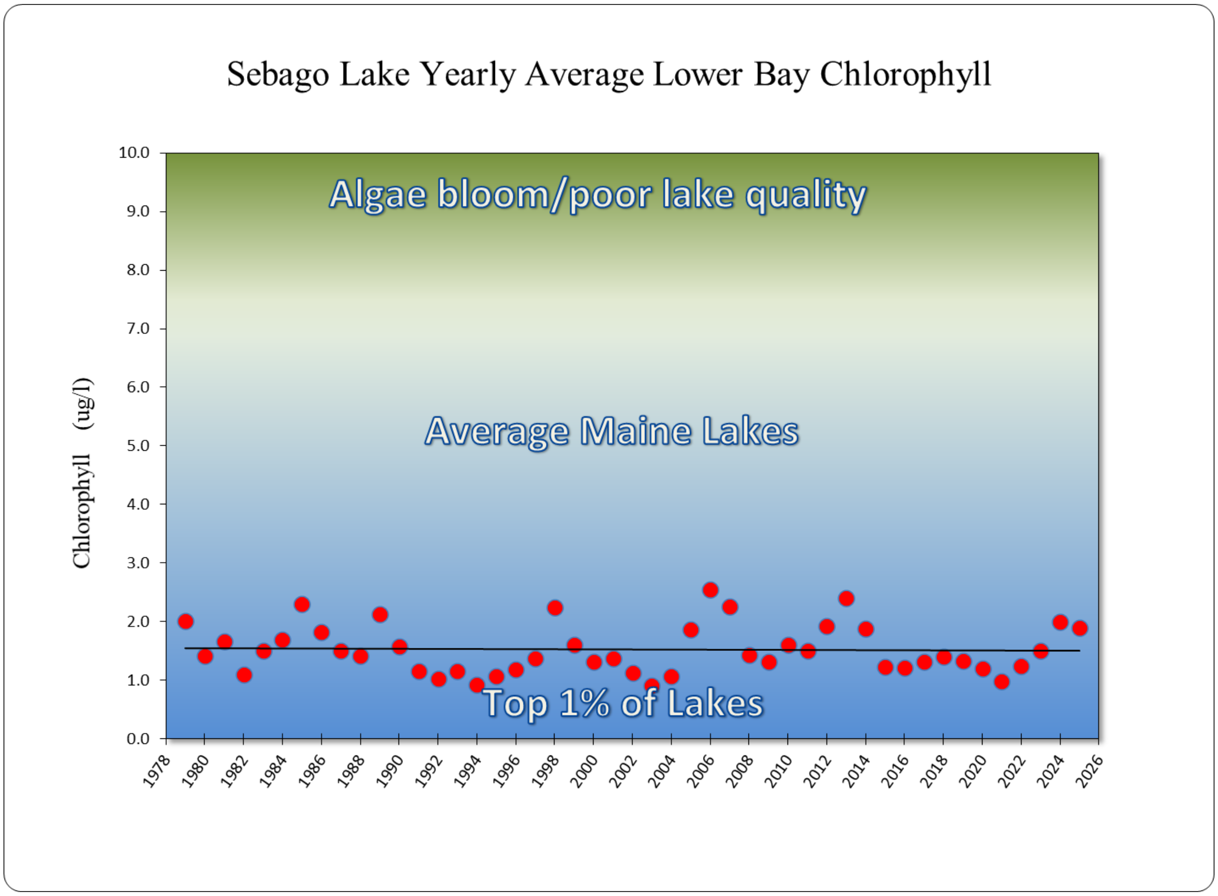


Dots on the map correspond to Secchi Disk readings. Dark blue dots represent clear lakes while dark green dots represent algal bloom lakes. Northeast United States has some of the clearest lakes in America and Sebago Lake is one of the clearest lakes in the Northeast.



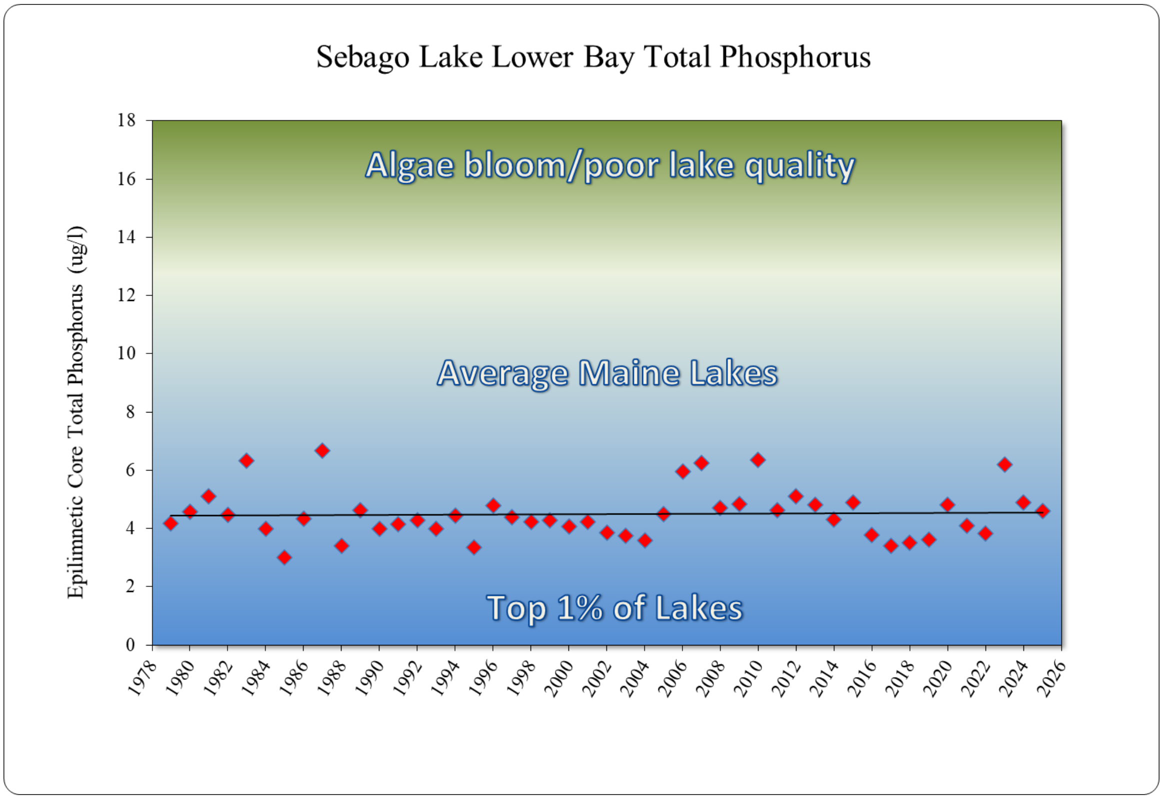
Lower Bay Chl a

The average chlorophyll *a* in Lower Bay since 1979 is 1.5 ug/L. The red dot on the chart represents the yearly average. The linear regression trend since 1979 shows no statistical change. There has been **no change in the chlorophyll concentration in Lower Bay since 1979.**



Lower Bay Total Phosphorus

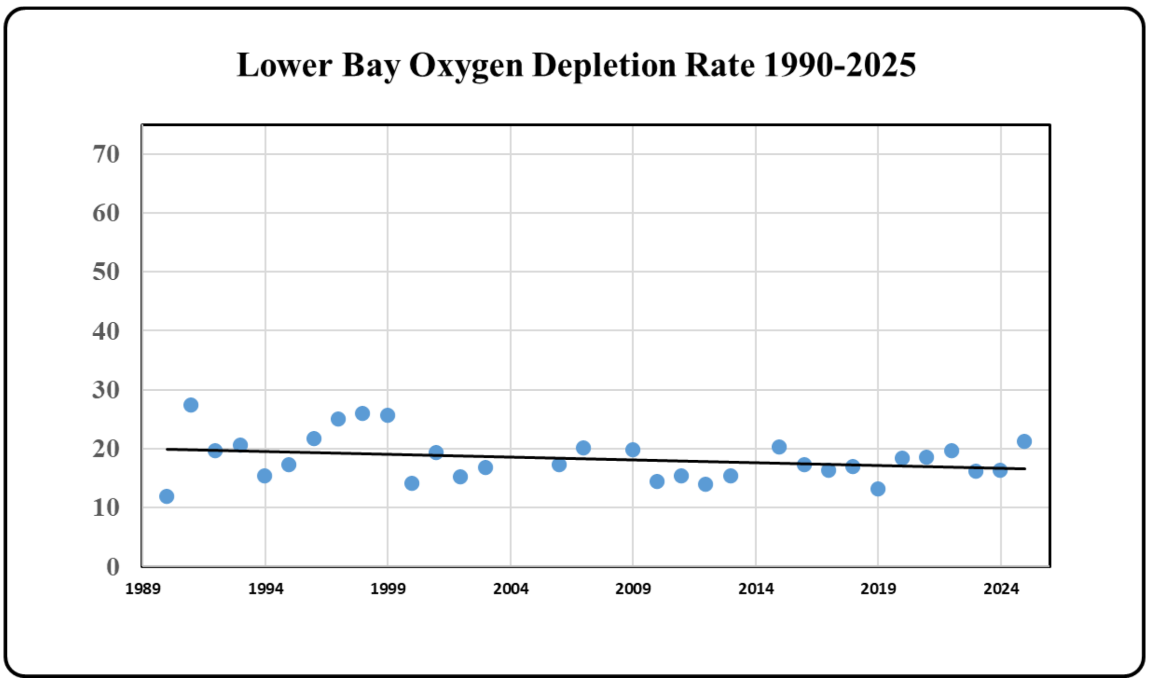
The average Total Phosphorus in Lower Bay since 1979 is 4.5 ug/L. The red dot on the chart represents the yearly average. The linear regression trend since 1979 is flat. There has been **no change in the Total Phosphorus of Lower Bay since 1979.**



Hypolimnetic Dissolved Oxygen Depletion Rate

Hypolimnetic oxygen depletion occurs when organic matter, dead algae cells, leaves, zooplankton, etc, sink to the bottom of the lake and are consumed through bacterial decomposition. This loss of oxygen is empirically related to primary productivity of algae, phosphorus concentrations, and mean summer water temperatures, and inversely related to Secchi disk transparency. This hypolimnetic oxygen loss assumes that the organic matter from the photic zone is reflected in hypolimnetic oxygen consumption. There are many other factors, such as hypolimnetic thickness, within-season variation in depletion rates, phytoplankton composition, and temperature, that affect dissolved oxygen loss rates. If done properly, HVOD (mg/m3/day) can be used to compare primary productivity in a lake over time.

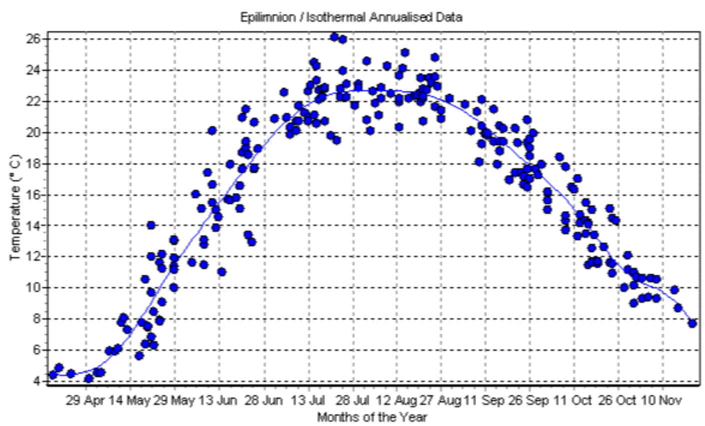
Results show that the hypolimnetic dissolved oxygen depletion rate (HVOD) is decreasing over time. The p-value at standardized temperature is < 0.05. In the simplest terms, there is an 95% chance that the dissolved oxygen concentration at the bottom of the lake will remain higher for a longer period of time. We can conclude that hypolimnetic primary productivity and respiration rates in the Lower Bay are gradually slowing.

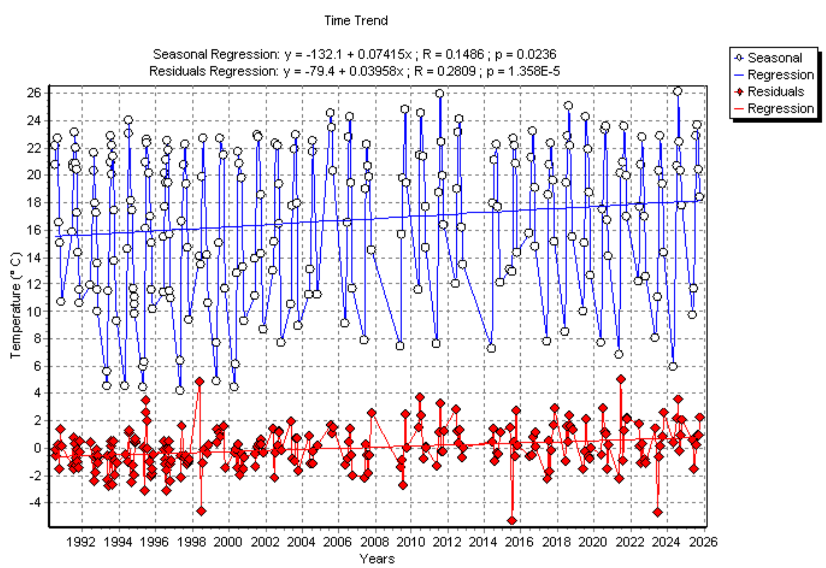


Temperature Trends

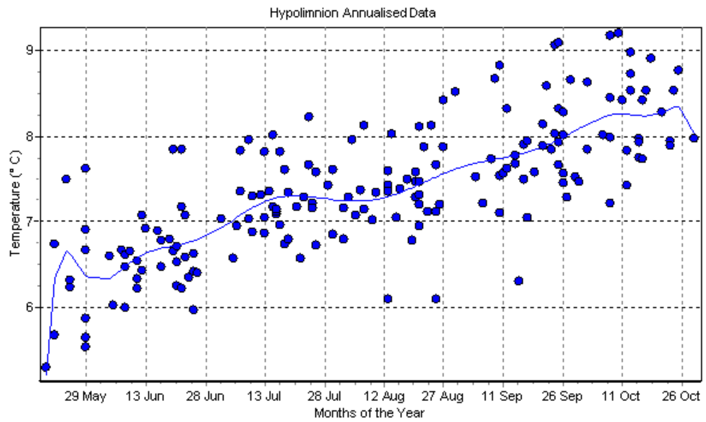
Monthly (epilimnetic/isothermal and hypolimnetic) average entire-profile temperatures, measured since 1990, are plotted as a function of the time of year of collection, with no regard for year. This process is called "anualizing" data. A best-fit polynomial curve was fitted to the annualized data. This provides an expected temperature for a given day of the year. A residual value is then calculated by the observed value minus the annualized value from the polynomial for its day of observation. This yields a residual value that is either +/- the expected value for that time of year.

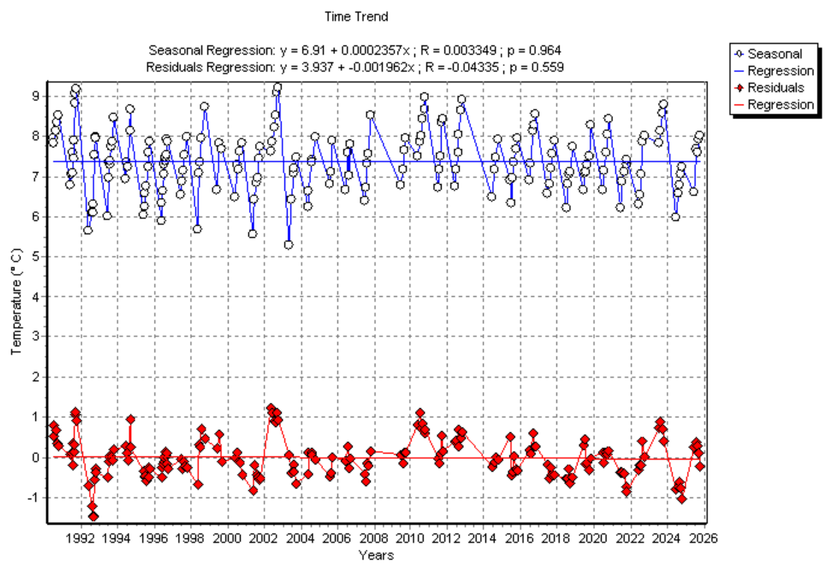
The observed and residual data are plotted against time, and straight-line fits are obtained using ordinary least-squares regression. A p-value is calculated for the lines fitted to the observed and residual data. A low p-value indicates that the trend in the data is unlikely to be due to chance. The residual data are considered "deseasonalized" because they are corrected for the expected temperature for that day of the year. Residual data trends are considered more legitimate than observed data because they are corrected for the time of year (spring, summer, or fall) typical of temperate climates.





Results show that Epilimnetic/Isothermal temperatures have risen 4.7 degrees F in Sebago Lake since 1990. ($p <$ 0.02)





Results show that Hypolimnetic temperatures have not changed in Sebago Lake since 1990. (p = 0.96)

Conclusion

2025 was a worse-than-average year for Sebago Lake water quality. The trophic state of Sebago Lake (based on the Lower Bay sampling station) has been stable since 1976. We focused on the Lower Bay dataset because it is the longest available. There are cyclical changes in the data set. However, the long-term trend is stable.

With cyclical data, linear regression analysis can sometimes give misleading results. This is because the line's slope depends on the time period of the analysis. If data collection begins at a high point in a cycle and ends at a low point, linear regression will have a negative slope. The opposite is also true; if data collection begins in a trough and ends in a peak, the slope will be positive. This may lead to false conclusions (Foster 2011).

Linear regression becomes more valuable for determining whether successive peaks are getting higher and successive valleys are getting lower with a large data set encompassing numerous periods of peaks and valleys. It can also be useful to analyze water quality data with different statistical methods. Often, different statistical analyses can yield greater insight into the data (Whalen 2011).

Fortunately, hypolimnetic oxygen levels appear to be nearly saturated and stable over time. This phenomenon only occurs in the clearest, most biologically unproductive lakes. Monitoring and understanding the hypolimnetic dissolved oxygen depletion rate is a key element for assessing lake water quality. The oxygen/sediment interface plays an important role in the internal recycling of phosphorus and ultimately lake primary productivity.

Sebago Lake water quality has been worse than average for the past two years. Some of this can be attributed to the greater-than-average precipitation for the past two years.

References

Burns, N.M., J.C. Rutherford and J.S. Clayton. 1999. A monitoring and classification system for New Zealand lakes and reservoirs. Lake and Reserv. Manage. 15 (4):255-271.

Whalen, Nathan S. 2011. Characterization of Sebago Lake Lower Bay Trophic State Since 1976

Foster, Grant. 2011. Sebago Lake Water Quality

Current and Historical Portland Water District
Sebago Lake Profile Sampling Stations