

Limnological investigations of Canadarago Lake, Otsego County, NY

W.N. Harman, M.F. Albright, T. Horvath

INTRODUCTION

Canadarago Lake (N42°48.9', W75°00.4') is a dimictic lake of glacial origin in the Towns of Richfield, Otsego and Exeter, Otsego County, NY (Figure 1). It has a surface area of 760 ha (1,877 ac) and a maximum depth of 13 m (43 ft). The surrounding watershed is 17,450 ha (43,100 ac) (watershed:surface area = 1:23) (Figure 2). The basin is largely agricultural, a fact that has led to concerns regarding sediment and nutrient loading to the Lake. The Village of Richfield Springs historically discharged its secondarily treated sewage into Ocquionis Creek (a tributary of Canadarago). This reportedly contributed substantially to nutrient inputs and resulted in excessive floating algal mats. Beginning in 1973, tertiary treatment was initiated, involving phosphorus removal by alum precipitation. Improvement was evident within a few years (Harr et al. 1980).

At the request of a member of the Canadarago Lake Association, a team from the Biological Field Station (BFS) visited the lake three times during the summer of 2001 to collect baseline data on its chemistry and biology to characterize the waterbody as related to management concerns. Temperature, dissolved oxygen, pH, conductivity, total phosphorus, nitrite+nitrate nitrogen, chlorides, alkalinity and calcium were profiled at the deepest point of the lake. Qualitative observations of the rooted plant communities were made, noting any presence or dominance of non-native species.

METHODS

Canadarago Lake was visited on 28 June, 31 July and 12 September 01. Transparency was measured with a standard Secchi disk. At the deepest site encountered (12.0-12.8 m; 39-42 ft), temperature, dissolved oxygen, pH and conductivity were measured at 1 or 2 m intervals using a Hydrolab Scout 2[®] multiprobe digital microprocessor which had been calibrated according to manufacturer's instruction (Hydrolab Corp., 1994) immediately prior to use. Water samples were retrieved from the mid-epilimnion (4 M) and 10 m for the analyses of total phosphorus, nitrate nitrogen, chlorides, and alkalinity and calcium. A summary of methodologies for chemical analyses employed is given in Table 1. While on the lake, qualitative notes were made on the presence of rooted aquatic plants. Species identification followed Fasset (1957) and Crowe and Helquist (2000).



Figure 1. Canadarago Lake, Otsego County, N.Y. Contours in feet (Weir, 1977).

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Parameter	Sample volume	Preservation	Method	Reference
Total Phosphorus-P	40 ml	H ₂ SO ₄ to pH<2	Persulfate digestion followed by single reagent ascorbic acid	EPA, 1983
Nitrite+Nitrate-N	25 ml	Filter and cool to <4° C	Cadmium reduction	APHA, 1989
Calcium	50 ml	None	EDTA titrimetric	EPA, 1983
Chloride	100 ml	None	Mercuric nitrate titration	APHA, 1989
Alkalinity	100 ml	Cool to <4°C, measure ASAP	Titration to pH=4.6	APHA, 1989

Table 1. Summary of laboratory methodologies employed.

RESULTS AND DISCUSSION

Profiles of the physical parameters and transparencies of Canadarago Lake are given in Table 2. The thermocline began at 4 m on 28 June; by 31 July it had descended to 6 m, and to 8 m by 12 September. There was a pronounced metalimnetic oxygen maxima (supersaturation of oxygen through the thermocline) on 28 June. While indicators of algae abundance (i.e. chlorophyll *a*) were not collected, undoubtedly algal photosynthesis was responsible. Even by that date, near-bottom dissolved oxygen concentrations were approaching zero as a result of algal respiration and/or decomposition. By the end of July the entire epilimnion (warm, upper water layer) was supersaturated with oxygen while the entire hypolimnion (cold strata below the thermocline) was anoxic (devoid of oxygen). By 12 September, some oxygen entrainment through the top of the hypolimnion was evident.

Conductivity (an indirect measure of ions in solution) was high throughout the column, reflective primarily of high levels of calcium (see below). Increases near the bottom are related to the anoxic situation there. Many compounds, including iron and phosphorus, become reduced under such conditions and are converted from an insoluble form to a soluble one. This situation was evident when deep-water samples were retrieved in that they smelled strongly of hydrogen sulfide (H₂S), a respiratory by-product of sulfur reducing bacteria, which is produced under anaerobic conditions.

Chemical profiles of the lake are given in Table 2. Alkalinity and calcium (which tend to be highly correlated in our area) are quite high. The lake is well buffered against pH swings potentially due to acid precipitation. However, the ranges of pH and calcium would provide ideal conditions for zebra mussels (*Dreissena polymorpha*) (D'Itri, 1998).

Date	Alkalinity (mg/l as CaCO ₃)		Calcium (mg/l)		Chlorides (mg/l)		Nitrites+nitrates (mg/l)		Total phosphorous (ug/l)	
	Epi.	Hypo.	Epi.	Hypo.	Epi.	Hypo.	Epi.	Hypo.	Epi.	Hypo.
6/28/01	135	162	63.9	65.4	19.5	19.5	0.18	0.30	21	30
7/31/01	106	165	65.7	52.1			0.05	0.25	32	166
9/12/01	109	171	48.3	66.9			0.09	0.21	12	167

Table 2. Epilimnetic (4 m) and hypolimnetic (10 m) concentrations of alkalinity, calcium, chlorides, nitrite+nitrate nitrogen and total phosphorus at Canadarago Lake, summer 2001.

It has long been recognized that nutrient concentrations dictate algal production in lakes (Vollenweider, 1968). The total nitrogen:total phosphorous ratio in algal biomass is generally 7-10 (Vallentyne, 1974). The ratio of mean epilimnetic nitrates:total phosphorus in Canadarago Lake is approximately 5, suggesting possible nitrogen limitation (though other nitrogen fractions, including ammonia and soluble organic nitrogen, were not considered). Previous studies have indicated phosphorus limitation (Harr et al., 1980). Internal loading of that nutrient is evident, as concentrations near-bottom are roughly fourteen times that of surface waters by mid-September. This phenomenon is associated with the deoxygenation of waters overlying sediments, resulting in a reducing environment and a subsequent release of phosphorous from iron complexes (i.e., Marsden, 1989). The dynamics of internal phosphorus release observed during the summer of 2001 was practically identical to that described in 1968 by Harr et al. (1980), despite the reduction of external phosphorus introduction related to the upgrading of Richfield Spring's sewage treatment plant in 1973. However, prior to the plant's upgrade, bioavailable phosphorus was being introduced throughout the growing season, constantly providing nutrients for algal growth. Currently, phosphorus is being lost from the photic zone, exemplified by gradual reductions over the growing season (see Table 2).

It seems likely that when hypolimnetic phosphorous is redistributed throughout the water column during fall turnover, algal blooms would be stimulated. This situation makes efforts to manage phosphorous by reducing external sources difficult. However, controlling inputs during the summer would maintain water quality throughout most of the recreational season. Any reduction will slow eutrophication (the process by which algal production increases, transparency decreases and rates of oxygen depletion increase, with an eventual increase in submergent and emergent rooted vegetation).

While dominated by smaller-bodied rotifers, the zooplankton community included large-bodied crustaceans (Table 3). These included the cladocera *Bosmina longirostris* as well as calanoid copepods, all at fairly high densities. While limited in scope, these observations suggest little changes in the zooplankton communities noted in 1935 (Tressler and Bere, 1936) and in the 1970s (Harr et al., 1980). The present assemblage would have a high filtering capacity and presumably is responsible for the lake appearing less eutrophic (usually being clearer) than its chemistry would suggest. Any shift toward fewer, or smaller-bodied, plankton would result in changes mimicking eutrophication (increased turbidity).

Order	Species name	Abundance
Cladocera	<i>Bosmina longirostris</i>	2
Copepoda	<i>Diacyclops bicuspidatus</i>	1
	<i>Senecella calanoides</i>	1
	<i>Nauplii spp.</i>	3
Rotifera	<i>Asplacha priodontus</i>	1
	<i>Brachionus spp.</i>	1
	<i>Cephalodella spp.</i>	1
	<i>Gastropus stylifer</i>	1
	<i>Kellicotia longispina</i>	5
	<i>Keratella cochlearis</i>	5
	<i>Keratella spp.</i>	5
	<i>Polyartha vulgaris</i>	4
	<i>Trichocera multicrinis</i>	1

Table 3. Zooplankton collected on 27 June 01 (1= lowest, 5= highest abundance).

The following submergent/floting plants were noted on Canadarago Lake over the summer:

<i>Chara vulgaris</i>	Stonewort
<i>Potamogeton illinoensis</i>	Illinois pondweed
<i>P. richardsoni</i>	Clasping-leaved pondweed
<i>P. crispus</i> ¹	Curly pondweed
<i>Ceratophyllum demersum</i>	Coontail
<i>Stuckenia pectinata</i>	Sago Pondweed
<i>Myriophyllum spicatum</i> ¹	Eurasian water milfoil
<i>Zosterella dubia</i>	Water star-grass
<i>Vallisnaria Americana</i>	Eel grass
<i>Elodea Canadensis</i>	Waterweed
<i>Nuphar variegata</i>	Bullhead lily

¹non-native species

While not intensively studied this year, plant diversity seems substantially reduced since the 1935 survey, when 21 submergent species were considered abundant, common or frequent (Muenscher, 1936). The three most abundant species noted then, *Potamogeton pectinatus* (now *Stuckenia pectinata*), *Heteranthera dubia* (now *Zosterella dubia*) and *Ceratophyllum demersum*, still dominate, though the non-natives *Potamogeton crispus* and *Myriophyllum spicatum* have become common in the early summer and by mid-summer, respectively.

SUMMARY

When considering management objectives of any water body, its pristine state should be considered. By that we mean what the nature of the lake would be in the absence of all cultural disturbances. All historical information available indicates that Canadarago Lake would be quite productive (eutrophic) even without cultural influences. However, evidence does suggest that artificial nutrient enrichment has accelerated rates of eutrophication. The state-wide survey conducted in 1935 (Tressler and Bere, 1936) revealed 1.5 and 1.0 mg/l oxygen at the bottom at 40 ft (12.2 m) and 42 ft (12.8 m), respectively, on 25 July of that year. Bottom waters had fallen to 0.5 mg/l by 28 June 01 and, by 31 July, the bottom 5 m were essentially anoxic. This situation is likely the result of the lake receiving secondarily-treated municipal sewage for many decades. Phosphorus removal from the sewage since 1973 has greatly improved water quality during summer months, as seen by reduced algal growth. However, the history of fertilization has brought about deep water oxygen depletion, triggering substantial phosphorus release from the sediments. A positive-feedback cycle of this nature is not likely to be reversed, as the subsequent phosphorus availability will contribute to future oxygen losses. However, limiting phosphorus inputs during the summer would maintain water quality during that time. Potential nutrient sources that could be addressed include agricultural activities (currently being addressed through the Environmental Quality Incentive Program) and from near-shore development. That includes the creation of impervious surfaces, shoreline destabilization (which can lead to erosion and resuspension of nutrient-rich sediments by wave and wake action), and, possibly the most important, septic system leachate. Management activities to consider include the creation of vegetated buffer strips around the lake, maintaining aquatic vegetation in shallow areas and limiting activities that agitate shallow water and the substrate beneath it. Current technologies exist that can intercept phosphorus derived from septic systems (see Baker et al., 1998).

Canadarago does not seem to be as degraded by exotic species as many area lakes. A healthy zooplankton community, dominated by larger-bodied crustaceans, not only improves clarity by filtering algae from the water, but also provides an important link in the food web that ultimately promotes a healthy game fishery. Maintaining that situation should be the primary objective of managing the lake. Given Canadarago's pH, calcium concentration and shallow depth, it would be most hospitable for the notorious zebra mussel, as well as numerous other exotic plant, plankton and fish species. The introduction of any planktivorous fish could decimate the zooplankton community which would, at the very least, compromise the aesthetic quality of Canadarago Lake. An infestation by the exotic water chestnut (*Trapa natans*), which has been collected in Otsego County, would devastate the lake's recreational value. Public education, through signage at the access point, ideally augmented with boat washing facilities, is recommended. Allowing the use of baitfish by fishermen should be questioned.

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