Water quality monitoring of five major tributaries to Otsego Lake, summer 2004

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INTRODUCTION

Throughout the 1990s, continued limnological monitoring of Otsego Lake had indicated a trend toward increasing eutrophy. The loading of dissolved nutrients, a major source of eutrophication, can be attributed to different manmade sources, including septic systems (Meehan 2004a) and runoff from residential, commercial and agricultural land use. Algae resulting from this nutrification initially decrease water clarity and ultimately deplete dissolved oxygen levels as the organic material decomposes. Combined, these factors affect recreational boating and fishing, as well as the aesthetic appeal of the lake. Additionally, Otsego Lake provides drinking water the historic Village of Cooperstown and lakeside residents (Harman et al. 1997). High concentrations of algae result in unpleasant taste, color, and odor of water. Also, when chlorine is used to disinfect water containing dissolved organics, reactions can produce harmful carcinogens (Cooke et al. 1993).

Otsego Lake is located in a glacially over deepened valley with a north-south orientation. Fed by a series of small tributaries, the lake is 13.28 kilometers long and an average of 1.28 kilometers wide, with an average depth of 22.6 meters. Otsego's outflow is the Susquehanna River, located at the southern end of the lake and draining to the Chesapeake Bay. The five drainage basins of the northern watershed provide three quarters of the Lake Otsego's total inflow (Harman et al. 1997).

Since approximately 75 percent of Lake Otsego's watershed is located to the north of the lake, studying the northern watershed is crucial to understanding the status of the lake. These tributaries include White Creek, Cripple Creek, Hayden Creek, Shadow Brook, and a small creek running off Mount Wellington (Figure 1). Of the 14,090 acres of land drained by these streams, 48.4 percent is used for agriculture. Less than one percent of the remaining land is settled (Harman et al. 1997). Therefore, the majority of nutrient loading from the northern watershed is likely influenced by agricultural activities.

General concerns about nutrient loading have led to national legislation, primarily implemented by the Natural Resources Conservation Service (NRCS), a division of the U.S. Department of Agriculture (USDA). The 1995 Farm Bill included the Environmental Quality Incentive Program (EQIP) (NRCS 1996). Promoting the compatibility of agricultural production and environmental quality, this program provided incentive payments and cost-sharing to eligible farmers willing to implement environmentally friendly agricultural management practices. Once

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farmers applied for EQIP, county organizations determined eligibility using a ranking system. Ranking factors included proximity of farm to water resources, potential conservation methods, and how the land was currently being used (NRCS 2004). Once an application was accepted, agricultural Best Management Practices (BMPs) were implemented based on suggestions by the USDA-NRCS. BMPs specific to watersheds included controlling run off from fields, finding alternate water sources for cattle, controlling cattle access to the streambed, conservation tillage, and cattle waste management (EPA 2003). Since 1995, 22 farms situated in the drainage basins of the northern watershed were accepted into the program (Figure 1) (Pullano 2000).

In conjunction with this legislation, the Biological Field Station has been regularly monitoring levels of total phosphorus and nitrate+nitrite concentrations in the northern watershed since 1995 (Heavy 1996). This effort was originally intended to document degraded stream segments which would most likely benefit from BMP implementation (Albright 2004a). In addition, the effects of BMPs on Shadow Brook are being evaluated (Albright 2004b), including precipitation based monitoring to evaluate nutrient and sediment delivery. The purpose of these continuing studies is not only to document the effectiveness of the BMP programs, but also to monitor the quality of the water entering Otsego Lake.

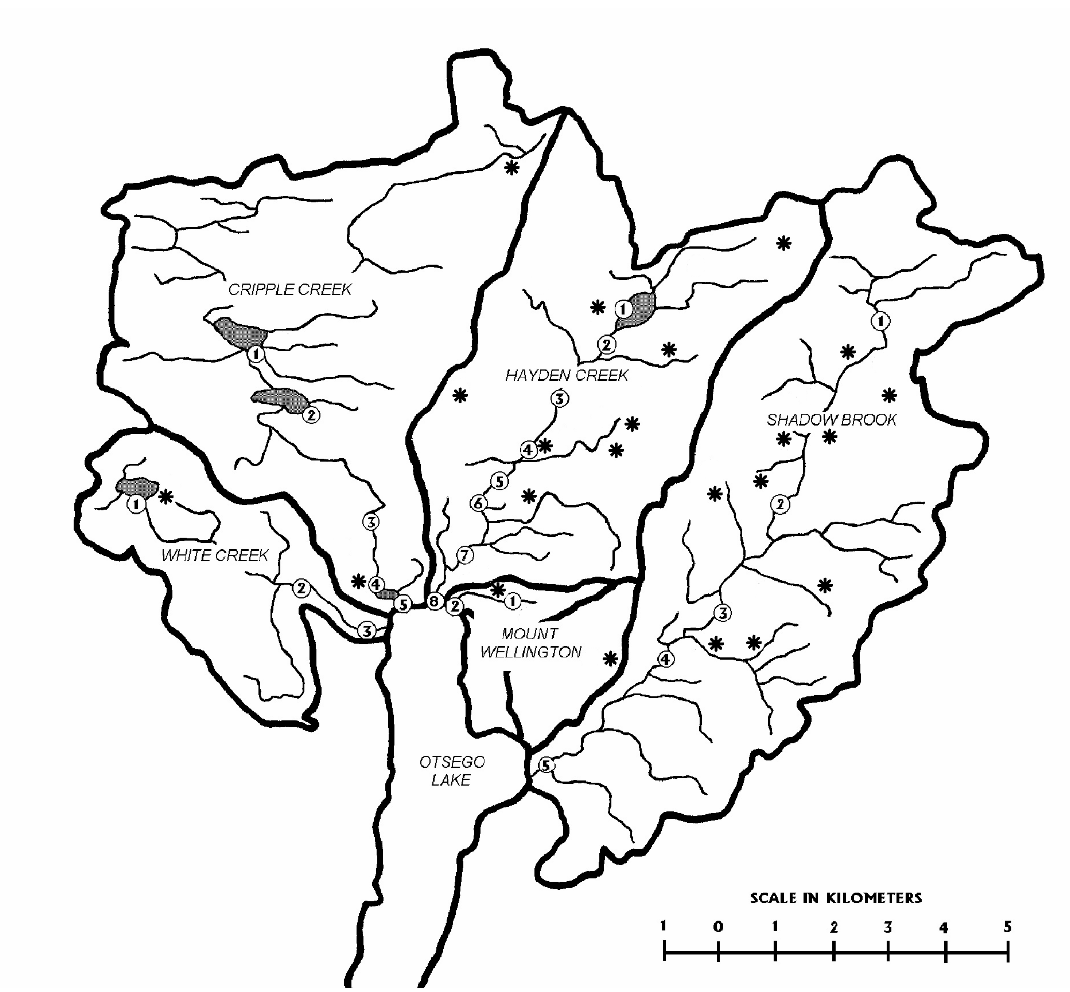

Figure 1. Northern watershed sampling sites. BMPs are indicated by asterisks.

METHODS AND MATERIALS

From 1 June through 10 August 2004, weekly samples were taken at each of 23 sites (Figure 1) previously established in 1995 (Heavy 1996) and modified in 1996 (Hewett 1997). Table 1 details their locations and describes each site. As samples were collected, readings of dissolved oxygen and temperature were taken using a YSI Model 95 Dissolved Oxygen and Temperature System®. The system was calibrated prior to sampling using a precalibrated Hydrolab Scout 2®.

Collected samples were taken back to the lab where they were processed weekly for total phosphorus and nitrite+nitrate nitrogen. Total phosphorus was analyzed using persulfate digestion followed by the ascorbic acid method (APHA 1992). Nitrite+nitrate nitrogen was analyzed using the cadmium reduction method (APHA 1992).

Table 1. Locations and descriptions of sampling sites visited weekly from 1 June to 10 August, 2004 (modified from Poulette, 1999).

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. A fence was installed during the first week of July 2004, deepening the sampling site slightly.

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 2001, 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 2075) 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. This site is located on an active dairy farm. 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

Temperature

A key factor in freshwater environments, water temperature effects both aquatic biota and water chemistry. Metabolic rates, reproduction, behavior, respiration, and photosynthesis in freshwater organisms are affected by temperature changes (Brönmark and Hansson 1998). Other factors aside, the amount of dissolved oxygen is inversely related to water temperature. Mean temperatures ranged from 16.32°C at HC3 to 21.69°C at HC1 (Figure 2). The mean low temperature in 2003 was 14.39°C at CC3 (Meehan 2004b), nearly two degrees lower than then the mean low temperature of summer 2004. This may be due to high amounts of rainfall or the discrepancies in the time span data were collected. Streamside BMPs such as revegetating riparian corridors, can lower water temperatures by providing shading.

Dissolved Oxygen

Dissolved oxygen (DO) is one of the most critical measurements taken in a water quality study. It indicates the capacity of water to receive organic matter and support aquatic life (Wetzel et al. 1990). Generally, less than 3 mg/L of DO will not support most aquatic life (Lind 1979). Mean DO readings for summer 2004 ranged from 3.75mg/L at CC1 to 10.89mg/L at SB4 (Figure 3). In 2003, the mean low DO reading was also at CC1 with a value of 6.03mg/L. In general, mean DO readings from 2004 were lower than those from 2003 (Meehan 2004b). This can be likely attributed to the higher mean water temperatures through out the summer of 2004.

Nitrogen

Nitrogen is a major agricultural runoff that contributes to nutrient loading (Cole 1979), although in Lake Otsego phosphorus in the limiting agent in eutrophication (Harman et al. 1997). It is, however, important to note that the Chesapeake Bay, to which Otsego Lake drains, is nitrogen limited, and the reduction of loading by that nutrient is the primary objective in restoration efforts there. During summer 2004, mean nitrate+nitrite-N concentrations ranged from 0.13 mg/L at CC1 to 1.58 mg/L at MW2 (Figure 4). The mean high and low concentrations, as well as the mean concentrations at most of the sites, were lower than summer 2003 (Meehan 2004b). This year's wet summer and lower nitrate+nitrite concentrations are consistent with the inverse relationship between runoff and this nutrient's concentration in streams (Albright 1996).

Total Phosphorus

Total phosphorus is the sum of inorganic and organic forms of phosphorus. In Otsego lake, as in many water bodies, the growth of primary aquatic producers, and thus the productivity of the lake, is phosphorus limited (Brönmark and Hansson 1998). Otsego Lake is oligotrophic (Harman et al. 1997), meaning that, according to the classification of Brönmark and Hansson (1998), it has between 10µg/L and 30µg/L of total phosphorus. Mean total phosphorus concentrations were highest at CC2, with an average of 144.1µg/L, and lowest at HC2, with an average of 22.7µg/L (Figure 5). Both of these sites last year had the highest and lowest average readings, respectively, though they were considerably lower than this year's averages. Generally, total phosphorus levels increased from summer 2003 to summer 2004 (Meehan 2004b), following the direct relationship between runoff and total phosphorus concentration in streams (Albright 1996). Figure 6 compares mean summertime total phosphorus concentrations at the outlets of White Creek, Cripple Creek, Hayden Creek, Shadow Brook and Mount Wellington for 1991, 1992 and 1995-2004.

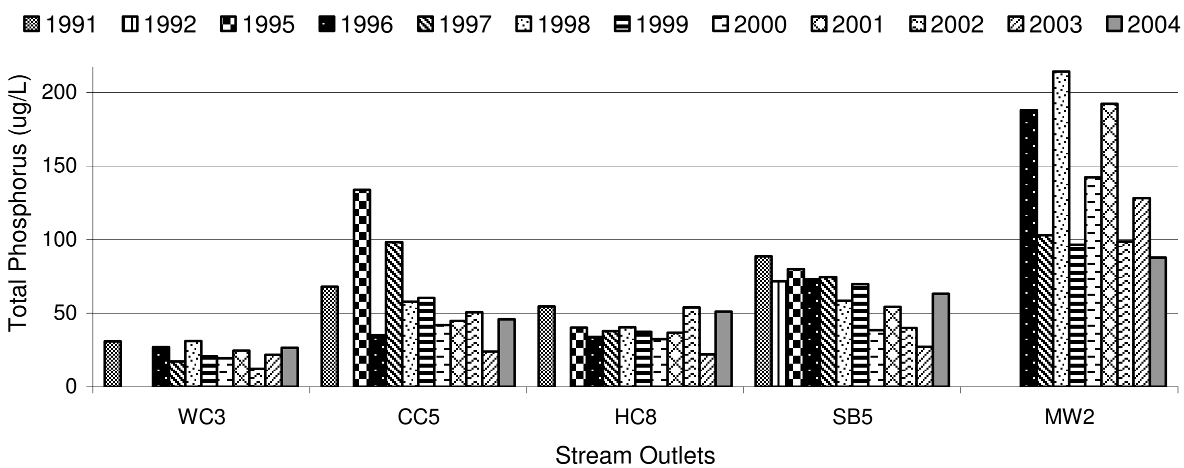

Figure 6. Mean total phosphorus concentrations at the stream outlets of each tributary monitored during the summers of 1991, 1992 and 1995-2004 (modified from Meehan 2004).

CONCLUSION

The heavy rainfall, and resulting high stream flows, throughout the summer of 2004 likely overshadowed changes in water quality attributable to the establishment of agricultural BMPs in the northern watershed of Otsego Lake. (During the study period, 29.2 cm of rain fell in Cooperstown, compared to a mean of 22.6 cm). Prior to 2004, it appeared that total phosphorus was generally dropping (Figure 6). However, the data from the summer of 2004 show a return to total phosphorus concentrations recorded in the late 1990's. It is difficult to distinguish how much of this difference can be attributed to high amounts of rainfall, variations in stream flow, or changes in land management practices. This ambiguity will continue unless these and other variables are accounted for in this study. However, long-term monitoring should eventually compensate for annual meteorological fluctuations.

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