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2019 Range Ponds Water Quality Overview

Perspective:

The annual characterization of the water quality of Maine lakes has always been a challenge to lake scientists because aquatic ecosystems experience a high degree of "natural variability". One of the strongest influences on this natural process is the weather, and typically, foremost among the many forces of weather on lakes is precipitation. Many Maine lakes tend to be clearer during drier years, ostensibly because of reduced stormwater runoff during such periods, and stormwater runoff is the vehicle that transports phosphorus and other pollutants from watersheds to lakes. Conversely, lakes tend to be less clear during years when there is more precipitation during the period from January through the middle of summer.

While a majority of Maine's lakes "behave" this way, there are exceptions to this simplistic generalization, both in the degree of variability that occurs with individual lakes, and the fact that some lakes respond to precipitation in an opposite manner, for reasons having to do with other weather influences (temperature, wind, etc.), as well as factors pertaining to the unique characteristics of individual lake ecosystems, including the annual flushing rate, watershed geochemistry, bathymetry and much more. Highly productive lakes that experience regular algae blooms sometimes benefit from the diluting effects of precipitation, because phosphorus concentrations are already moderately high.

Climate warming is compounding the complexity of tracking, predicting and characterizing lake water quality. Reduced periods of ice cover, resulting in longer periods of light penetration, and warmer lake water, when combined with more severe weather events during the open water season, will almost certainly have a negative effect on the health of Maine's lakes over time.

Some lakes that have historically been "on the edge", as well as some that were considered stable, have experienced a significant decline in recent years, very likely, in part to a warming climate.

Range Ponds 2019 Overview and Summary of Findings:

Upper Range:

The following is based on sampling conducted on Upper Range Pond on August 6 and September 5, 2019. Additional lake water clarity data gathered by LSM Certified Volunteer Monitor, Matt Brettler, have been included, as well. Historical data reference sources are the Maine Department of Environmental Protection, Lake Stewards of Maine (www.lakesofmaine.org), and LWRMA field records and reports.

Please refer to Table 1, below regarding all data obtained in 2019, and historical averages.

Overall, the water quality of Upper Range Pond continues to be relatively stable. In 2019, overall water quality was very close to the historical average for the lake. The 6.0 meter water clarity average was one nearly one meter clearer than the historical average (6.4M). Figure 1 illustrates the range of water clarity readings from May through August. Figure 2 illustrates the considerable annual variability in water quality that has been documented since 1980. Some of the variability that has occurred from year to year may be partially influenced by the frequency and timing of readings taken.

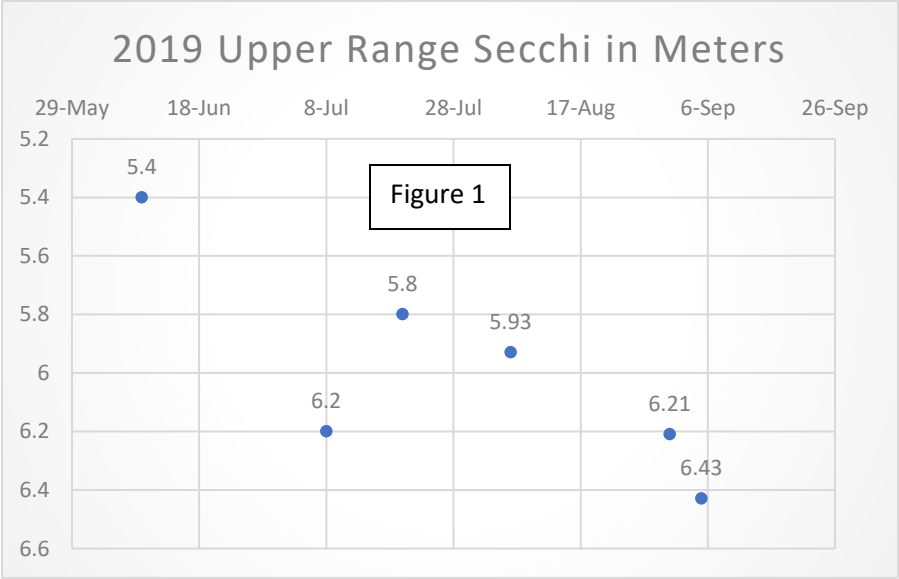
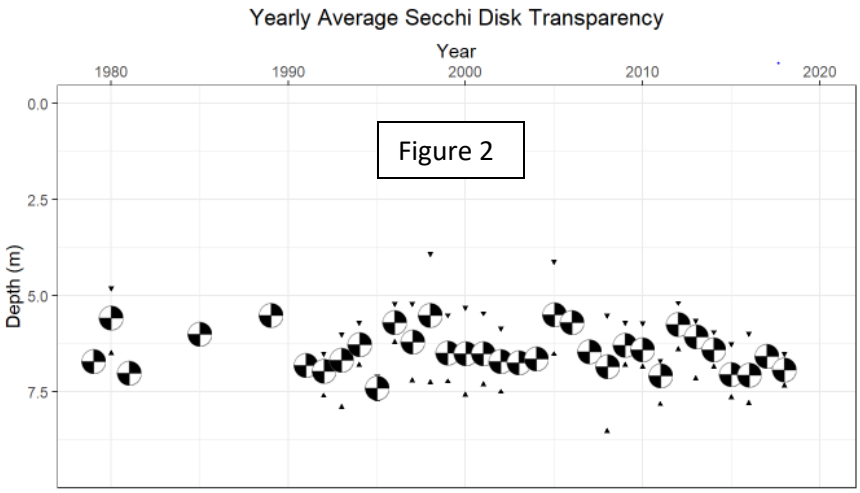


Figure 1

Graph Legend: Secchi symbols = average Secchi Disk Transparency Values; tick marks = maximum and minimum values for each year.



The August and September epilimnetic core total phosphorus samples measured 7 and 6 ppb, averaging 6.5 ppb which was slightly lower (better than) than the historical average (7.5ppb) for the lake. Samples taken near the bottom of the deepest point in the lake averaged 9ppb, compared to the historical average of 13ppb. The lake was strongly thermally stratified on both sample dates, and dissolved oxygen was depleted in the deepest area of the lake, similar to, and consistent with historical late summer conditions for Upper Range.

The chlorophyll-a (a direct measure of planktonic algae density) concentration in August and September (3 and 4 ppb – averaging 3.5 ppb) was very close to the historical average for the lake (3.9ppb), as indicated in the Figure 1 table below.

True Color, measured in August and September measured 22 and 7 SPU (Standard Platinum Units), averaging 14.5 SPU was slightly higher than the historical average of 8 SPU. Total Alkalinity and pH measured on the two sampling dates were similar to the historical averages for the lake.

Specific Conductance, measured in August and September averaged 80 microsiemens/cm, compared to the historical average of 55 – a significant increase in this indicator that is sometimes associated with soil erosion, road salt and other sources of inorganic ions, which are capable of passing an electrical current. However, it appears than many Maine lakes sampled in the late summer of 2019 showed spikes in specific conductance, possibly due to significant precipitation in the spring, resulting in increased runoff from their watersheds during the period.

No Gloeotrichia (cyanobacteria) colonies were observed on either sample date in 2019. Gloeotrichia is a form of lake algae that has historically not been uncommon in a number of clear Maine lakes during the late summer-early fall period. In recent years, the phenology of this alga has changed dramatically in some lakes throughout New England. Research suggests that an increase in the presence of "Gloeo" may be associated with a negative change in water quality – possibly driven by a warming climate.

Temperature and dissolved oxygen profiles taken in both August and September showed moderate dissolved oxygen loss, in the deepest area of the lake, but possibly to a lesser extent than has been documented in recent years. This may have been due to any of a number of influences, including cool spring weather, resulting in a delay in the onset of thermal stratification in regional lakes.

The baseline ratio of the algal photosynthetic pigment phycocyanin, to other forms of chlorophyll was measured on both dates. The purpose of this analysis is to observe the extent to which the ratio changes over time – a possible indicator of a shift from the normal assemblage of algal species in the lake to one that is more dominated by cyanobacteria/bluegreen algae. This was only the second year during which this analysis has been conducted. Data cannot be interpreted until multiple years of information has been gathered.

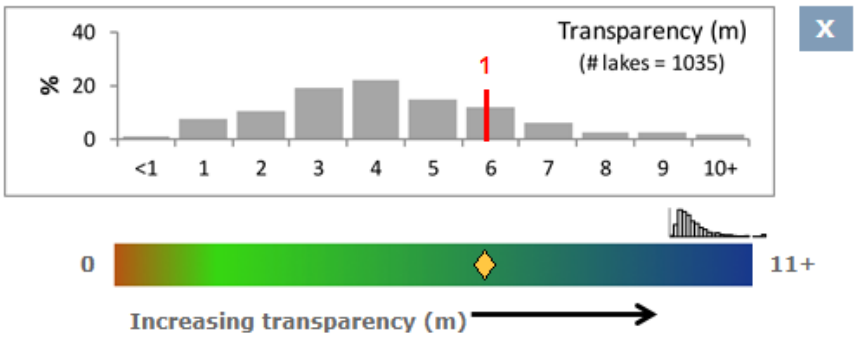
Table 1: 2019 and Historical Data Summary Information: Upper Range Pond

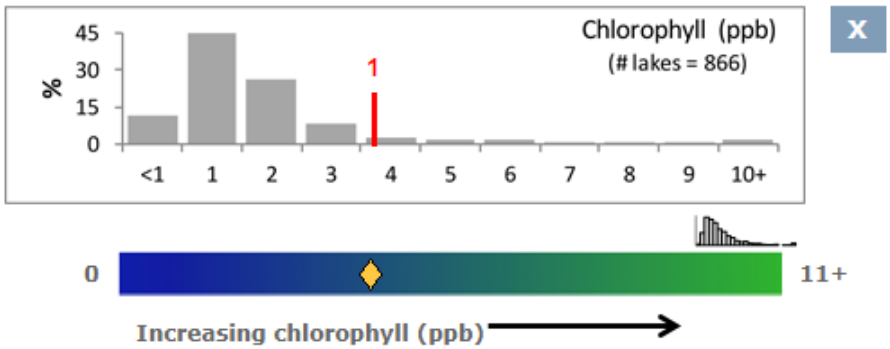
Indicator	Range: (Lowest to Highest)	2019 Average	Historical Average	Notes
Secchi Transparency in Meters	5.4-6.4	6.0 (5 Months)	6.4	Very clear in 2019
Total Phosphorus in ppb	6-7	6.5	7.5	
Chlorophyll-a in ppb	3-4	3.5	3.9	Measures planktonic algae
True Color (SPU)	7-22	14.5	8	
pH (std units)	7.56	7.56	7.00	
Total Alkalinity in mg/l	13.5	13.5	13.0	pH Buffering capacity
Specific Conductance (MicroSiemens/cm	78-81	80	55	Unusually high in 2020
Gloeotrichia	0	0	0	
Dissolved Oxygen mg/l	Depletion 9-11 meters depth in Aug and Sept	N/A	Similar, but to a lesser degree	History of late summer hypolimnetic anoxia

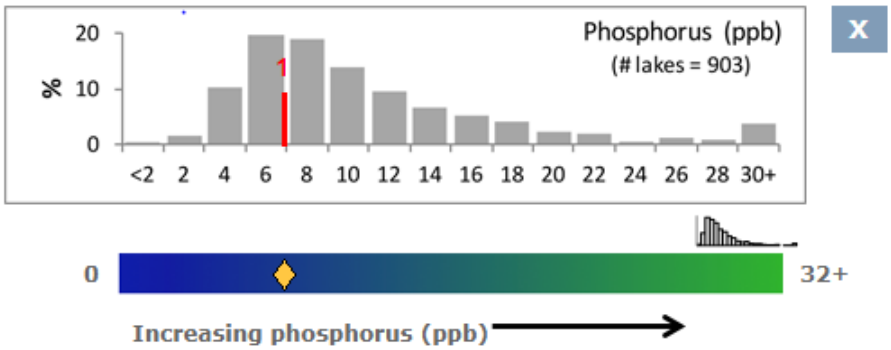
The graphics below illustrate the historical average (yellow star) for each of the three primary water quality indicators (Secchi Transparency, Total Phosphorus and Chlorophyll-a). Each color "ramp" shows the continuum of data for Maine lakes. In each case, the long-term average for Upper Range Pond is indicated by the yellow diamond above the bar. Note that while "Increasing Transparency" (water clarity) indicates better water quality, the reverse is true for both chlorophyll (algae pigment) and phosphorus, which is why the diamonds are nearer the

lower end of the scale for the latter two indicators. Graphics are courtesy of www.lakesofmaine.org .

The bar chart accompanying each color ramp is a histogram that illustrates the distribution frequency for Maine lakes for each indicator. The red line indicates the historical average for the lake. This graphic illustrates where the average is situated, relative to several hundred Maine lakes (indicated by "# of lakes)".







Middle Range:

The following is based on sampling conducted on Middle Range Pond on August 6 and September 5, 2019. Additional lake water clarity data gathered by LSM Certified Volunteer Monitor, Barry Kutzen have been included, as well. Historical data reference sources are the Maine Department of Environmental Protection, Lake Stewards of Maine (www.lakesofmaine.org), and LWRMA field records and reports.

Please refer to Table 1, below regarding all data obtained in 2019, and historical averages.

Overall, the water quality of Middle Range Pond continues to be relatively stable. In 2019, overall water quality was slightly above (better than) the historical average for the lake. The 6.6 meter water clarity average was clearer than the historical average (6.2M). Figure 1 illustrates the range of water clarity readings from May through October. Figure 2 illustrates the considerable annual variability in water quality that has been documented since 1974 (one reading), then from 1980. Some of the variability that has occurred from year to year may be partially influenced by the frequency and timing of readings taken. There is an apparent positive (improving) trend in the clarity of Middle Range Pond during the period, in that minimum, maximum and average readings have deepened.

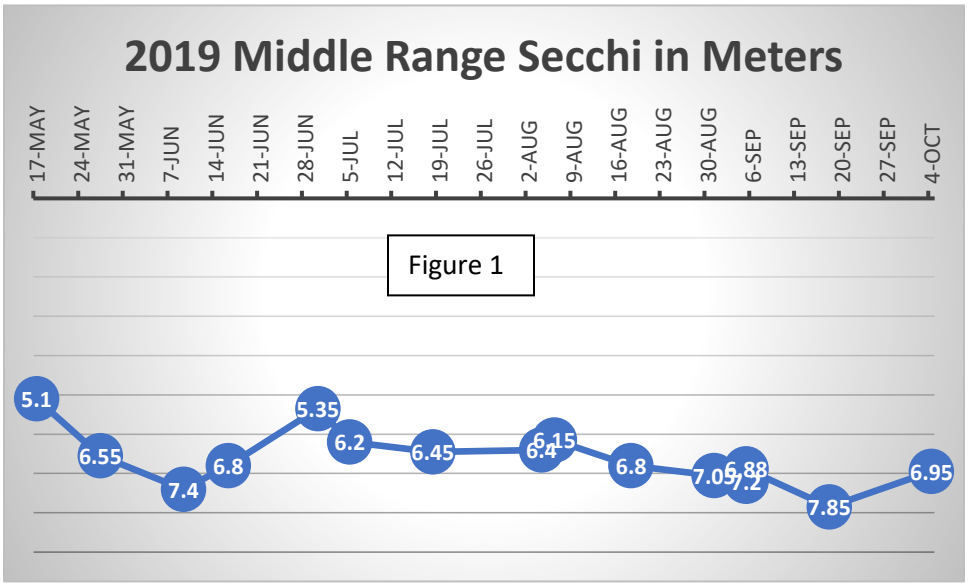
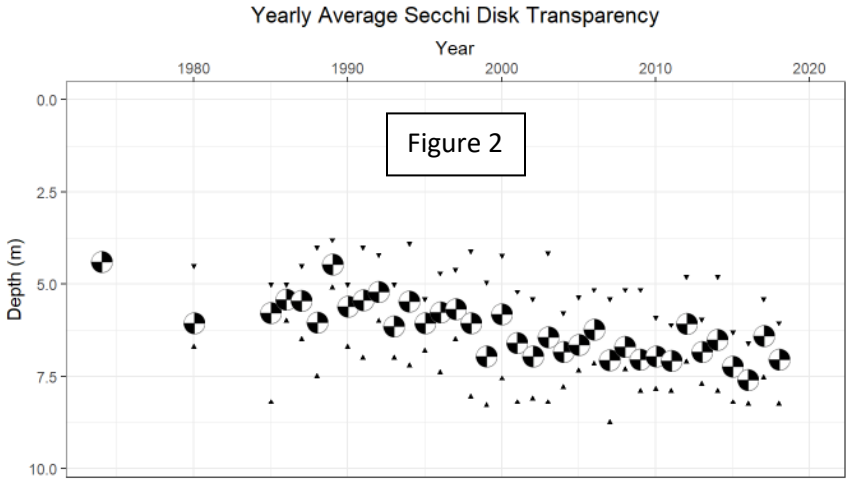


Figure 1

Graph Legend: Secchi symbols = average Secchi Disk Transparency Values; tick marks = maximum and minimum values for each year.



August and September epilimnetic core total phosphorus samples each measured 6 ppb, averaging 6.0 ppb which was lower (better than) than the historical average (7.7ppb) for the lake. Samples taken near the bottom of the deepest point in the lake averaged 8ppb, compared to the historical average of 11ppb. The lake was strongly thermally stratified on both sample dates. Dissolved oxygen was depressed in the deepest few meters of the lake in August, and was depleted in the deepest few meters in early September, similar to, and consistent with historical late summer conditions for Upper Range – but somewhat less loss was noted in 2019, compared to recent years.

The chlorophyll-a (a direct measure of planktonic algae density) concentration in August and September (3 and 5 ppb – averaging 4.0 ppb) was very close to the historical average for the lake (3.9ppb), as indicated in the Figure 1 table below.

True Color, measured in August and September measured 22 and 6 SPU (Standard Platinum Units), averaging 14.5 SPU was very close to the historical average of 14 SPU. Total Alkalinity and pH measured on the two sampling dates were similar to the historical averages for the lake.

Specific Conductance, measured in August and September measured 81 and 92 microsiemens/cm, averaging 87 ms/cm compared to the historical average of 60 – a significant increase in this indicator that is sometimes associated with soil erosion, road salt and other sources of inorganic ions, which are capable of passing an electrical current. However, it appears than many Maine lakes sampled in the late summer of 2019 showed spikes in specific conductance, possibly due to significant precipitation in the spring, resulting in increased runoff from their watersheds during the period.

No Gloeotrichia (cyanobacteria) colonies were observed on either sample date in 2019. Gloeotrichia is a form of lake algae that has historically not been uncommon in a number of clear Maine lakes during the late summer-early fall period. In recent years, the phenology of this alga has changed dramatically in some lakes throughout New England. Research suggests that an increase in the presence of "Gloeo" may be associated with a negative change in water quality – possibly driven by a warming climate.

Temperature and dissolved oxygen profiles taken in both August and September showed moderate dissolved oxygen loss, in the deepest area of the lake, but possibly to a lesser extent than has been documented in recent years. This may have been due to any of a number of influences, including cool spring weather, resulting in a delay in the onset of thermal stratification in regional lakes.

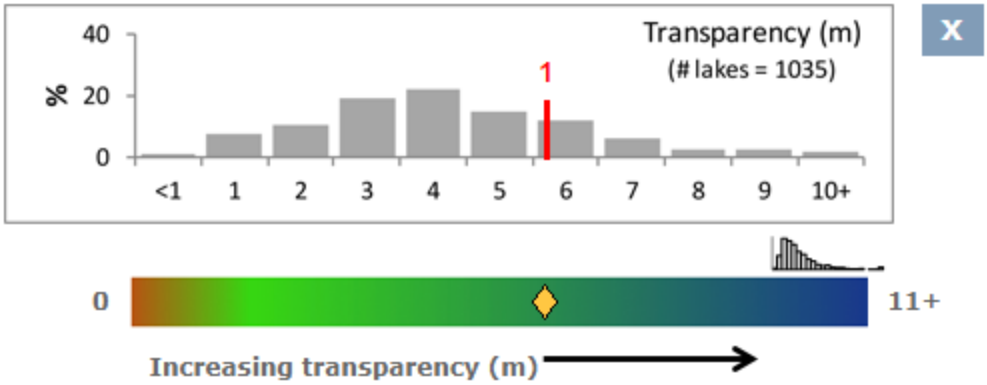
The baseline ratio of the algal photosynthetic pigment phycocyanin, to other forms of chlorophyll was measured on both dates. The purpose of this analysis is to observe the extent to which the ratio changes over time – a possible indicator of a shift from the normal assemblage of algal species in the lake to one that is more dominated by cyanobacteria/bluegreen algae. This was only the second year during which this analysis has been conducted. Data cannot be interpreted until multiple years of information has been gathered.

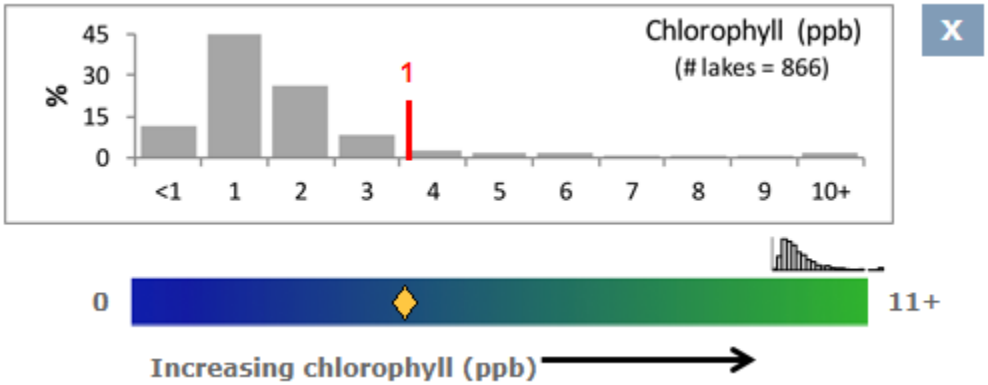
Table 1: 2019 and Historical Data Summary Information: Middle Range Pond

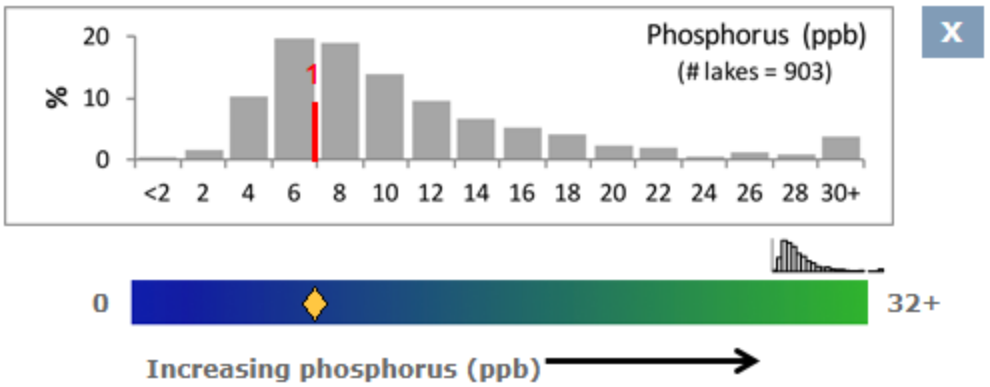
Indicator	Range: (Lowest to Highest)	2019 Average	Historical Average	Notes
Secchi Transparency in Meters	5.1 in May to 7.9 in September	6.6	6.2	Very clear in 2019
Total Phosphorus in ppb	6.0 (both dates)	6.0	7.7	
Chlorophyll-a in ppb	3-5	4	3.9	Measures planktonic algae
True Color (SPU)	6-22	14.5	14	
pH (std units)	7.34	7.34	7.0	
Total Alkalinity in mg/l	14.0	14.0	12.0	pH Buffering capacity
Specific Conductance (MicroSiemens/cm	81-92	87	60	Unusually high in 2020
Gloeotrichia	0	0	N/A	
Dissolved Oxygen mg/l	Minor depression in deepest area	Minor depletion in deepest area	Possibly less loss in 2019 due to multiple factors	History of late summer hypolimnetic anoxia

The graphics below illustrate the historical average (yellow star) for each of the three primary water quality indicators (Secchi Transparency, Total Phosphorus and Chlorophyll-a). Each color "ramp" shows the continuum of data for Maine lakes. In each case, the long-term average for Middle Range Pond is indicated by the yellow diamond above the bar. Note that while "Increasing Transparency" (water clarity) indicates better water quality, the reverse is true for both chlorophyll (algae pigment) and phosphorus, which is why the diamonds are nearer the lower end of the scale for the latter two indicators. Graphics are courtesy of www.lakesofmaine.org .

The bar chart accompanying each color ramp is a histogram that illustrates the distribution frequency for Maine lakes for each indicator. The red line indicates the historical average for the lake. This graphic illustrates where the average is situated, relative to several hundred Maine lakes (indicated by "# of lakes)".







Lower Range:

The following is based on sampling conducted on Lower Range Pond on August 6 and September 5, 2019. Additional lake water clarity data gathered by LSM Certified Volunteer Monitor, Poppy Connor-Crouch have been included, as well. Historical data reference sources are the Maine Department of Environmental Protection, Lake Stewards of Maine (www.lakesofmaine.org), and LWRMA field records and reports.

Please refer to Table 1, below regarding all data obtained in 2019, and historical averages.

Overall, the water quality of Lower Range Pond continues to be relatively stable. In 2019, overall water quality was average to slightly above (better than) the historical average for the lake. The 6.8 meter water clarity average was very close to the historical average (6.9M). Figure 1 illustrates the range of water clarity readings from June through October. Figure 2 illustrates the considerable annual variability in water quality that has been documented since 1974 (one reading), then from 1980 (note significant gap from 1981-1993). Some of the variability that has occurred from year to year may be partially influenced by the frequency and timing of readings taken.

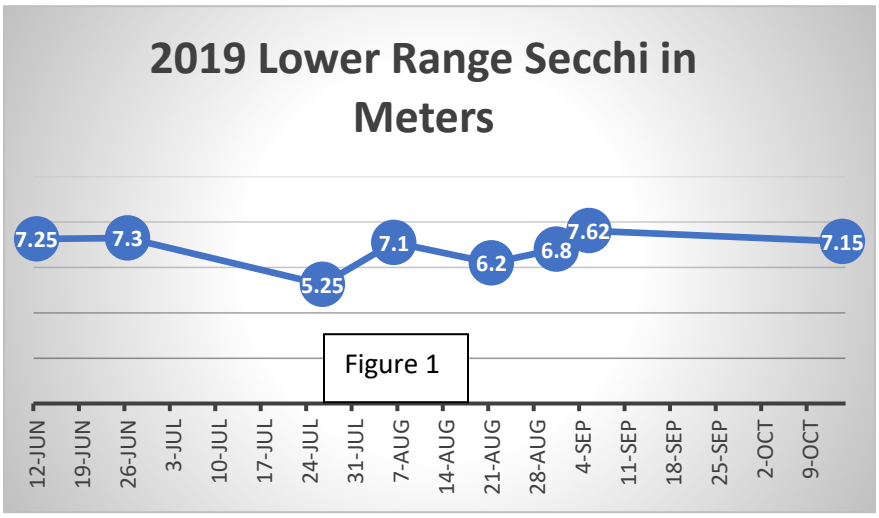
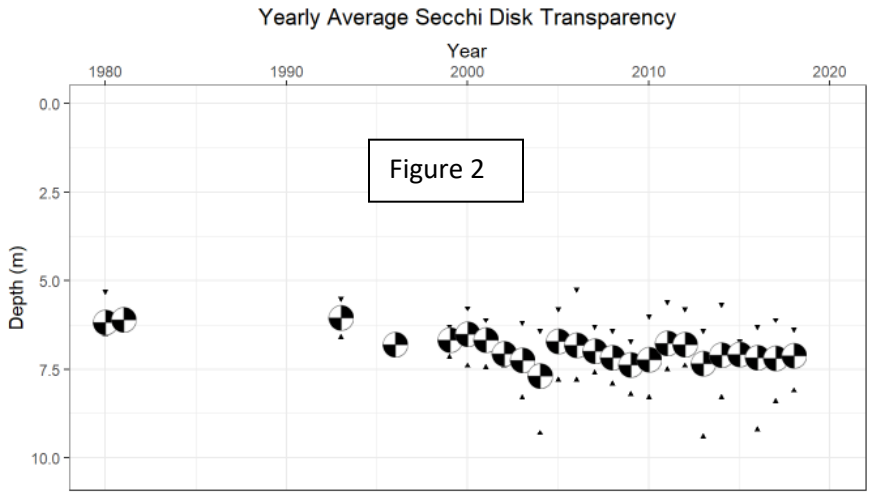


Figure 1

Graph Legend: Secchi symbols = average Secchi Disk Transparency Values; tick marks = maximum and minimum values for each year.



August and September epilimnetic core total phosphorus samples measured 6 ppb and 4 ppp, averaging 5.0 ppb which was lower (better than) than the historical average (7.1ppb) for the lake. Samples taken near the bottom of the deepest point in the lake averaged 14ppb, compared to the historical average of 13ppb. The lake was strongly thermally stratified on both sample dates. Dissolved oxygen was depleted in the deepest several meters of the lake in both August and early September. While this was consistent with recent historical conditions, it is worth noting that historical and current sampling have taken place at the "deep hole" (appx. 14 meters depth) on Lower Range Pond – a relatively small percentage of the surface area of the lake. Most of the lake is substantially less deep, and is therefore not subject to the late summer oxygen depletion measured at the deep station. This limits the extent to which any negative implications of anoxic conditions will influence overall water quality.

The chlorophyll-a (a direct measure of planktonic algae density) concentration in August and September was 2.0 ppb on both dates, averaging 2.0 for the period. This is significantly lower (better) than the historical average of 3.6 ppb.

True Color, measured in August and September measured 5 SPU (Standard Platinum Units) on both dates, averaging 5 SPU which was slightly lower than to the historical average of 8 SPU.

Total Alkalinity and pH measured on the two sampling dates were similar to the historical averages for the lake.

Specific Conductance, measured in September measured 108 microsiemens/cm, compared to the historical average of 60 – a significant increase in this indicator that is sometimes associated with

soil erosion, road salt and other sources of inorganic ions, which are capable of passing an electrical current. However, it appears than many Maine lakes sampled in the late summer of 2019 showed spikes in specific conductance, possibly due to significant precipitation in the spring, resulting in increased runoff from their watersheds during the period.

No Gloeotrichia (cyanobacteria) colonies were observed on either sample date in 2019. Gloeotrichia is a form of lake algae that has historically not been uncommon in a number of clear Maine lakes during the late summer-early fall period. In recent years, the phenology of this alga has changed dramatically in some lakes throughout New England. Research suggests that an increase in the presence of "Gloeo" may be associated with a negative change in water quality – possibly driven by a warming climate.

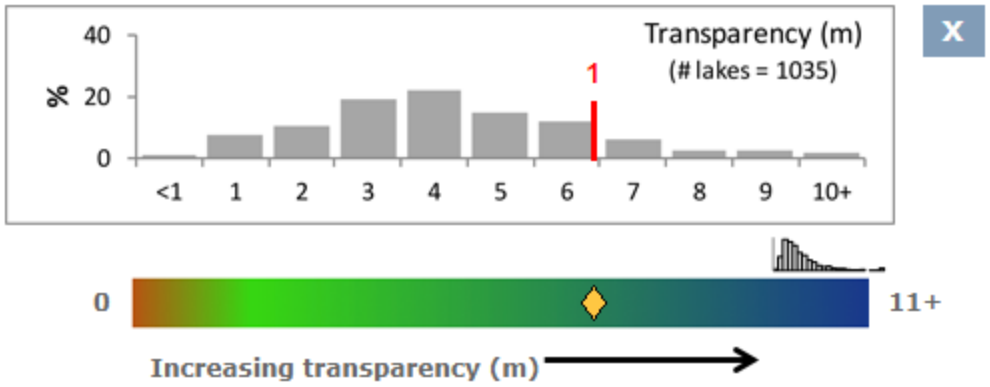
The baseline ratio of the algal photosynthetic pigment phycocyanin, to other forms of chlorophyll was measured on both dates. The purpose of this analysis is to observe the extent to which the ratio changes over time – a possible indicator of a shift from the normal assemblage of algal species in the lake to one that is more dominated by cyanobacteria/bluegreen algae. This was only the second year during which this analysis has been conducted. Data cannot be interpreted until multiple years of information has been gathered.

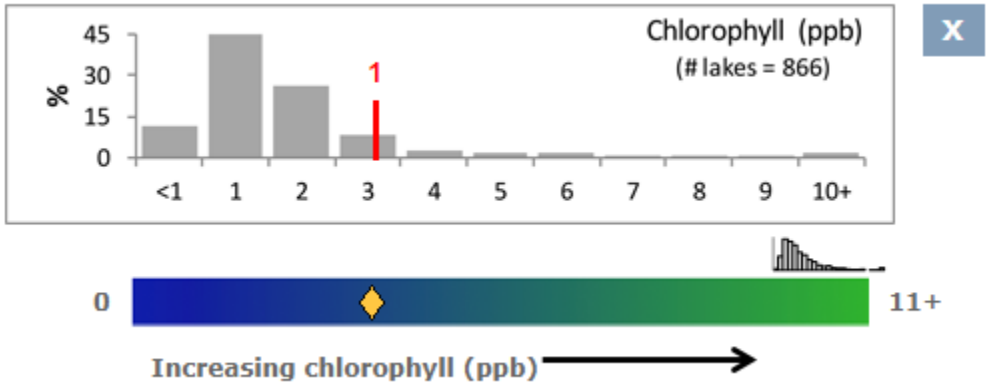
Table 1: 2019 and Historical Data Summary Information: Lower Range Pond

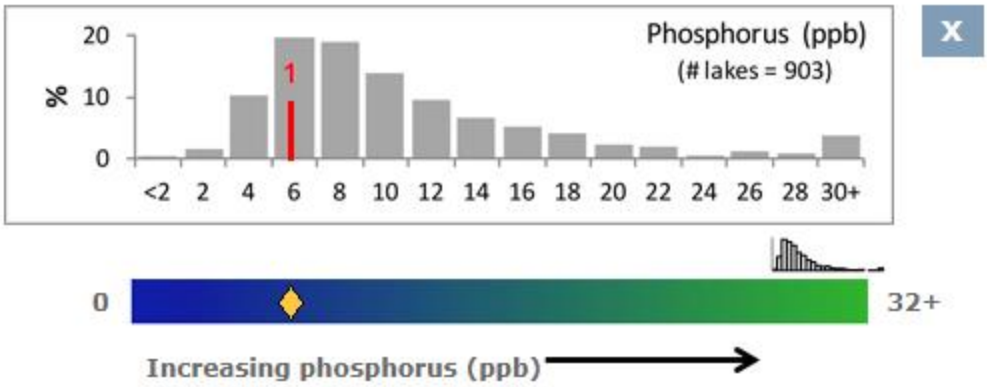
Indicator	Range: (Lowest to Highest)	2019 Average	Historical Average	Notes
Secchi Transparency in Meters	5.3 in July to 7.6 in Sept.	6.8	6.9	Very clear in 2019
Total Phosphorus in ppb	4-6	5	7.1	
Chlorophyll-a in ppb	2	2	3.6	Measures planktonic algae
True Color (SPU)	5	5	8	
pH (std units)	7.41	7.41	7.1	Most historical based on single August sample
Total Alkalinity in mg/l	15	15	13	pH Buffering capacity
Specific Conductance (MicroSiemens/cm	108	108	65	Unusually high in 2020
Gloeotrichia	0	0	N/A	
Dissolved Oxygen mg/l	Depleted below 8 meters depth	Depleted below 8 meters depth	Similar conditions to 2019	History of late summer hypolimnetic anoxia

The graphics below illustrate the historical average (yellow star) for each of the three primary water quality indicators (Secchi Transparency, Total Phosphorus and Chlorophyll-a). Each color "ramp" shows the continuum of data for Maine lakes. In each case, the long-term average for Lower Range Pond is indicated by the yellow diamond above the bar. Note that while "Increasing Transparency" (water clarity) indicates better water quality, the reverse is true for both chlorophyll (algae pigment) and phosphorus, which is why the diamonds are nearer the lower end of the scale for the latter two indicators. Graphics are courtesy of www.lakesofmaine.org .

The bar chart accompanying each color ramp is a histogram that illustrates the distribution frequency for Maine lakes for each indicator. The red line indicates the historical average for the lake. This graphic illustrates where the average is situated, relative to several hundred Maine lakes (indicated by "# of lakes)".







Summary and Recommendations:

Overall, the three Range Ponds experienced average to above average water quality in 2019, compared to their historical averages. We are fortunate to have three dedicated certified lake monitors on the three bodies of water. Matt Brettler, Barry Kutzen and Poppy Connor-Crouch have donated their time to add substantially to the body of historical data for Upper, Middle and Lower Range Ponds. Their good work on behalf of our understanding of the health of these lakes is invaluable.

The Range Ponds Environmental Association has undertaken a number of significant initiatives to protect the three lakes in recent decades, including a comprehensive watershed survey, and a mitigation project to resolve problems identified in the survey. The organization has also developed a long-term, comprehensive plan for the management of the watersheds for the three lakes.

The influences of climate change over time will likely stress the three Range Ponds in a number of ways in the future. As lakes warm, and weather events become more extreme, resulting in an increase in watershed soil erosion, the potential for increasing algae growth, reduced water clarity, and additional loss of dissolved oxygen will likely increase.

A high percentage of Maine's lakes could experience change in both expected and unanticipated ways in the future as a result of climate change. Our lakes may be more highly colored (and less clear) from increasing humic acids, and also less clear from increasing planktonic algae growth, caused by reduced periods of ice cover and warmer water temps. Some lakes will experience severe cyanobacteria/bluegreen algae blooms, which may result in toxic conditions in the lake. In recent years, several lakes situated in southern and central Maine have experienced unanticipated, severe algal blooms.

Conservation practices that have been promoted by the Range Ponds Association, including the comprehensive watershed survey, and a mitigation project to resolve issues identified in the watershed will continue to serve the lakes well as our climate warms. The preservation of vegetated buffers throughout the shoreline and watershed is one of the most effective measures for offsetting the effects of a warming climate and protecting water quality. Minimizing sources

of soil erosion and stormwater runoff will also continue to be very important, as will be efforts to control new shoreline and watershed development.

Prepared by Scott Williams

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