Investigation of trophic changes in Lake Minnewaska, a pristine sky lake in Ulster County, New York

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Introduction

Lake Minnewaska is a central feature of Minnewaska State Park Preserve in New Paltz, NY. In the 1990s and at the turn of this century, Lake Minnewaska was considered a "sky lake". Water clarity was very high, pH and nutrient levels were low, and the lake had a unique, beautiful turquoise color. The lake also possessed unique biota, most notably a moss (*Sphagnum trinitense*) growing at the deeper levels of the lake. Two rare salamander populations were also found at the lake and exhibited unusual breeding behaviors, due to a lack of predators. High water clarity made Lake Minnewaska a popular recreational diving area. Results from baseline studies clearly show that Lake Minnewaska was oligotrophic at the turn of the century. However, over the past decade, increases in pH and phytoplankton have steadily occurred, moving the lake toward mesotrophic conditions. The illegal introduction of two fish species in the past five years has had major impacts to the lake's ecosystem. In response to these changes, State Parks staff increased monitoring in 2011 and 2012 to assess the changes in trophic level.

Estimating Trophic Level

One of the important steps in assessing the water quality of lakes is to describe its trophic level. The trophic level of a lake is a reflection of its algal productivity. There are three general levels, oligotrophic (low productivity), mesotrophic (moderate productivity), and eutrophic (high productivity). Overall, lake productivity can affect the types and numbers of fish and aquatic vegetation found within a water body. Trophic level is assessed by comparing lake sampling results to NYS DEC's Citizens Statewide Lake Assessment Program (CSLAP) criteria for phosphorus, chlorophyll a (an indicator of algal biomass), and water clarity.

Parameter	Eutrophic	Mesotrophic	Oligotrophic
Phosphorus (µg/L)	> 20	10 - 20	< 10
Chlorophyll a (µg/L)	> 8	2 - 8	< 2
Water Clarity (m)	< 2	2 - 5	> 5

Methods

Data relating to basic water quality has been collected from Lake Minnewaska yearly from 2000-2006, 2009, and 2011-2012. Lake Awosting has been monitored yearly from 2000-2006, 2009, and 2012 and is used as a control lake for comparison. Data collected includes sampling of the lake's surface for chemical, biological, and physical parameters such as water clarity (Secchi depth), phytoplankton, chlorophyll a, and nutrients. Nutrient samples were also collected from near bottom waters.

Lake Minnewaska

Lake Awosting

Chlorophyll a

In 2009, samples collected from both lakes contained very low concentrations of chlorophyll a, indicating low productivity. Samples collected from Lake Minnewaska in 2011 indicated a higher concentration of chlorophyll a. The higher concentration of chlorophyll a was also visually observed, with the water taking on a bright green coloration (*Fig. 1, 2*). Samples were collected bi-weekly from both lakes throughout the summer of 2012, and indicated much lower concentrations of chlorophyll a at Lake Minnewaska (average 1.97 µg/L). The decline in chlorophyll a present in the lake was also observed visually, as the water lost its bright green color.

Figure 1. Chlorophyll a filter from surface water sample (August 2011).

Figure 2. Surface water coloration at Lake Minnewaska (August 2011).

Total Phosphorus

Surface total phosphorus levels in Lake Minnewaska and Lake Awosting have fluctuated over time (*Fig. 3)*. Samples collected from Lake Minnewaska in 2004 and 2009 were within the oligotrophic range. In 2011, results from total phosphorus samples were within the mesotrophic range. In comparison, surface total phosphorus readings for Lake Awosting have remained within the oligotrophic range. Samples collected from near bottom waters illustrate higher levels of total phosphorus, most likely due to migration of nutrients from the bottom sediment (*Fig. 4*).

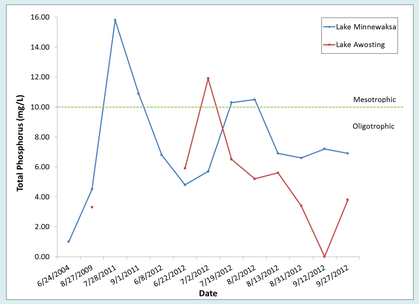

Figure 3. Surface water total phosphorus (2004-2012).

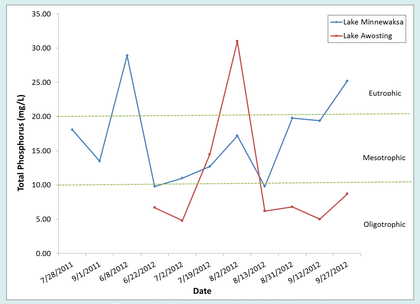

Figure 4. Bottom water total phosphorus (2011-2012).

Water Clarity

Water clarity measurements from Lake Minnewaska have fluctuated over the past decade (*Fig. 5*). Water clarity readings at Lake Minnewaska from 2000-2009 were within either the oligotrophic range (>5 m) or at the high end of the mesotrophic range (2-5 m). During the same time period, Lake Awosting had even greater clarity. In mid-summer 2011, the water clarity of Lake Minnewaska declined to within the eutrophic range (<2 m), which was the lowest clarity ever observed. Readings in 2012 indicate a rebound in clarity. However, the current water clarity is still much lower compared to historic data. Readings in 2012 indicate that Lake Awosting has retained the same level of clarity, with an average of 6.43 meters.

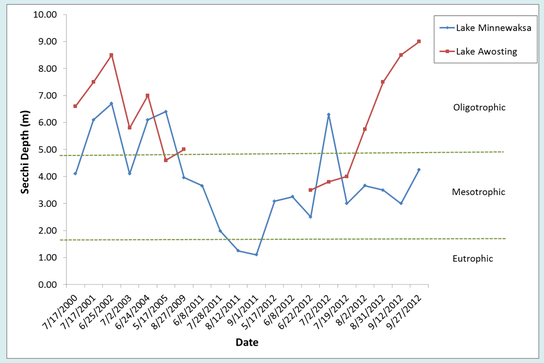

Figure 5. Water clarity measurements (2000-2012).

Trophic Level Changes

Based on all available data, it is clear that the current trophic level of Lake Minnewaska reflects an increase in productivity in recent years. Lake Awosting has not experienced an increase in productivity and remains oligotrophic.

	LAKE MINNEWASKA			LAKE AWOSTING	
Parameter	2000-2009	2011	2012	2000-2009	2012
Total Phosphorus (µg/L)	2.75	12.60	9.76	3.3	8.06
Chlorophyll a (µg/L)	1.60	13.20	1.97	1.1	0.59
Water Clarity (m)	5.30	2.00	3.60	6.42	6.43
Trophic Status	Oligotrophic	Mesotrophic/ Eutrophic	Oligotrophic/ Mesotrophic	Oligotrophic	Oligotrophic

Trophic Cascade

The primary factor contributing to the shift in trophic level was the introduction of a non-native bait fish species, the Golden Shiner (*Notemigonus crysoleucas*). The first observations of the golden shiners occurred in 2008. Previously, highly acidic water prevented the survival of fish in Lake Minnewaska. Overall, shifts from oligotrophic-mesotrophic to eutrophic-hypertrophic conditions were found to be greater with an increase in zooplanktivorous fish biomass (Quiros 1998). A decrease in zooplankton herbivory and increased in nutrients from excretion result in greater phytoplankton biomass, which leads to an overall increase in lake productivity.

In 2012, another species of fish, largemouth bass (*Micropterus Salmoides*), was introduced into Lake Minnewaska. The impacts of the introduction of largemouth bass are not fully understood, and are likely to result in major changes to the lake's trophic structure.

Quiros, R. 1998. Fish effects on trophic relations in the pelagic zone of lakes. Hydrobiologia 361:101-111.

Next Steps

Lake trophic level can change based on fluctuations of individual parameters. Continued monitoring is key to assessing the overall health of a lake ecosystem. NYS Parks will also continue to collaborate with partners, including universities and non-profit organizations. NYS Parks will also develop educational signage and programming to inform our patrons regarding the introduction of non-native aquatic species, as well as providing information regarding the lake ecosystem.

Site Location

Minnewaska State Park Preserve

NYS Parks Lake Program

NYS Parks' Environmental Management Bureau – Water Quality unit has monitored Lake Minnewaska and Lake Awosting as part of a statewide lake monitoring program. The goal of the lake monitoring program is to collect sufficient water quality data to attain an accurate representation and classification of water bodies across the state.

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