2010 Report on the Health of the Norway Lakes

The Lakes Association of Norway, with support from the Town of Norway, continued to monitor the health of the four Norway Lakes in 2010. Water quality monitoring was a combined effort of volunteers and lake professionals. Monitoring of the lakes takes place from early May through September, during the time of year when lakes and ponds are the most biologically productive, and water quality problems are most likely to occur. In addition to monitoring lake water quality, LAON also conducted a screening survey for invasive aquatic plants on the four lakes, the results of which are also included in this report.

The weather that occurs during and preceding lake monitoring often has a strong influence on indicators of lake water quality, and is likely responsible for some of the variability that is seen within individual seasons and from one year to the next. Unlike the previous two years, which were extremely wet, resulting from heavy winter snowfall and frequent extreme rain events through the spring and summer (2009 had the wettest summer in 138 years in southern Maine), 2010 will long be remembered for record early "ice out" on lakes throughout Maine, followed by unusually warm spring and early summer weather. Although rain events were frequent, they were less severe and overall precipitation was certainly down, compared to 2008 and 2009.

Rain and snow produce stormwater runoff, which is the primary means by which phosphorus and other pollutants are carried into lakes from their watersheds. One might expect that for years when excess precipitation has occurred during the spring and summer period, lakes with developed watersheds might be less clear. Although that is often the case, each lake responds uniquely to the many factors that influence water quality. In 2010, the Maine Volunteer Lake Monitoring Program and Maine Department of Environmental Protection monitored the water clarity of 447 Maine lakes, which includes data from volunteers, agency personnel and other professionals. The four Norway Lakes are included in this group.

Statewide Perspective on Lake Water Clarity in 2010:

Figure 1 below shows the extent to which water clarity (Secchi transparency) has varied for Maine lakes over time. The chart shows the average water clarity for all Maine lakes monitored in a given year – denoted by the dot on each annual line of the graph. The average of the highest and lowest readings for each year are indicated by the high and low limits of each annual line. Note that the average has, for most years since this information has been tracked, fallen between 5.0-5.5 meters. The average in 2010 was 5.6 meters. Figure 2 illustrates only the annual average for Maine lakes, using a Secchi disk symbol.

Variation from one year to the next is influenced by many factors, not the least of which is weather. Maine lakes may be clearer overall during relatively dry years because stormwater runoff from rainfall carries phosphorus and other pollutants from the watershed to the lake.

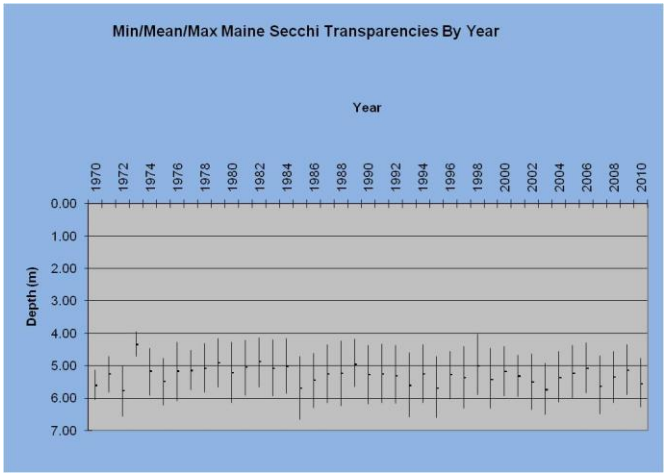

Figure 1: Source Maine DEP and Volunteer Lake Monitoring Program

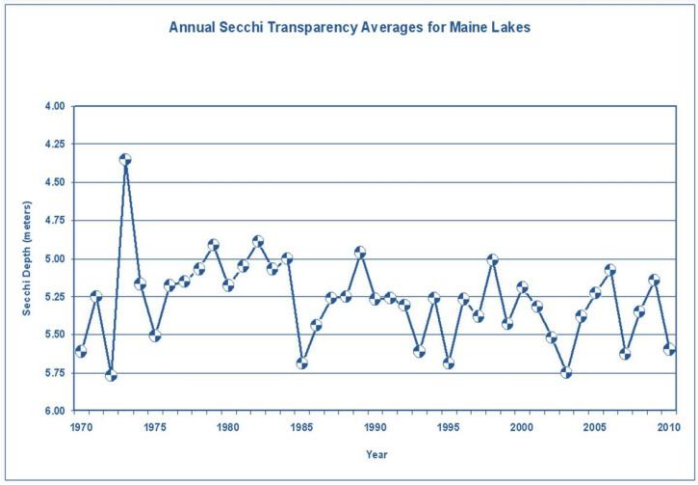

Figure 2: Average Secchi disk transparency for all Maine lakes monitored for the years shown

The two illustrations above show that for the period from 2004-2006, the "average" clarity of Maine lakes dropped substantially. This may have been due to the fact that much of the state experienced above average precipitation during the period. But in 2007, Maine lakes as a whole were significantly clearer, most probably due to reduced precipitation during the winter, spring and early summer months, when a high percentage of watershed phosphorus loading typically occurs for lakes. Maine experienced very wet conditions in 2008 and 2009 (which was one the wettest years on record for the state), during which time the average declined, as is indicated. But in 2010, this decline reversed, as the average for Maine lakes increased to 5.6 meters. It is worth noting that the statewide minimum for 2010 wasn't as low as it has been for many previous years, which is also consistent with improved conditions for many Maine lakes last year.

The graphs show that a number of similar dramatic changes have occurred historically. Some of the "clearest" years for Maine lakes have been those during which drought has recently occurred, such as 1985 and 2002 and 2003, which followed the severe statewide drought of 2001. But 2010 will long be remembered as highly unusual, in that winter produced relatively little snow accumulation, and record early ice out conditions occurred in lakes throughout Maine. This was followed by unusually warm weather, starting in April and running through the summer months. One might expect that under such circumstances, lakes would be less clear during the April through September monitoring period, due to an extended, warm, growing season for algae. But clearly, other factors played a role in this picture, possibly including opportunistic rooted aquatic plants and filamentous algae (which may have benefitted from the early loss of ice and clear water) tying up phosphorus that would otherwise have been available to the planktonic algae, which are most responsible for influencing water clarity in most lakes.

To put into perspective the significance of the 2010 lake clarity findings, consider that out of 447 Maine lakes that were assessed last year, 64.9% were clearer, only 26.8 % were less clear, and 8.3% were unchanged, compared to their historical average (Figure 3 below).

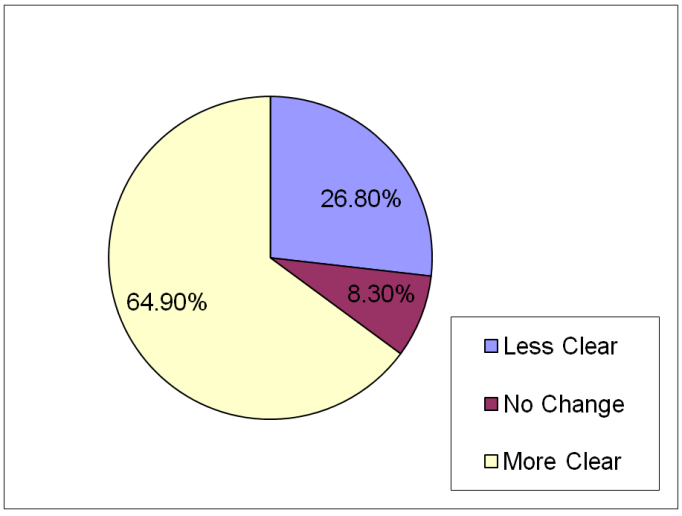

Figure 3: Percentage of 447 Maine Lakes that were clearer, less clear, or unchanged, compared to their historical average in 2010 (Source: MDEP and Maine VLMP)

It is likely that the very substantial increase in the number of lakes that were clearer than average in 2010 was related to the very unusual weather conditions last year, although the exact way in which the record breaking conditions influenced lake water clarity has not yet been fully

explored. In sharp contrast, 2009 was one of the wettest years on record for the State of Maine. Information obtained from the National Weather service indicated that Portland and much of the State of Maine experienced the wettest summer on record. Many less lakes were clearer than they have been historically in 2009. Figure 4 illustrates this interesting phenomenon during the past decade. For most years, it has been possible to generally correlate changes in the number of lakes that were clear or less clear than they have been historically to dominant weather during the several months of the year before and during the monitoring season. The effect on Maine lakes of the extremely unusual and complex weather conditions that occurred in 2010 is currently being studied.

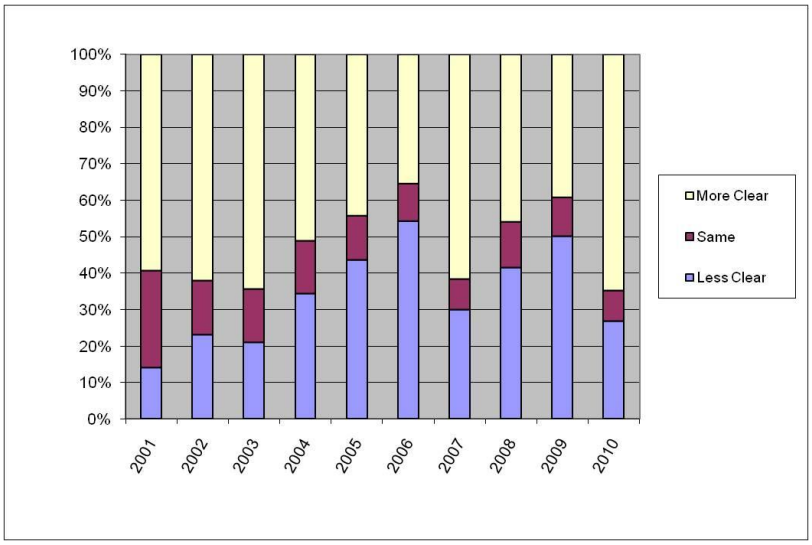

Figure 4: Percentage of monitored Maine lakes from 2001-2010 that have been clearer than, less clear, or unchanged, compared to their historical average clarity/transparency

Each lake and pond responds in a unique way to the influences of weather, changes in land use in the watershed, and other forces upon the ecosystem. This is because of the wide range of physical, chemical and biological characteristics of each lake basin and its watershed. Most lakes and ponds experience a moderate amount of natural annual variability.

Water clarity (Secchi transparency) is one of four primary indicators of the biological productivity of lake ecosystems, in addition to concentrations of the nutrient phosphorus, and chlorophyll a (a plant pigment used to measure of the concentration of algae in lake water), and the concentration of dissolved oxygen in deep areas of the lake during the summer months.

2010 Monitoring Results for the Norway Lakes

Pennesseewassee Lake:

Pennesseewassee Lake was slightly less clear in 2010, when compared to the historical 39 year average for the lake of 5.8 meters (~19 feet). Water clarity averaged 5.7 meters (about 19 feet) in 2010, which was also the average for 2009. During the five month period, water clarity readings

ranged from a high reading of 6.6 meters to a low reading of 4.6 meters. The average water clarity in 2009 was also 5.7 meters; 2008 was 5.4 meters; 5.6 meters in 2007, 6.0 meters in 2006.

The concentration of phosphorus (the nutrient that is responsible for the growth of algae in lakes) was slightly higher in 2010 than the historical average for the lake (9 parts per billion (ppb). The 2010 average was 10 ppb, which was lower than the 2009 average of 11 ppb.

Chlorophyll-a (CHL) is a pigment that is measured to determine the concentration of algae in lake water. The 2010 average concentration measured 4.3 ppb, compared to the 2009 average of 5.5 ppb, and the long term average for the lake of 4.5 ppb. The 2009 CHL average was one of the highest on record for Pennesseewassee, but in 2010 algae growth in the lake dropped to slightly less than the historical average.

The most severe loss of dissolved oxygen occurred in August, when the deepest 7 meters of water, measured at the deepest point (14.3 meters) in the lake, were essentially devoid of dissolved oxygen. By September, conditions had improved only slightly, as water temperatures cooled. Low concentrations of late summer dissolved oxygen serve as a warning that the lake is sensitive and vulnerable to a decline in water quality, regardless of conditions near the surface, where wind and wave action keep oxygen levels high throughout the summer.

Natural water color levels were slightly lower than average in 2010, pH and total alkalinity were in the average range for the lake.

No invasive aquatic plants were found in the complete screening survey of Pennesseewassee Lake in 2010.

A native species of Milfoil is known to occur in the lake, which was once again documented in 2010. However, this plant is *not* invasive! A species of non-native, invasive snail, referred to as the "Chinese Mystery Snail" has been documented in the lake. This snail has now been observed in all four of the Norway lakes, as well as in a number of regional lakes, including Thompson, the Range Ponds, and others. The ecological significance of this invader has not been determined. However, from a nuisance perspective, the large, dark green snails are offensive to the nose when they wash up on the shoreline, and there has been at least one report of oxygen depletion in a pond when a large number of the snails died over a short period of time.

Gloeotrichia is a colonial blue-green algae that occurs naturally in many Maine lakes. Looking down into the water, "Gleo" has the appearance of tiny off-white dots, often likened to tapioca. In recent years, this algae has become problematic on some Maine lakes and ponds, and it may be on the increase throughout Maine. Lighter gloeotrichia growth was observed in the surface water during the months of July and August than in the past few years. The concentration of this alga was extremely low in 2010.

Hobbs Pond (Little Penn):

Hobbs Pond water clarity in 2010 recovered from the sharp drop that was documented in 2009. The water clarity average for the summer increased to 5.8 meters (~19 feet), compared to the 2009 average of 4.9 meters (about 16 feet). The historical water clarity average for Hobbs Pond is 5.2 meters. Hobbs has been significantly clearer than its historical average for a number of years. However, in 2009 the pond experienced a sharp downward trend, most probably due to the cumulative effect of two years of very heavy precipitation and runoff. Improved conditions in 2010 included the high water clarity reading of 6.8 meters in August, (one of the highest in several years), despite the low reading of 3.8 meters that was taken on May 12.

Phosphorus levels were slightly lower than the average for this pond in 2010, averaging 9 ppb, which was also the 2009 average. The historical average is 10 ppb. Phosphorus levels in the pond ranged from a high of 15 ppb in May, to the low reading of 5 ppb in August. Hobbs experienced dramatic improvement in 2010, not just in comparison to the past two years, but from the start of the season, when the pond was very turbid and phosphorus levels were moderately high, to the much improved water clarity and low phosphorus levels in the late summer.

A phosphorus sample taken near the bottom of the deepest point in the pond on August 26 measured 24 ppb, suggesting that this nutrient is being released from the bottom sediments as a result of very low dissolved oxygen levels. The bottom sample concentration was nearly 5 times higher than the phosphorus level near the surface on that day.

The average concentration of chlorophyll-a in 2010 was 4.7 ppb, compared to 5.8 ppb – one of the highest annual averages on record for the pond – in 2009. The historical average for Hobbs is 4.9 meters. The average has been increasing as a result of the higher annual averages for several years. The CHL level in Hobbs has been climbing for the past several years, which indicates an overall increase in the amount of algae in the pond.

During the past decade, the water quality of Hobbs Pond has improved quite notably. Back in the late 1970's and early 80's, the annual water clarity was nearly always in the mid 4 meter range (about 15 feet). At times, individual water clarity readings were as low as 2.0 meters (about 6 feet). LAON took the initiative to work with landowners in the watershed to implement conservation practices, which resulted in a nearly immediate turnaround in water quality.

Late summer oxygen levels near the bottom of the pond were very low, and the phosphorus sample taken near the bottom of the lake in August was moderately high. When dissolved oxygen levels fall to less than ~2 ppm, phosphorus may be released from the bottom sediments, which increases the risk of a significant increase in algae growth, if the released phosphorus is transported to the surface through mixing currents.

Other water quality indicators that are measured to help support the primary data (color, pH, and total alkalinity) were within the normal range of readings for Hobbs in 2010.

No invasive aquatic plants were detected in Hobbs Pond in the 2009 screening survey that was conducted in August and September. However, as indicated above, the Chinese Mystery Snail was documented in the pond.

Sand Pond:

Sand Pond experienced a mixed year, with slightly below average water clarity, but both phosphorus and CHL (algae) levels were lower than the historical average for the lake.

Water clarity averaged 7.3 meters (about 23 feet), compared to the historical average of 7.4 meters. Sand Pond is the clearest of the four Norway Lakes, and in general, the water quality of this small pond is above average, compared to other Maine lakes. Consider that the average for all Maine lakes (447) that were monitored in 2010 was 5.6 meters.

The average total phosphorus concentration in Sand Pond last summer was 4 ppb, compared to 6 ppb in 2009, and the historical average of 7 ppb for the pond. The phosphorus average for Sand Pond was significantly lower than the average for Sand, and it was the lowest (best!) average for the four Norway Lakes in 2010.

Chlorophyll-a levels were lower in 2010, averaging 2.5 ppb. The historical average for Sand is 2.7 ppb. The relatively low level of CHL in Sand Pond is consistent with relatively low phosphorus levels and generally very good to excellent water clarity.

Despite other positive indicators of Sand Pond's water quality, late summer dissolved oxygen levels continue to be extremely low in the deepest area of the pond. Temperature and dissolved oxygen profiles in July, August and September, 2010 were similar to those documented in recent years. By the end of September, nearly ½ of the depth of the pond at (17.4 meters at the sampling station) was depleted of oxygen.

The maximum depth of Sand Pond is approximately 17 meters (56 feet). Phosphorus samples taken near the bottom of the deepest area of the pond in August were eight times as high (16 ppb) as a sample taken near the surface (2 ppb). This suggests that the pond is in a very sensitive state, and that water quality could change if conservation measures are not employed for both existing and new development in the watershed. The potential for phosphorus from the bottom of Sand Pond to become available to algae growing near the surface is moderate.

All additional support indicators of water quality were within normal ranges in Sand Pond during the 2010 monitoring season.

No invasive aquatic plants were detected in the 2010 screening survey of Sand Pond. Although the Chinese Mystery Snail has been documented in the pond in the past, none were observed during the 2008, 2009, or 2010 surveys.

North Pond:

North Pond is relatively shallow, having a maximum depth of less than 15 feet. The shallow depth often limits the value of water clarity readings that are taken with a Secchi disk, because the disk reaches the bottom of the pond before it disappears from view. In the 1970's and 1980's, the Seechi disk was nearly always visible on the bottom of North Pond. However, when the pond started to experience algal blooms, the situation changed. Often the disk would disappear in the algae-laden water before it reached the bottom at only 12-13 feet.

In 2010, the Secchi disk was visible on the bottom of North Pond for all of the five months, which represents an improvement over recent years. In fact, all of the 3 primary indicators (water clarity, phosphorus and chlorophyll) were at improved levels – better than the historical average for the pond – in 2010.

The average phosphorus concentration for the year was 16 ppb, compared to the historical average of 17 ppb for North Pond. Phosphorus levels in the pond ranged from a low concentration of 11 ppb in to a moderately high level of 21 ppb during the course of the monitoring period.

The concentration of algae in the water, as indicated by chlorophyll-a levels, was 4.7 ppb, which is significantly lower than the historical average of 6.2 ppb for North Pond. CHL ranged from a low of 2.5 ppb in May to a high of 6.2 ppb in August.

Phosphorus levels in North Pond are often higher than might be expected, based on water clarity and the actual concentration of algae in the water. This is most probably due to the fact that the very soft bottom sediments in this pond are easily resuspended in the overlying water, especially following periods of strong wind. The sediments raise the phosphorus levels in the water and reduce water clarity. But much of the phosphorus in the suspended sediment is not biologically available to the algae in the water.

Dissolved oxygen levels in North Pond generally remain high throughout the summer monitoring period, due to the fact that the pond is very shallow, and easily circulated by the wind, which replenishes any oxygen that is consumed through the decomposition of organic matter in the water.

Overall, North Pond experienced an above average year, with slightly improved water clarity, and below average levels of phosphorus and algae growth.

No invasive aquatic plants were detected in the 200 screening survey of North Pond, which included the extensive attached wetland areas that drain to Pennesseewassee. The Chinese Mystery Snail has existed in North Pond for more than a decade.

Summary:

Overall, there was a measurable improvement in the Norway Lakes in 2010, compared to the past two years, when conditions declined due to the cumulative effect of two years of very heavy

precipitation and runoff, which carried phosphorus and sediment from the watersheds into the four lakes. Hobbs, North and Sand Pond experienced significant improvements over their historical averages in 2010, and Pennesseewassee experienced mixed conditions, but was overall improved compared to recent years.

Each lake and pond responds in a unique way to the influences of weather, changes in land use in the watershed, and other forces upon the ecosystem. This is because of the wide range of physical, chemical and biological characteristics of each lake basin and its watershed.

The following is a summary of findings for Pennesseewassee Lake, and Hobbs (Little Penn), Sand and North Ponds.

LAKE	Water Clarity in Meters	Core Total Phosphorus (ppb)	Core Chlorophyll-a (ppb)	Color (SPU)	pH	Total Alkalinity
Pennesseewassee	5.7	10	4.3	11	6.8	15.0
Hobbs (Little Penn)	5.8	9	4.7	11	6.9	12.0
Sand	7.3	4	2.5	7	6.7	7.0
North	3.2(bottom)	16	4.7	15	6.8	11.5

Special thanks are due to certified volunteer lake monitors Patti Ann Douglas on Sand Pond, and Warren Bryant on Pennesseewassee, and Ray Snedeker on Hobbs, who have contributed additional Secchi disk transparency (water clarity) data. Their efforts substantially improve our confidence in the monitoring results for the Norway Lakes.

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