A Citizen’s Guide to Lake Monitoring

CT DEEP
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Why is Lake Monitoring Important?

Caring for our lakes is important to the preservation of natural resources, stimulation of economic growth, and elevation of the quality of life in our state. Lakes and ponds enhance our landscape and are used extensively for swimming, fishing, boating, and other forms of recreation. Money spent on recreation is important to local and state economies, and the high property values of lakefront homes augment tax revenues of surrounding communities. These benefits deteriorate with a decline in lake water quality.

Lake monitoring through the collection of water quality measurements helps inform lake management strategies, track changes in response to nutrient levels, and mitigate the impacts of cultural eutrophication. Lake monitoring allows us to establish baseline conditions and track long-term water quality trends. Lake pollutants contributed through human activity in and around the lake can result in excessive growth of algae, cyanobacteria, and aquatic plants while decreasing water clarity (cultural eutrophication). Nuisance algae and aquatic plant growth can interfere with boating, swimming, fishing and other recreational activities. As the excessive growth dies back each year it falls to the lake bottom, causing sediments to build up more rapidly while depleting oxygen during decomposition. This disrupts the natural habitat of a lake causing alterations in fish and wildlife populations. Human activity along a lake's shoreline and in the watershed can accelerate the amount of pollution entering a lake. Sources include: shoreline erosion, fertilizer run-off, run-off from dirt roads, failing septic systems, agricultural runoff, residential runoff, and erosion from logging and construction. Lake monitoring therefore enables us to track long-term water quality trends and inform best management practices for shoreline areas and within the lake watershed.

How do Lakes Change Over Time?

A lake's watershed consists of all land areas that drain directly into the lake and those watercourses that flow to the lake. Water entering the lake, especially after a storm, typically carries a load of nutrients, sediments, and other pollutants. The health of a lake depends greatly on the quality of the incoming water. Watershed topography, soil fertility, soil erosion, vegetation, and human activity all affect this quality, and, therefore, the lake itself.

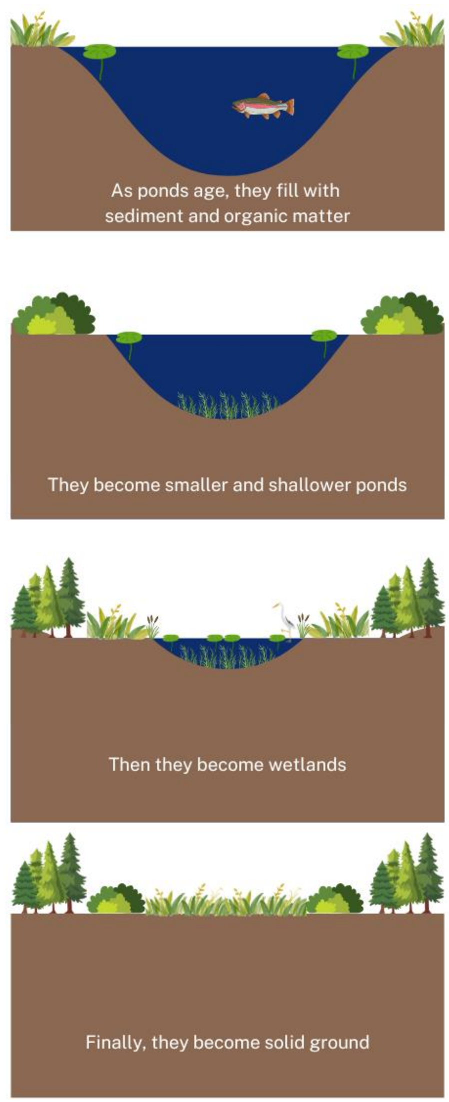

Figure 1: Natural lake succession over time

Lakes can be sorted into different trophic categories based upon the primary productivity of the lake – in other words, how much algae and plants (primary producers) are growing in a lake as a function of how nutrient-rich the lake is. A lake trends towards increasing productivity and higher nutrient levels throughout its lifespan as sediments and other nutrients are deposited in the lake. This process is known as eutrophication, a form of ecological succession, and is natural for lake systems.

However, human activity can contribute to eutrophication at a much higher rate than natural processes. Unnatural causes of eutrophication can include fertilizer runoff from lawns, agricultural inputs, and certain household products containing phosphates. Therefore, we often evaluate lake water quality conditions as a deviation from their natural state. Eutrophication is assessed negatively when nutrient loading is much greater than what the system can naturally handle. The trophic categories used in Connecticut are outlined in Table 1.

Table 1: Lake trophic categories and characteristics based on physical and chemical indicators to assess lake productivity in Connecticut.

Trophic Category	Characteristics	Summer Secchi Depth (m)	Summer Chlorophyll a (ppb)	Total Phosphorus (ppb)	Total Nitrogen (ppb)
Oligotrophic	**Low productivity** Classified by: Low nutrients, clear water, low algal growth, low macrophyte growth, hypolimnetic zone not anoxia	> 6	0-2	0-10	0-200
Early Mesotrophic	**Low/Moderate productivity**	4 - 6	2-5	10-15	200-300
Mesotrophic	**Moderate productivity** Classified by moderately clear, moderate algal growth and macrophyte growth, increase anoxia in the hypolimnetic zone in summer	3-4	5 -10	15-25	300-500
Late Mesotrophic	**Moderate/High Productivity**	2-3	10-15	25-30	500 -600
Eutrophic	**High Productivity** Classified by high nutrients, increased algal growth and macrophytes growth, anoxic hypolimnetic zone during the summer	1-2	15-30	30-50	600 -1000
Highly Eutrophic	**Excessive Productivity** Classified by high nutrients, dense algal and macrophyte growth, limited light penetration, anoxic hypolimnetic zone during the summer	0-1	>30	>50	>1000

The timescale of lake succession is typically measured in centuries to millennia. However, lakes also undergo seasonal changes that may dramatically impact water quality conditions in the lake.

In the summer, the surface of the lake is warmed by sunlight, causing the water to become less dense and rise to the surface. The colder, denser water not warmed by sunlight rests at the bottom of the lake. This process is known as stratification and can result in different water quality conditions between warm surface waters and cool bottom waters. In lakes with high nutrient loading, the subsequent increased rates of biological processes in cool bottom waters, and the lack of oxygen mixing into this layer, can result in bottom waters losing oxygen (becoming anoxic). This can in turn make the lake's bottom waters inhospitable to some aquatic life, like fish. Similarly, summertime algae blooms can be driven by a combination of warmth, sunlight, and excessive nutrients. Algae blooms can deplete available oxygen at night, and likewise when they begin to decompose, as the decomposition process may rapidly deplete oxygen. Some algae blooms, known as harmful algae blooms (HABs) produce toxins. Both scenarios may result in the death of aquatic organisms, like fish, known as a “fish kill”.

In the fall, wind and wave action mix the surface waters with the bottom waters of the lake, reversing stratification. Sometimes algae blooms are observed in the fall when nutrient-rich bottom waters are brought to the surface and exposed to sunlight. This is known as the fall turnover.

In the winter, a mild inverse stratification can be observed. Water at the surface cools and freezes into ice at 32° Fahrenheit (0° Celsius), floating over warmer waters beneath it. Should the lake entirely freeze over, winter fish kills can occur when the slow winter consumption of oxygen outpaces the time periods when the lake surface is not exposed to air, when oxygen exchange can occur.

Climate change and the resulting average increases in air temperature will potentially make great impacts on the cycling of water during the winter as the surfaces of lakes may spend less time frozen.

In the spring, the action of wind and waves will once again mix surface waters with bottom waters. This is known as the spring turnover.

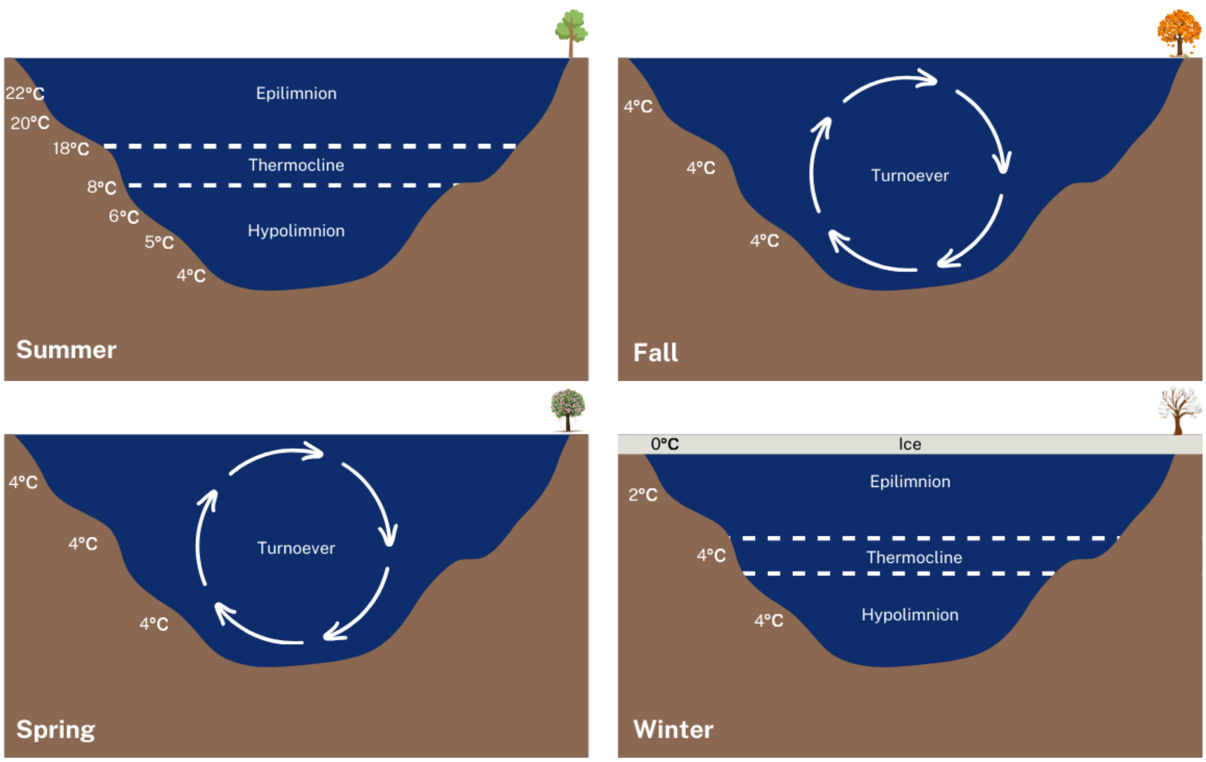

Figure 2: Lakes undergo seasonal changes. This results in lake stratification during the summer and winter seasons.

What do the Lake Monitoring Measurements Tell Us?

Secchi Disk Measurements

What is a Secchi Disk?

A Secchi disk is a simple device to measure water transparency (clarity). It is a 20-centimeter (8-inch) diameter weighted disk that is painted white and black in alternating quadrants. A calibrated measuring line is attached to the center of the disk. To obtain a measurement, the disk is lowered slowly straight down into the water until the disk disappears. The depth at which it disappears is the Secchi disk reading and indicates the transparency of the lake at that time.

Did You Know?

The original Secchi disk was a white disk invented around 1865 by Angelo Secchi, an Italian astrophysicist. It was used to determine transparency in the Mediterranean Sea for navigational purposes. Around 1899, George Whipple modified the disk into today's modern form for use in freshwater ecosystems. He believed the high contrast of alternate black and white sections gave the most accurate means of determining the water transparency.

Why Do We Take Secchi Disk Measurements and What Do They Mean?

Measuring transparency is important for several reasons, with one of the most significant being its ability to reflect the impact of human activities on the land surrounding a lake. When measured consistently during the spring and summer seasons and across multiple years, rapid and consistent changes in transparency can reveal trends in lake health. These trends can serve as early warning signs of land-based activities affecting the condition of the lake, offering a clear indication of cultural eutrophication or the lake's changing trophic status as a result of human activity.

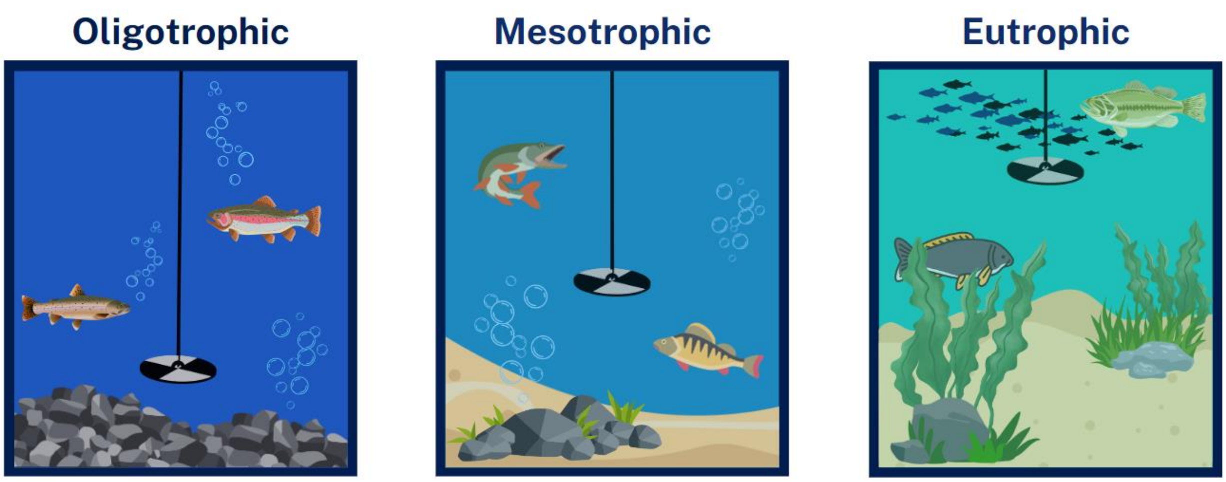

Figure 3: An illustration showing the relationship between Secchi disk depth and trophic status of a lake.

In Connecticut, the Water Management Bureau uses six trophic categories to classify lake trophic conditions: Oligotrophic, Early Mesotrophic, Mesotrophic, Late Mesotrophic, Eutrophic and Highly Eutrophic. Secchi disk readings associated with different trophic categories are outlined in Table 1.

Water clarity is important because it controls how far light penetrates the water column. This affects many components of the ecosystem, such as lake temperature, algae growth, aquatic plants, and even the oxygen levels for aquatic organisms that live in the water, such as fish. Lake transparency is often related to nutrient inputs, as increased nutrients drive algae growth, which in turn clouds the water. However, other factors may affect Secchi readings.

What Affects Secchi Disk Measurements?

The transparency of a lake's water can be affected by the color of the water, algae, zooplankton, suspended sediments from eroded soil, or from resuspended bottom sediments. All these factors can interfere with light penetration and reduce water clarity.

Lakes are typically blue, brown, or green in color, with variations in color and clarity revealing their ecological health and the influence of surrounding landscapes on the lake ecology. Blue lakes typically result from dissolved minerals and are often characterized by their clear waters. Brown lakes are frequently associated with forested or wetland areas, where organic matter such as leaves and plant debris dissolves into the water, creating a tea-like coloration. This process is natural, but can be amplified by human activities, such as agriculture, deforestation, or land development. Green lakes are indicative of high algal concentrations, which reflect elevated nutrient levels and increased biological productivity. Excessive nutrient enrichment, often caused by agricultural runoff, septic system failures, or lawn fertilization, promotes algal growth. This can lead to greener water and reduced water clarity as measured by Secchi disk readings. Understanding these factors helps assess the impacts of land use and human activity on lake ecosystems.

What Other Water Quality Measurements are Collected in Lakes?

Other water quality measurements collected in lakes measures in lakes include temperature, dissolved oxygen, nitrogen, phosphorus, phycocyanin, and Chlorophyll-a. All of these parameters help to evaluate water quality conditions in the lake.

Water temperature is another component of understanding lake water quality conditions. Water temperature is associated with dissolved oxygen concentrations. Warmer waters can hold less oxygen, which may impact aquatic life. Warm surface waters in the summer may also contribute to algal blooms. When taking water temperatures throughout the lake water column (i.e. taking a temperature reading every 1 meter down to the bottom of the lake), one can also identify if the lake is stratified and at what depth. This is done by taking and looking at the temperature measurement differences from the top surface waters of the lake to the bottom water. Identifying if the lake is stratified is important because oxygen may become depleted in bottom waters when the water is not mixing. The dissolved oxygen content is another measurement taken throughout the lake water column.

Nitrogen and phosphorus are essential nutrients in aquatic ecosystems, but their excessive concentrations in lakes can significantly impact water quality and ecosystem health. These nutrients are often introduced through agricultural runoff, wastewater discharges, urban developments, and septic systems. Measuring nitrogen and phosphorus provides a direct measurement of the nutrient enrichment of lakes, but relies upon more expensive analytical methods, like lab analysis of water samples.

Phycocyanin is a pigment found in cyanobacteria (otherwise known as blue-green algae) that serves as an indicator of cyanobacteria blooms in lakes. Chlorophyll-a is similarly a pigment found in algae and green plants that can be correlated to lake productivity and therefore trophic status, but it is not specific to cyanobacteria. Measuring phycocyanin provides a method for assessing the presence and intensity of cyanobacterial populations, which can have significant ecological and public health implications. Cyanobacterial blooms can produce toxins harmful to humans, animals, and aquatic ecosystems and can be directly linked to excessive nutrients inputs or eutrophication.

How Can I Help My Lake?

The most important aspect of maintaining a healthy lake is understanding the relationship between the lake's water quality and the surrounding watershed. What happens on the land will ultimately run off into the lake's water. Thus, the quality of a lake is defined largely by the quality of the water that flows into it. The primary runoff concerns for degrading water quality conditions are sources of nutrients like nitrogen and phosphorous. Implementing some of the Best Management Practices (BMPs) outlined below helps to mitigate runoff that ultimately degrades the water quality.

Vegetative Buffers

Vegetative buffers are among the most effective tools for protecting water quality and supporting lake ecosystems. These areas of native vegetation along shorelines act as natural filters, reducing runoff, stabilizing soils, and moderating the impacts of rainfall. They also provide critical habitat for both aquatic and terrestrial life. Concerned lake property owners can choose to add a vegetative buffer of native plants along their shoreline.

Reducing or Eliminating Fertilizer Use

Residents in lake watersheds should use fertilizers cautiously or not at all. Fertilizers that are commonly applied to lawns, home gardens, and ornamental shrubs and trees contain the plant nutrients nitrogen, phosphorus, and potassium. In a lake watershed, these nutrients from fertilizers may enter the lake, thereby fertilizing aquatic plant growth. If used, the type of fertilizer should match the specific needs of the soil and the plants being grown. The timing of fertilizer applications is important. Applications should be avoided in the late summer and fall when plant growth has ended. Furthermore, fertilizers should not be applied if heavy rain is forecast. Nutrients not captured by plants are likely to be transported off the property during rainstorms.

Reducing Impervious Surfaces

Reducing impervious surfaces, such as asphalt, is another effective BMP for improving lake water quality. Impervious surfaces prevent water from soaking into the ground, leading to increased runoff that can carry pollutants and excess nutrients into lakes. By replacing these surfaces with permeable alternatives like porous pavement or vegetation, stormwater flows into the ground instead of over it, reducing the volume of runoff. Strategies, such as the creation of rain gardens, are another actionable way for concerned citizens to mitigate the impacts of runoff.

Washing Vehicles

Wash waters from washing vehicles can transport sand, oil, and phosphorus from soaps and detergents that degrade the water quality of a waterbody. Even non-phosphate "biodegradable" soaps can be toxic to aquatic organisms at low concentrations. Connecticut law requires that all vehicle washing must be performed in a manner which prevents the direct discharge of soapy washwater to a stream, river, or other surface waterbody. Washwaters must not enter a stormwater catch basin because the vast majority of these storm drains ultimately discharge to a surface waterbody. Vehicle washing must be performed in an area where all washwater enters a municipal sanitary sewer for proper treatment. More information on vehicle washing can be found on CT DEEP's website.

Volunteer for CT Lake Watch

If you live on a lake, consider volunteering for CT Lake Watch. Check with your Lake Association to see if they participate in CT Lake Watch and how you can get involved. If your lake does not yet participate in CT Lake Watch, fill out the New Water Quality Monitoring Volunteers form to be added to our training list.

Report Aquatic Invasive Species

The Connecticut Agricultural Experiment Station (CAES), Office of Aquatic Invasive Species (OAIS) has an Interactive Web App that allows you to explore waterbodies across Connecticut to discover where aquatic invasive species have been documented. This tool provides up-to-date information on aquatic invasive species throughout the state. You can report aquatic invasive species here: Report AIS & Update Database | AIS Data Repository

Additional Resources

CT DEEP Lake and Pond Water Quality Monitoring
(https://portal.ct.gov/deep/water/inland-water-monitoring/lake-water-quality-monitoring)

Connecticut Lake Watch Program
(https://portal.ct.gov/deep/water/inland-water-monitoring/connecticut-lake-watch)

Connecticut Statewide Lake Nutrient TMDL
(https://portal.ct.gov/-/media/deep/water/watershed_management/bantamlake/ct-statewide-lake-nutrient-tmdl_core-final.pdf)

A Fisheries Guide to Lakes and Ponds of Connecticut
(https://portal.ct.gov/deep/fishing/general-information/lake-and-pond-book)

Caring for Our Lakes: Watershed and In-Lake Management for Connecticut Lakes
(https://portal.ct.gov/-/media/deep/water/lakes/caringforourlakespdf.pdf)

CT DEEP Volunteer Lake Watch Data
*(*https://ctdeepwatermonitoring.github.io/Volmon-Map-App/*)*

CT DEEP Nonpoint Source Management Program Plan
(https://portal.ct.gov/-/media/deep/water/nps/connecticut_nps_management_program_plan2024.pdf)

Vermont Federation of Lakes and Ponds Shoreland Protection
(https://vermontlakes.org/shoreland-protection/)

Vermont DEC Shoreland Best Management Practices
(https://dec.vermont.gov/watershed/lakes-ponds/lakeshores-lake-wise/shoreland-best-management-practices)