Annual Report for Silver Lake 2012

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Table of Contents

Acknowledgements

We thank the E.L. Rose Conservancy and the Actus Foundation for sponsorship of this study and continued support of Cornell research on Silver Lake. Our partnership with the Conservancy has led to a deeper understanding of factors influencing the biological and physical features of Silver Lake. Insights gained through our work on Silver Lake also have potential applications to protection and management of other lakes in the region. This work is becoming increasingly important as development pressures continue to increase and stress the natural resources of northern Pennsylvania. We thank Chris Hotaling and Cathy Gumtow of the Cornell Biological Field Station for processing of zooplankton and alewife samples. We also thank interns Jon Hunn and Sarah Hutchinson for their assistance in the field. We thank resident Russ Cole for sampling zooplankton and water clarity throughout the summer of 2012. Finally, we thank Patty Bloomer for the use of her boat, trolling motor, and property and the hospitality she continues to extend to us. Their assistance and enthusiasm is greatly appreciated.

Executive Summary

The primary focus of Cornell researchers in 2012 was on continuing efforts to assess the status of the alewife population in Silver Lake and gauge the effectiveness of a trout-stocking program as a means of controlling impacts from alewife. The alewife (*Alosa pseudoharengus*) is a non-native fish species believed to have been introduced to Silver Lake sometime after 1992. In a classic trophic cascade, predation by this fish has subsequently caused a decrease in abundance of large zooplankton, which, in turn, has caused a reduction in consumption of algae by the zooplankton, and has resulted in a decrease in water clarity. With the goal of reducing alewife abundance, rainbow and brown trout 300 mm in size were stocked (300 fish/yr) each fall from 2006-2009. Initial improvements (increased water clarity, reduced alewife abundance, more large zooplankton) in 2008 were not sustained in 2009 and 2010. Therefore, stocking was paused in 2010 and 2011 to reevaluate the program. In 2012, to further evaluate the on-going trout stocking program and better characterize the overall status of the alewife population in Silver Lake, the overall abundance, condition, and growth of alewife was again estimated through field surveys and hydroacoustic sampling and estimation.

-The hydroacoustic estimate of the alewife population was 3738 fish/ha; this was comparable to previous measurements from 2008-2011.

-The size structure of the alewife in the gill nets of 2012 illustrates large interannual variation in the strength of individual year classes. For example, age-1 fish were noticeably absent in 2011 but age-1 fish represented nearly 80% of the population in 2012. Therefore, overwinter mortality is likely contributing to the differential success of year classes in the context of a historically mild winter of 2011-12. Trout predation is also likely a structuring force on alewife populations.

-The presence of a large year class of juvenile age-1 fish approaching reproductive age led to our recommendation to renew trout stocking in Silver Lake in the fall of 2012 for the first time since Fall 2009.

-Through an active community effort, the lake was stocked with 600 250 mm (10-inch) rainbow trout from Fish Haven Farm in Candor, New York on Oct 27, 2012. It was a pulsed effort twice that of previous years. The cost came out to $3.50 each fish or a total of $2100 funded by the Silver Lake Association.

-Water clarity during the summer of 2012 reached our desired goal of a 4 m Secchi depth. Seasonal measurements indicated a decrease in the autumn to 2.5 m, a pattern commonly observed in previous years. Increased precipitation after a dry summer, along with the decrease of herbivorous zooplankton populations, likely led to this seasonal decrease in water clarity.

-With improved seasonal coverage of zooplankton sampling in 2012, we tracked the seasonal changes in zooplankton, particularly large-bodied grazers *Daphnia*. Populations of this species were high during the summer period of high water clarity but crashed by late August. This seasonal decline could be due to predation by growing young-of-year alewife, but there are other possible mechanisms for a fall decline.

-Water column profiles of temperature and oxygen indicate that sufficient trout habitat is present throughout the lake, from 5-10 m at the peak heat of summer, and from 0-10 m into the fall, when deepwater habitats become anoxic.

Introduction

The E. L. Rose Conservancy and the Actus Foundation have supported environmental conservation with a philosophy of stewardship and a desire for contemporary knowledge of the area's natural resources. This desire has led to the cooperative relationship between these groups and Cornell University in an effort to understand, improve, and protect the water quality, fisheries and aquatic ecosystem associated with Silver Lake. The 2012 field season marked the ninth year of this cooperative relationship to monitor and manage the aquatic resources of Silver Lake. The initial focus of Cornell researchers was to review available historical information on the aquatic resources of Silver Lake and assess the biological integrity and the fish community of Silver Lake through a variety of field sampling efforts. Efforts and attention in recent years have concentrated on investigating impacts from introduced alewife, and evaluating the stocking of trout as a means to control these impacts. Nine annual (2004-2012) reports summarize the findings of these investigations to date.

The Alewife is a non-native fish species believed to have been introduced to Silver Lake sometime after 1992. The presence of alewife has subsequently caused a decrease in water clarity as a result of alewife overgrazing large zooplankton, which, in turn, leads to a reduced consumption of algae. With support from the E.L. Rose Conservancy and the Silver Lake Association, a trout-stocking program, using both rainbow trout and brown trout, was implemented in Fall of 2006 with the goal of reducing alewife abundance through predation by trout and subsequently increasing water clarity. Results of investigations conducted in 2007 indicated that stocking of trout was having the desired effect of reducing alewife abundance and lessening the impact of alewife on water clarity and other aquatic resources of Silver Lake. However, by 2009, it seemed that the initial success was not sustained. Therefore stocking of trout occurred in the Fall of 2007, 2008, and 2009, but was suspended in 2010 and 2011.

Over the course of the program, the primary focus of Cornell researchers has been to develop annual estimates of alewife abundance in Silver Lake, primarily using hydroacoustic surveys in which alewife abundance in the open lake was estimated by sonar to detect and count fish. Information gathered through these surveys is the primary method to assess the effectiveness of trout stocking as a means of controlling alewife numbers, and to understand how alewife abundance is influencing physical and biological components of the Silver Lake ecosystem.

Research activities conducted in 2012 included the following:

-Hydroacoustic sampling of the open water portion of the lake was conducted on the night of October 9, 2012 to develop estimates of the density and biomass of alewife in Silver Lake.

-Gill-net surveys were conducted concurrently with the hydroacoustics to sample the fish community in open-water portions of the lake. These samples provide supporting data for the hydroacoustic analysis and yielded specimens of alewife for evaluating the overall condition and age structure of the population.

-With the assistance of resident Russ Cole, limnological sampling was conducted several times over the summer of 2012, and included-

- -Water clarity measures using a Secchi disk.
- -Vertical profiles of temperature and dissolved oxygen to evaluate trout habitat.
- -Vertical profiles of chlorophyll *a* to evaluate phytoplankton productivity and measurements of turbidity to evaluate inorganic suspended material load.
- -Vertical zooplankton nets to evaluate direct impacts of alewife predation on zooplankton such as *Daphnia*.

Part 1. Hydroacoustic and Gill Net Estimates of Alewife (*Alosa pseudoharengus*) Abundance in Silver Lake, PA, 2012.

Abstract: The alewife (*Alosa pseudoharengus)* population in Silver Lake, Pennsylvania, was surveyed October 9, 2012 using small-mesh pelagic gill nets and hydroacoustics (123 kHz split beam). Over a period of about 2.2 hours, 423 fish were caught in 6 vertical nets set at different depths. This included 416 alewife, 3 brown trout, 2 yellow perch, and 2 rock bass. The ages of the fish were determined by examining annual rings of otoliths, small calcium carbonate structures in the inner ear. Average length of age-0 alewife (young of year, or YOY) was 61 mm (52-72 mm range) and YOY fish represented 11.3% of the alewife caught. Age-1 fish represented 76.7% of the alewife population and averaged 113 mm (95-123 mm range). Alewife older than age-1 made up 12% of the population. Three alewife older than 5 years in age ranged from 234 to 252 mm. Percent dry weight (an indication of condition) was 24.2% (18.6% for YOY, 25.5% for age 1, 25-30% for older alewife), which is low relative to New York alewife populations. Such a low body condition indicates a high abundance of alewife relative to the productivity of the lake. By fall, the spring YOY had attained a size comparable to those of previous years. In the hydroacoustic surveys, fish density in October 2011 for targets > -60dB was estimated to be 3738 alewife per ha for the entire water column, but almost all fish were in the top 10 m of water, within the warm surface layer. Biomass was estimated from a synthesis of the average weight of alewife caught in the three surface nets (11.6 g) and the acoustic density. The corresponding fish biomass is 43.3 kg/ha. Alewife distribution was uneven across the lake, and densities among separate 5-minute intervals ranged from 679 to 5039 fish/ha, resulting in a relative standard error (SE/mean) of 16.8%.

Introduction

The alewife, *Alosa pseudoharengus*, is an effective planktivore. Therefore abundant alewife populations cause declines in large zooplankton, which are efficient grazers of algae. For this reason, abundant alewife populations are usually associated with high chlorophyll levels and decreased water clarity. This is a classic trophic cascade where increases in planktivorous fish result in decreases in the main herbivore, and an increase in the primary producers - algae. Understanding the causes of water clarity changes in Silver Lake therefore requires understanding of the dynamics of the alewife population. In this report, we summarize the results of the 2012 acoustic and gill net survey for alewife in Silver Lake, Pennsylvania.

Materials and Methods

Acoustics. Silver Lake was surveyed using a 123 kHz split beam echo sounder (Table 1), on the night of October 9, 2012 between 20:17 and 20:58. A total of 6 transects along the major axis of the lake were collected during the night and analyzed for alewife abundance (Figure 1). Additional data were collected during the day. Acoustic transects were evenly spaced across the whole lake and were analyzed in 5-minute sections (9 intervals).

Acoustic data were recorded directly to a laptop computer in the field and analyzed with the Echoview software (version 5.1, Myriax). The unit was calibrated with a tungsten carbide sphere (33.2 mm diameter) as a standard target on the same night, and gains were applied to the echo integration and target strength (TS) data based on this calibration (0.54 dB gain offset). All data were visually inspected for consistent bottom detection and corrected when needed, as well as examined for interference from surface bubbles and aquatic vegetation. Those areas were removed from the analysis. Noise levels were -122.5 dB at 1 m in the Sv domain, corresponding to -147.7dB in the TS domain. This is low enough to register fish with a TS of -64 dB at 50 m depth without bias and thus is sufficient for the alewife survey in Silver Lake. Analysis was done for depth layers from 2-10 m and from 10 m-bottom, and lake-wide averages were calculated using the average of these intervals. The near-field of this transducer is approximately 1.5 m (Parker-Stetter et al. 2009), and the transducer was mounted on a rigid pole 0.4 m below the surface. Therefore, the acoustic analysis is restricted to a depth below 2 m from the surface. As a complement, a second 123 kHz transducer was mounted horizontally and used to insonify the surface water. However, interpretation of these side-looking data is still under development and not reported here.

Fish density was calculated from the average measured *in situ* TS and ABC as follows. *In situ* TS distributions were obtained with EchoView, using targets within the half power beam angle and settings for single fish determination following the Standard Operating Procedure for Great Lakes Acoustics (Table 1, Parker-Stetter et al. 2009). Alewives were assumed to be targets larger than -60dB. The peak in targets below -60 dB is interpreted as invertebrates. *Chaoborus* (phantom midge) larva occurs in Silver Lake. Fish density was calculated based on *in situ* target strengths larger than -60dB. Appropriate depth varying thresholds were applied to the Sv data following Parker-Stetter et al. (2009). For the top 2 m, fish densities in were calculated based on relative catches in vertical gill nets, following Rudstam et al. (2011).

Spatial locations of the data were recorded using a handheld GPS unit, but not automatically registered due to the poor GPS signal on the unit attached to the acoustic computer. Total fish density was obtained from the ABC values and the *in situ* TS within each 5-min section, and averaged over all intervals. Fish density in deeper water was calculated based on all *in situ* TS in water deeper than 10 m, due to the limited number of targets observed at those depths (-51.07dB based on 225 targets over -60dB). All averages and calculations are made in the linear domain and back transformed to dB units when appropriate. In addition, the depth distribution was obtained in 1-m intervals using all data collected during the survey and the average *in situ* TS for all targets (-50.4dB), to evaluate vertical distributions of alewife.

In addition to hydroacoustic surveys, fish were sampled simultaneously using vertical gill nets. The 6-m deep and 21-m long nets consisted of 7 panels, each with a different mesh size (6.25, 8, 10, 12.5, 15, 18.75, and 25 mm bar mesh). This array of mesh sizes will catch alewife between 50 and 240 mm (Warner et al. 2002). The nets were set in pairs at three locations, with one net fishing from the surface to 6 m depth, and the other from 6 to 12 m (Table 2). Nets were left in place for about 2.2 hours. Fish were identified to the level of species and the depth of catch was recorded in 2 m intervals. All fish were measured and weighed. The ages of the alewife were determined by examining annual rings of otoliths, which are small calcium carbonate structures in the inner ear. Wet-to-dry weight was determined by drying fish in an oven for 5 days at 60^{o}C.

Results and Discussion

Net sampling. A total of 423 fish were caught in the gill nets and 416 of the fish caught were alewife (Table 2). The observed pattern of gill-net-captured alewife coincided with the data from the lake-wide acoustic surveys Individuals were found from the surface, to a depth of 13 m, with a peak in the top 4 m. In addition, very few fish were caught in the nets or measured with acoustics in water deeper than 10 m. The gill net data also complemented the acoustic data by capturing the uppermost portions of the water column, revealing an additional component of the fish population that is not adequately sampled by down-looking acoustics.

The size distribution of alewife that were caught in nets in 2012 had one primary size/age class (Table 3). Age-1 fish represented 77% of the total catch, with an average length of 113 mm and an average weight of 12.1 g. The YOY class (age-0) represented a smaller proportion of the gill net catch in 2012 than in 2011 (11% compared to 64%), and averaged 61 mm (52-72 mm range; Figure 3). Alewives typically reach lengths of 60 to 90 mm by September of their first year of life in New York inland lakes, but can get larger, up to 140 mm, in productive lakes with large zooplankton (e.g., Canadarago Lake, Rudstam et al. 2011). For Silver Lake in 2012 both the average length and the index of condition of 20.4% dry weight were low compared to regional populations several other populations of alewife (Rudstam et al. 2011). Thus, both growth rate and condition of YOY alewife in Silver Lake were low, consistent for a lake with low productivity and a relatively high alewife population.

Seven fish of three species other than alewife were caught in the gill nets (Figure 5). Two male brown trout were caught in a floating net (site 2) and one male was caught in a sinking net (site 3). These three trout with ages from 6-7 years old, ranged in size from 536 to 586 mm, and from 1.77 to 2.19 kg. Two male rock bass (aged 9 and 10 years old), captured in a sinking net (site 1), had lengths of 268 and 295 mm and weighed 457 and 558 g, respectively. In addition, two yellow perch, caught in sinking nets (sites 1 and 3), were 270 mm and 342 mm in length and weighed 214 and 548 g. The larger perch was a female with an age of 11 years, and the smaller male was 8 years old. All of the seven individuals were in good body condition, showing outward signs of health and robustness. Further examination of the otoliths of the trout also revealed good annual growth rates, indicating steadily beneficial conditions throughout their lives.

Acoustic data. The combination of the gill net captures and the lake-wide acoustic data, and the comparisons of these two complementary methods of sampling, provides a more comprehensive summary of the fish populations of Silver Lake. Calculating the target strengths (TS) of individual fish and examining average TS values across the lake can yield estimates of important population characteristics such as size/age distribution. Equally important is the potential to calculate population densities, locations around the lake, and distribution of fish throughout the water column.

Similar to the gill nets, acoustic data also showed a peak in numbers in the top 4 m, with an additional peak deeper than the surface nets, at 6 to 8 m depths (Figure 2). Average TS of alewife in Silver Lake calculated from single fish targets larger than –60 dB was –50.7 dB in the top 10 m, and -48.6 dB in depths of 10 to 16 m (overall range -29.3 to -60dB). These were smaller values than might be expected from the gill net size distribution pattern. Modal TS of the alewife caught in the gill nets (length range 52 to 256 mm) would be expected to range from -48.2 dB to -35.2 dB, with a mean TS expected from the average fish caught in the gill nets to be -44.0 dB (top 6 m) and -42.6dB for 6 to 10 m in depth (Brooking and Rudstam 2009). In 2012, the actual acoustically observed TS values were smaller than predicted from the sizes of the gill net catches; this was a pattern also observed in 2010 and 2011. This is likely because we are missing small alewife in the gillnet catches. The smallest fish we can catch in these nets is about 50 mm long and the smallest age-0 fish that we did catch were 50 to 75 mm long. The observed average TS should result in an average length of alewife of 40 mm, a size that is too small for the mesh sizes used in the vertical gillnets (Warner et al. 2002). These smaller fish would have to be caught with a mid-water trawl, which we cannot use on Silver Lake, as they require a larger boat than we can get into the lake. Thus, acoustic sampling provides a nice complement to the net surveys.

Fish density calculated from the *in situ* TS data obtained from the nine 5-min intervals was 2781 fish/ha, extending from depths of 2 m to the bottom, with almost all fish in the top 10 m of the water column (Table 4). Densities at depths below 10 m averaged 54 fish/ha. Densities from 0-2 m were calculated from acoustic densities from 2-6 m, which were 957 fish/ha, assuming the catchability in the gill nets is the same from 2-6 m and 0-2 m portions of the water column (see Rudstam et al. 2011). Therefore, total fish density in 2012 was estimated to be 3738 fish/ha. Relative standard error calculated for densities from 2 m to the bottom (SE/mean) was 16.8%. Assuming all of these fish were alewife, with an average weight of 11.6 g (from surface nets in 0-6 m of water, Table 2), the alewife biomass was calculated to be 43.3 kg/ha (Table 4).

Acoustic densities obtained from the 2012 survey were similar to 2008, 2009 and 2011 (3831, 2850 and 3031 fish/ha, respectively), but lower than 2010 (6165 fish/ha). For comparison, densities around 2000 to 3000 fish/ha are common in New York lakes (Fitzsimons et al. 2005, Wang et al. 2010, Rudstam et al. 2011). Other indicators of high alewife abundance are low growth rate and poor body condition of YOY. Catches in gill nets were much higher than previous years.

It should be noted that high densities of fish close to the surface add some uncertainty to the acoustic density estimates because they rely on interpolation from limited net catches. This combines with the possibility of missing small alewife due the size selectivity of the nets. Lower than expected average TS values as well as the small size of age-0 fish that we did catch suggest that this may be the case. If this is true, the biomass estimate is biased high and the proportion of age-0 alewife in the population is biased low. The overall estimate of total alewife density, however, would not be affected.

Table 1. Settings used for acoustic estimates of open water fish in Silver Lake, October 9, 2012. Thresholds and detection limits according to Parker-Stetter et al. (2009), see also Rudstam et al. 2009).

Parameter	**Values**
Date and time	20121009, 20:17 - 20:58
Unit	Biosonics 123 kHz, 7.3^{o} beam width, split beam
Analysis software	EchoView 5.1
Analyzed by	Lars G Rudstam, 10/20/2012
Pulse rate/ pulse length	3 pps / 0.2 ms
Lower threshold for fish	-60dB
Absorption coefficient and sound speed	Constant 0.00393 dB/m / 1465m/s
Equivalent beam angle	-20.35 dB
Noise at 1 m (Sv/TSu)	-122.3 dB / -147.7 dB
Detection limit TS -64dB without bias	50 m
Calibration offset Sv/ TSu	Sv: 0.54dB, TSu: 0.54dB
<u>Single fish detection criteria</u>	
Max beam compensation	12dB
Pulse duration min, max	0.6, 1.5
Standard Deviation of angles	0.6, 0.6

Table 2. Summary of fish catches in the six vertical gill nets with variable mesh size set in Silver Lake on October 9, 2012. Nets were set at dusk and retrieved around 2.2 hours later. Most of the fish caught were alewife, with three brown trout, two yellow perch and two rock bass also caught. Upper and lower depth is the depth of the upper and lower net line (measured with acoustics for the sinking nets). Sinking nets were set from the bottom at 12 m, up to 6 m; surface nets were set from the surface down to 6 m depth.

	Site 1 (West) floating	Site 1 (West) sinking	**Site 2 (East) floating**	Site 2 (East) sinking	**Site 3 (South) floating**	Site 3 (South) sinking
Latitude N	**41.9340 N**	41.9340 N	**41.9344 N**	41.9344 N	**41.9319 N**	41.9319 N
Longitude W	**75.9543 W**	75.9543 W	**75.9497 W**	75.9497 W	**75.9500 W**	75.9500 W
Set time (h)	**18:30**	18:40	**18:55**	19:05	**19:20**	19:30
Retrieve time (h)	**20:42**	20:52	**21:07**	21:17	**21:32**	21:42
Soak time (h)	**2.2**	2.2	**2.2**	2.2	**2.2**	2.2
Upper depth (m)	**0**	6	**0**	6	**0**	6
Lower depth (m)	**6**	12	**6**	12	**6**	12
# alewife caught	**155**	33	**63**	2	**122**	41
Catch / hour all	**70.5**	15.0	**28.6**	0.9	**55.5**	18.6
Upper 1/3	**29.4**	2.5	**10.8**	0	**23.8**	9.6
Median 1/3	**21.2**	7.5	**10.8**	0.9	**18.5**	7.5
Lower 1/3	**19.9**	5.0	**7.0**	0	**13.2**	1.5
Alewife						
Mean Length (mm)	**109**	121	**110**	145	**105**	124
Range (mm)	**55-142**	57-236	**53-156**	129-160	**52-190**	54-256
Mean Weight (g)	**11.7**	17.2	**11.7**	26.8	**11.4**	20.6
Range (g)	**1.5-23.1**	1.2-106.5	**1.4-30.3**	17.4-36.1	**1.3-53.1**	1.5-130.7
Prop <80mm (%)	**9.7**	3.0	**4.8**	0	**19.7**	9.8
Other Fish		2 rock bass 1 y. perch	**2 br. trout**			1 br. trout 1y.perch

Table 3. Percent dry weight and length-at-age for alewife from Silver Lake caught in October of 2008-2012.

Age	Length	Range	N	% DW	Range	N
2008						
0	69.2	58-80	6	22.3	17.7-25.3	12
1	92.0	85-97	10	22.9	20.2-24.3	10
2	111.8	105-120	10	25.0	22.7-28.2	18
3	130.7	119-144	3			
4	140.7	133-152	3			
2009						
0	63.8	55-69	10	23.4	21.0-25.9	15
1	86.7	80-92	4	23.8	22.3-26.4	8
2	105.5	99-110	6	25.2	22.9-27.2	17
3	126.0	118-136	7			
4	137.0	133-143	3			
2010						
0	65.0	55-75	10	22.4	19.3- 24.7	17
1	76.0	70-82	2	21.7	-	1
2	90.2	83-108	9	22.2	29.3-22.5	22
3	113.5	106-121	4			
6	175		1			
7	187		1			
2011						
0	65	52-77	12	20.4	15.8-25.0	27
1			0			
2	128	122-135	15	24.7	21.8-25.5	9
3	137	132-140	5	25.2	23.4-27.4	3
4	148	147-150	3			
5	165		1	24.9		1
8	208		1	24.7		1
9	220		1	26.0		1
2012						
0	61	52-72	47	18.6	15.8-25.2	5
1	113	95-123	319	25.5	23.2-29.8	87
2	127	116-133	19	26.9	22.6-30.9	17
3	153	142-166	11	24.2	21.5-26.9	11
4	169	157-190	4	24.6	23.5-27.3	5
5	234	234	1	31.7	31.7	1
7	244	235-252	2	31.1	30.7-31.5	2

Table 4. Results from acoustics estimate of alewife in Silver Lake October 9, 2012, using a 123 kHz split beam unit. Density includes the whole water column (see methods). Density is calculated from ABC/σ_{bs}, where σ_{bs} is target strength in the linear domain (back scattering cross section: $\sigma_{bs} = 10^{(TS/10)}$). Fish density is calculated based on interval specific *in situ* TS. Biomass is the density multiplied with the average weight of all alewife caught in gill nets in 0-6 m (11.6 g). Note that mean TS for water deeper than 10 m is calculated for all targets found 10 m and deeper and therefore the same for each interval. Also, the density in 0-2 m is calculated based on average 2-6 m density and catch in the nets and therefore the same for all intervals.

Interval #	Time	Mean Depth (m)	Mean TS (dB) 2-10 m	Mean TS (dB) 10-30 m	Density 0-2 m (fish/ha)	Density (f/ha) 2-10 m	Density (f/ha) 10 m-bottom
1	5 min	13.2	-52.0	-51.1	957	2364	225
2	5 min	10.4	-47.4	-51.1	957	679	1
3	5 min	14.3	-51.9	-51.1	957	1124	2
4	5 min	22.6	-51.0	-51.1	957	5039	41
5	5 min	23.5	-49.8	-51.1	957	3513	24
6	5 min	11.8	-48.6	-51.1	957	3169	23
7	5 min	11.6	-49.5	-51.1	957	2442	27
8	5 min	24.2	-50.7	-51.1	957	2021	23
9	5 min	13.4	-50.5	-51.1	957	3702	120
Mean	**5 min**	**17.1**	**-50.3**	-51.1	**957**	**2727**	**54**
Biomass (kg/ha)					**11.1**	**31.6**	**0.6**

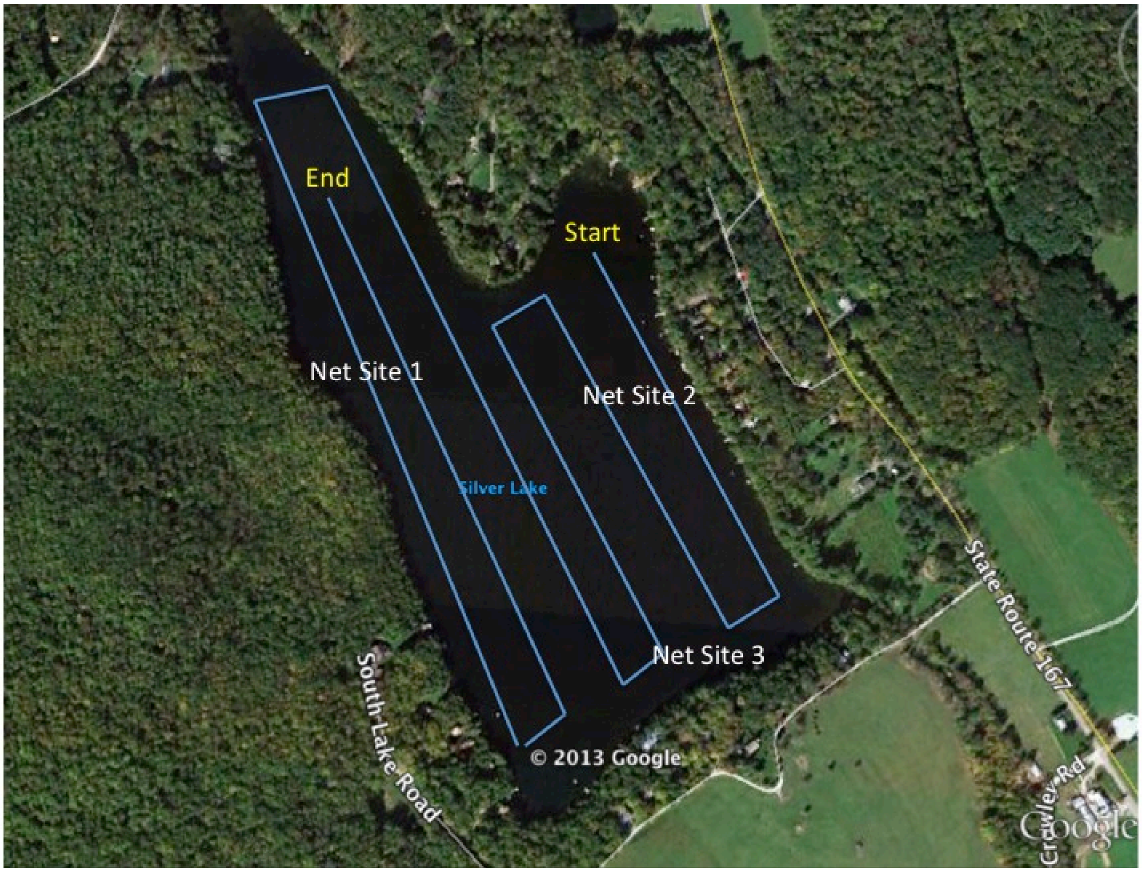

Figure 1. Acoustic and net sampling in Silver Lake on the night of October 9, 2012. The cruise track and three gill net sampling sites are marked.

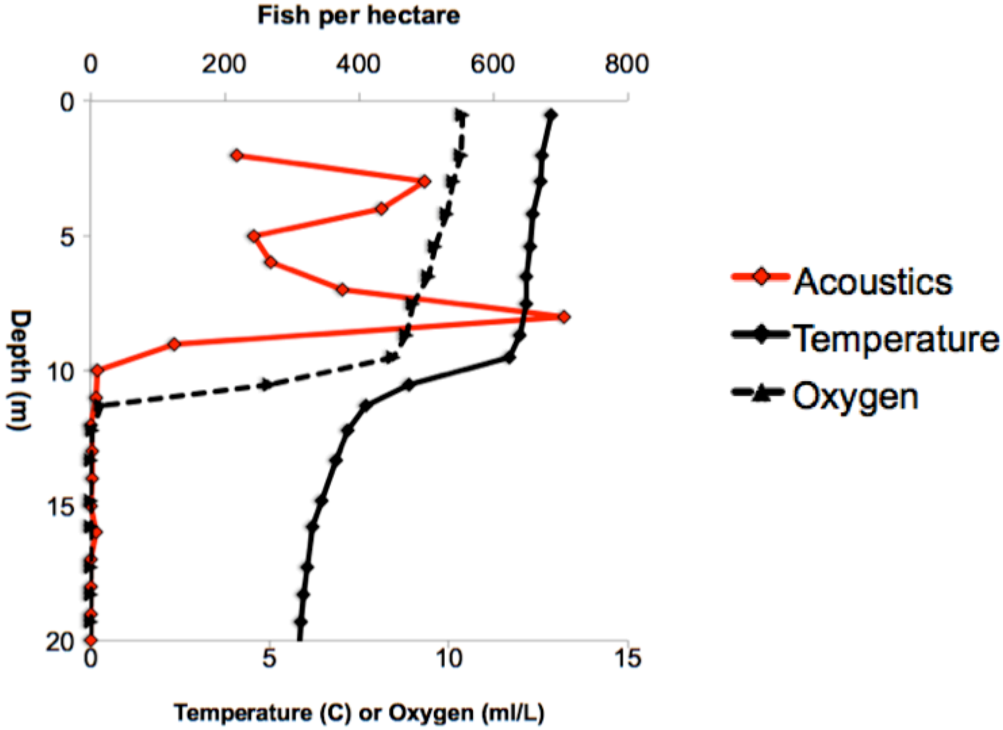

Figure 2. Depth distribution of acoustically determined fish density (October 9, 2012) and temperature and dissolved oxygen profiles (October 26, 2012).

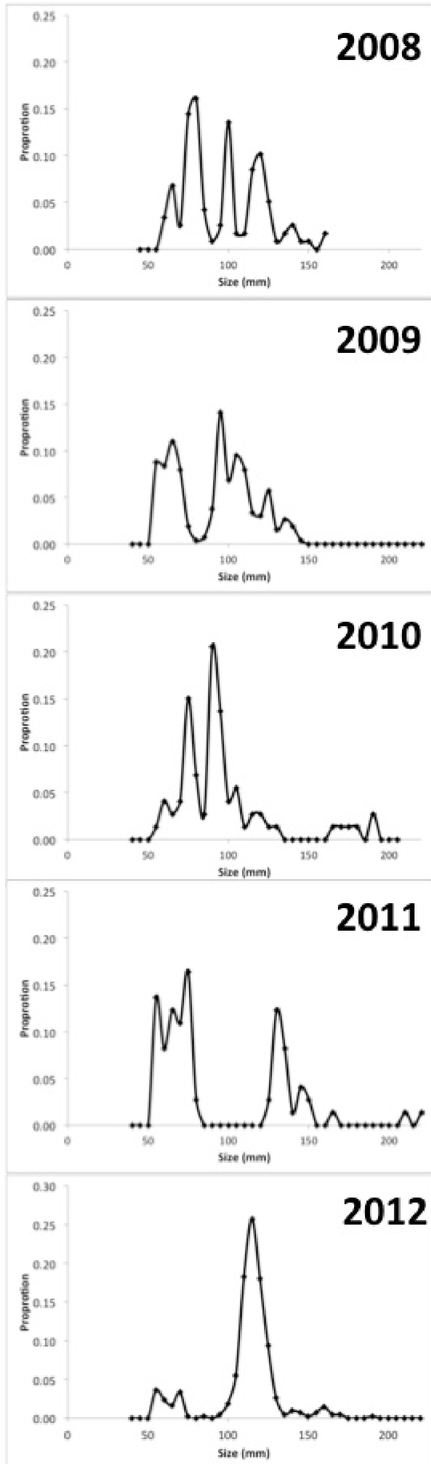

Figure 3. Size distribution of measured alewife in Silver Lake in 2008-2012. Note the absence of age-1 sized fish in 2011 but a strong age-1 year class in 2012.

Figure 4. Alewife caught in sinking net at Site 3 that were aged as YOY, age-1, or older.

Figure 5. Brown trout, yellow perch, and rock bass caught in gill nets in Silver Lake.

Part 2. Limnology of Silver Lake

Continued limnological monitoring of Silver Lake is critical for answering four key questions for assessing the success of the alewife management project.

1) Is water clarity improving?

2) Are large-bodied zooplankton Daphnia recovering?

3) Are conditions in the lake still suitable for cold-water species, such as rainbow trout and brown trout that are our primary tool for alewife management?

4) Has the lake maintained its historical low-mid productivity trophic state or is it showing signs of increased nutrient loading?

An objective of the 2012 sampling was to improve the seasonal coverage of our measurements. In this regard, the involvement of resident Russ Cole was crucial to our understanding of seasonal changes.

Water Clarity

1) Is water clarity improving?

Water clarity in Silver Lake is measured with a Secchi disk, a weighted, 8-inch diameter disk with four alternately colored black-and-white sections. The depth to which the disk can be viewed provides a standardized measure of water clarity, roughly the depth at which 18% of the surface light penetrates. With the help of resident Russ Cole, we were able to track water clarity over the entire summer of 2012.

Water clarity met or exceeded our desired goal (4 m secchi depth) from June 11 to August 23, 2012 (Figure 6). The Secchi depth reading decreased to 2.5 m in October 2012, which is a commonly observed seasonal pattern. For example, in 2010 Secchi depth was near 4.25 m on June 21-25 and decreased to 2.5 m in August 28-September 8. This autumn decrease has often been attributed to alewife predation impacts on large zooplankton grazers of algae and subsequent algal increases. In 2012, increased runoff due to autumn rains may have also contributed to lower clarity. The strong seasonal trend emphasizes the importance in the timing of sampling for an interpretation of the impact of alewife grazing, but nevertheless the overall pattern of clarity was a positive sign.

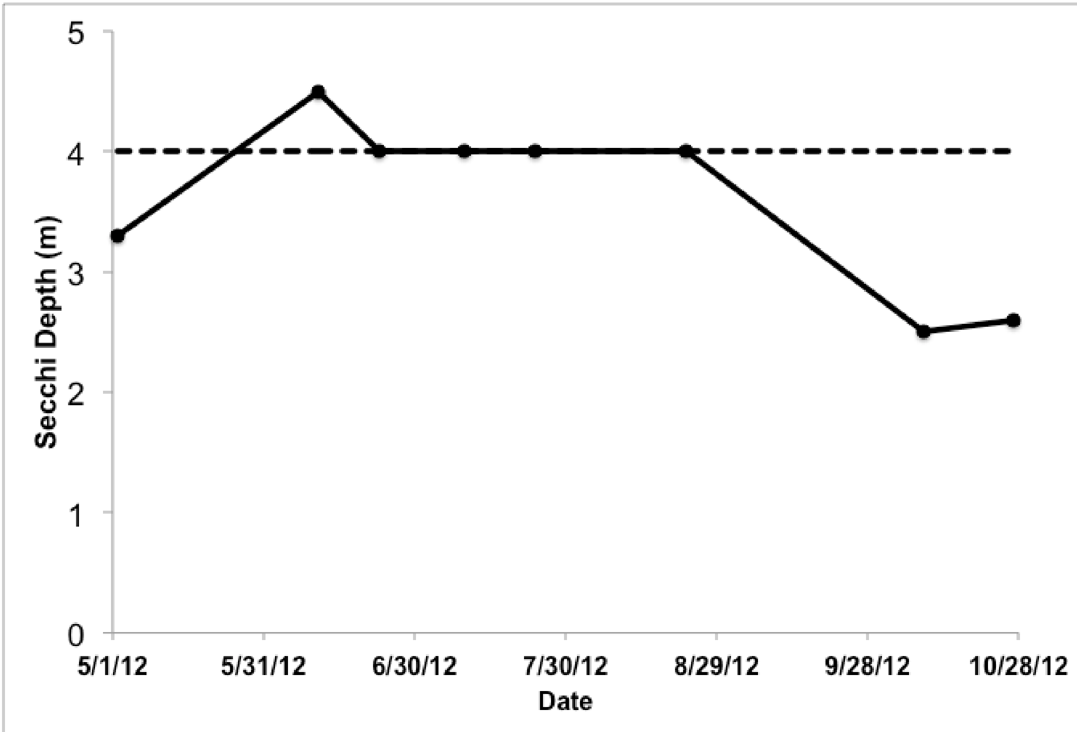

Figure 6. Seasonal changes of Secchi depth (in m) in Silver Lake over the summer of 2012. Dashed line represents the desired goal of 4 m secchi depth.

Zooplankton Community

2) Are large-bodied zooplankton (Daphnia) present?

Alewife preferentially consume large zooplankton that graze upon the phytoplankton that, in turn, are responsible for algal blooms in lakes. When large-bodied zooplankton, particularly *Daphnia* species (a genus of Cladoceran that is a highly effective consumer of phytoplankton), are reduced or eliminated by heavy predation, the density of phytoplankton in the water column increases, and water clarity decreases. To measure zooplankton, samples are collected near mid-lake using a Wisconsin-style plankton net (153 um mesh) that is lowered to a depth of 20 m (~66 ft) and slowly lifted vertically to the surface. The absence of *Daphnia* in zooplankton samples collected in 2006 supported the hypothesis that alewife were the cause of decreasing water clarity. These observations led to the initiation of a trout-stocking program.

The subsequent presence of *Daphnia* in 2007 and 2008 suggested that the stocking of trout since October 2006 was having a positive impact on the zooplankton community by reducing the abundance of predatory alewife. However, in 2009 and 2010, average density (number/liter of water) of *Daphnia* declined from 2008 values by anywhere from 52-88%. Accordingly, the decline in *Daphnia* in 2009 coincided with a decline in water clarity during this same period. These changes suggested that alewife abundance had increased since 2008, and the greater abundance of alewife was negatively affecting the abundance of efficient phytoplankton grazers like *Daphnia*.

With the help of resident Russ Cole in 2012, we were able to track *Daphnia* abundance through the entire summer. As a result of the higher scrutiny we observed that *Daphnia* density peaked at 12.8/L on June 23, 2012 and remained high through late July. Early in the summer, three species were present (*D. mendotae*, *D. pulicaria*, and *D. retrocurva*), but by late July only *D. mendotae* was present in the samples. However, all *Daphnia* species were present but rare (0.1/L) on August 23, 2012 and remained rare in October (Figure 7). The high summer abundance of *Daphnia* is an encouraging sign – prior to the trout stocking program, in 2006, *Daphnia* were rare as early as June 30.

However, as previously seen with the Secchi depth data, any interpretation of these data for the evaluation of alewife impact needs to keep in mind the strong seasonal fluctuations. The historical time series focuses on comparison of tows during limited times of the year (early August and early October) where *Daphnia* density variations of 0-5 individuals/L were important. For example, *Daphnia* abundance in October was at the high end of this range in 2008 and 2011 while absent in 2006, 2009, and 2010. In this context our October 2012 *Daphnia* are low even though densities earlier in the summer were among the highest measured in any year. This strong seasonal fluctuation suggests that alewife predation intensifies in late summer as the young-of-year alewife grow in size, or that *Daphnia* populations seasonally crash due to other factors such as invertebrate predation, diseases, parasites, or changes in the food quality of the algae. We did observe the phantom midge larvae (*Chaoborus*) in the acoustic survey, and this is also a predator on zooplankton.

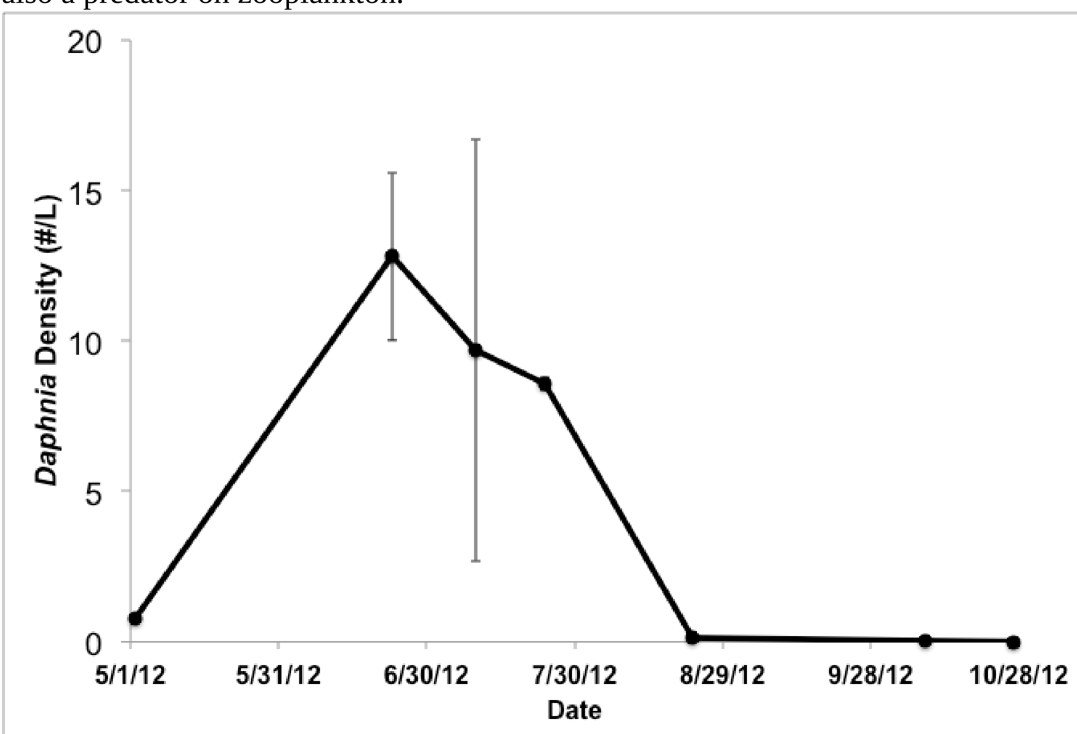

Figure 7. Density (#/L) of *Daphnia* in Silver Lake during summer of 2012. Average densities based on duplicate tows for each date (error bars represent one S.E.).

Dissolved Oxygen/Water Temperature

3) Are conditions in the lake still suitable for cold-water species, such as rainbow trout and brown trout that are our primary tool for alewife management?

Rainbow and brown trout require cool, well-oxygenated water year-round. These species prefer water temperatures below 72°F (22°C) and dissolved oxygen levels above 5 mg/L. Water column profiles of temperature and dissolved oxygen were taken on May 2, July 24, and October 26, 2012. Similar profiles were measured by Cornell in 2005-2011, and some historic data from 1946, 1992, and 2002 are also available from Silver Lake.

Profiles collected in 2012 were consistent with similar data collected in recent years and continues to indicate that thermal stratification in this lake is fairly consistent during late summer (i.e., a layer of warm, less dense water overlays a dense, colder water layer) (Figure 8). The transition area between these water layers, known as the thermocline, was near 4 m depth in late July. Trout are limited to waters below the thermocline (known as the hypolimnion) during summer because waters shallower than the thermocline are unsuitably warm. In the late summer and fall, dissolved oxygen levels are depressed within the deep hypolimnion due to minimal mixing with more oxygenated surface waters and biological oxygen demand associated with bottom sediments. If a lake is to sustain trout year-round, a large enough volume of cool, well-oxygenated water must be available within the hypolimnion to allow trout to survive throughout the summer. Even during the warmest time of the year, a sufficiently large volume of the hypolimnion in Silver Lake remains sufficiently oxygenated and cool enough to support trout, although trout were limited to depths between 5 and 10 m in the late summer.

Trophic State

4) Has the lake maintained its historical low-mid productivity trophic state or is it showing signs of increased nutrient loading?

Lakes are ranked according to three productivity levels- low (oligotrophic), mid (mesotrophic) and high (eutrophic). Four water quality parameters (Secchi depth, chl *a*, hypolimnetic oxygen depletion, and total phosphorus) are used in this classification scheme. Silver Lake generally lies near the dividing line of low and mid productivity lakes, which corresponds to a Secchi depth of 4 m, chl *a* level of 4 ug/L, a hypolimnetic oxygen depletion of 10%, and total phosphorus of 10 ug/L. Silver Lake is within the mesotrophic range of 2-4 m Secchi depth, 4 to 10 ug/L chl *a*, some oxygen depletion and TP at 10-20 ug/L. Samples for surface chl a and TP were collected but data from their analysis were not available at the time of this year's report and will be included in next year's report. Continued monitoring is important for detecting shifts in trophic state, especially if nutrient loading increases.

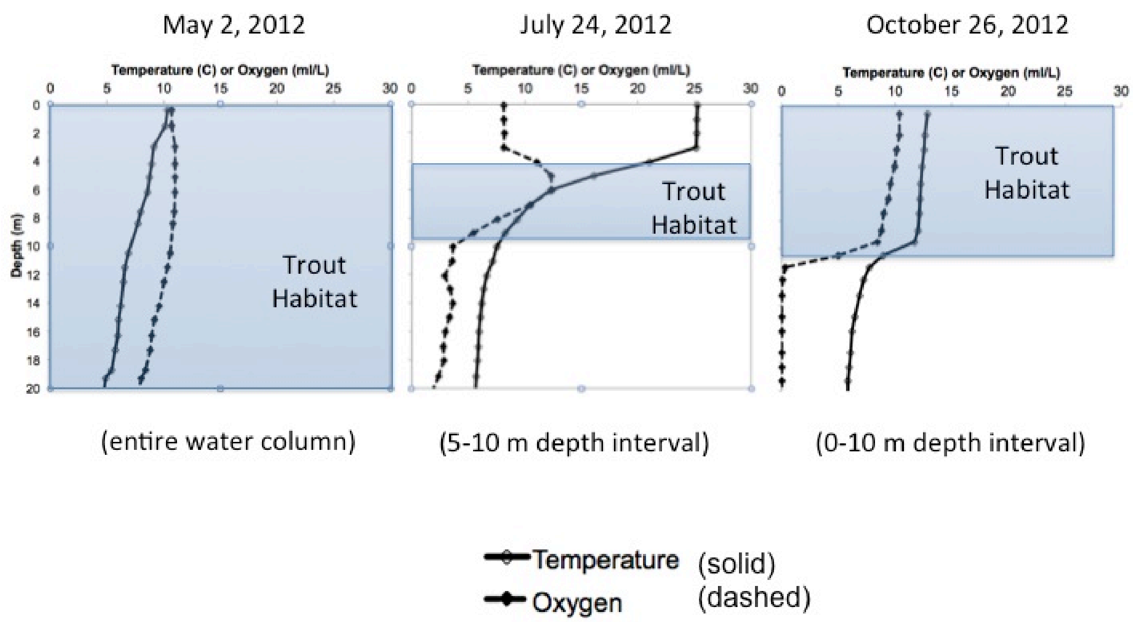

Figure 8. Temperature and dissolved oxygen profiles for May 2, July 24, and October 26, 2012. Shaded areas represent potential trout habitat at these three times where temperature was less than 20°C and dissolved oxygen was more than 5 ml/L.

Part 3. Renewal of Trout Stocking in Fall, 2012

Six hundred 10" rainbow trout from Fish Haven Farm in Candor, New York, were released into Silver Lake at about 1:30PM on Oct 27, 2012. Many thanks to Reuben, Evan, Seth and Beth Everitt as well as Anthony and Dante Palombaro and Sam Fike for their help in getting them in the water and to everyone in the Silver Lake Association for making it possible to buy them. Note they put the fish in just prior to Superstorm Sandy's passage with a great community effort and a new more local source of fish. The local source reduced transport costs considerably. The cost came out to $3.50 each fish or a total of $2100 funded by the Silver Lake Association.

This stocking was the first since the fall of 2009. Our acoustic estimate of the alewife population from this year’s survey was 3738 fish/ha. Previous years have had alewife estimates at 3831 (2008), 2850 (2009), 6165 (2010), 3031 (2011) so this year is close to previous years but lower than 2010. Our gill nets this year indicate that 77% of the alewife are age-1 fish at 4-5 inches in size (last year's year class). We recommended the larger pulse of stocking this year that may have more of an impact than a lower annual effort.

Our recommendation was based on an estimate of how many alewife each stocked fish would eat relative to the current population of alewife. The lake is 36.4 ha (90 acres) for a total of 136,063 fish. Using our average weight for alewife in the floating nets (11.6 g) this translates to 1,578 kg of alewife forage. We revisited Jesse Lepak’s bioenergetics-based estimate of trout consumption in 2007 (within Biological Assessment of Silver Lake, 2007). In that year they caught a rainbow trout that had grown 152 mm (to 440 mm, 716 g) in the one year after stocking. Two brown trout grew 102 and 127 mm (to 415 and 430 mm, 850 and 940 g) over the one year. Lepak estimated that a single rainbow trout consumes 3.86 kg of alewife per year while a brown trout consumes 3.31 kg of alewife. This consumption suggests that 409 rainbow trout or 478 brown trout could control the current population of alewife. This calculation assumes that all stocked trout will survive and that predation from older trout will not be important. Therefore we increased our final recommendation to 600 trout. Next fall's survey will be an important evaluation of this pulsed stocking approach.

The three brown trout caught in this year’s gill nets were aged at 6 to 7- originating from the stocking efforts in 2006 or 2007. Brown trout were stocked in those years at 305 mm in size. The otolith rings used for aging were also used to back-calculate growth rates over this time period, yielding an average growth rate of 48 mm/year. This year’s stocked rainbow trout were approximately 254 mm in size and their growth will now be closely monitored.

Part 4. Management for 2013

-Evaluate 2012 stocking effort

2013 will be an important year for assessing the impact of our pulsed stocking effort. We expect the newly stocked fish to help control the 2013 year-class of alewife, while older trout (2007- 2009 stocking efforts) continue to control age-1 and older reproducing alewife. The success of the stocking will depend largely on the response of this year's large age-1 population. The winter of 2012-2013 has been colder than last year's mild winter, so overwinter mortality of young alewife may be high. Close monitoring of this year's stocked trout will provide important growth information.

-Continue improved seasonal coverage of limnological data

With the help of resident Russ Cole, our 2012 seasonal coverage of zooplankton and clarity measurements provided much needed data for early and mid-summer conditions. The 2012 data coverage demonstrated that water clarity goals were maintained for most of the summer and that zooplankton abundance can be dynamic. With the help of Russ we hope to have a similar sampling coverage over the summer of 2013.

-Additional themes to investigate

The small size of young-of-year alewife make them difficult to sample with our gill nets and hydroacoustics. We will explore other means of sampling these small fish. Spring sampling may help us assess overwinter mortality and reproduction.

A migration at sunset of the "phantom midge" *Chaoborus* from the sediments to the upper water column was observed in our hydroacoustics profiles of 2012. This is a common insect larva of lakes and is particularly well adapted to low oxygen conditions. It is also known to be an important predator on zooplankton. Therefore it is likely acting with alewife to graze *Daphnia* causing lower water clarity. We propose adding night plankton tows to evaluate the population of this invertebrate predator.

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