Report on the Health of Thompson Lake 2015

This report is a summary and analysis of findings of water quality monitoring of Thompson Lake from May through September, 2015. Most of the readings, samples and observations were gathered at the deepest point in the lake, situated to the west of Hayes Point in Oxford. The majority of historical water quality information for Thompson Lake is also based on sampling at the Hayes Point deep station.

In addition to the sampling that we conducted, Maine VLMP-certified volunteer lake monitors Ron Armontrout, provided a complete season of Secchi transparency (lake water clarity) readings. This additional information has been very helpful in developing an overview of conditions in the lake during the 2015 monitoring season.

All sampling was conducted in accordance with protocol and quality assurance standards established by the Maine DEP and the Maine Volunteer Lake Monitoring Program.

Overview: Overall, Thompson Lake experienced *above average* water quality in 2015 (compared to historical averages for this waterbody), based on the clarity of the water, and on the concentrations of the nutrient phosphorus over a 5 month period. The concentration of chlorophyll-a (an algal pigment) in water core samples taken at the deep station was higher (more algae growth) than the historical average, however, the average was skewed by a single very high reading that does not correlate with other baseline indicators, indicating possible laboratory error.

Weather Influences:

Weather conditions can have a strong influence on indicators of lake water quality. Much of the natural variability that is common in lakes from year to year can often be attributed, in part, to overall weather patterns, and sometimes to individual storm events.

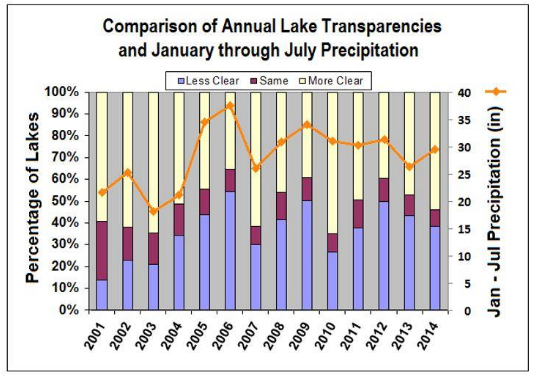
Extreme weather events, including heavy rain, strong wind, and abnormally high temperatures associated with climate change may be increasingly frequent in the future. Such events are likely to have a measurable effect on lake systems, including a reduction in the period of ice cover, lower dissolved oxygen concentrations in deep areas during late summer, an increase in nutrient and sediment levels in stormwater runoff from soil erosion in lake watersheds, and more.

*2015 Weather Influences:

Weather conditions prior to, and during the annual lake monitoring period can strongly influence the indicators used to assess lake water quality, and often account for a significant percentage of the "annual variability" that occurs in lakes.

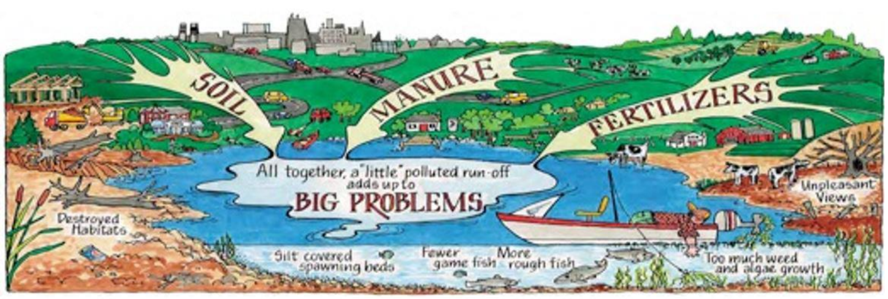
Temperature, wind, sunlight, and precipitation influence the biology, chemistry and physical aspects of lakes throughout the year. Understanding how weather-related variability affects lakes from year to year can be daunting. Factors include: 1) duration of ice cover, 2) long and short-term precipitation amounts, 3) storm event intensity, 4) fluctuations of lake water levels, 5) timing of the onset, and duration of thermal stratification, and others.
Lake water clarity (and corresponding Secchi transparency readings) seem to have a significant correlation to precipitation.

Figure 1 (right) illustrates the relationship between annual precipitation (January through July, Portland, Maine) and the annual average Secchi transparency for monitored Maine lakes over a period of fourteen years. There is an apparent inverse correlation between the two variables; in other words, as annual precipitation increases, Secchi transparency decreases in most, but not all, years. Preliminary statistics indicate that one-third of the variation we see in lake transparency is due to precipitation.



The correlation is significant, but not perfect by any means, due, no doubt to the interaction of many variables that make each lake somewhat unique, including the fact that the precipitation data from the National Weather Service is from one region of the State of Maine (Portland), whereas the Secchi average includes lakes throughout the state. Maine is a large state, and weather can vary considerably from north to south, east to west, and in between. However, a substantial percentage of the lakes represented in the VLMP database are situated in the south/southwesterly area of Maine, relatively close to Portland. A stronger correlation might exist if the graph were to only represent lakes situated within a short distance of where the precipitation was measured.

Given the correlation discussed above—imperfect or no—it is reasonable to assume that, on average, a majority of Maine lakes will be less clear during high-precipitation years, especially if precipitation occurs the winter before and/or during the lake monitoring season. That is because lakes are the natural repository of much of the stormwater runoff that results from precipitation events. As stormwater (including snowmelt) moves across the landscape, it picks up pollutants that can negatively impact water clarity, such as phosphorus—which stimulates algal growth— and eroded soil particles. (See **Figure 2** below.)



A significant percentage of the annual phosphorus transported to Maine lakes typically occurs during the "spring runoff period", when the winter snowpack is melting, spring showers are taking place, and soils are often either frozen or saturated with water (resulting in greater runoff).

As suggested above, the correlation between precipitation and water clarity is not entirely straight forward. Qualitative factors, such as the timing and intensity of storm events can have a strong bearing on the extent to which precipitation runs off, as opposed to filtering slowly into the ground. Frequent low-intensity rain events cause less soil erosion and phosphorus export to lakes than high intensity storms, in which rain comes too fast to filter through the soil, often resulting in significant erosion and stormwater runoff to lakes. Also, for a relatively small group of lakes that experience internal phosphorus recycling, frequent rain events—by regularly flushing phosphorus-laden water from the lake—may actually have the opposite effect, causing an improvement in Secchi transparency.

2015 Weather Synopsis:

None of us need to be reminded that the winter of 2015 was long, cold and very snowy! However, precipitation in February and March was below normal in Portland, even though snowfall and the standing snowpack was above normal during that period. Very little melting occurred in February, and March was also colder than normal, the net effect of this being that in late winter/early spring, there was still a great deal of snow on the ground throughout much of the state. All of this set the stage for potential flooding and heavy runoff in the spring– not the best scenario for lakes.

Fortunately, April was only slightly warmer than normal, and precipitation—the first rain since December—was less than an inch above normal. As a result, the snowpack continued to melt slowly, with little flooding, and minimal runoff to lakes from their watersheds, as the snow and rain slowly infiltrated into the gradually warming soils.

Although May was unusually warm, precipitation was below normal, and with the exception of one storm that produced just under an inch of rain, much of what fell from the sky in May was likely to have infiltrated into the soil.

June was unusually cool, and although rainfall for the month was above normal, year-to-date precipitation was only .02 inches above normal.

Temperatures moderated in July, but precipitation was substantially below normal, being one of the driest Julys in 145 years! During such conditions, very little, if any, stormwater runoff made it to Maine lakes.

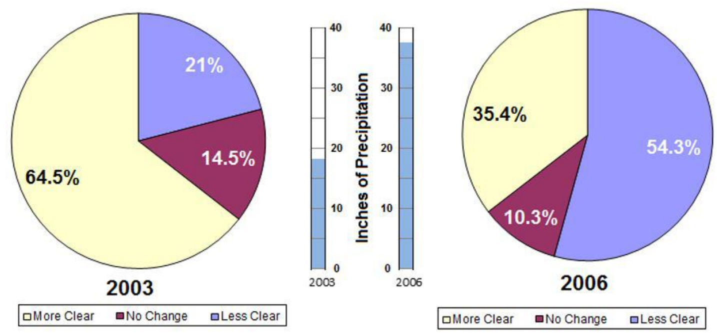
August was warmer than normal, but precipitation for the month remained below average, and conditions on the ground were becoming very dry. Once again, very little stormwater runoff occurred in the area. During the month of August, a number of volunteer lake monitors reported “better than average” Secchi readings for the month.

Warmer-than-average conditions persisted into September, and precipitation for the month was above normal, making it a notably wet month. However, much of the precipitation occurred in a 6 inch rain event on the 29th and 30th of September; too late to have any bearing on summer Secchi readings.

In summary, weather conditions in the Portland, Maine area during the first several months of 2015 would likely have had a favorable influence on lakes in the region, as a result of 1) relatively slow warm-up and snowpack melt in the spring, followed by 2) average, to below average rainfall during the mid and late summer period, likely resulting in relatively little runoff and soil erosion from lake watersheds during the period.

Note: The complete NWS narrative weather summary on which this information is based can be viewed at: http://www.mainevlmp.org/wp-content/uploads/2015/11/NWS-2015-Narrative-Summaries.pdf.

Now for some disclaimers: While the conditions noted above could have an overall beneficial effect for many lakes, weather is just one of a myriad of factors that determine how individual lakes will "behave" during the lake monitoring period. Moreover, Secchi transparency is only one indicator of lake water quality – albeit a pretty good one for gaging the overall health of a lake. For every year when a relatively high percentage of Maine lakes are clearer than they have been historically, many are also less clear, as the two pie charts in **Figure 3** (right) illustrate. Note the differences in precipitation for the two years.

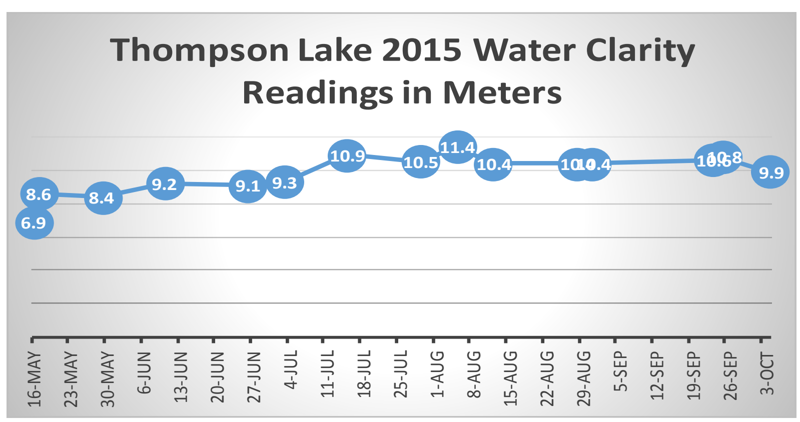


**Note: The weather synopsis above is excerpted from an article authored by Scott Williams in the 2015 edition of The Water Column, the newsletter of the Maine Volunteer Lake Monitoring Program. Some graphics courtesy of Linda Bacon, Maine DEP.*

Another critical factor that influences the sensitivity and vulnerability of individual lakes is the amount of time that it takes for a lake to completely "flush" or replace the water in the lake basin. Lake flushing rate is based on the volume of the lake basin, the area of the watershed and the average annual precipitation. The lower the flushing rate, the longer water is retained in the lake. Lakes that flush slowly, like Thompson (which takes more than 3 years to replace all of the water in the basin) are more sensitive to phosphorus, because of the amount of time that it takes to replace the water.

2015 Water Quality Monitoring Summary:

A key indicator of biological productivity in lake systems is water clarity (aka Secchi transparency) Lake clarity is primarily influenced by the concentration of algae in the water. However, suspended sediment particles from eroded soil in the watershed can at times also influence clarity. The clarity of the water in Thompson Lake was consistently above average for the lake throughout the 5 month monitoring season.



Water Clarity: During the course of the monitoring season, the distance that one could see down into the water from the lake surface (aka: Secchi transparency) varied from a very high (good) reading of 11.4 meters on August 5, taken by Ron Armontrout, to the lowest reading of the season – 6.9 meters, also taken by Ron on May 16. The low reading in May was very likely the result of a spring rain event, combined with winter runoff, because a reading taken only a day later by Scott Williams measured 8.6 meters. The exceptionally clear reading in August occurred during a time in the season when weather conditions were dry and calm. Historical water clarity data for Thompson have shown on many occasions that the lake is very sensitive to heavy rain events and stormwater runoff, often resulting in rapid measurable negative changes in water clarity. *The average for the May through October period was 9.9 meters (about 32 feet!), which is nearly a full meter* *higher/better/clearer than the Thompson Lake historical average of 9.0 meters!* The previous five years had shown a short-term decline in Thompson's water clarity. However, similar trends have been observed in the lake in the past, followed by recovery, including short-term improvements in lake clarity. The sharp improvement in 2015, while no doubt due, in part to the influences of weather, also demonstrates the resilience (and sensitivity) of the lake system.

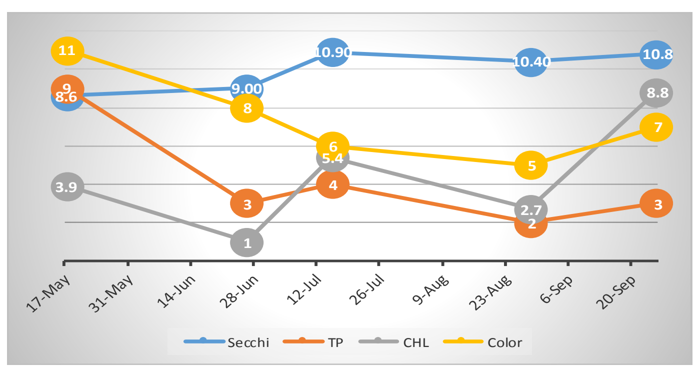
<u>Total Phosphorus:</u> The concentration of the nutrient phosphorus in lake water largely determines the growth of algae in the water, which in turn influences water clarity and oxygen levels. The average concentration of total phosphorus (TP = combined organic and inorganic forms) in the lake in 2015 was 4 parts per billion, as was the case in 2014. The historical average for the lake is 5 ppb. During the course of the 5 month monitoring period, TP varied from a very low concentration of 2 ppb in August, to a high of 9 ppb in May, following the period of spring runoff. The June sample measured 3 ppb, and remained low for the remainder of the summer. Thompson Lake has experienced relatively high concentrations of phosphorus a number of times from spring samples, suggesting possible watershed runoff-related factors.

<u>Chlorophyll-a:</u> The average concentration of chlorophyll-a, (CHL) a direct measurement of algae growth in the water was 4.4 ppb, compared to 2.6 ppb in 2014. As discussed earlier, the higher average in 2015 was strongly influenced by the September reading (8.8 ppb), which may have been the result of laboratory error. CHL ranged from a very low concentration of 1.0 ppb in June to the high September reading.

It is worth noting that while over time there is generally good correlation between water clarity and the concentration of total phosphorus and chlorophyll-a in lake water, the inter-related physical, chemical and biological processes that are represented through the water quality data do not necessarily correlate well when viewed as single monthly readings/samples. During a typical lake monitoring season, the sampling represents an instantaneous "snapshot" of conditions in the lake when the samples and readings were taken. But lake ecosystems are highly variable and dynamic, resulting in what may appear to be (and very likely are) temporal phase discontinuity between the indicators.

Another factor to be considered when comparing annual averages to historical is that historical averages are continuously changing, as each previous years' data is included in the calculation of the average

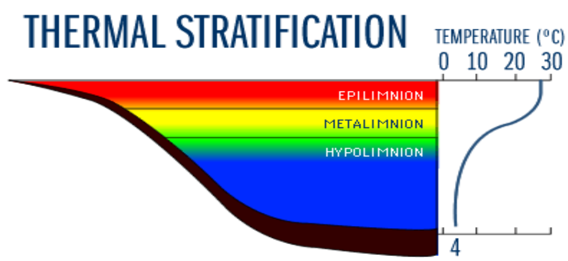
The chart to the right illustrates the changes that were measured throughout the 2015 lake monitoring season for the three "tropic state" indicators (measurements of lake biological productivity): Secchi transparency (water clarity), total phosphorus, and chlorophyll-a. Also shown is the concentration of natural color in the water during the period – an indication of the concentration of humic acids in the water, influenced primarily by the leaching of organic compounds from wetland vegetation in the watershed. High concentrations of lake color can have a complex influence on the trophic indicators. But the color concentration in Thompson is relatively averaging about 10 SPU's over the history of data collection from 1980- present. Some lake scientists have predicted that climate change is likely to cause



an increase in humic acid in lakes over time, resulting in the “browning” of lakes, as well as dysfunction for physical, chemical and biological processes in lake systems.

Dissolved Oxygen:
The amount of oxygen that is dissolved in the water in the deepest area of a lake during the late summer and early fall, until the lake mixes or “turns over” is a critical indicator of overall lake health. Thompson Lake has maintained high levels of dissolved oxygen through the summer/fall period for as long as data have been collected for the lake – even in the deepest, and most critical location of the “deep station” near Hayes Point. This characteristic of exceptional water quality is the primary factor that allows coldwater fish to thrive in Thompson lake.

Water temperature and dissolved oxygen profiles measured throughout the 5 month monitoring period *may* be showing a slight decline in oxygen in the deepest area of the lake during the month of September. This *may* be due to the combined influences of increasing lake water temperature, and a lengthening of the period of thermal stratification, during which cold, oxygen-rich water in the deep area of the lake is isolated from the atmosphere.



One climate-related factor that may negatively influence this process is the lengthening of the period of time during the year when the lake is free of ice cover. Warm ambient temperatures in the fall may cause deep lakes like Thompson to “turn over”, or mix, in the fall, resulting in a longer period of time when the hypolimnion (deep, cold layer) is isolated from the atmosphere. Late mixing of the water in the fall could, and likely, will, result in lower dissolved oxygen levels prior to mixing. Earlier “ice-out” in the spring will likely result in the earlier onset of stratification. When combined with late mixing (destratification) in the fall, oxygen levels in the deepest area of the lake will almost certainly be lower at a critical time of the year for the coldwater fishery. Dissolved oxygen levels in Thompson Lake are currently high throughout the year, due primarily to low biological productivity, thereby providing the fishery and water quality with somewhat of a “buffer” against change. But the influence of climate change has already been thought to have had significant negative consequences on some Maine lakes.

Conductivity is a measure of the ability of lake water to pass an electrical current. It is a measure of the concentration of ions in the water. As lake watersheds become more developed, and indicators of water quality show evidence of a negative change, conductivity concentration generally increases. The historical conductivity concentration in Thompson Lake is 38 ms/cm, based on eight samples taken since the 1970’s. A sample taken in August, 2015 measured 43 ms/cm, and was 44 in 2014.

Gloeotrichia:
We continued to monitor the presence of Gloeotrichia in Thompson Lake in 2014. This blue-green algae has often appeared in Thompson historically at low densities during mid to late summer. “Gloeo” colonies are typically observed relatively close to the water surface, having the appearance of tiny, fuzzy, green-white dots. Gloeotrichia is sometimes described as having the appearance of “tapioca in lake water”. It is found in many lake algal communities throughout Maine. However, Gloeo may be increasing in some lakes, and it has been associated with water quality concerns in a small number

Maine lakes in recent years. Gloeo is the subject of current research, in an attempt to determine why it may be more prevalent in Maine lakes in recent years, and possible implications for lake ecosystems.

Monthly observation/measurement of Gloeo density in Thompson documented 0 colonies until August when colonies were reported at low density, consistent with both the timing and density of what has been observed historically in Thompson Lake. Gloeo colonies were somewhat more abundant at the public boat launch on Rte 121 on the August sampling date, ostensibly due to accumulation from the southwest wind, and wave action.

TLEA Participates in Pilot Lake Vulnerability Study: A sustainability grant from the George Mitchell Center at the University of Maine has enabled staff from the Maine Volunteer Lake Monitoring Program, the Maine DEP, the University of Southern Maine, and scientists from the Mitchell Center and VLMP Advisory Board to conduct a critically important pilot study of 24 Maine lakes (including Thompson) to determine ways in which the chemistry of lake sediments influences lake vulnerability. An equally important factor that is being considered in this process is lake community capacity for effecting stewardship over time.

Representatives of TLEA, and VLMP Certified Lake Monitor, Ron Armontrout, participated in this study in 2015, which entailed the baseline sampling of Thompson Lake, including the collection and analysis of the bottom sediments. Also included was the participation in surveys designed to assess community capacity for lake protection. The project is investigating important inter-relationships between physical and social science in the long-term stewardship of Maine lakes. During the next several weeks, focus groups consisting of participating VLMP lake monitors (including Ron) and lake associations (including TLEA) will meet to further discuss and investigate the ways in which physical and social science can be used to enhance lake protection. This study will ultimately lead to a significant refinement of Maine's Lake Vulnerability Index. TLEA's role in the pilot study has been, and will continue to be very helpful, benefitting all of Maine's lakes.

Summary:

Overall, the water in Thompson Lake was substantially clearer than the historical average for the lake in 2015. The concentration of phosphorus in the lake was lower (better) than the historical average, and the concentration of algae in the lake, while higher than average for Thompson, may (or may not) have been the result of anomalous conditions in the lake during one of the sampling visits, or possibly laboratory error for one of the samples . Late summer oxygen levels in the deepest area of the lake have been relatively low during the past few years, possibly due to shorter duration of the period of ice cover, warmer water temperatures, and a resulting lengthening of the period of thermal stratification. The September, 2015 oxygen concentration at the deepest area of the monitoring station was not as low as it has been during the past few years – likely due to the fact that "ice-out" was closer to average for the lake in 2015, unlike recent years when ice-out has been earlier than average for Maine lakes. Factors that cause the temperature of the lake water to increase, or the period of thermal stratification to be longer, will very likely have a negative effect on late season dissolved oxygen levels in the lake.

Thompson Lake continues to exhibit water quality that is significantly above the average for Maine lakes. The number, and complexity of threats to Maine lakes will very likely continue to grow as climate change exacerbates the effects of everything from watershed development to the breadth of invasive species infestations. TLEA has played a critically important role in protecting the lake for more than four decades. The protection of our lakes is ultimately a local issue, and TLEA has the proven experience and capacity to assume the role of leadership in the Thompson Lake watershed community.

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