Lake Water Quality Reports

The Lake Water Quality Monitoring Reports contain summaries for measurements most often used to describe the water quality of lakes and ponds in Maine. The heading of the lake report displays the lake name, MIDAS number (lake ID), and sampling station. Monitoring data for each lake and pond are organized into separate tabs:

Lake Information	Secchi Transparency	Trophic & Chemistry Data	Temperature & Oxygen Profiles	Water Quality Trends	Fish List

The information contained within each tab is summarized in the sections below.

Lake Information

This section contains general information about the lake, such location (town, county, Maine DeLorme atlas map number), elevation, depth, surface area and drainage area. The term “true basin” is different from “sampling station” and is used to define areas within a lake that are hydrologically separated by shallow reefs or shoals and therefore function as separate lakes. There are approximately 50 lakes in the state that have more than 1 true basin. Flushing rate is the number of years the volume of water in a lake is replaced. For example, a lake with a flushing rate of 2.0 flushes twice per year. A lake with a flushing rate of 0.5 flushes once every two years.

The map on the bottom left shows the outline of the lake and the location of the sampling station. The map to the right shows the location of the lake in the state; the regions depicted in this map represent the three lake regions of Maine: Coastal, Inland, and Northern (Figure 1). More information about these regions and how they help to understand lake condition may be found in this article.

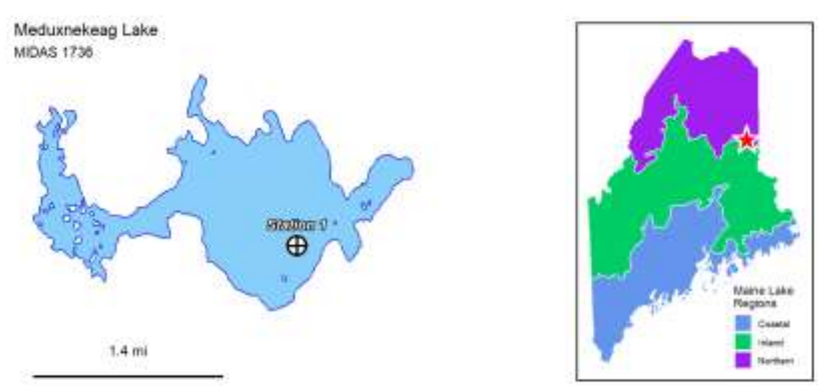

Figure 1. Example maps of a lake and sampling station (left) and the location of the lake in Maine (right).

Secchi Transparency

Secchi Disk Transparency (SDT) is a measure of the water clarity, or transparency, of the lake. All Secchi disk readings are in meters (1 meter (m) = 3.28 feet). Factors which reduce clarity include algae, zooplankton, water color and silt. Since algae are generally the most abundant of these factors, measuring transparency indirectly measures algal production. SDT readings can be used to track changes in water quality over time. Transparency values in Maine have ranged from less than 0.5 m (about 20 inches) to 21.3 m (70 ft; Jordan Pond in Bar Harbor on May 27th, 1999), with an average of about 5.5 m (18.0 ft) across all Maine lakes. Unless a lake is highly colored (see explanation of water color below) or another factor is interfering, a transparency of less than 2 m (6.6 ft) indicates that excess nutrients in the lake have resulted in an algae bloom. In Maine, average SDT readings relate to algal productivity using the following guidelines: Productive = 4 m (13 ft) or less; Moderately Productive = 4 - 8 m (13 - 26 ft); Unproductive = 8 m (26 ft) or greater.

Two SDT graphs are displayed in this section of the lake report if transparency readings have been collected at the lake. The first graph represents the average SDT readings for each year data are available (Figure 2). The Secchi disk symbols indicate the average SDT value for each monitoring year, and the tick marks represent the minimum and maximum Secchi disk readings for that year. This graph allows tracking of water quality over many years. The second graph shows monthly readings during the open water season of the previous year if data were collected (Figure 3).

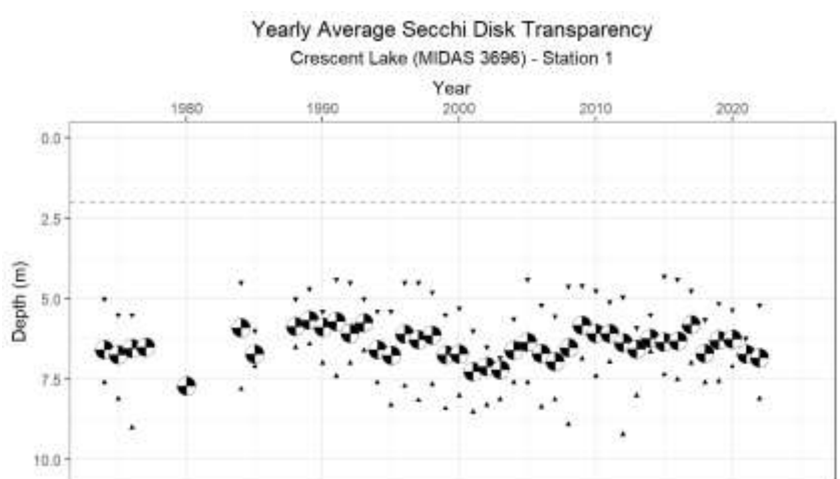

Figure 2. Example plot of yearly average Secchi Disk Transparency readings.

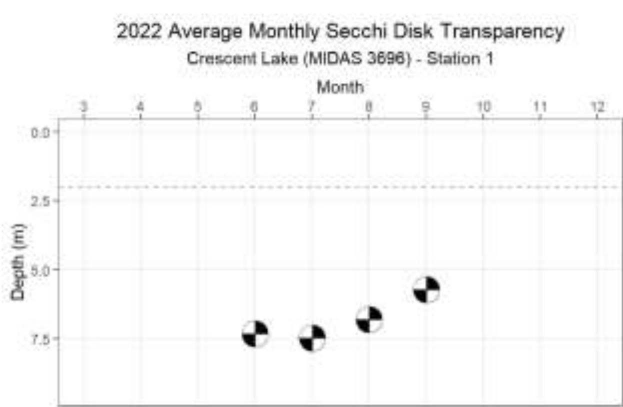

Figure 3. Example plot of average monthly Secchi Disk Transparency readings.

Trophic & Chemistry Data

Trophic is an ecological word used in relation to how organisms acquire food or nutrients. In lake science, the word is used to describe factors involved with nutrient levels in the lake. More specifically, it is used in relation to the availability of nutrients (primarily phosphorus) that stimulate algae growth. This relationship affects all other biological activity in the lake. Chemistry data relates to measurements that describe various characteristics of the water in a lake. These characteristics can provide clues as to how the lake is being affected by biological processes in the lake as well as how the lake is being influenced by runoff from its watershed. The information in this tab is separated into three components:

- The first row of values are the overall averages for a trophic and chemical measurements taken from the lake across all years. Missing values indicate that a measurement has never been collected from the lake.
- Next, there is a plot that contains several pieces of information: the ranges of values of seven trophic and chemical measurements for most Maine lakes (95th percentiles; represented by colored bars), the state average value for each measurement (thick black line), and the expected range of each parameter for the particular lake type (cross-hatched area). The grand average for the lake (i.e., the average across all years of data collection) is represented by the white diamond. (Figure 4).
- Lastly, there is a table of yearly average values for each measurement. Missing values indicate that that measurement was not taken from the lake in that year.

The different trophic and chemistry measurements discussed in this section are described below.

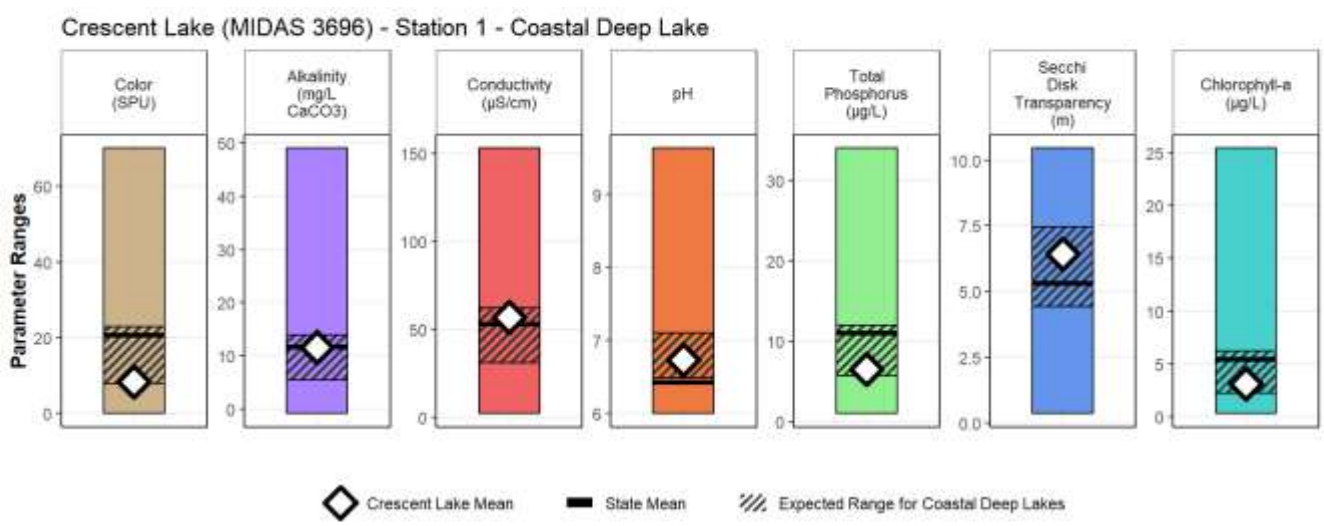

Figure 4. Example plot of trophic of chemistry measurement data.

- **COLOR**: The amount of "color" in a lake refers to the concentration of natural dissolved organic acids such as tannins and lignins which can give water a tea color. Color is measured by comparing a sample of the lake water to Standard Platinum Units (SPU). Highly colored lakes (>30 SPU) show reduced transparency readings due to the color of the water. The lake reports display "True Color" data, which is the color of the lake water after all particulates (including algae cells) have been filtered out. True Color ranges from 0 to 197 SPU in Maine lakes, with an overall average of 20.7 SPU.

Epilimnion: the warmer top layer of water in a stratified lake which rests on top of cooler bottom waters. The epilimnion is the section of the lake that usually receives the most light, wind activity, and mixing, and contains most of the biological organisms living in the lake. Many water samples are taken from the epilimnion because of its importance to the biota and productivity of the lake.

- **pH**: The pH of a lake reflects how acidic or basic the water is and helps determine which plant and animal species may be present in the lake. The measure of the acidity of water is based on a scale of 1-14, with a value of 7 indicating neutral acidity. The pH of acidic waters is below 7; basic waters have pH values above 7. A one unit change in pH represents a 10-fold change in the concentration of hydrogen (H^+) ions, which determine the acidity of water. Epilimnetic pH samples in Maine lakes can vary from 4.2 to 9.6 in Maine, with an overall average of 6.8.

- **ALKALINITY**: Alkalinity is a measure of the capacity of water to neutralize acids. This can also be described as the *buffering capacity* of the water. Alkalinity in lakes is primarily governed by watershed geology and is affected by the presence of naturally available bicarbonate, carbonate, and hydroxide ions. It is an important factor for lake organisms that are sensitive to fluctuations in pH levels. Epilimnetic alkalinity samples in Maine lakes have varied from -1.5 milligrams per liter (mg/L) to 190.0 mg/L, with an overall average of 11.7 mg/L.

- **CONDUCTIVITY**: Conductivity measures the ability of water to carry an electrical current and is directly related to the dissolved ions (charged particles) present in water. Conductivity is measured in microSiemens per centimeter (µS/cm). 95% of Maine lakes have epilimnetic specific conductivity values below 95.3 µS/cm. Lakes that are influenced by ocean water, and therefore contain marine-derived salt-based ions in the water, can have conductivity values in the tens of thousands (the highest conductivity ever recorded from a Maine lake was at West Harbor Pond in Boothbay Harbor, on the Maine coast, at over 25,000 µS/cm). Alternatively, lakes with very low concentrations of ions can have conductivity below 3.0 µS/cm. Conductivity will increase if there are pollutants entering the lake or pond from residential or urban areas and roadways; stormwater runoff containing road salt is the most common pollutant in Maine lakes that can raise conductivity values. The average conductivity for all Maine lakes is 53.0 µS.cm.

- **TOTAL PHOSPHORUS:** Phosphorus is one of the essential nutrients needed for plant growth. It is generally present in the smallest amount of all essential nutrients in lakes and is therefore usually the nutrient *limiting* the growth of algae in lakes. As phosphorus increases, generally the amount of algae in a lake also increases. It is measured in micrograms per liter (µg/L), which is equivalent to parts per billion (ppb). The term "total phosphorus" (or TP) refers to all forms of phosphorus in the lake; for example, TP includes phosphorus that is both dissolved in the water and also in particulate form, such as the phosphorus contained in algae cells. Maine lakes show variation in Epilimnetic TP from 1.0 µg/L to over 426.0 µg/L, with an overall average of 11.1 µg/L. Phosphorus is sampled in various ways, each of which are noted in the lake report with the following codes: EC = Epilimnetic Core sample, which is a mixed sample from the warmer surface layer or epilimnion; SG = Surface Grab, a sample taken at the water's surface; BG = Bottom Grab, a sample taken near the bottom of lake (bottom grab results that are higher than epilimnion or surface results can indicate that internal recycling of phosphorus is occurring), PG = Profile Grabs, in which samples are taken at regular depth intervals from the surface to the bottom and the values are averaged.

- **SECCHI DISK TRANSPARENCY**: See above for description of Secchi Disk Transparency (SDT) data. Secchi data are presented in the following formats here: Min = minimum (or shallowest) Secchi disk depth reading recorded; Avg = average of monthly averages of Secchi disk reading; Max = maximum (or deepest) Secchi disk reading taken; n = number of months with readings taken; b = number of times Secchi disk was observed touching the bottom of the lake.

- **CHLOROPHYLL-*a*:** Chlorophyll-*a* is a measurement of the green pigment found in all plants including microscopic plants such as algae. It is measured in micrograms per liter (µg/L), which is equivalent to parts per billion (ppb). Chlorophyll-*a* is used as an estimate of algal biomass in the lake; the higher the Chlorophyll -*a* value in a water sample, the higher the concentration of algae in the lake. Epilimnetic Chlorophyll-*a* has varied from 0.3 ppb to 182 ppb in Maine lakes, with an average of 5.4 ppb. The following data are presented here: Min = minimum or lowest Chlorophyll -*a* observed; Avg = average Chlorophyll -*a* reading; Max = maximum or highest Chlorophyll hl-*a* reading observed.

Temperature and Oxygen Profiles

Dissolved Oxygen (DO) is the measure of the amount of oxygen gas that is dissolved in the water. Organisms living in lakes use the oxygen dissolved in the water to breathe. Low DO conditions can severely reduce the diversity and populations of aquatic organisms in a lake. Water with less than 2 milligrams per liter (mg/L, which is equivalent to parts per million, or ppm), of oxygen is considered anoxic (meaning only a negligible amount of oxygen is present); less than 5 mg/L of oxygen is generally considered too stressful for most coldwater fish like trout and salmon to survive. A concentration of DO above 5 mg/L is needed for fish to grow and reproduce sustainably. Anoxic conditions can also induce phosphorus release from lake sediments.

Temperature measures the amount of heat in the water. Water temperature can affect the lake's chemistry and biology. For example, the amount of oxygen water can hold is directly related to the temperature of the water. The higher the temperature, the less dissolved oxygen the water can hold. Oxygen will naturally decline during the summer months as water temperatures rise and biological respiration in the lake consumes DO. Lakes deeper than 25-30 feet can also stratify into layers defined by a gradient of water temperature. Warm water will stay on top of cooler deep water, restricting circulation and aeration of the lake water. Prolonged stratification can contribute to oxygen loss (anoxia) in the deeper waters. Temperature can also control the kinds of plants and animals found in lakes. Certain species of fish, insects and algae will predominate during the cooler temperatures of the spring and fall, yet disappear during the warmer temperatures of summer. For instance, salmonid fish (such as trout and salmon) generally prefer temperatures below 18°C (65°F) but can tolerate slightly higher temperatures for short periods of time. Species more tolerant of warmer waters will predominate in lakes without cold water habitat during the more stressful summer months.

Peak Stratification: The condition of a lake when the thermal gradient –the difference in temperatures – between the warmer epilimnion and the colder hypolimnion is the greatest. In Maine, peak stratification usually occurs in late summer (August and early September).

The first component of this tab section is a series temperature & DO plots from profiles taken in late summer (August 1st – September 7th) (Figure 5). This time period represents the stage at which most lakes in Maine are at their *peak stratification*, or when lakes are most strongly stratified. If a lake has high water temperature or DO loss it will be observed during this time. This plot series shows up to four of the most recent late summer profile sampling events. Depth is on the vertical (y-axis) axis of the graphs, so that the surface of the lake (Depth = 0 m) is at the top of the graph and deeper water is represented on the bottom of the graphs. The blue line represents DO and the red dashed line represents temperature values. The values on the x-axis (horizontal) are for both dissolved oxygen (units = mg/L) and temperature (units = °C). For deeper lakes that stratify, the temperature curve will bend to the left (getting closer to 0°C) as depth increases, indicating cooler water on the bottom of the lake. If low DO conditions are present, the blue dissolved oxygen curve will also bend to the left (closer to 0 mg/L) as depth increases, indicating lower DO in deeper water. If the lines are straight up and down, this indicates there is no change in temperature or DO from the top to bottom and the lake water is thoroughly mixed.

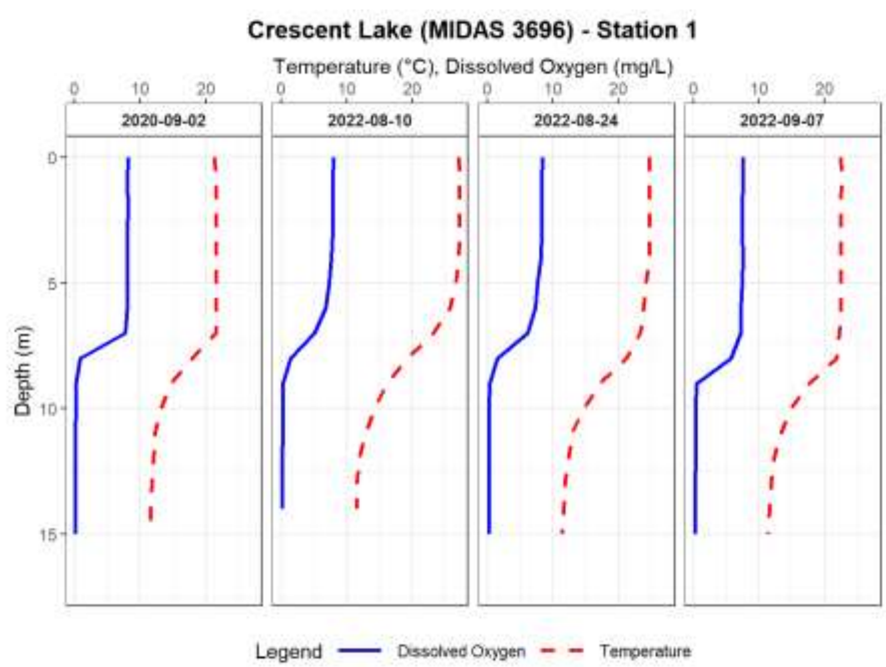

Figure 5. Example Temperature and Dissolved Oxygen profile plot series showing stratification in both temperature and dissolved oxygen.

Some lakes are intensively surveyed for temperature and DO profiles over the course of an ice-off season to monitor temperature stratification and potential DO loss. If the lake has been surveyed in at least five different months from May through October, the report will show contour plots, or “heat maps”, in the next space in this tab. These plots are a graphical representation of the progression of mixing and stratification of the lake into thermal layers (temperature plot) and patterns in DO concentration during this time period (Figure 6). These plots interpolate the profile information between discrete sampling events, providing a more complete picture of lake mixing and stratification dynamics over the course of the open water season. In the example here, the temperature heat map (Figure 6, top) shows the lake mixed (same temperature from top to bottom) in April, followed by a steadily warming epilimnion (top layer) to *peak stratification* (largest thermal gradient between top and bottom) in August, when the top waters are the warmest. After peak stratification, the warm epilimnion steadily cools until the lake completely mixes again in late November.

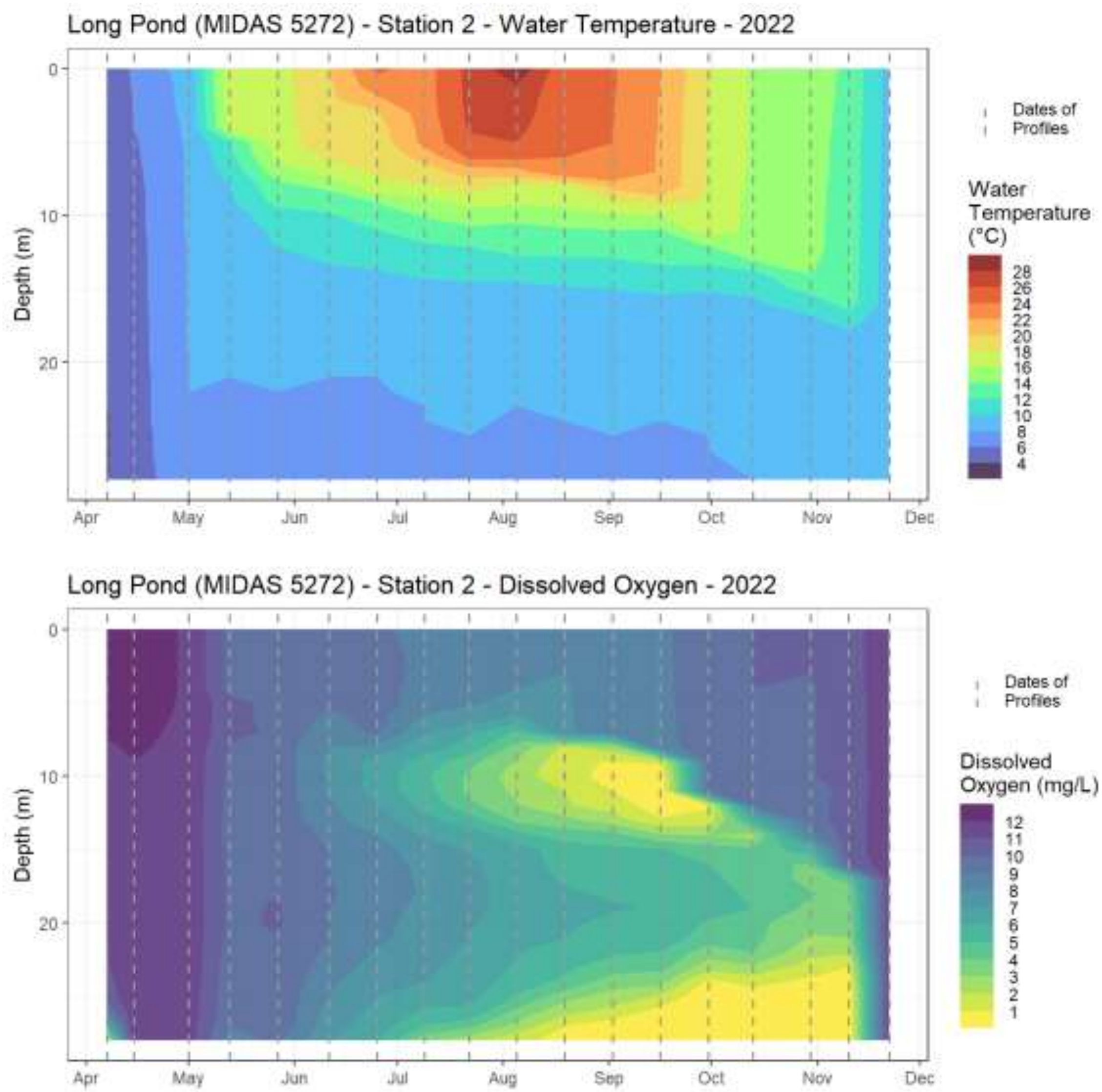

Figure 6. Example heat map plots of Temperature (top) and dissolved oxygen (bottom), created from distcrete profile sampling events. Profile event dates are represented by the dashed vertical lines.

In the dissolved oxygen heat map (Figure 6, bottom), the April and November mixing events are seen with uniform DO concentrations from top to bottom. The low dissolved oxygen along the bottom from August – November is from respiration (oxygen consumption) at the sediment-water interface; the end of anoxia is seen when the lake mixes in late November. In this example, there is a period of low DO concentrations at about 7-12 m depth from July – October. This is called a *metalimnetic minima*, which indicates high respiration activity has consumed oxygen in the metalimnion (the transitional layer between the warmer epilimnion and deeper, colder hypolimnion). The metalimnetic and hypolimnetic anoxic areas gradually expand towards each other as respiration out-paces re-oxygenation through the fall, until DO is replenished throughout the entire lake during the November mixing event.

The *Temperature and Dissolved Oxygen Profile Data* table presents the most recent oxygen and temperature data obtained during the late summer period. Up to eight recent profile surveys may be included in the report. The sampling date is noted in the first row of the table, with the corresponding measurements in the two columns below each date. <u>Depth (m)</u> = Depth in meters (1 m= 3.28 ft) of each reading; <u>TEMP</u> = Temperature in degrees Celsius (°C); <u>DO</u> = Dissolved oxygen readings in milligrams per liter (mg/L).

Water Quality Trends

Long-term Secchi Disk Transparency (SDT), total phosphorus (TP), and Chlorophyll-a data are used to determine if the *trophic state* (general status of nutrient availability) of a lake is changing. Long-term trends may be calculated if there are at least 10 years of data collected within the last 30 years (1993-2022). If there are at least eight years of data within the most recent 10 years, a recent trend test may be calculated as well. The results of trend tests for all three parameters for both long-term and 10-year trends are presented if there have been enough data collected from the lake for any of these three parameters. All plots show years along the horizontal x-axis, measurement values along the vertical y-axis, dots representing the yearly average values, and a weighted moving-average trendline (Figure 7).

The Maine DEP uses Mann-Kendall Tau (τ) trend tests on these data to test for significantly changing conditions. The tau value is a measure of trend direction and magnitude. Positive tau values indicate positive (upward) trends, negative tau values indicate negative (downward) trends. Values further from zero (closer to -1 or 1) indicate a stronger trend. Tau values less than -0.5 or more than 0.5 here suggest the trophic state of a lake may be changing. Trends with p-values less than 0.05 indicate statistically significant trends. The results of each Mann-Kendall Tau trend test are included below each trend plot.

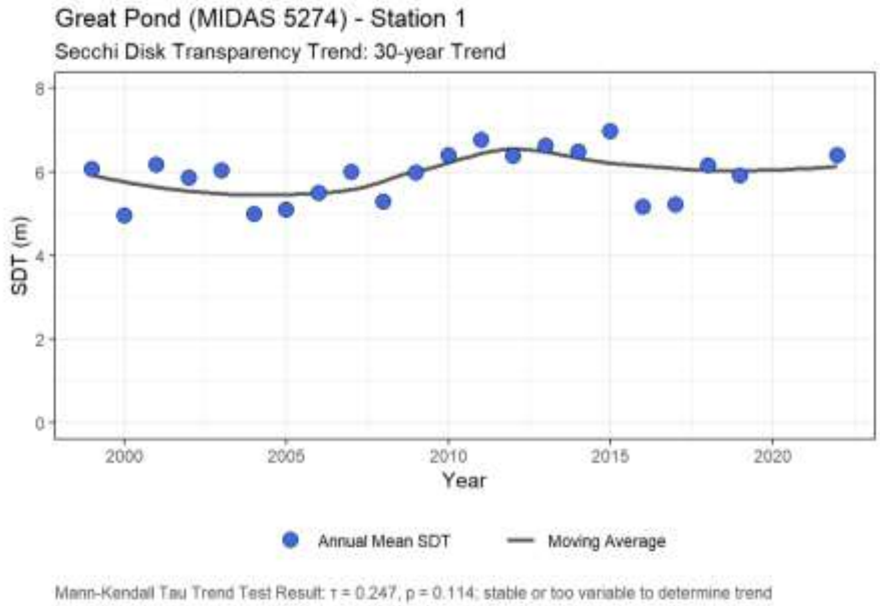

Figure 7. Example trend plot for Secchi Disk Transparency (long-term trend).

Fish List

The Maine Department of Inland Fisheries and Wildlife (MDIFW) routinely surveys fish populations in lakes across Maine. The data from these surveys are used to inform decisions related to conservation status assessments, stocking programs, angler use and pressure, and environmental changes. The list of fish observed from each lake are presented here, if the lake's fish population has been surveyed by MDIFW. For more information about these surveys and what the data are used for, see [this link].

The fish data in each lake report are arranged as in the example below. The common name, scientific name, and origin status (Native or Introduced) are displayed along with an image of the fish species. The common names contain an embedded link that will lead to an informational webpage about each species.

Brook Trout	*Salvelinus fontinalis*	Native
Chain Pickerel	*Esox niger*	Native
Landlocked Salmon	*Salmo salar*	Native
Rainbow Smelt	*Osmerus mordax*	Native
Smallmouth Bass	*Micropterus dolomieu*	Introduced