Water quality monitoring of five major tributaries in the Otsego Lake watershed, summer 2005

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ABSTRACT

Monitoring of the Northern Otsego Lake watershed was conducted to determine the effectiveness of the Best Management Practices located in the White Creek, Hayden Creek, Shadow Brook, Cripple Creek, and Mount Wellington drainage basins. Analysis of nitrate+nitrite, total nitrogen, total phosphorus, ammonia, dissolved oxygen, and temperature was conducted weekly to determine the quality of water entering Otsego Lake. Water quality across the five tributaries has shown improvements in some areas, but has degraded in others. Mean nitrate+nitrite concentrations have shown a slight decrease from last years averages; however, total phosphorus levels increased at most sites, substantially in some.

INTRODUCTION

In recent years, limnological monitoring of Otsego Lake has shown a trend towards increasing eutrophication rates (Harman et al. 1997; Albright 1998; 1999; 2000; 2001; 2002). These increased rates are attributed to dissolved nutrient loading from manmade sources such as runoff from agricultural (Murray and Leonard 2005), residential land use (Albright 2005a), and from lake front septic systems (Meehan 2004a). Nutrient influxes lead to algal blooms that result in decreased water clarity and lowered deep-water oxygen concentrations. These changes negatively affect the plants and animals of the lake, reduce the recreational potential (boating and fishing), and significantly reduce the aesthetic appeal of the lake. In addition, Otsego Lake provides drinking water to the Village of Cooperstown and lakeside residents. Increased algal concentrations affect the taste, color, and odor of the drinking water.

In the northern portion of the Otsego Lake watershed, 48 percent of the land is used for agriculture, making it the predominant land use (Harman et al. 1997). This northern watershed consists of five drainage basins that include: White Creek, Hayden Creek, Shadow Brook, Cripple Creek, and a small tributary that drains Mt. Wellington. Actively farmed drainage basins have the potential to have increased nutrient export rates Because agriculture accounts for nearly half of the watershed's land use, the nutrient load contributed from this source is likely significant (Meehan 2003). The nutrients from agricultural fertilizers and livestock waste have been identified as the primary cause of anthropogenic eutrophication in freshwater inland lakes in the United States (Daniel et. al 1994).

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The USDA Natural Resources Conservation Service (NRCS) has turned its efforts towards addressing nutrient and sediment runoff from farms by implementing Best Management Practices (BMPs). These BMPs are a set of guidelines and methods used to control non-point source pollution from farms. Some of the suggested practices include: alternate drinking sources for livestock, stream bank fencing, manure storage facilities, sediment retention ponds, conservation tillage, contour strip-cropping, and cattle crossings over streams (EPA 2005). Twenty-two BMP sites have been established throughout Otsego Lake's northern watershed (Figure 1). The purpose of this study is to continue to evaluate the effectiveness of these Best Management Practices by monitoring water quality parameters including: total nitrogen, nitrate+nitrite nitrogen, ammonia, total phosphorus, temperature, and dissolved oxygen. Similar data have been collected in the summers of 1995 (Heavy 1996), 1996 (Hewett 1997), 1997 (Miller 1998), 1998 (Poulette 1999), 1999 (Collins and Albright 2000), 2000 (Miner 2001), 2001 (Parker 2002), 2002 (Meehan 2003), 2003 (Meehan 2004), and 2004 (Murray and Leonard 2005).

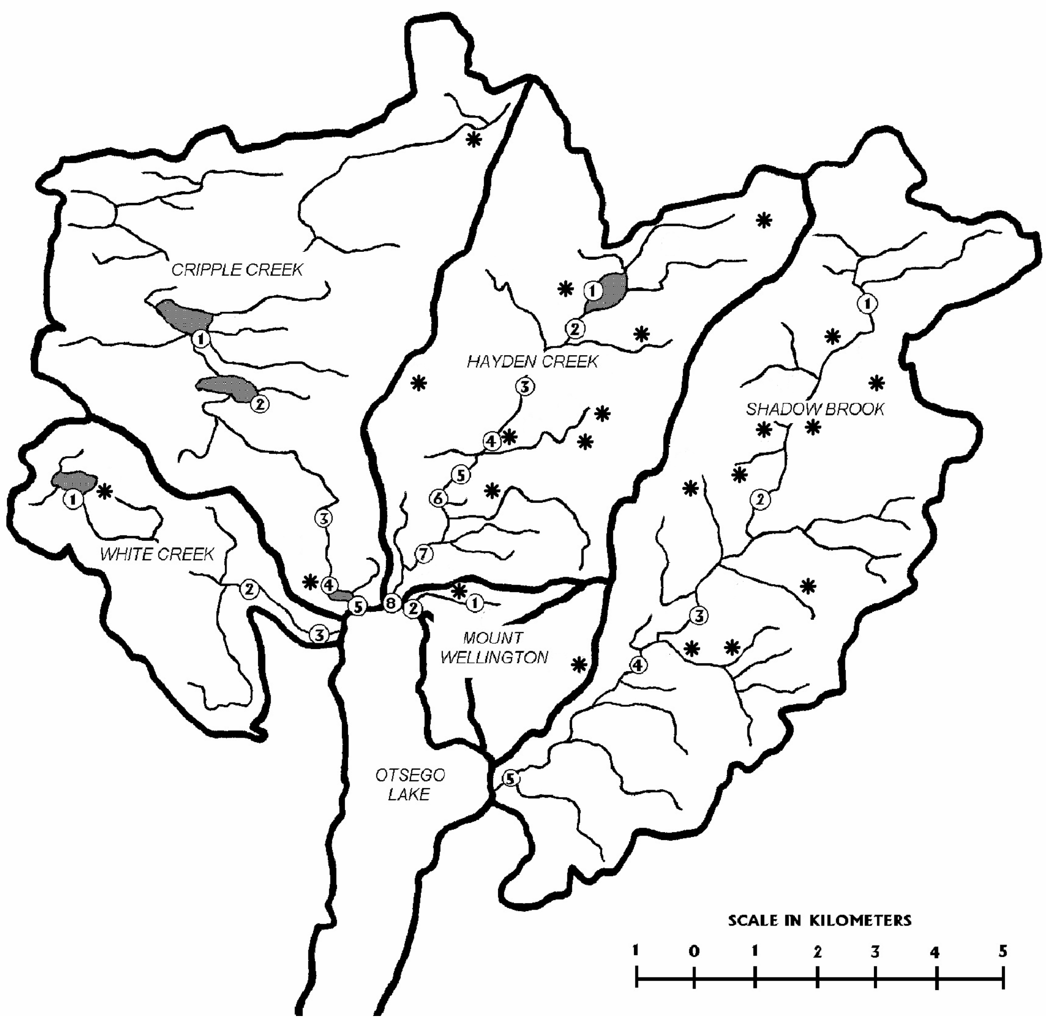

Figure 1. Map of the monitored tributaries showing sampling stations (numbered) and locations of agricultural BMPs (asterisks).

MATERIALS & METHODS

Water samples were collected weekly at 23 sites on five tributaries in the northern watershed of Otsego Lake (Figure 1) between 7 June and 9 August 2005. The sites were established by Heavy in 1995 (1996) and expanded in 1996 by Hewett (1997). Best Management Practices that were completed by the conclusion of the 2004 monitoring period are indicated in Figure 1. Detailed sampling site descriptions are provided in Table 1.

Temperature and dissolved oxygen readings were taken on site using a YSI Model 95 Dissolved Oxygen and Temperature System® or a Hydrolab Scout 2®. The systems were calibrated directly before use as per the manufacturer's protocol. Water samples were collected and analyzed weekly for total phosphorus using the ascorbic acid method following persulfate digestion (Liao and Marten 2001), total nitrogen using the cadmium reduction method (Pritzlaff 2003) following peroxodisulfate digestion as described by Ebina et. al (1983), ammonia using the phenolate method (Liao 2001), and for nitrate+nitrite nitrogen using the cadmium reduction method (Pritzlaff 2003). All of these parameters were analyzed using a Lachat QuikChem FIA+ Water Analyzer®.

Table 1. Locations and descriptions of sampling sites visited weekly from 7 June to 9 August 2004 (modified from Poulette 1999). Sites can be seen in Figure 1.

<u>White Creek 1</u>: 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.

<u>White Creek 2</u>: 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.

<u>White Creek 3</u>: N 42° 48.355′ W 74° 54.210′
East side of large stone culvert on Route 80.

<u>Cripple Creek 1</u>: 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.

<u>Cripple Creek 2</u>: 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.

<u>Cripple Creek 3</u>: 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.

<u>Cripple Creek 4</u>: 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.

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

Table 1(cont.). Locations and descriptions of sampling sites visited weekly from 7 June to 9 August, 2004 (modified from Poulette 1999). Sites can be seen in Figure 1.

<u>Hayden Creek 1</u>: 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. A fence was installed during the first week of July 2004, deepening the sampling site slightly.

<u>Hayden Creek 2</u>: N 42° 51.324′ W 74° 51.294′
North side of culvert on Dominion Road.

<u>Hayden Creek 3</u>: 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.

<u>Hayden Creek 4</u>: 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.

<u>Hayden Creek 5</u>: N 42° 49.997′ W 74° 52.533′
Immediately below the Shipman Pond spillway on Route 80.

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

<u>Hayden Creek 7</u>: N 42° 49.258′ W 74° 53.010′
Large culvert on the south side of County Route 53.

<u>Hayden Creek 8</u>: 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.

<u>Shadow Brook 1</u>: 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 2001, this site has a history of drying up by mid-summer.

<u>Shadow Brook 2</u>: 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.

<u>Shadow Brook 3</u>: N 42° 48.788′ W 74° 49.852′
Private driveway (Box 2075) leading to a small wooden bridge on a dairy farm.

<u>Shadow Brook 4</u>: N 42° 48.333′ W 74° 50.605′
One lane bridge on Rathburn Road. This site is located on an active dairy farm. The stream bed consists of exposed limestone bedrock.

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

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

<u>Mount Wellington 2</u>: 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 & DISCUSSION

Temperature

Water temperature affects both aquatic biota and water chemistry and is one of the most important factors in freshwater environments. Temperature is also inversely related to dissolved oxygen concentrations. Mean temperatures ranged from 17.89˚C at CC2 to 26.89˚C at HC1. The mean low temperature in 2004 was 16.32˚C and the mean high temperature was 21.69˚C. This year's temperatures show a slight increase, which has been the general trend over the past two years. This is most likely due to the high temperatures and low amounts of rainfall throughout the 2005 monitoring period. The mean temperatures for all watershed sites are given in Figure 2.

Dissolved Oxygen

Dissolved oxygen is a key indicator of the health of an aquatic ecosystem. Low concentrations can indicate increased amounts of organic matter or excessive temperatures (Meehan 2003). The minimum concentration to support most warm water biota is 3 mg/L (Novotny and Olem 1994). Average dissolved oxygen concentrations ranged from 5.78 mg/L at WC1 to 9.64 mg/L at SB4. The mean low oxygen concentrations this year are higher than those of 2004; however, the mean high concentrations are slightly lower than past years. This is probably due to higher mean water temperatures observed this year. The mean dissolved oxygen concentrations for all watershed sites are given in Figure 3.

Total Phosphorus

The productivity of Otsego Lake is limited by phosphorus (Harman et al. 1997). Major sources of phosphorus are most likely agricultural fertilizers and livestock wastes. According to Lampert and Sommer (1997), to maintain an oligotrophic lake like Otsego Lake, total phosphorus levels should be maintained between 5 to 10 ug/L. Mean total phosphorus concentrations were highest at MW2, with an average concentration of 147.3 ug/L, and lowest at WC3, with an average concentration of 27.7 ug/L (Figure 4). This is a change from last year, where the highest concentration was at CC2 and the lowest was at HC2. Mount Wellington receives runoff not only from agricultural lands, but also from a nearby golf course. However, flow at Mount Wellington is minimal, so nutrient loading is not likely excessive. Looking at the concentrations of phosphorus at the outlets of each tributary, an increase from last years concentrations can be seen (Figure 5).

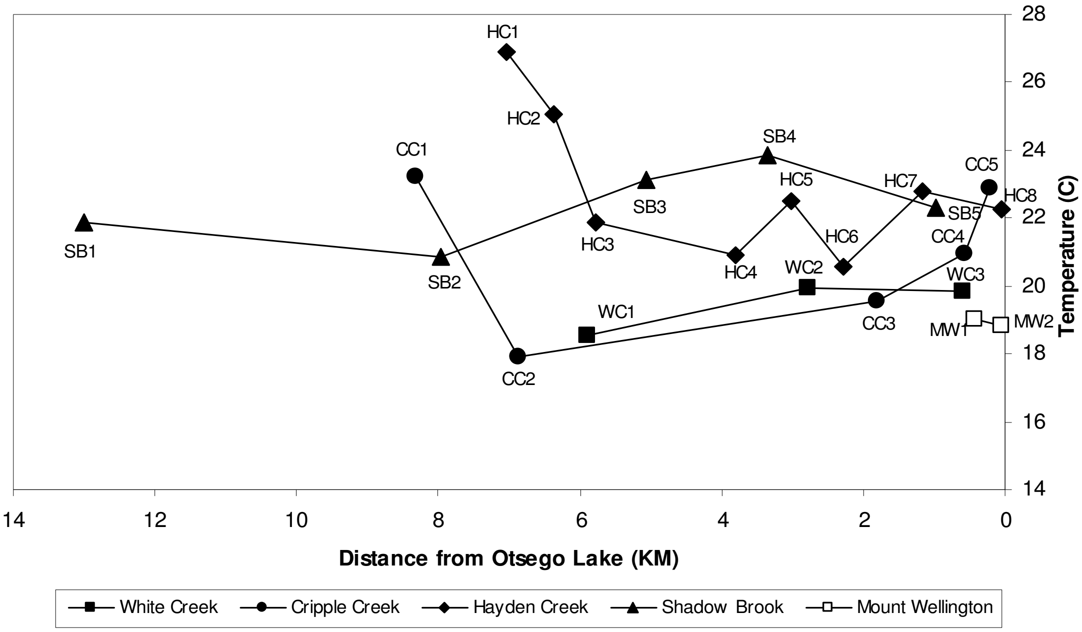

Figure 2. Average Temperature (˚C) at tributary sites in the Otsego Lake watershed, summer 2005.

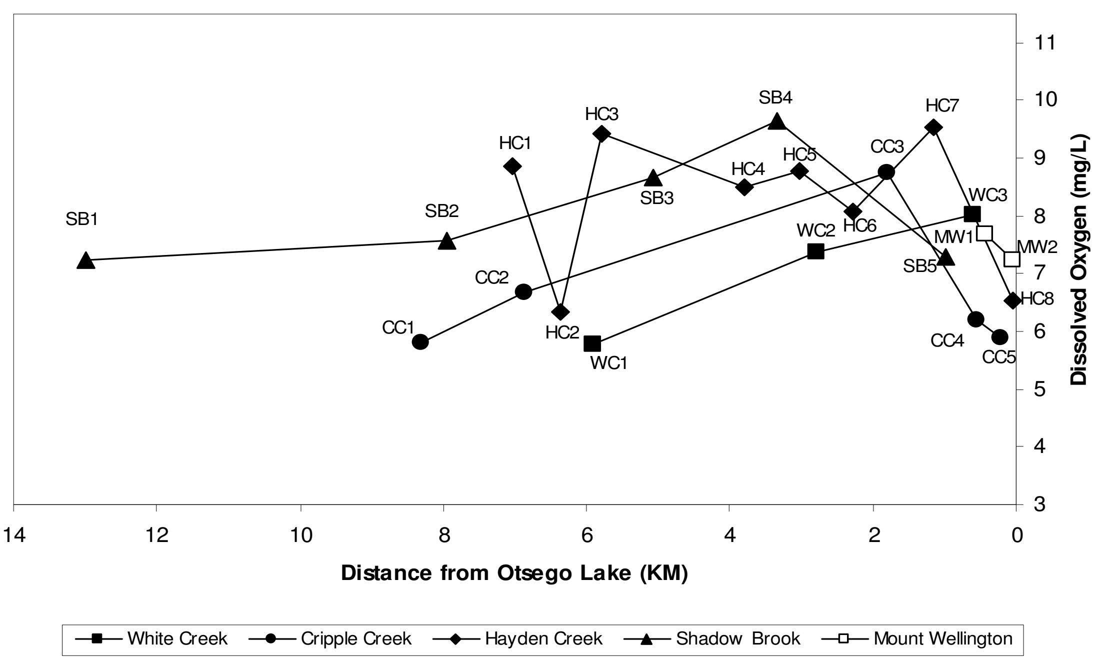

Figure 3. Average dissolved oxygen concentrations (mg/L) at tributary sites in the Otsego Lake Watershed, summer 2005.

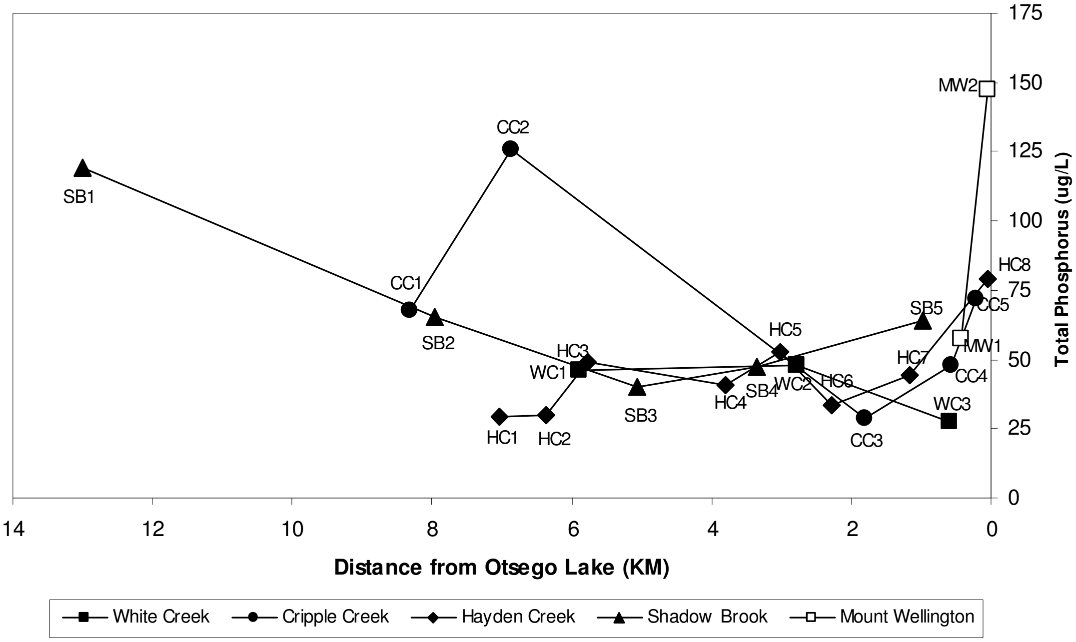

Figure 4. Average total phosphorus concentrations (ug/L) at tributary sites in the Otsego Lake watershed, summer 2005.

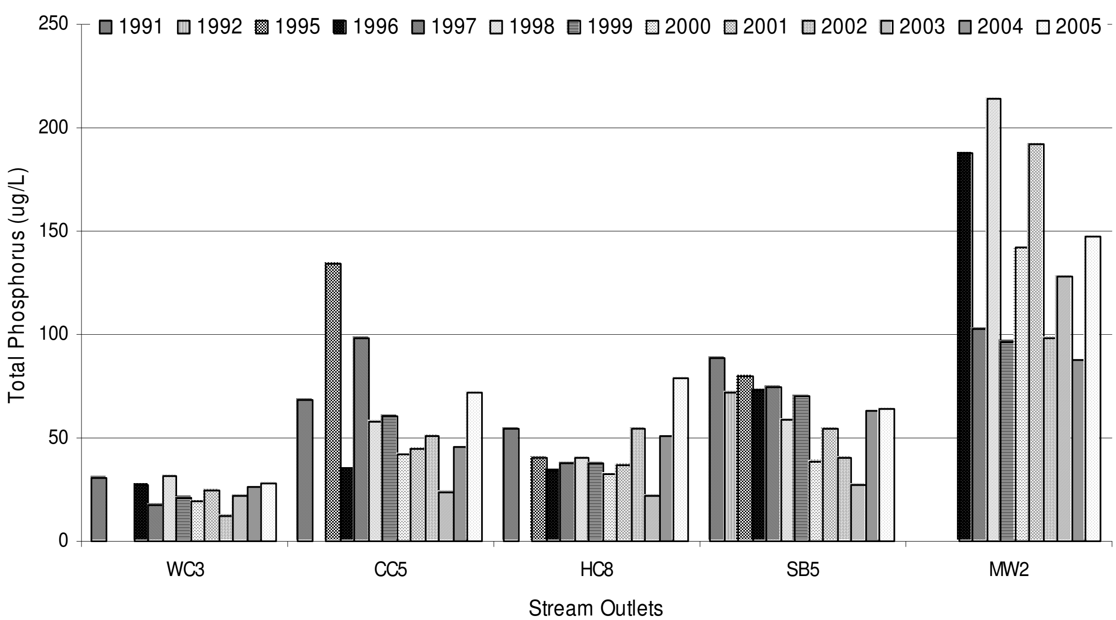

Figure 5. Mean total phosphorus concentrations at the stream outlets of each tributary monitored during the summers of 1991, 1992, and 1995-2005 (modified from Murray and Leonard 2005).

Total Nitrogen, Nitrate+Nitrite, and Ammonia

Nitrogen, although an essential nutrient, limits algal production less often than phosphorus in inland waters (Cole 1983). Nitrogen enters the lake through surface water, ground water, and precipitation (Lampert and Sommer 1997). The major sources of nitrogen entering Otsego Lake are most likely septic leachate, agricultural fertilizers, and livestock wastes. The total nitrogen concentrations are the combined nitrate, nitrite, ammonia, and organic nitrogen concentrations. Total nitrogen concentrations ranged from 0.48 mg/L at WC3 to 1.81 mg/L at HC8 (Figure 6). As this is the first year that total nitrogen has been analyzed, there are no comparisons to be made. Average total nitrogen concentrations for all watershed sites are given in Figure 6.

During summer 2005, mean nitrate+nitrite-N concentrations ranged from .014 mg/L at HC1 to 1.26 mg/L at HC6 (Figure 7). The mean high and low concentrations, as well as the mean concentrations at most of the sites, were lower than those of summer 2004 (Murray and Leonard 2005). It is the hope that this trend of decreasing nitrate+nitrite concentrations is a sign of the positive effects of the BMPs. Ammonia is the byproduct of heterotrophic bacterial breakdown of organic substances and is another component of total nitrogen (Cole 1983).

Ammonia is toxic to fish at relatively low levels. Average ammonia concentrations ranged from .082 mg/L at MW1 to .847 mg/L at WC1, which would indicate that the organic nitrogen fraction is minimal (Figure 8). However, year to year comparison can not be made because this is also the first year that ammonia has been monitored.

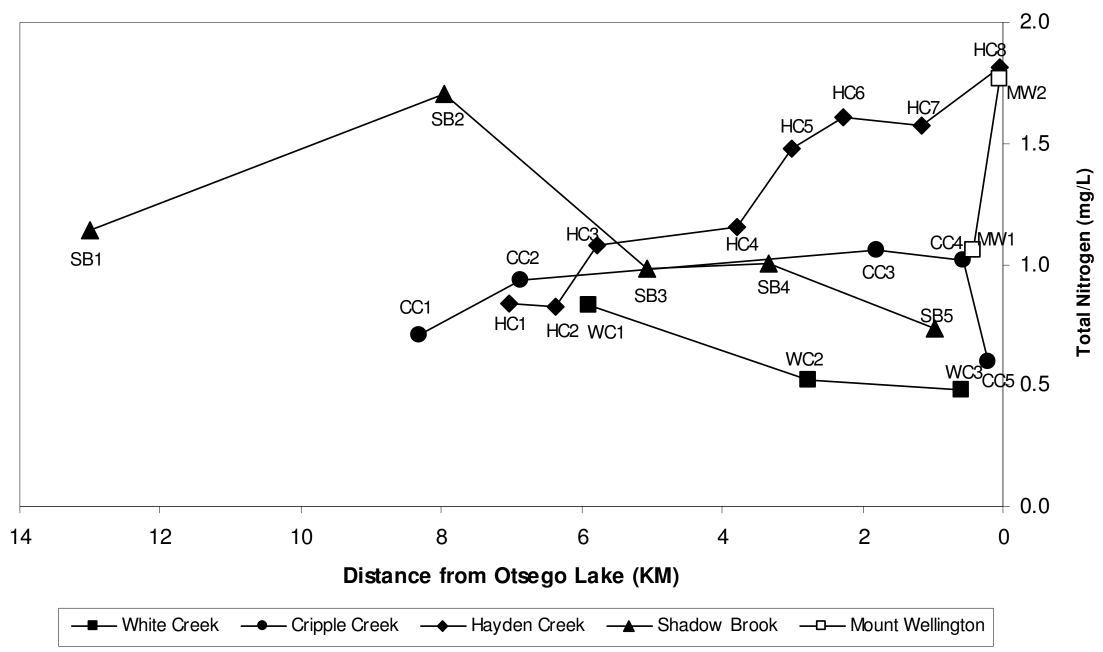

Figure 6. Average total nitrogen concentrations (mg/L) at tributary sites in the Otsego Lake watershed, summer 2005.

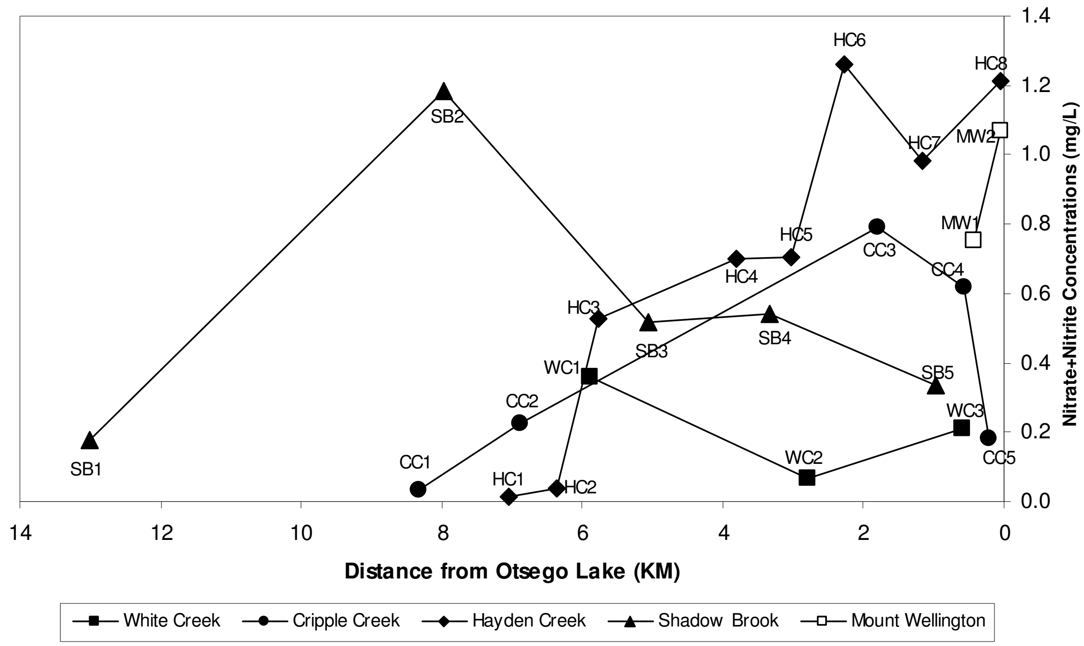

Figure 7. Average nitrate+nitrite concentrations (mg/L) at tributary sites in the Otsego Lake watershed, summer 2005.

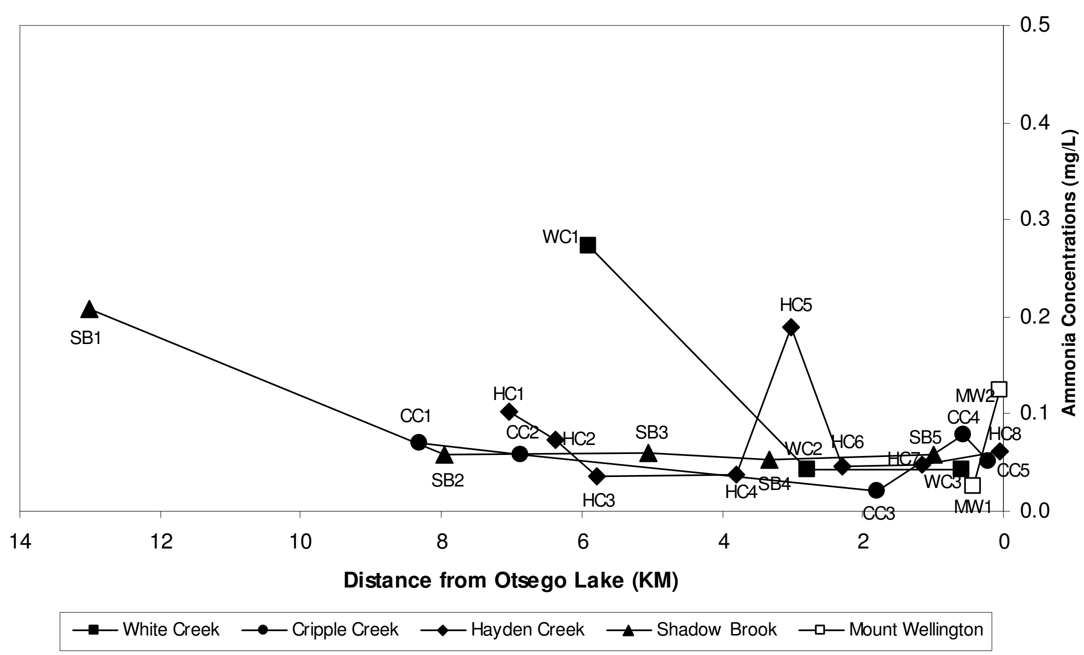

Figure 8. Average ammonia concentrations (mg/L) at tributary sites in the Otsego Lake watershed, summer 2005.

CONCLUSIONS

Water quality across the five tributaries has shown improvements in some areas, but has degraded in others. Mean nitrate+nitrite concentrations have shown a slight decrease from last years averages; however, total phosphorus levels increased at most sites. Hayden Creek, having the most BMPs in the watershed (10), exhibited a steady increase in both total nitrogen and total phosphorus. This leads to the conclusion that the BMPs are in fact not having much affect on improving the water quality to date. On the other hand, the mean high and low nitrate+nitrite concentrations, as well as the mean concentrations at most of the sites, were lower than summer 2004, which sends a mixed signal. Albright (2005b) states that the amount of time necessary for land use changes to be manifested in water quality changes is unknown because similar research is lacking and that which is available is recent. Further watershed monitoring will be necessary to make any final conclusions on the efficiency of these agricultural Best Management Practices.

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