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Range Ponds 2022 Water Quality Monitoring and Assessment Report

Executive Summary:

This summary is based on two baseline sampling visits to each of the Range Ponds in mid-July and early September. Additional water clarity data, gathered by trained volunteers on each of the lakes, were also included in the analysis.

The water quality of the three Range Ponds in 2022 varied from slightly above average to substantially below average, in the case of Middle Range, which experienced an unanticipated and substantial, but not severe, algal bloom during the late summer.

Upper Range was slightly clearer than the historical average for the lake, but the concentration of phosphorus was slightly higher, as was the concentration of algae in the lake. However, conditions did not vary substantially from the historical average in either direction.

Despite the algal bloom in Middle Range, the average water clarity was close to the historical average for the lake. However, the 2022 average was a sharp drop from recent years, when the lake has been significantly clearer than the historical average. The concentration of phosphorus was also close to the historical average, but the overall concentration of chlorophyll-a, a direct measure of algal density, was nearly double the historical average, due to the high density of algae in the lake primarily during the month of September. The bloom was beginning to subside by early October, and water clarity was improving at that time.

An analysis of the various factors that can trigger late summer algal blooms suggests that a combination of unusually warm water temperatures (approximately 77 degrees F by mid-July), combined with a substantial rain event during the period, which produced runoff to Upper and Middle Range ponds from their watersheds, created favorable conditions to support the proliferation of bluegreen algae/cyanobacteria, which constituted the bloom.

Fortunately, the bloom did not reach “severe” conditions (defined as 2.0 meters or lower Secchi water clarity), and the duration was relatively short, very likely due to the rapid uptake and depletion of the phosphorus from the stormwater runoff, combined with cooler ambient temperatures and shorter periods of sunlight in September and October, as well as a return to dryer conditions following the summer storm. Based on multiple year toxicity sampling of lakes throughout Maine that have experienced algal blooms, the risk to public health from the 2022 Middle Range bloom was low.

Lower Range was slightly clearer than the historical average for the lake, and phosphorus and algal density were very close to the long term average.

Significant dissolved oxygen loss occurred in the deepest area of each of the three lakes, with slightly greater loss than has been documented in recent years. Very warm mid-summer water temperatures likely contributed to the oxygen loss. It is possible that this triggered the release of phosphorus from lake-bottom sediments in Upper and Middle Range, which may also have contributed to the Middle Range bloom.

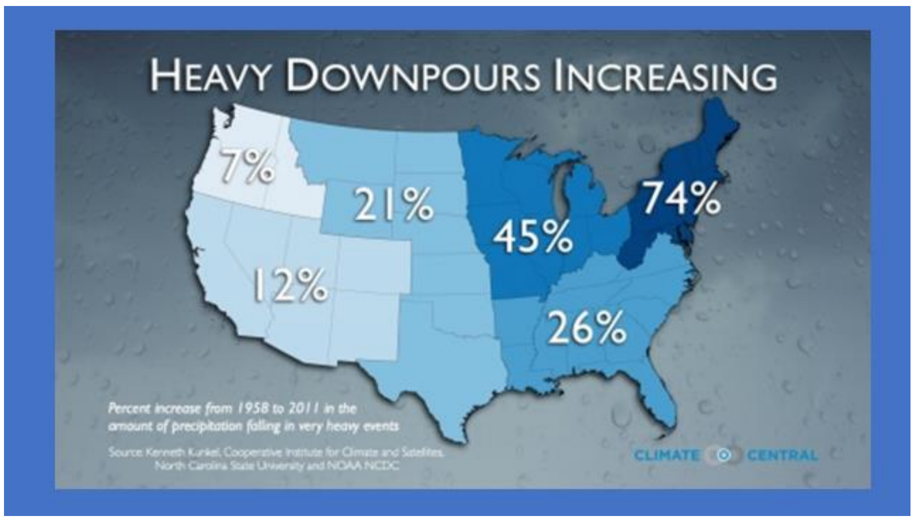
A warming climate, characterized by reduced periods of lake ice cover, warmer lake water temperatures during the summer months, and severe weather events ranging from extended drought to increases in heavy rain and runoff producing storm events, poses a significant threat to the health of the Range Ponds. Water quality conservation and protection practices throughout the Range Ponds watersheds will continue to be the best measures of defense and protection to the lakes from the negative influences of climate warming.

Lake Water Quality in the Era of a Warming Climate:

Lake water quality may be influenced at any point in time by a wide range of both natural and anthropogenic factors. The combined effect of these has a bearing on the extent to which monthly, seasonal and annual “natural variability” occurs in many of the indicators that are used to assess lake ecosystems.

Annual weather fluctuations and trends in temperature, wind, and precipitation typically influence both short and long-term conditions that occur in individual lakes. The degree to which they affect individual lakes depends on the natural characteristics of the lake, and the extent to which the lake and watershed have been altered through development. Natural characteristics include, but are not limited to the bathymetry (depth profile) and shape of individual lake basins and its orientation to prevailing winds, and the geographic area, soil chemistry, and hydrologic characteristics of the watershed. Natural features such as wetlands within the watershed may also be factors. The combined effect of these variables plays a role in the sensitivity and response of individual lakes to watershed development.

Foremost among the influences of weather on our lakes are precipitation and temperature, both of which are increasing in intensity through the process of climate warming. In recent years, unusually warm ambient temperatures throughout the year have resulted in historic high summer lake water surface temperatures (low to mid 80's F in southern and central Maine), later formation of ice cover in the fall/winter, and earlier "ice out" in the spring. The overall reduced period of ice cover on lakes is a clear indicator of the potentially profound changes that climate warming will likely have on Maine's lakes, relative to their historical conditions.



Precipitation events are becoming more extreme throughout the Northeastern US, and multiple years of moderate to severe drought have occurred throughout much of Maine during the past two decades. Intense rain events can significantly increase the erosive force of watershed stormwater runoff, transporting more sediment and phosphorus into lakes. Drought reduces the inflow of water to lake basins from their watersheds and increases evaporation of lake water, resulting in low water levels, which can cause the desiccation of sensitive, beneficial aquatic plant communities, reduce fishery habitat, and it may contribute to shoreline erosion. Drought is often associated with warmer ambient temperatures and an increase in lake water temperature.

Localized extreme precipitation events, often result in moderate-velocity, erosive stormwater runoff from lake watersheds, carrying with it elevated concentrations of soil particles, nutrients and other pollutants to lakes. In recent years, unusual algal blooms that have been observed and documented in a number of Maine lakes are likely to have been triggered by the combined effects of extreme weather.

Historically, it has generally been accepted that clearer lake water is an indication of healthy lake ecosystems. This may not always be the case in the era of climate change. Many Maine lakes tend to be clearer during drier years, ostensibly due to reduced stormwater runoff from their watersheds during such periods, resulting in less algal growth. However, algae are essential to the overall health and biological diversity of lake ecosystems. Dramatic declines in algae populations in their various forms, combined with warming lake temperatures, could result in the disruption of lake ecosystem food webs, which, along with rising water temperatures, may contribute to fish mortality and the loss of critical habitat for some species.

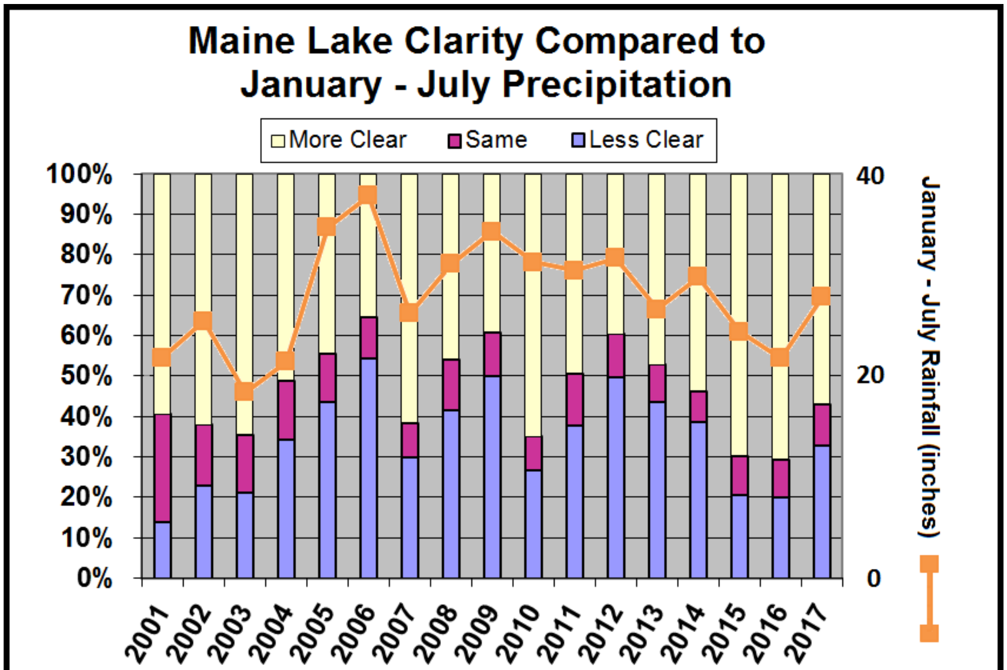


Figure 1 Source: Bacon, MDEP; Williams, LSM

An observational analysis of the Secchi transparency (water clarity) of Maine lakes from 2001 through 2017 (Linda Bacon/MEP; and Scott Williams/LSM) showed that during that period of time, a significant number of Maine lakes tended to be clearer during drier years (Figure 1). Stormwater runoff is the vehicle by which phosphorus and other pollutants are transported from watersheds to lakes. Lakes tended to be less clear during years when there was more precipitation and runoff during the period from January through mid- summer. Periods of drought may be deceptively causing apparent improving trends (based on water clarity) in water quality for some lakes in Maine, based on deeper Secchi disk readings, and lower concentrations of phosphorus and planktonic algae. This observational study suggests that stormwater runoff from lake watersheds contributes to reduced lake clarity, but it also raises questions about whether an increase in lake clarity should always be considered beneficial to lakes. In the future, it will be increasingly important to take into account the influence of extreme weather associated with a warming climate when assessing lake water quality.

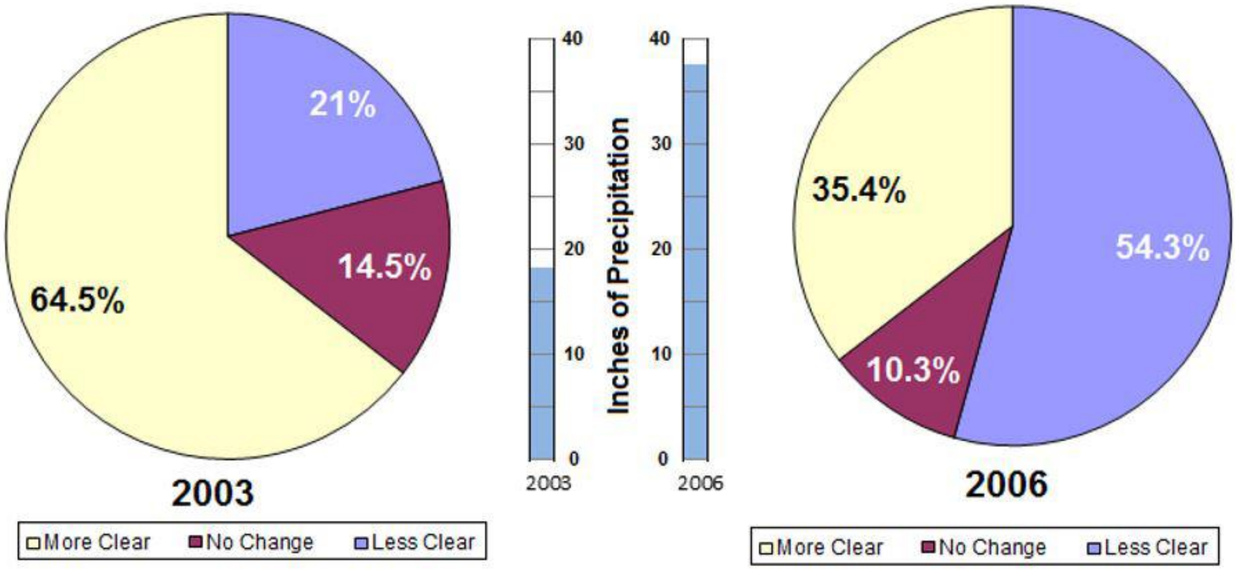
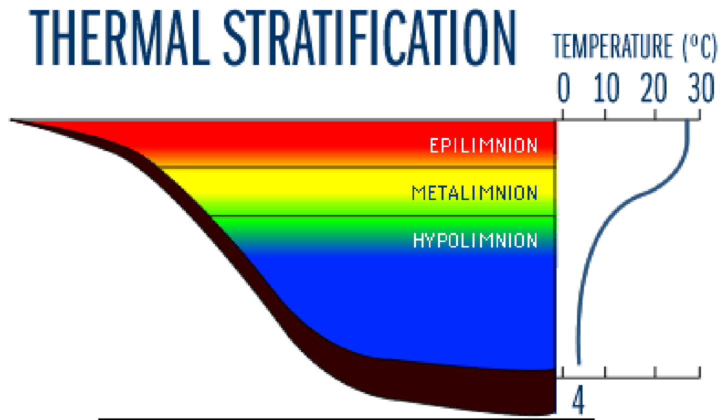


Figure 2: Source: Bacon/MDEP; Williams/VLMP

The pie charts in Figure 2 (above) illustrate the dramatic change that occurred in the number of lakes that were clearer than, less clear, or unchanged from their historical averages in 2003 and 2006. The bar graph between illustrates the differences in precipitation for the period from January through July for each of the years.

While a majority of Maine's lakes have been clearer to varying degrees during drier years, smaller groups of lakes have either been unchanged, or in some cases, have been less clear than their historical average. This may be due to several factors, including current water quality conditions in individual lakes, the degree to which individual lake watersheds are developed, whether or not a lake is experiencing internal phosphorus loading and recycling (in additional to external/watershed sources) - and more recently, the possibility that warming lake water temperatures are causing longer periods of thermal stratification. Relatively shallow lakes that have undergone little or no stratification in the past are now experiencing this phenomenon – which may, in some cases, exacerbate dissolved oxygen loss and the release of phosphorus from lake sediments to the overlying water, resulting in greater planktonic algae growth and reduced water clarity.

An extended period of thermal stratification typically results in greater loss of dissolved oxygen in a lake's water column during the period because warmer water is able to "contain" less dissolved oxygen, and water in the deepest area of stratified lakes is isolated from atmospheric sources of oxygen for longer periods of time. Depending on the biological productivity of individual lakes, oxygen concentrations may drop to critically low levels, triggering the release of phosphorus in the lake sediments to the overlying water. The "pulse" of phosphorus associated with this internal release process may, under certain circumstances, result in an increase in planktonic algal growth, and reduced water clarity, especially during the warm summer and early fall period.



Typical Summer Temperature Profile in a Thermally Stratified Lake

Another small group of lakes that may be clearer during wet years are those that are highly productive, and which experience persistent severe algae blooms. These lakes may actually benefit from the diluting effects of precipitation, because phosphorus concentrations in the body of water are higher than incoming levels in stormwater runoff.

Climate warming, and associated extreme weather events may compound (and confound) the complexity of tracking, predicting and characterizing lake water quality. In recent years, an increasing number of lakes that have historically experienced relatively "good" water quality, and which have otherwise been considered to be stable, have experienced significant changes, very likely due to the de-stabilizing influence of a warming climate. Although in some cases it may be possible to predict the manner in which individual lakes will respond to climate change, the process through which warming effects complex biogeochemical reactions in lake ecosystems may not always be clear in advance of the changes.

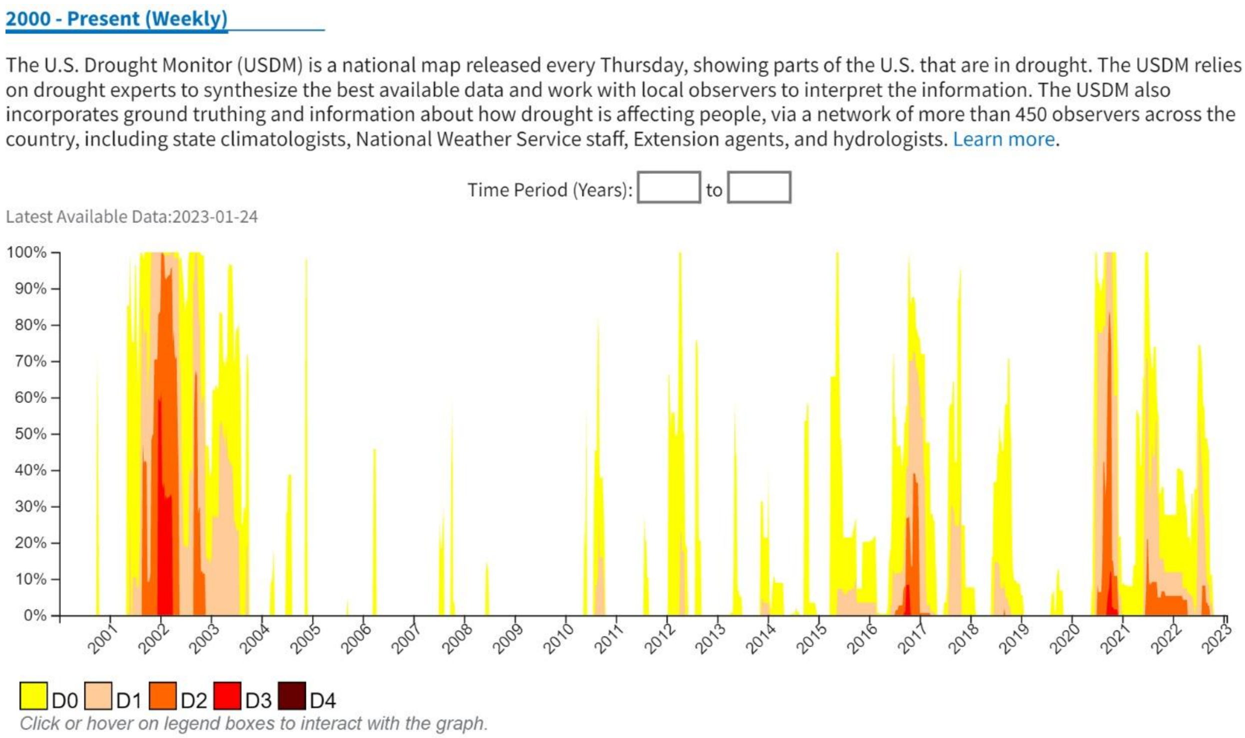
Potential Weather Influences in 2022:

Maine once again experienced a relatively dry summer in 2022. While the extent of the drought varied, most of the state experienced below average precipitation for the first several months of the year. For the past few years, Maine has experienced drought ranging from "abnormally dry conditions" to "moderate and severe drought" (source: Drought.gov).

The effects of drought on lakes may be cumulative, depending on the amount of time that it takes (on average) for the volume of water in a lake to be replaced, or "flushed" (not to be confused with "turning over", or mixing). Because this natural process is relatively slow, a dry year may continue to influence water quality and ecological effects for a year or more following the period of drought. Drought-related effects may be cumulative, depending on the duration and severity of the event.

Drought conditions in Maine changed dramatically during the last months of 2022, which has been characterized as one of the wettest periods in more than a century. The abrupt reversal, resulting from multiple heavy precipitation events, may result in many lakes being less clear than their historical average in 2023 – depending, in part on conditions during the spring runoff period, following snowmelt.

The graphic below (Source: Drought.gov) illustrates the significant drought conditions in Maine from 2000-present (January, 2023). The color box in the lower left begins with “abnormally dry” in yellow, to more extreme conditions in the far right boxes. Note that many years since the severe drought period of 2001-2003, show significant drought conditions.



2022 Overview and Summary of Findings for the Range Ponds:

The following summary information is the product of “baseline” sampling and assessment that was conducted at the three Range Ponds by LWRMA staff on July 15 and September 9, 2022. Additional Secchi Transparency (water clarity) data were gathered from May through October by Certified Volunteer Lake Monitors on each of the three lakes. Their data have been included in this report. The value of the work of trained volunteer lake monitors in assessing the health of Maine's lakes cannot be overstated.

Water quality monitoring/sampling was conducted at the "deep hole" station, which is the deepest known location in the lake, and it is the area where the greatest volume of historical data has been obtained for several decades. Each of the three Range Ponds is considered to be a single-basin lake, although the three are hydrologically connected. Each has its direct land drainage area (watershed). However, Middle Range also receives the outflow of Upper Range and its watershed, and Lower Range receives flowage from Middle and Upper Range Ponds and their watersheds.

For most Maine lakes, August and early September sampling is generally considered to be the most critical period of the year because potentially stressful conditions in the lake associated with several months of warm weather are typically most evident. Ideally, in order to confidently detect both short-term changes (such as an impending algal bloom), as well as long-term trends, a minimum of monthly sampling frequency is required for at least five continuous months during the open water period from May through September or October. Historical data sources referenced are from the Maine Department of Environmental Protection, Lake Stewards of Maine (www.lakesofmaine.org), and LWRMA field records and reports.

The characterization of changes that take place in a lake from one year to the next is a nuanced process. While terms such as "above and below average" may be relevant for one or more critical indicators of water quality, they may, or may not, reflect the fact that lakes are highly dynamic systems that are in a constant state of flux, with significant fluctuations occurring throughout any given year. Trends over longer periods of time are generally a more reliable indicator of actual change in lake ecosystems. Because sampling is an "instantaneous" measurement, it is important to be aware that the dynamic process of lake metabolism can cause sampling results to appear to be out of synch with each other. This is particularly true of the relationship between the primary "trophic state" indicators (Secchi Transparency (clarity), total phosphorus and chlorophyll-a).

Water Quality Indicators and Related Phenomena

Figures 3-5 illustrate the 2022 sampling averages for the three primary water quality indicators for the three Range Ponds, compared to the historical averages (averages last updated by MDEP in 2018).

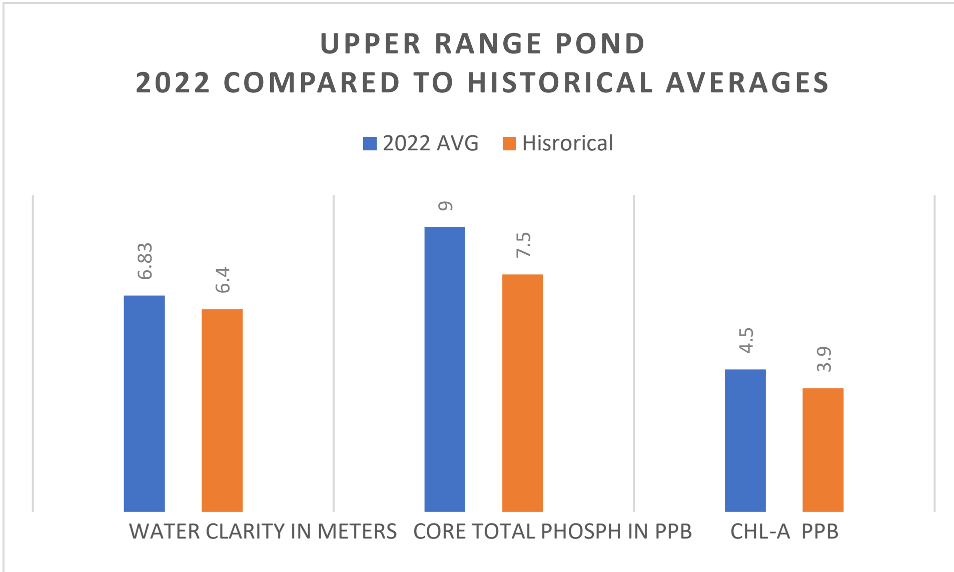


Figure 3

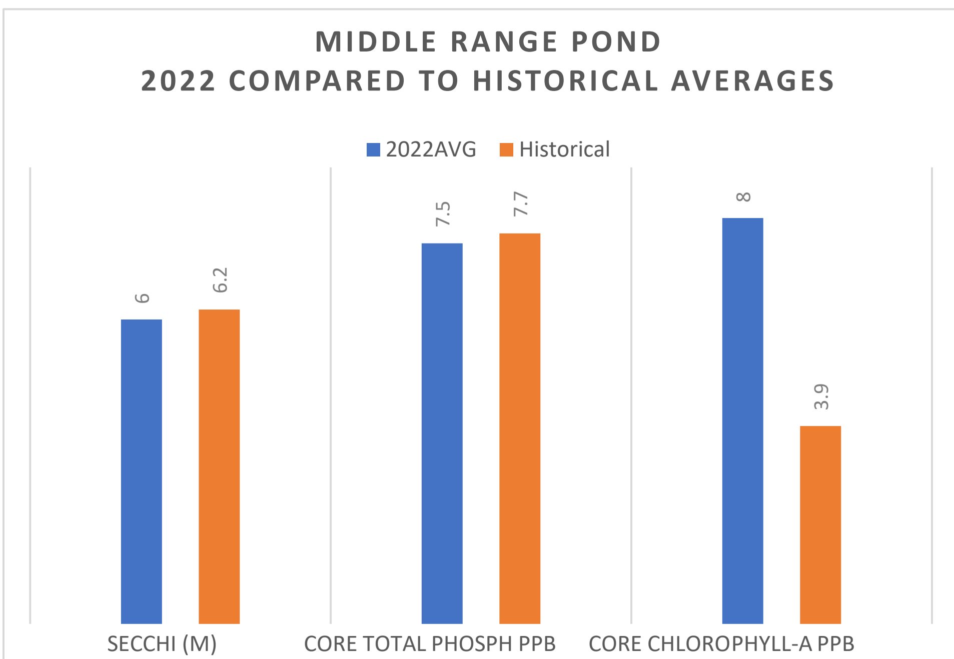


Figure 4

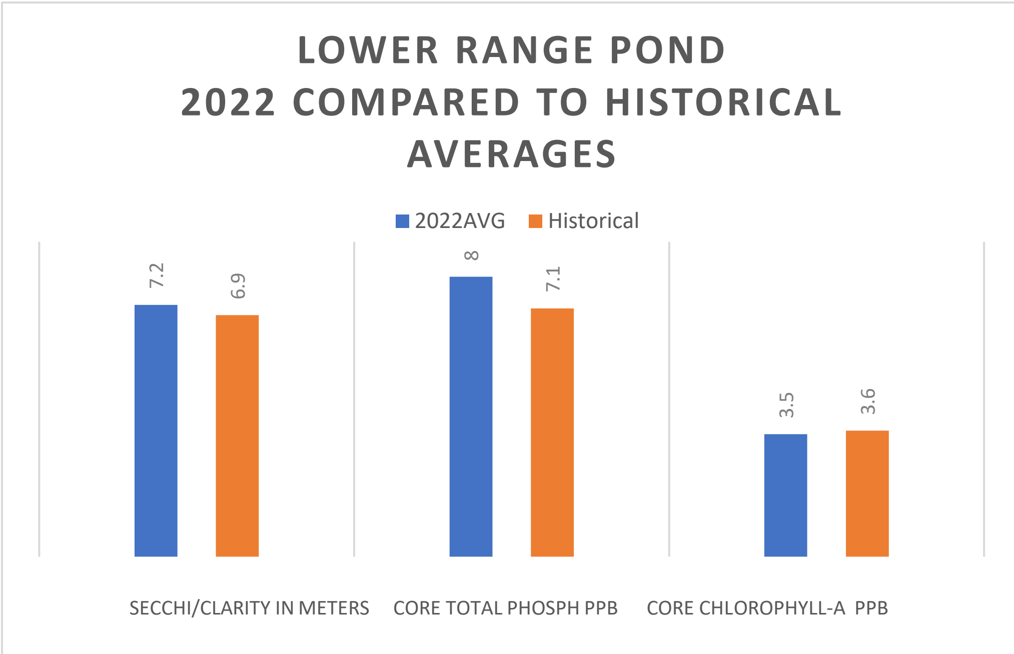


Figure 5

Figures 6-8 illustrate the variability in **Secchi transparency (water clarity**) readings at the designated monitoring stations for each of the Range Ponds in 2022. The number of readings taken for each, in addition to our readings in July and September, represent data gathered by certified volunteer monitors on each lake. The line and numbers show the depth in meters of the individual readings taken, and the information is also shown in the table at the bottom of the graph. Lake transparency (clarity) can vary substantially during the monitoring period. Weather factors, the normal cycles of phytoplankton (algae) populations, and internal biogeochemical interactions can all have a bearing on lake clarity. The clarity variability in both Upper and Lower Range Ponds was relatively stable.

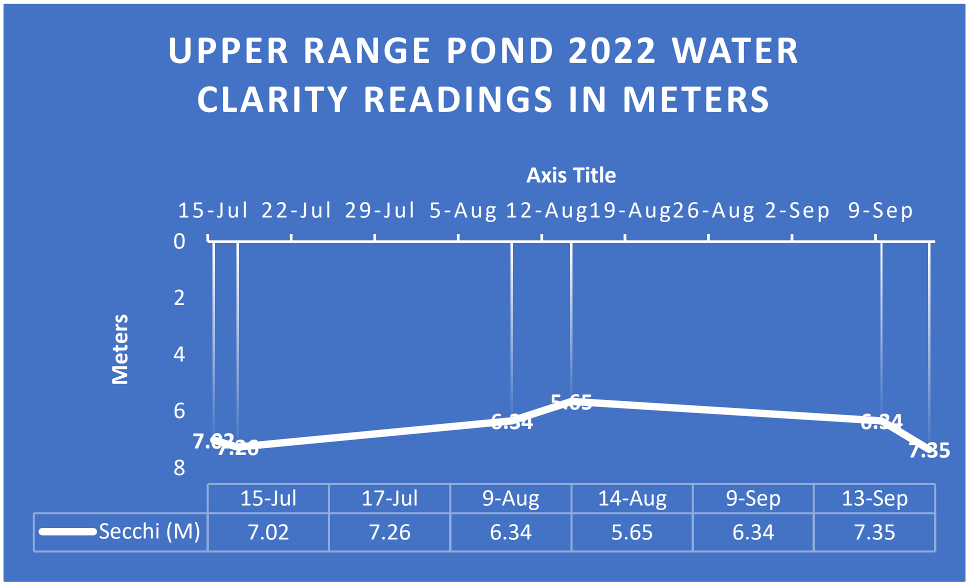


Figure 6

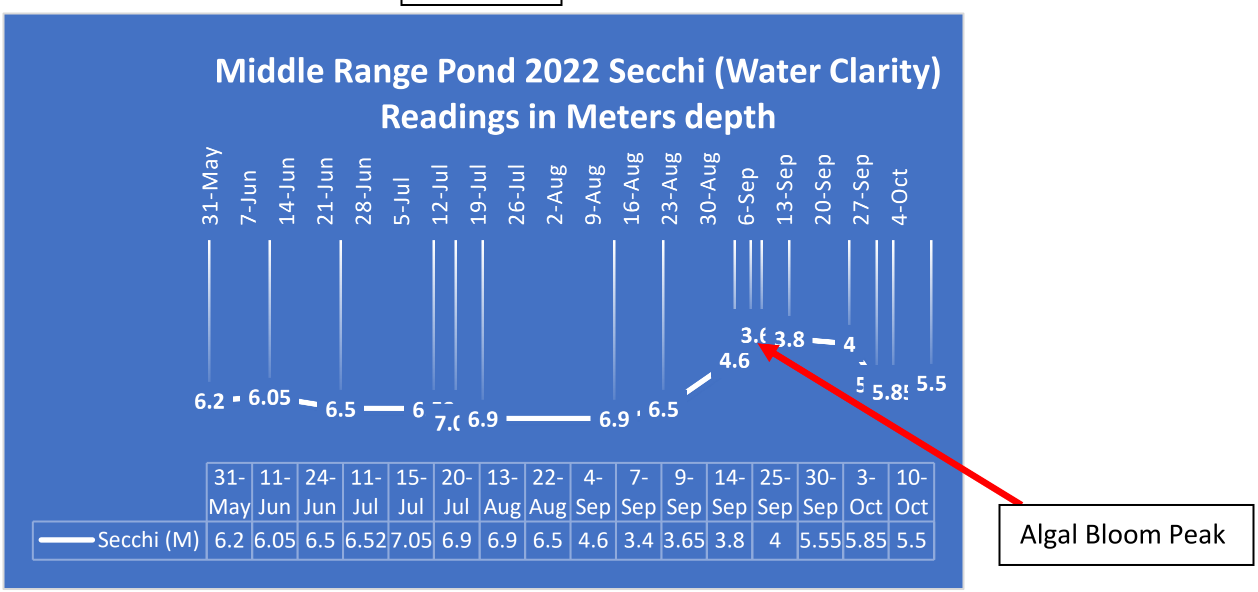


Figure 7

The 2022 algal bloom that occurred in Middle Range is evident in Figure 6. Readings taken from May through August 22 are within the normal range for the lake, representing above average water quality, compared to other Maine lakes. On September 4, the clarity measured 4.6 meters depth – a substantial two meter decline since August 22. A change of this magnitude over a short period of time would be unusual in any lake. The bloom intensified to 3.4 meters on September 7, after which the event slowly returned to near normal conditions when the last reading was recorded on October 10. Additional readings taken later in October by a volunteer who had received preliminary training indicated that water clarity continued to improve.

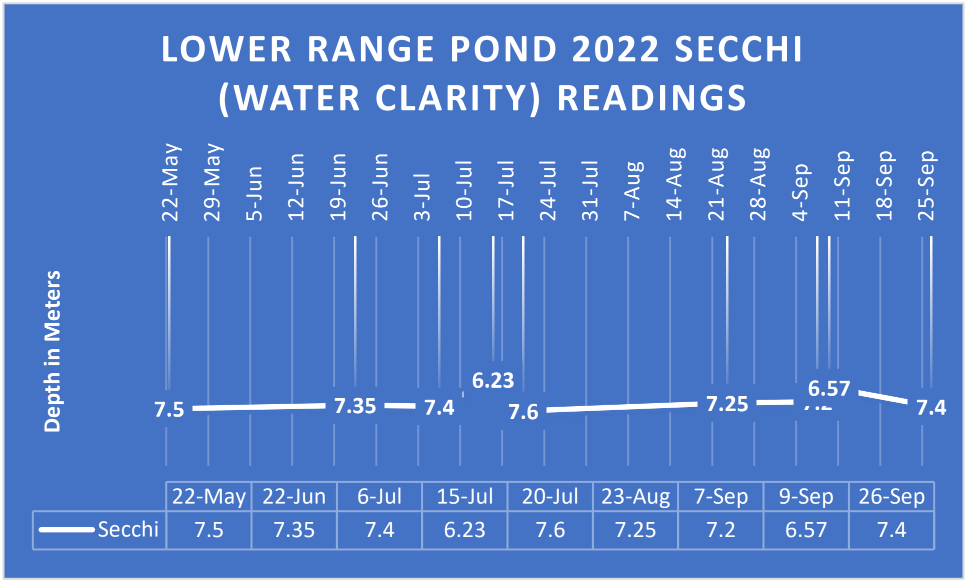
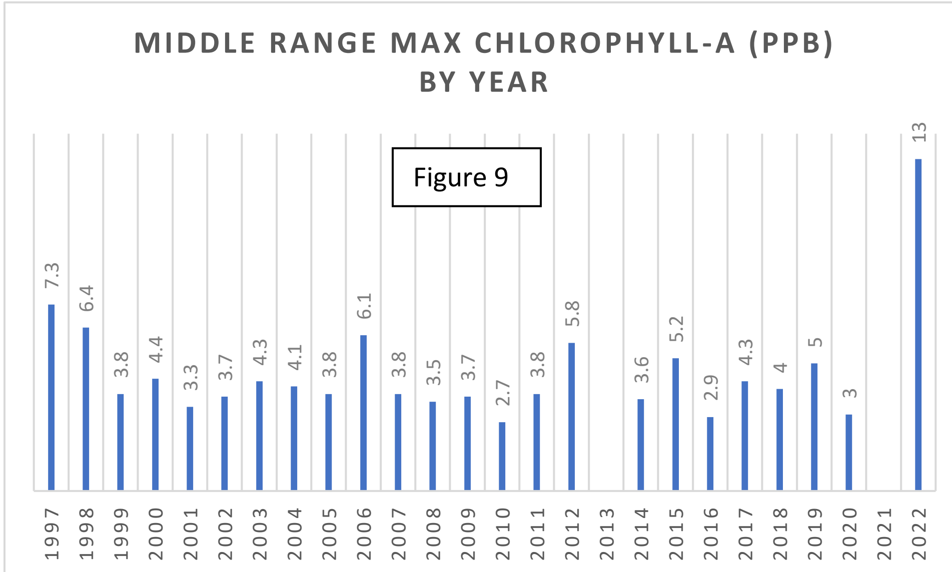


Figure 8

Figure 9 shows the highest chlorophyll-a sample concentrations in parts per billion (ppb) in Middle Range from 1997-2022. No sampling took place in 2021, and for a few of the years, only a single sample was taken. However, it is clear that the September sample from 2022 was nearly double the second highest sample from 1997, and was 3-4 times the level of most years between. The 13 PPB concentration from September 2022 was consistent with the bloom conditions documented in the water clarity reading(s). At that time, the color of the water in Middle Range was distinctly green.



Water color, a natural phenomenon that is primarily influenced by humic compounds contained in watershed wetland vegetation and deciduous leaves, was relatively low (less than 10 Standard Platinum Cobalt Units – SPU) on all sample dates for the three Range Ponds, with the exception of the September reading for Middle Range.

Unusually high lake **water temperatures** were documented in lakes throughout Maine during the summer of 2022. On July 15, the surface water temperatures for the three Range Ponds were all above 25 degrees Celsius (approaching 80 degrees F). By September 9, the surface temperatures had dropped from 1-3 degrees C. from Upper to Lower Range.

The three lakes were strongly thermally stratified in both July and September, with gradients from thermal gradients of more than 15 degrees from surface to the deepest points at the monitoring stations.

Significant anoxia (less than 1.0 parts per million – ppm dissolved oxygen –DO) was documented by July 15 in Upper and Lower Range Ponds, and severe anoxia was documented in all three of the lakes by September 9. The oxygen loss in Middle Range was greater than historically documented oxygen loss for the lake. Bloom conditions in the lake at that time would likely be contributing to the DO loss as senescent algal cells were decomposing in the water column. Figure 10 illustrates the changes in dissolved oxygen concentrations from the surface to the bottom of the deepest point in each of the three lakes.

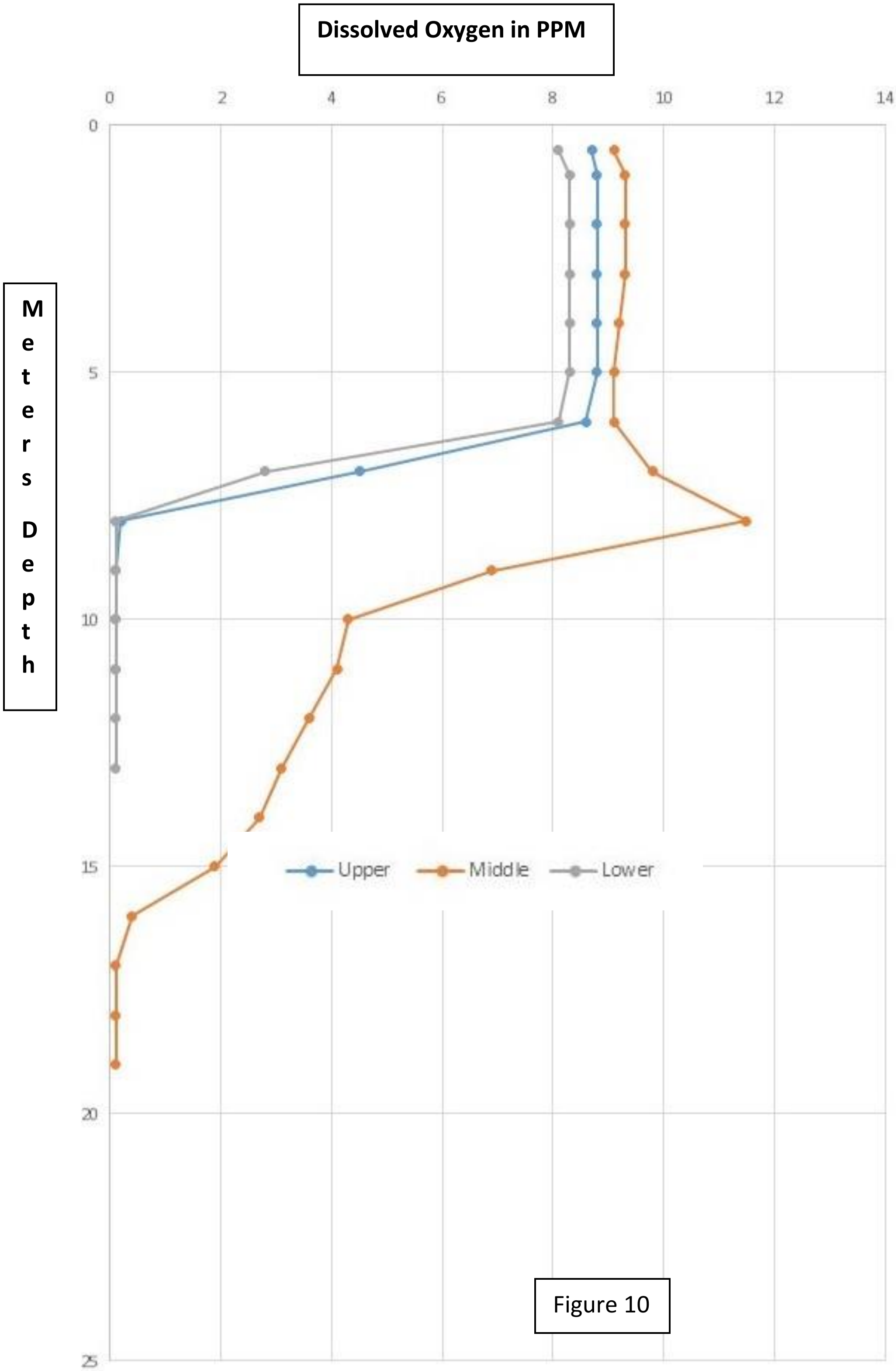

Dissolved Oxygen in PPM
0
2
4
6
8
10
12
14
0
5
10
15
20
25
Meters Depth
Upper
Middle
Lower

Figure 10

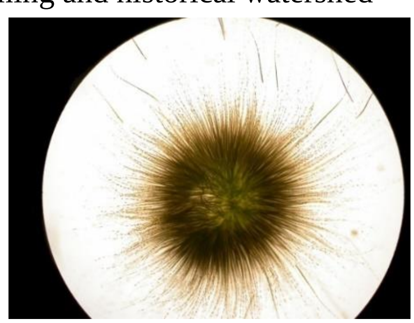
Lake water temperatures combined with moderate to high concentrations of phosphorus are significant risk factors for an increase of potentially harmful (toxic) algal blooms in Maine's lakes. Unusually warm lake water also stresses the biota, and has been linked to fish mortality in a number of Maine lakes in recent years.

Total Alkalinity is a measure of the capacity of lake water to buffer acidified precipitation and water entering the lake from its watershed. Alkalinity, measured in August and September, was close to historical averages for the three lakes.

"Metaphyton" is a broad term for a number of species of filamentous algae that form cotton candy-like green/yellow "clouds" in shallow areas of lakes, and streams. Metaphyton occurs naturally, and provides a number of ecological benefits to lake ecosystems. The algae that constitute metaphyton are common in lakes throughout Maine. They provide food and beneficial habitat for a wide range of lake Fauna. However, many lake communities, volunteer lake monitors, and professional lake scientists have reported a substantial increase in metaphyton abundance in recent years (observational data). The significance of this increase is not fully known, but may be the result of some influence(s) of weather events associated with climate warming. Continued monitoring and reporting unusual changes in the abundance and location of this algae will hopefully lead to a better understanding of its ecological significance.

Our monitoring of metaphyton in the Range Ponds in 2022 was limited to observational monitoring of the shallow boat launch cove areas between Middle and Upper Range, and at the State Park launch facility. Minimal metaphyton was observed, at low densities in each of the three lakes.

Gloeotrichia echinulata is a bluegreen algae (cyanobacteria) that has been observed/documented historically in a number of relatively clear Maine lakes. However, historical concentrations of this species, which forms colonies that are visible to the naked eye, have been very low. In recent years, "Gloeo" has been documented in an increasing number of less clear lakes, and at higher densities. The significance of this increase is not fully understood, but some information suggests that it may be influenced by factors associated with climate warming and historical watershed land use. Gloeo was documented in moderate to high densities in the severe algal bloom that occurred in Lake Auburn in 2012.



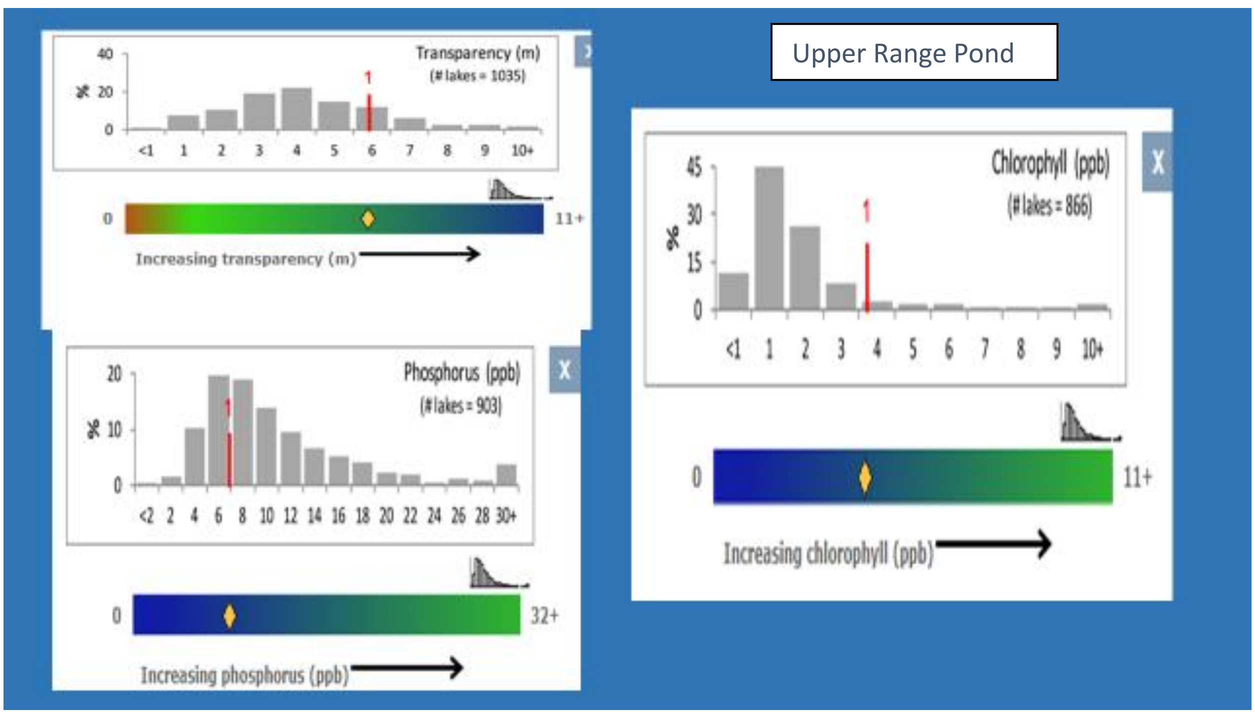
Magnified Image of *Gloeotrichia Colony*

Gloeotrichia concentrations measured at the deep monitoring station in August and September were at the low end of the density scale (1.0) for Upper and Lower Range, and slightly higher (2.0) for Middle Range in early September at the time of the algal bloom. However, Gloeo colonies were not the dominant algal species in the bloom.

Additional Water Quality Visualization Graphics

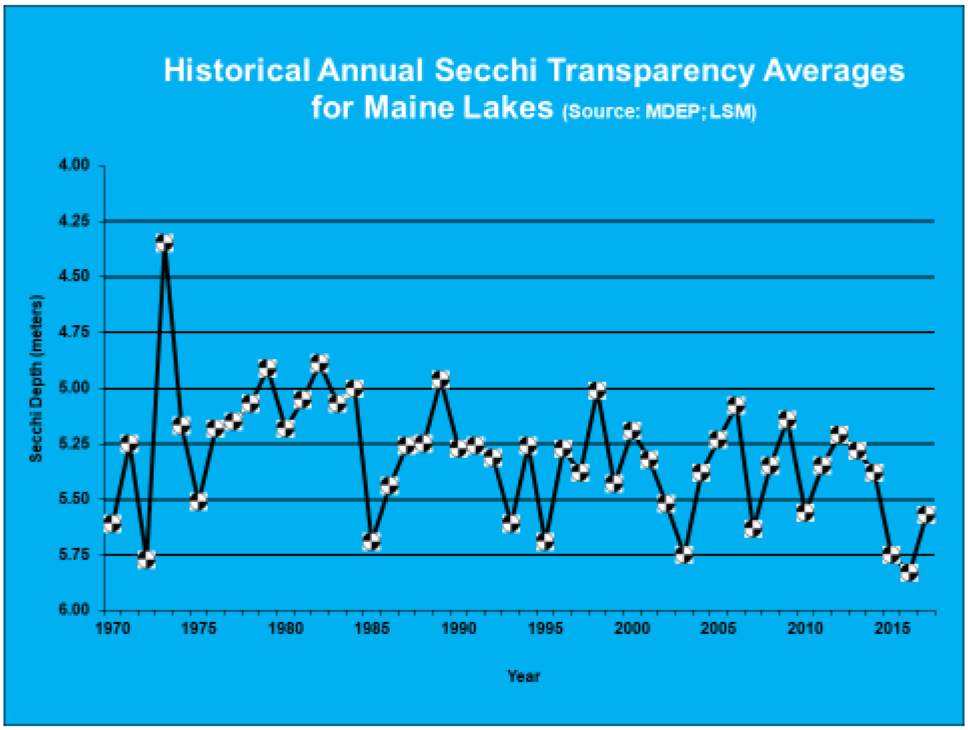
The “color ramps” below, produced on the www.lakesofmaine.org website, illustrate the range of data for several indicators of water quality for several hundred Maine lakes. The yellow diamond on each ramp indicates the historical average value for the indicator. The bar charts shown above each color ramp is a histogram that illustrates the distribution frequency for Maine lakes for each indicator. The red line in each indicates the historical average for the lake. The histogram shows where the lake is situated, relative to the total number of Maine lakes assessed/represented (indicated by “# of lakes”).

 The first ramp shows water clarity, ranging from least clear on the left, to clearest on the right. The yellow diamond depicts the historical average, relative to more than 1,000 Maine lakes. The bar graph (histogram) situated illustrates the position of the lake relative to others in the group.

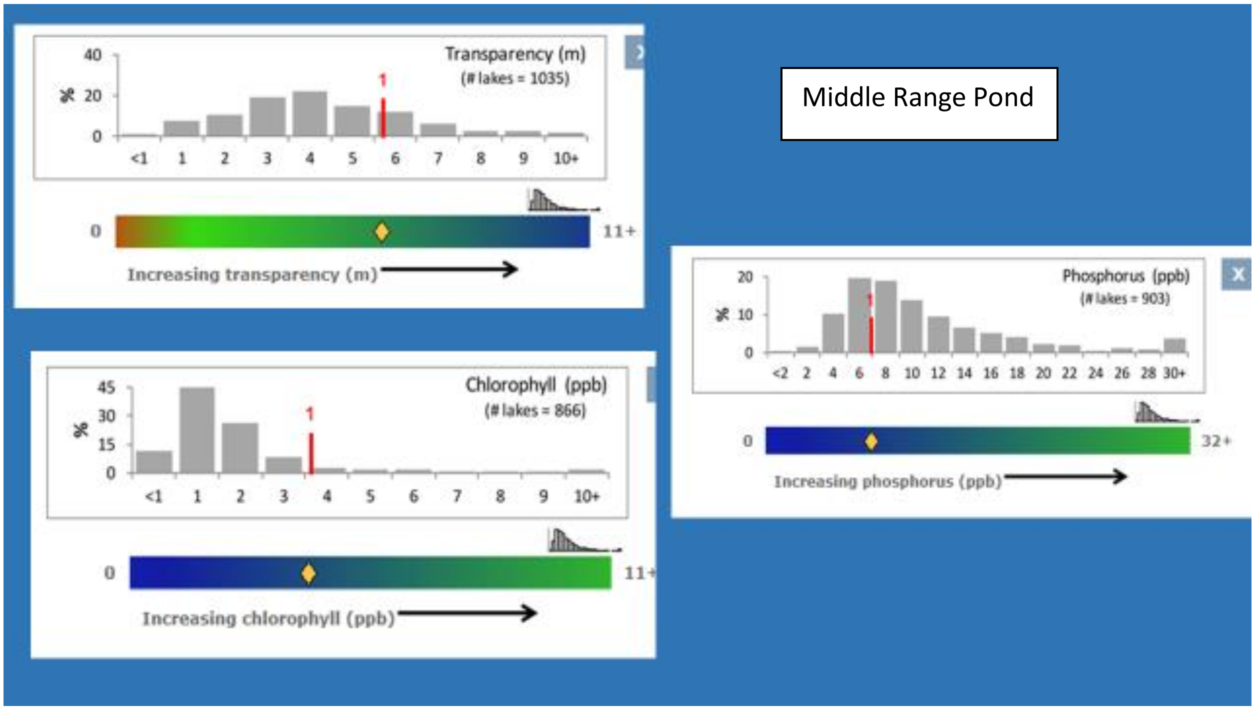


The historical water clarity annual averages for Maine lakes (based on data from numerous sources for more than 1,000 lakes) has varied in the 4.75-5.75 meter range for the past few decades.

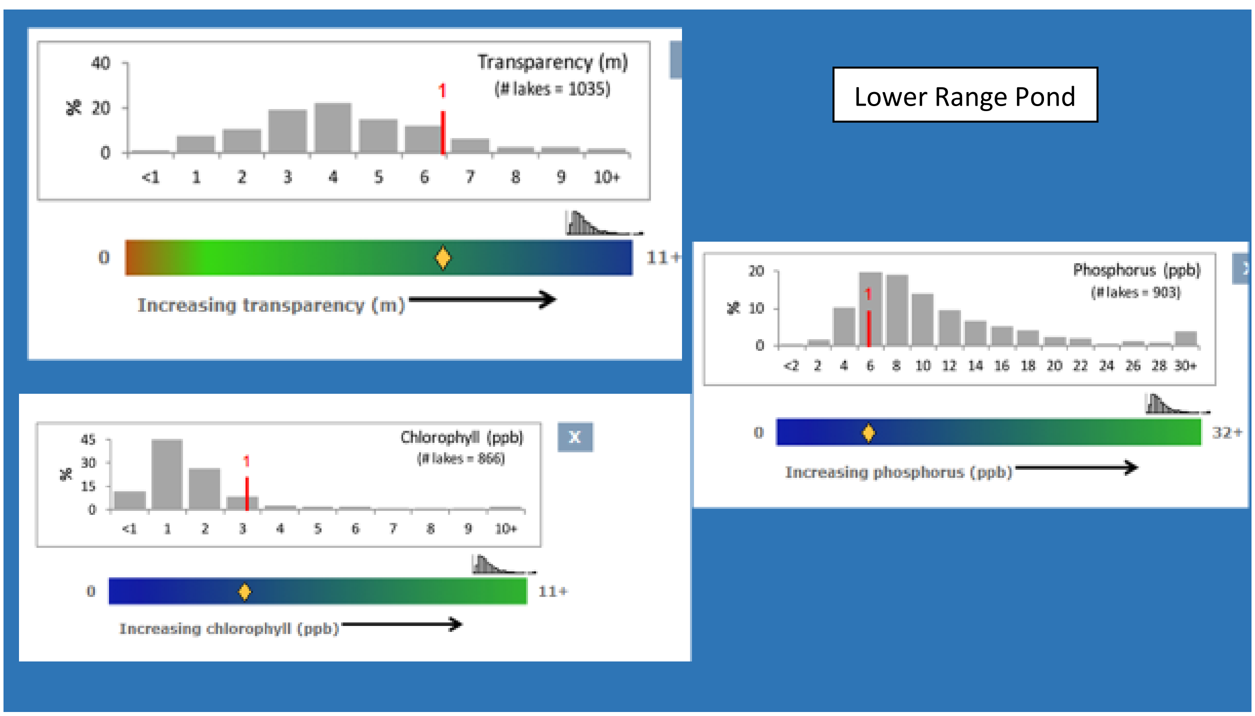
The following graphic illustrates the annual average Secchi value for Maine lakes, based on the number of lakes for which data were available for the individual years.



Note that the color ramp scales for total phosphorus and chlorophyll below illustrate higher water clarity on the lower left side of the ramp, whereas the Secchi transparency ramp above shows higher water clarity/quality on the right end of the scale.



Middle Range Pond
Transparency (m)
(# lakes = 1035)
Increasing transparency (m)
Phosphorus (ppb)
(# lakes = 903)
Increasing phosphorus (ppb)
Chlorophyll (ppb)
(# lakes = 866)
Increasing chlorophyll (ppb)



Lower Range Pond
Transparency (m)
(# lakes = 1035)
Increasing transparency (m)
Phosphorus (ppb)
(# lakes = 903)
Increasing phosphorus (ppb)
Chlorophyll (ppb)
(# lakes = 866)
Increasing chlorophyll (ppb)

Summary and Recommendations:

Both Upper and Lower Range Ponds exhibited relatively stable water quality in 2022, compared to historical conditions. However, late summer dissolved oxygen concentrations in the deepest region of both lakes were very low - similar to, but lower than historical conditions, likely the result of warmer water temperatures.

Middle Range Pond experienced an unanticipated moderate planktonic algal bloom during the late summer. The bloom was not severe, and was of relatively short duration, both being characteristic of the timing and intensity of initial algal blooms in a lake. Although it is not possible to know whether or not the lake will experience a similar bloom in 2023, increasing the frequency and intensity of monitoring the lake is recommended. Doing so may shed light on the mechanistic dynamics of the 2022 event, as well as the early detection of a future event.

Climate warming is a very real threat to the ecological health of the Range Ponds. Mid summer lake water temperatures in the low to mid 80's(F) in Maine lakes, combined with other weather extremes that have been documented in recent years, including intense, localized precipitation and runoff events, drought, reduced periods of ice cover, and other unusual meteorological phenomena pose a significant threat to relatively stable historical conditions of Maine's lakes.

Once a lake exceeds its natural assimilative capacity, restoration may be difficult, uncertain, and very costly.

Given the circumstances of the Middle Range bloom in 2022, and the rapid manner in which changes can take place at this point in time, continued vigilance in monitoring and protecting the three lakes and their watersheds will be essential to maintaining their overall health and stability.

Both the Upper and Middle Range Pond watersheds should be surveyed in the near future to identify sources of polluted stormwater runoff to the lakes, using the "Citizen's Guide to Lake Watershed Survey methodology and guidelines established by the Maine DEP (see link below).

https://www.maine.gov/dep/land/watershed/materials/lakewsurveyguide.pdf

Preventing, documenting and resolving disturbances in the watershed sis critically important. Ensuring that new residential development, agriculture and timber harvesting incorporate "best water quality protection practices", as well as revisiting and evaluating the effectiveness of existing water quality protective measures (properly sized culverts, runoff diversion practices and vegetated buffers) will be necessary, as the erosive intensity of stormwater runoff associated with extreme precipitation increases.

Prepared by Lake & Watershed Associates Senior Limnologist, Scott Williams