A survey of Otsego Lake's zooplankton community, summer 2008

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INTRODUCTION

This study was a continuation of long-term monitoring of Otsego Lake's zooplankton community in order to document any changes that might be attributable to top down management efforts to control alewife (*Alosa pseudoharengus*) through the re-establishment of walleye (*Sander vitreus*).

Historically, Otsego Lake has been considered oligo-mesotrophic based on various trophic state indicators. Some of the earlier, comprehensive limnological data collected on Otsego Lake revealed transparencies and algal standing crops indicative of oligotrophic conditions (Godfrey 1977), despite phosphorus loading rates at levels typically associated with a more mesotrophic state (Godfrey 1979). This was attributed to Otsego's large-bodied crustacean zooplankton, which were more abundant than in other New York lakes studied at that time (Godfrey 1977).

Alewife, a visually-oriented, efficient plantivore, was first documented in Otsego Lake in 1986 (Foster 1990) and by 1990 it was the dominant forage fish in the lake. The zooplankton community had shifted to dominance by crustaceans, especially *Daphnia* spp., to rotifers (Foster and Wigens 1990). Rotifers are poor quality food items for fish, and they sequester less nutrients and have substantially lower algal grazing rates than do crustacean plankton (Warner 1999). Depressed abundances and lower mean sizes of crustacean zooplankton have been documented from the onset of alewife dominance through at least 2002; concurrent with this shift, mean summer transparencies, algal standing crops and rates of hypolimnetic oxygen depletion have increased (Harman et al. 2002). This was despite various mitigative efforts designed to reduce nutrient inputs to the lake (i.e., Murray and Leonard 2005; Albright 2005). Thus, the apparent shift toward more eutrophic conditions through the 1990s seemed attributable to cascading trophic changes resulting from the establishment of alewives and the subsequent declines in large crustacean zooplankton.

Otsego Lake has been stocked with walleye since 2000 at a targeted rate of 80,000 pond fingerlings each year. The primary intent was to take advantage of the forage base provided by alewives to re-establish this popular sports fish. Concurrent monitoring has attempted to document any changes that might be related to this trophic modification (Cornwell 2005).

METHODS

Samples were generally collected bi-weekly, from 8 May to 19 September 2008, at TR4C, the deepest part of Otsego Lake (Figure 1). At this site a 0.2m diameter conical plankton net with a 147um mesh was hauled from 12 m (approximately the top of the hypolimnion) to the surface. A G.O. TM mechanical flow meter mounted across the net opening allowed for the determination of the volume of lake water filtered. Samples were preserved in ethanol. The volume of the preserved samples was recorded, allowing for the later back-calculation of zooplankton abundances in lake water. One ml of each sample was placed on a grided Sedgwick rafter cell. Zooplankton were identified, enumerated and measured using a research grade compound microscope with digital imaging and analysis capabilities. At least 100 organisms were viewed.

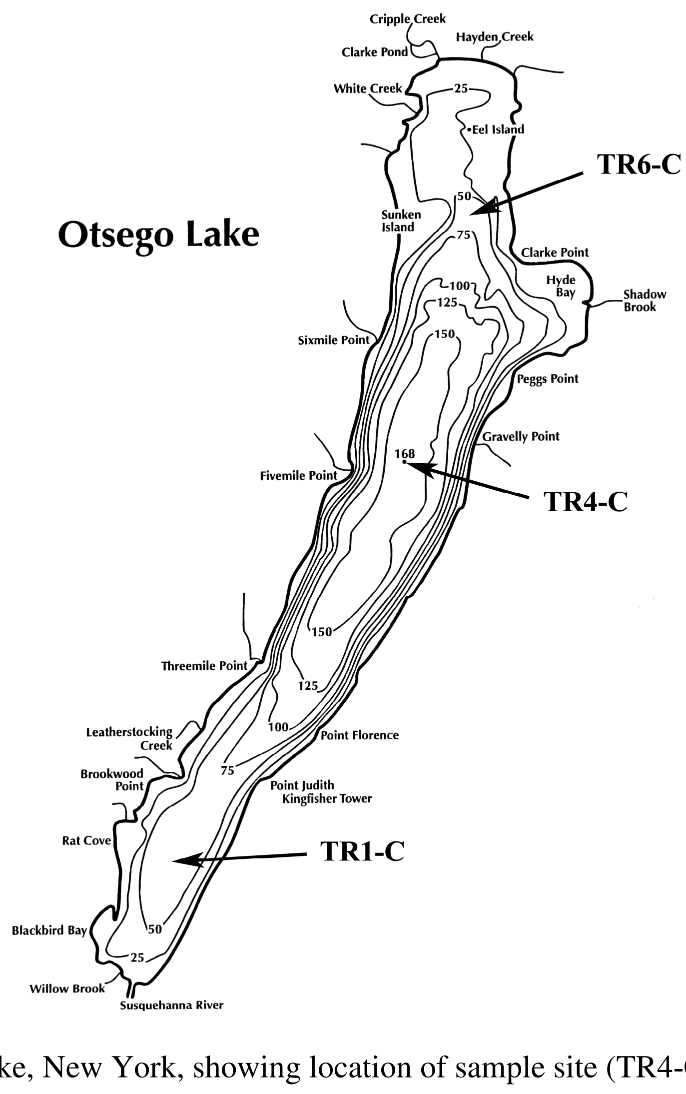

Figure 1. Otsego Lake, New York, showing location of sample site (TR4-C).

Mean densities and lengths for cladocerans, copepods and rotifers were used to calculate dry weight (Peters and Downing 1984), daily filtering rate (Knoechel and Holtby 1986) and phosphorus regeneration (Esjmon-Karabin 1983) on each date sampled according to the equations given in Table 1.

Dry Weight:	D.W.=9.86*(length in mm)^2.1
Filtering Rate:	F.R.=11.695*(length in mm)^2.48
Phosphorous regeneration:	
Cladocerans:	P.R.=.519*(dry weight in ug)$^{-.023}$*e $^{0.039}$*(temp.in C)
Copepods:	P.R.=.229*(dry weight in ug)$^{-.645}$*e $^{0.039}$*(temp.in C)
Rotifers:	P.R.=.0514*(dry weight in ug)$^{-1.27}$*e $^{0.096}$*(temp.in C)

Table 1. Equations used to determine zooplankton dry weight, filtering rate, and phosphorus regeneration.

RESULTS AND DISCUSSION

Table 2 provides a summary of the data, including mean epilimnetic temperature, numbers of each taxon per liter, average length, mean dry weight per individual and per liter, phosphorus regeneration rates per individual and per liter, filtering rates and the percentage of the epilimnion filtered per day.

While the mean summer density of crustacean zooplankton has remained relatively constant since 2000, mean sizes of Cladacera have been quite variable (Table 3). The zooplankton community historically was comprised largely of *Daphnia* spp., though they declined markedly following the alewife introduction (Harman et al. 2002) and remained low through 2003 (Burns 2004). During that period, smaller *Bosmina* dominated the crustacean community. Throughout more recent summers, *Daphnia* became more prevalent. This shift led to a substantial increase in mean cladaceran size (0.55 mm), as *Daphnia* averaged 0.84 mm compared to the average size of 0.36 mm for *Bosmina*. (However, during the summer of 2007, *Daphnia* were smaller, averaging just 0.54 mm). Because of the exponential nature of the length:biomass relationship, this shift lead to an approximate doubling in epilimnetic filtering rates between 2000-2003 and 2004-2006 (Table 3). In 2008, filtering rates were the highest measured since 2000.

A	B	C	D	E	F	G	H	I	J
	Avg. Temp.	**#/L**	**Avg length**	**mean**	**Dry wt**	**Phos. Regen. Rate**	**Phos. Regen.**	**Filtering Rates**	**% Epilimnion**
5/8/2008	**(deg. C)**		**(mm)**	**Dry Wt (ug)**	**(ug/l)**	**$ugP*mgdrywt^{-1}*ind*h^{-1}$**	**Rate (ug/l/day)**	**ml/ind/day**	**filtered/day**
Cladocera	9.4	**4**	**0.456**	1.895	6.63	0.645	0.103	1.668	0.58
Copepods		**245**	**0.280**	0.681	166.75	0.257	1.030	0.498	12.19
Rotifers		**273**	**0.117**	0.109	29.73	0.632	0.451	0.057	1.56
total					**203.12**		**1.584**		**14.34**
5/21/2008									
Cladocera	10.7	**7**	**0.417**	1.571	11.00	0.709	0.187	1.336	0.94
Copepods		**63**	**0.279**	0.676	42.56	0.270	0.275	0.493	3.11
Rotifers		**227**	**0.108**	0.092	20.90	0.887	0.445	0.047	1.06
total					**74.45**		**0.907**		**5.11**
6/5/2008									
Cladocera	13.2	**5**	**0.528**	2.579	12.89	0.700	0.216	2.400	1.20
Copepods		**45**	**0.372**	1.236	55.62	0.440	0.587	1.007	4.53
Rotifers		**161**	**0.141**	0.161	25.95	0.558	0.347	0.091	1.46
total					**94.46**		**1.151**		**7.19**
6/19/2008									
Cladocera	16.3	**16**	**0.430**	1.676	26.81	0.871	0.561	1.442	2.31
Copepods		**53**	**0.380**	1.292	68.50	0.511	0.840	1.061	5.63
Rotifers		**209**	**0.101**	0.080	16.71	1.826	0.733	0.040	0.83
total					**112.02**		**2.133**		**8.76**
7/3/2008									
Cladocera	17.7	**142**	**0.285**	0.706	100.31	1.119	2.695	0.520	7.38
Copepods		**187**	**0.187**	0.292	54.52	0.206	0.269	0.183	3.42
Rotifers		**242**	**0.100**	0.078	18.95	2.131	0.969	0.039	0.94
total					**173.79**		**3.934**		**11.74**

Table 2. Summary of mean epilimnetic temperature, zooplankton densities and mean length per taxa, as well as derived values for mean weight per individual and per liter, phosphorus regeneration per individual and per liter, filtering rates per individual and the percent of the epilimnion filtered per day. The formulas used to derive these values in Excel® are given in a format compatible with that software. The letters in the formulas refer to the column headers across the top of the sheet.

A	B	C	D	E	F	G	H	I	J
	Avg. Temp.	**#/L**	**Avg length**	**mean**	**Dry wt**	**Phos. Regen. Rate**	**Phos. Regen.**	**Filtering Rates**	**% Epilimnion**
7/17/2008	**(deg. C)**		**(mm)**	**Dry Wt (ug)**	**(ug/l)**	**$ugP*mgdrywt^{-1}*ind*h^{-1}$**	**Rate (ug/l/day)**	**ml/ind/day**	**filtered/day**
Cladocera	18.61	**296**	**0.741**	5.254	1555.20	0.732	27.331	5.561	164.60
Copepods		**244**	**0.264**	0.602	146.77	0.341	1.201	0.430	10.49
Rotifers		**177**	**0.145**	0.171	30.25	0.867	0.629	0.097	1.72
total					**1732.22**		**29.161**		**176.82**
7/31/2008									
Cladocera	19.27	**10**	**0.983**	9.511	95.11	0.655	1.496	11.208	11.21
Copepods		**108**	**0.217**	0.399	43.04	0.268	0.277	0.264	2.86
Rotifers		**228**	**0.142**	0.164	37.29	0.976	0.874	0.092	2.11
total					**175.44**		**2.647**		**16.17**
8/15/2008									
Cladocera	19.16	**15**	**0.601**	3.385	50.77	0.828	1.009	3.308	4.96
Copepods		**38**	**0.289**	0.727	27.64	0.394	0.261	0.538	2.05
Rotifers		**121**	**0.120**	0.115	13.90	1.513	0.505	0.061	0.74
total					**92.31**		**1.775**		**7.74**
8/28/2008									
Cladocera	18.93	**80**	**0.544**	2.746	219.65	0.861	4.538	2.584	20.67
Copepods		**42**	**0.240**	0.492	20.68	0.303	0.151	0.340	1.43
Rotifers		**203**	**0.136**	0.149	30.33	1.060	0.772	0.083	1.69
total					**270.65**		**5.460**		**23.78**
9/19/2008									
Cladocera	17.4	**55**	**0.360**	1.154	63.46	0.990	1.508	0.928	5.10
Copepods		**81**	**0.209**	0.368	29.83	0.237	0.170	0.241	1.95
Rotifers		**88**	**0.178**	0.263	23.13	0.447	0.248	0.162	1.42
total					**116.42**		**1.925**		**8.48**
Excel® formula format		Cladocera		9.86*D^2.1	C*E	(0.519*E^-0.23)*(EXP(0.039*B))	G*E*C*24/1000	11.695*D^2.48	C*I/10
		Copepods		"	"	(0.229*E^-0.645)*(EXP(0.039*B))	"	"	"
		Rotifers		"	"	(0.0154*E^-1.27)*(EXP(0.096*B))	"	"	"

Table 2. Summary of mean epilimnetic temperature, zooplankton densities and mean length per taxa, as well as derived values for mean weight per individual and per liter, phosphorus regeneration per individual and per liter, filtering rates per individual and the percent of the epilimnion filtered per day. The formulas used to derive these values in Excel® are given in a format compatible with that software. The letters in the formulas refer to the column headers across the top of the sheet.

	2000	2002	2003	2004	2005	2006	2007	2008
Mean cladoceran size (mm)	0.29	0.30	0.36	0.532	0.551	.551	.340	0.535
Mean crustacean density (#/l)	208	146	132	163	159	164	154	178
Mean crustacean dry weight (ug/l)	175	145	177	261	206	164	128	321
Mean % of epilimnion filtered /day)	11.9	9.9	12.7	25.1	19.2	15.9	12.2	31.9
Mean phosphorus regeneration (ug/l/day)	4.49	2.6	3.1	4.4	2.7	2.4	3.0	5.8

Table 3. Mean crustacean density, mean cladoceran size and mean dry weight, percent of the epilimnion filtered per day and phosphorus regeneration by crustaceans in 2000 and 2002 -2007.

CONCLUSION

During the summers of 2004 through 2006, mean crustacean size and biomass were higher than in any other year monitored since alewife establishment. Over 2007, densities of both cladaceran zooplankton, and, more specifically *Daphnia*, were comparable to those encountered in 2004 through 2006. However, mean cladaceran size was reduced due to smaller Daphnia and an increased abundance of the smaller Bosminans. These changes in mean crustacean size and biomass are concurrent with top down management efforts related to attempts to re-establish walleye (Cornwell 2005). In 2008, crustacean abundance was among the highest observed since 2000. That, coupled with a high mean cladacera size, resulted in the highest algal grazing rate observed over this decade. Secchi transparencies over the summers of 2007 and 2008 were similar than those of recent years, and the rate of areal hypolimnetic oxygen depletion were among the lowest recorded since 1988 (Albright 2009). This suggests that many of the variables measured seem to be dependent upon alewife densities. Continued monitoring seems necessary, however, to ascertain whether walleye re-establishment is sufficient to control alewife numbers.

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