Water quality monitoring of five major tributaries in the Otsego Lake watershed, summer 1999

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INTRODUCTION

Numerous studies conducted on Otsego Lake in recent years have documented trends toward eutrophy (e.g. Harman et al., 1997; Albright, 1997; 1998; 1999). Eutrophic conditions cause algal blooms leading to undesirable tastes, odors and colors, and resulting dissolved organics react with chlorine used to disinfect drinking water to form carcinogens (Harman et al., 1997). Low hypolimnetic dissolved oxygen concentrations also jeopardize cold water species, namely salmonid fish. Water flowing into the lake is largely responsible for the character of the lake; the quality of inflowing water is dependent upon land forms and land uses within the watershed (Albright et al., 1996). This study continues ongoing monitoring of the northern watershed of Otsego Lake, which contributes nearly two thirds of the water flowing into the lake.

Otsego Lake has a U-shaped basin with a north-south orientation. It lies in the glacially over-deepened Susquehanna River valley. The northern watershed consists of five sub-units: those drained by White Creek, Cripple Creek, Hayden Creek, Shadow Brook and a small tributary on Mount Wellington (Figure 1). Problems exist in this part of the watershed due to nutrient-rich soils and associated agriculture (Harman et al., 1997). Nutrients from agricultural nonpoint sources have been identified as the main cause of cultural eutrophication in freshwater inland lakes of the U.S. (Daniel, 1994).

Through the 1996 Farm Bill, the Environmental Quality Incentive Program (EQIP) was established to assist crop and livestock producers in dealing with environmental and conservation improvements on the farm (USDA, 1996). In addition to other incentive programs, EQIP Best Management Practices (BMP) have been instituted on 20 sites throughout the northern watershed (see Figure 1) utilizing matching funds provided by the Otsego County Conservation Association (Poulette, 1999). Land treatment using BMPs is believed to be the most effective approach to the control of agricultural pollution sources (Meals, 1993). A variety of practices exist, which when implemented, can maintain high surface water quality (Daniel, 1994). Examples of such practices include crop rotation, nutrient management, and the construction of barnyard water management systems and manure storage facilities (Poulette, 1999). A goal of this study is to develop a measurement of the effectiveness of these practices and to note any unanticipated phenomena contributing to nutrient loading. The most effective ways of determining changes as a result of BMP implementation are precipitation-based studies to determine nutrient loading, which are much more expensive than this monitoring protocol. A more extensive, precipitation-based study is currently being conducted on Shadow Brook, the largest tributary to the lake whose basin has been most managed by BMPs. Modifying human activities throughout the watershed should reduce the damaging effects on Otsego Lake (Miller, 1997).

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Figure 1. Map of the five major tributaries to Otsego Lake showing the sampling stations. Symbols represent agricultural best management projects, funded through EQIP, completed by summer 1999 (modified from Poulette, 1999).
METHODS

Between 3 June and 18 August 99 water samples were taken weekly at 23 sites on five tributaries of Otsego Lake. Sites were first established in 1995 (Heavey, 1996) and were expanded upon in 1996 (Hewitt, 1997). These tributaries, shown in Figure 1, include White Creek, Cripple Creek, Hayden Creek, Shadow Brook and the stream draining Mount Wellington. Barnyard improvement projects completed by the commencement of 1999 monitoring are indicated. Detailed site descriptions are given in Table 1. On site, conductivity, dissolved oxygen, pH, and temperature were measured using a Hydrolab Reporter® or a Hydrolab H2O® which had been calibrated immediately prior to use following manufacturer's protocol (Hydrolab Corporation, 1995). Due to equipment malfunction, conductivity was unavailable on 9 and 29 June and 6 July. Water samples were collected and analyzed weekly for total phosphorus using the ascorbic acid method following persulfate digestion (APHA, 1992) and analyzed bi-weekly for nitrite+nitrate using the cadmium reduction method (APHA, 1992).

Table 1. Physical descriptions and coordinates of sites sampled throughout the summer of 1998 (Poulette, 1999). Sites are seen in Figure 1.

White Creek 1:

N 42° 49.646'  W 74° 56.986'
South side of Allen Lake on County Route 26 near outlet to White Creek. This lake is the water supply for the town of Richfield Springs.

White Creek 2:

N 42° 48.931'  W 74° 55.303'
North side of culvert on County Route 27 (Allen Lake Road) where there is a large dip in the road.

White Creek 3:

N 42° 48.355'  W 74° 54.210'
East side of large stone culvert on Route 80.

Cripple Creek 1:

N 42° 48.919'  W 74° 55.666'
Weaver Lake accessed from the north side of Route 20. Water here is slow moving and there is an abundance of organic matter.

Cripple Creek 2:

N 42° 50.597'  W 74° 54.933'
Young Lake accessed from the west side of Hoke Road. The water at this site is shallow; some distance from shore is required for sampling.

Cripple Creek 3:

N 42° 49.437'  W 74° 53.991'
North side of culvert on Bartlett Road. The water at this location is cold and swift. This site is immediately downstream of an active dairy farm.
Cripple Creek 4: N 42° 48.836’ W 74° 54.037’
Large culvert on the west side of Route 80. The stream widens and slows at this point; this is the inlet to the Clarke Pond.

Cripple Creek 5: N 42° 48.822’ W 74° 53.779’
Dam just south of Clarke Pond accessed from the Otsego Golf Club.

Hayden Creek 1: N 42° 51.658’ W 74° 51.010’
Summit Lake accessed from the east side of Route 80, north of the Route 20 and Route 80 intersection.

Hayden Creek 2: N 42° 51.324’ W 74° 51.294’
North side of culvert on Dominion Road.

Hayden Creek 3: N 42° 50.890’ W 74° 51.796’
Culvert on the east side of Route 80 north of the intersection of Route 80 and Route 20.

Hayden Creek 4: N 42° 50.258’ W 74° 52.144’
North side of large culvert at the intersection of Route 20 and Route 80. This site is adjacent to an active dairy farm.

Hayden Creek 5: N 42° 49.997’ W 74° 52.533’
Immediately below the Shipman Pond spillway on Route 80.

Hayden Creek 6: N 42° 49.669’ W 74° 52.760’
East side of the culvert on Route 80 in the village of Springfield Center.

Hayden Creek 7: N 42° 49.258’ W 74° 53.010’
Large culvert on the south side of County Route 53.

Hayden Creek 8: N 42° 48.874’ W 74° 53.255’
Otsego Golf Club, above the white bridge adjacent to the clubhouse. The water here is stagnant and murky.

Shadow Brook 1: N 42° 51.831’ W 74° 47.731’
Small culvert on County Route 30 south of Swamp Road. Although flow was recorded throughout the summer of 1998, this site has a history of drying up by mid-summer.

Shadow Brook 2: N 42° 49.882’ W 74° 49.058’
Large culvert on the north side of Route 20, west of County Route 31. There is heavy agricultural activity upstream of this site.

Shadow Brook 3: N 42° 48.788’ W 74° 49.852’
Private driveway (Box 652) leading to a small wooden bridge on a dairy farm.
Shadow Brook 4: N 42° 48.333' W 74° 50.605'
One lane bridge on Rathbun Road near active dairy farm. This site is located on an active dairy farm where the animals have been observed wading in the stream on several occasions. The stream bed consists of exposed limestone bedrock.

Shadow Brook 5: N 42° 47.436' W 74° 51.506'
North side of large culvert on Mill Road behind Glimmerglass State Park.

Mount Wellington 1: N 42° 48.864' W 74° 52.594'
Stone bridge on Public Landing Road adjacent to an active dairy farm.

Mount Wellington 2: N 42° 48.875' W 74° 52.987'
Small stone bridge is accessible from a private road off Public Landing Road; at the end of the private road near a white house there is a mowed path which leads to the bridge. Water here is stagnant and murky.

RESULTS AND DISCUSSION

CONDUCTIVITY

Conductivity is an indirect measure of the dissolved ions in solution. It is an estimate of the inorganic constituents in water (Poulette, 1999). Mean values ranged from 215 umho/cm at site CC2 to 543 umho/cm at CC3. Average conductivity for White Creek (WC), Cripple Creek (CC), Hayden Creek (HC), Shadow Brook (SB), and the stream draining Mount Wellington (MW) are seen in Figure 2.

DISSOLVED OXYGEN

Dissolved oxygen is an important factor in determining the health of an aquatic ecosystem. Decreased levels of dissolved oxygen are indicative of increased organic matter or excessive temperatures. When there is an abundance of organic material, a large amount of dissolved oxygen is consumed during microbial decomposition. The minimum concentration to support warm water biota is 3 mg/L (Novotny & Olem, 1994). Concentrations should be above 6 mg/L to support a diversity of aquatic biota (Harman et al., 1997). Average values ranged from 5.86 mg/l (CC1) to 9.74 mg/l (SB4). Mean concentrations for all sites are given in Figure 3.

pH

Many organisms are sensitive to changes in pH. Most aquatic biota prefer a pH of 7 (neutral), but can tolerate a range of 6 to 8.5 (Novotny & Olem, 1994). Runoff in Otsego’s northern watershed tends to be slightly alkaline and buffered, which is to be expected given that the bedrock in these areas is dominated by limestone. Average pH (ranging from 7.24 at CC1 to 8.55 at CC2) for White Creek, Cripple Creek, Hayden Creek, Shadow Brook and the stream on Mount Wellington are seen in Figure 4.
Figure 2. Average conductivity (µmho/cm) at tributary sites in the Otsego Lake watershed, summer 1999.

Figure 3. Average pH at tributary sites in the Otsego Lake watershed, summer 1999.
TEMPERATURE

Temperature affects aquatic organisms both directly and indirectly. Stenothermal species of aquatic biota can only tolerate a narrow range of temperatures and are negatively impacted if temperatures occur outside that range. The biota may also be indirectly affected, because dissolved oxygen concentrations are inversely related to temperature. Temperature ranged from 17.73°C at MW1 to 26.12°C at HC1. Figure 5 gives mean temperature for all sites.

PHOSPHORUS

The United States consumes 25% of the world’s phosphorus and 76% of that is used in agricultural fertilizers (Kramer, 1972). The productivity of Otsego Lake is limited by phosphorus (Harman et al., 1980). The use of agricultural fertilizers, as well as nutrient recycling through manure applications, has presumably increased nutrient loading to the lake. Phosphorus is the single most important nutrient to manage for controlling accelerated eutrophication in freshwater lakes (Daniel, 1994). The goal of this study is to characterize streamwater with respect to phosphorus content. Mean concentrations ranged from 19.4 μg/l at CC2 to 96.5 μg/l at MW2. Though MW2 consistently had the highest concentration, the summer average was lower here than since monitoring began in 1996. Average total phosphorus for all sites are seen in Figure 6.

NITROGEN

Nitrogen is a nutrient that often contributes to eutrophication and is often concentrated in agricultural runoff. The site having the lowest mean concentration was CC2 (0.03 mg/l); the highest mean concentration was 1.21 mg/l at site SB2. Average nitrite+nitrate for all sites are seen in Figure 7.

CONCLUSION

The results for most streams indicate an improvement in water quality since 1991 with some exceptions. There is currently one BMP site in the White Creek basin. Mount Wellington shows a decrease in phosphorus since 1997 at MW1, but an increase in phosphorus at MW2. BMP projects have been funded for this basin though none have been completed to date. Nutrient levels in Hayden Creek have remained relatively constant since 1997. There are currently nine BMP sites in the Hayden Creek basin. Phosphorus levels have decreased in Cripple Creek since 1997, but levels of nitrite+nitrate have increased in the downstream reaches of the stream this year. The high levels of nitrates+nitrites could be due to the great amount of precipitation seen early in the summer of 1998. As flow increases, nutrient concentrations from non-point sources increase and those from point sources will decrease due to dilution (Brown et al., undated). Further monitoring will be necessary to determine if nitrogen levels are indeed rising due to changes in land use or climactic conditions. Currently, there is only one BMP site in the Cripple Creek basin. Shadow Brook
Figure 4. Average dissolved oxygen (mg/l) at tributary sites in the Otsego Lake watershed, summer 1999.

Figure 5. Average temperature (°C) at tributary sites in the Otsego Lake watershed, summer 1999.
Figure 6. Average total phosphorus (ug/l) at tributary sites in the Otsego Lake watershed, summer 1999.

Figure 7. Average nitrite+nitrate (mg/l) at tributary sites in the Otsego Lake watershed, summer 1999.
shows a decrease in phosphorus and nitrite+nitrate since 1997. There are eight BMP sites in the Shadow Brook basin.

Figure 8 shows total phosphorus at the stream outlets for the years 1991, 1992 and 1995–99. Shadow Brook was the only stream monitored in 1992 (Albright, 1996). White Creek and the stream on Mount Wellington were not monitored in 1995. The general trend, though not statistically significant, seems to be that phosphorus is declining throughout the watershed. Mount Wellington tends to have the highest concentration of phosphorus. Its small drainage basin and ephemeral nature mean the overall loading by this stream is relatively slight. It isn’t yet known if the BMP sites on Hayden Creek, Cripple Creek, and Shadow Brook are affecting phosphorus levels. Shadow Brook is perhaps the best indicator to date, since BMP development in that basin have been most intensive and have been initiated the earliest, some being implemented before 1995. As shown in Figure 8, the total phosphorus at the Shadow Brook outlet has decreased over the period since implementation of BMPs. Although these results are encouraging, continued monitoring is necessary before any solid conclusions can be made about the effectiveness of the BMP projects in the northern watershed. There reportedly is a direct relationship between watershed size and the time frame required to observe water quality improvements (Maas, 1988). Similar programs have shown that for a lake, the total time between implementation of BMPs and documented improvements in the lake is from 6 to 14 years (Maas, 1988), depending on the size of the lake.

Figure 8. Mean total phosphorus concentrations at the near-lake sites of each tributary monitored, summers of 1991, 92 and 95-99 (modified from Poulette, 1999).
It should be noted that on collection dates when high levels of phosphorus and nitrite+nitrate were observed, samples were taken during rainstorm events. For streams lacking point sources, there is an increase in the range of observed phosphorus and sediment concentrations with increasing stream discharge (Brown et al., Undated). Discharge rates are not included in this study. That valuable information could be used to determine nutrient loading, which better evaluates how changes in land use effect a lake. Surveys conducted 1991-93 were intended to provide baseline nutrient concentration data; those years constant flow data were collected on Shadow Brook. More BMPs are currently under construction. The BFS has initiated a precipitation-based monitoring protocol on Shadow Brook beginning in 1999 thanks to funding by OCCA.

REFERENCES


