Biological Assessment of Silver Lake: 2007

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Acknowledgements

We thank the E.L. Rose Conservancy for sponsorship of this study and its continued support of Cornell research on Silver Lake. The efforts of the Conservancy in cooperation with Cornell University are producing real progress in addressing potential threats to the unique natural resources of Silver Lake and promoting stewardship of these resources. We would also like to personally thank Patty and Billy Bloomer for the use of their boat, trolling motor, and property and their extra efforts to make Cornell researchers feel comfortable while conducting sampling efforts. Their hospitality and concern for Silver Lake are greatly appreciated.

Executive Summary

The 2007 research effort primarily focused on evaluating the effectiveness of stocking trout to control alewife and their associated impact on water clarity. Alewife are a non-native fish species believed to have been introduced to Silver Lake sometime after 1992, and have subsequently caused a decrease in water clarity as a result of overgrazing of large zooplankton. Brown trout and rainbow trout were stocked into Silver Lake on September 16, 2006 with the goal of reducing alewife abundance through predation by trout and subsequently increasing water clarity. Cornell researchers investigated several aspects of the Silver Lake ecosystem in 2007 to evaluate the ability of the lake to support long-term survival of trout and determine if the stocking of trout had measurably reduced the impact of alewife on the aquatic community.

Dissolved oxygen and water temperature were measured on August 15, 2007 to assess conditions for supporting trout during the summer. Water clarity and zooplankton community composition were evaluated to measure changes in parameters following 11 months of trout predation on alewife. The fish community was sampled in October by gill nets and angling to gather information on size distribution of alewife, growth of trout since stocking, and diet composition of any captured predatory fish. Finally, bioenergetics modeling using trout growth data was used to estimate consumption of alewives by trout since stocking.

Results of investigations conducted in 2007 indicate that Silver Lake is capable of supporting long-term survival of trout, and the stocking of trout in September 2006 is likely having the desired effect of reducing alewife abundance and the impact of alewife on water clarity and other aquatic resources of Silver Lake. Water temperature and dissolved oxygen levels during summer indicate a large zone of cool, well-oxygenated water capable of supporting trout during the warmest time of the year. Water clarity as measured by secchi depth readings has improved since the stocking of trout, with the August 15, 207 value of 13.9 ft well within the range of values recorded prior to 2006 and very near values recorded before the establishment of alewife in the lake. Desirable changes in the zooplankton community, most notably increasing abundance and variety of large zooplankton (Daphnia, large copepods, large rotifers), indicate that alewife abundance has been reduced enough to allow large zooplankton to persist in Silver Lake. Collections and observations of the fish community indicate that both trout and bass are using alewife as a forage base. Modeling of trout bioenergetics suggests that trout consumption of alewife is likely high, and observed responses of various aspects of the aquatic community suggest that the stocking of trout in September 2006 has resulted in a biologically meaningful reduction in alewife. Supplemental stocking of trout in November 2007 should help to further reduce alewife abundance and the negative impacts of this species on Silver Lake.

Introduction

The E. L. Rose Conservancy of Susquehanna County has 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 the Conservancy and Cornell University in an effort to understand and improve the water quality, fisheries and aquatic ecosystem associated with Silver Lake. The 2007 field season marked the fourth year of the cooperative relationship between the E.L. Rose Conservancy and Cornell University in an effort to monitor and manage 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 fish community of Silver Lake through a variety of field sampling efforts. Three annual (2004-2006) reports summarizing the findings of these investigations have been prepared (see Appendix A for executive summaries of these previous reports).

Items of concerns raised by initial work conducted in 2004 included low oxygen levels in the hypolimnion (water below the thermocline) of Silver Lake and the possibility that nutrient loading may be a problem within the Silver Lake watershed. Based on these findings Cornell researchers focused their 2005 effort on assessing the offshore fish community and further characterizing the water quality of Silver Lake, with an emphasis on evaluating phosphorus levels, the limiting nutrient in most freshwater systems. During 2006 the Cornell research team focused on: (1) assessing the impacts of the introduced rock bass and alewife in the system, and (2) measuring mercury levels in tissue from several fish species within Silver Lake. Secondary goals included conducting a littoral zone survey for available prey items and additional evaluations of thermal and oxygen conditions within Silver Lake.

The 2007 research effort primarily focused on evaluating the effectiveness of stocking trout to control alewife and their associated impact on water clarity. Alewife are a non-native fish species believed to have been introduced to Silver Lake sometime after 1992, and have subsequently caused a decrease in water clarity as a result of overgrazing of large zooplankton. With support from the E.L. Rose Conservancy and the Silver Lake Lake Association, 150 brown trout and 150 rainbow trout were stocked into Silver Lake on September 16, 2006 with the goal of reducing alewife abundance through predation by trout and subsequently increasing water clarity. The following activities were conducted by Cornell researchers in 2007.

- A dissolved oxygen and water temperature profile of the lake was measured on August 15, 2007 to assess conditions for supporting trout during the summer when dissolved oxygen and water temperature conditions are most stressful to trout.
- Water clarity was also measured on this date using a secchi disk to measure change in water clarity following 11 months of trout predation on alewife.
- The zooplankton community was sampled near mid-lake to determine if noticeable changes in zooplankton community composition have occurred since the trout stocking.
- Gill net sampling for alewife and trout was conducted on October 16, 2007 to determine the size distribution of alewife and growth of trout since stocking.
- Angling was conducted October 16, 2007 to sample other aspects of the fish community and determine if fish other than trout may be feeding on alewife.
- Bioenergetics modeling was performed to estimate consumption of alewives by trout since stocking.

Dissolved Oxygen/Water Temperature

Rainbow and brown trout require cool, well-oxygenated water year-round. These species prefer water temperatures below 72 ºF and dissolved oxygen levels above 5 mg/L. Dissolved oxygen and water temperature profiles were measured near mid-lake on August 15, 2007 to further assess the suitability of Silver Lake for long-term survival of trout. Similar profiles were measured by Cornell researchers in 2006 and 2005, and some historic data from 1946, 1992, and 2002 are also available from Silver Lake.

Data collected on August 15, 2007 are consistent with similar data collected in the past (Figures 1 and 2) and indicate that the lake is thermally stratified during the summer (i.e., a layer of warm, less dense water overlays a dense, colder water layer). The transition area between these water layers is known as the thermocline. Typically, trout are limited to waters below the thermocline (known as the hypolimnion) during summer, since waters shallower than the thermocline are unsuitably warm. However, dissolved oxygen levels can sometimes be depressed within the hypolimnion due to minimal mixing with more oxygenated surface waters and biological oxygen demand associated with lake bottom sediments. If a lake is to sustain a population of trout year-round, there must be a great enough volume of cool, well-oxygenated water within the hypolimnion to allow trout to survive throughout the summer. Past data and the data collected in 2007 indicate that a sufficiently large volume of the hypolimnion in Silver Lake remains well oxygenated during the warmest time of the year to support cold-water species such as trout (Figures 1 and 2). On August 15, 2007, the zone of the hypolimnion ranging in depth from 15 to 55 feet contained water less than 72 ºF with dissolved oxygen greater than 5 mg/L.

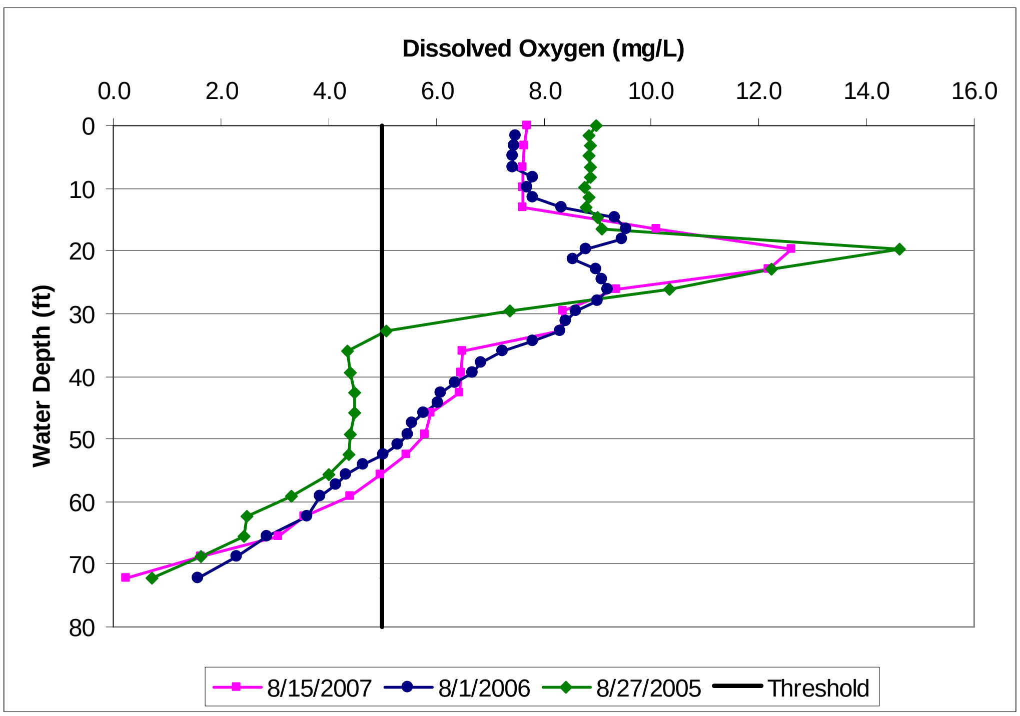


Figure 1. Dissolved oxygen profiles for Silver Lake on August 15, 2007, August 1, 2006, and August 27, 2005.

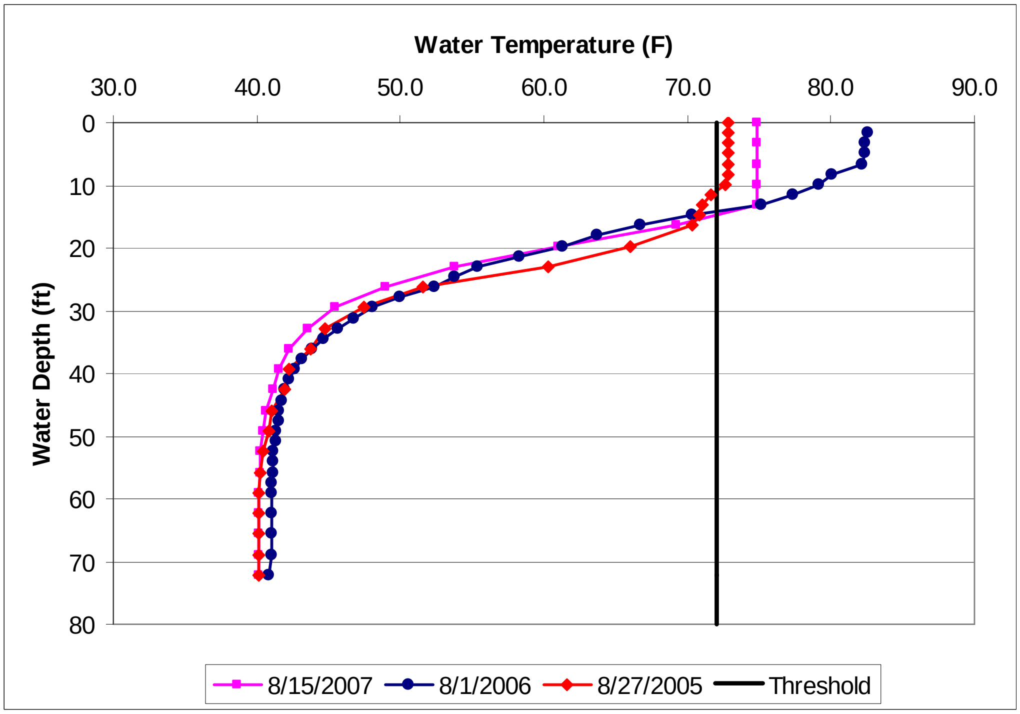


Figure 2. Water temperature profiles for Silver Lake on August 15, 2007, August 1, 2006, and August 27, 2005.

Water Clarity

Water clarity was measured on August 15, 2007 with a secchi disk, a weighted, 8-inch diameter disk with four alternately colored black and white quarter sections. The depth to which the disk can be viewed provides a standardized measure of water clarity. Secchi depths for Silver Lake prior to the establishment of alewife were high, ranging from 15 to 20 ft (Figure 3). Following the introduction of alewife sometime after 1992, secchi depths remained relatively high (13-15 ft) until 2006, when they declined to as low as 5.6 ft (Figure 3). The range of values measured in 2006 was from 5.6 ft on June 30 to 11.9 ft on October 12. The 5.6-ft value was measured during a flood event, so it likely reflects a worst-case scenario, but the values for August 1 (9.6 ft) and October 12, 2006 (11.9 ft) were still lower than any previous measurements.

The secchi depth measured on August 15, 2007 was 13.9 ft, well within the range of values recorded prior to 2006 and very near values recorded before the establishment of alewife in the lake. Furthermore, while conducting fish sampling on October 16, 2007, Cornell researchers anecdotally noted that the water clarity appeared even better on this date than during their August 15, 2007 visit to the lake. Unfortunately, no secchi depth was measured on October 16 to confirm this observation. Based on measurements and observations made in 2007, it appears that water clarity in Silver Lake has improved since the stocking of trout to control alewife in October 2006.

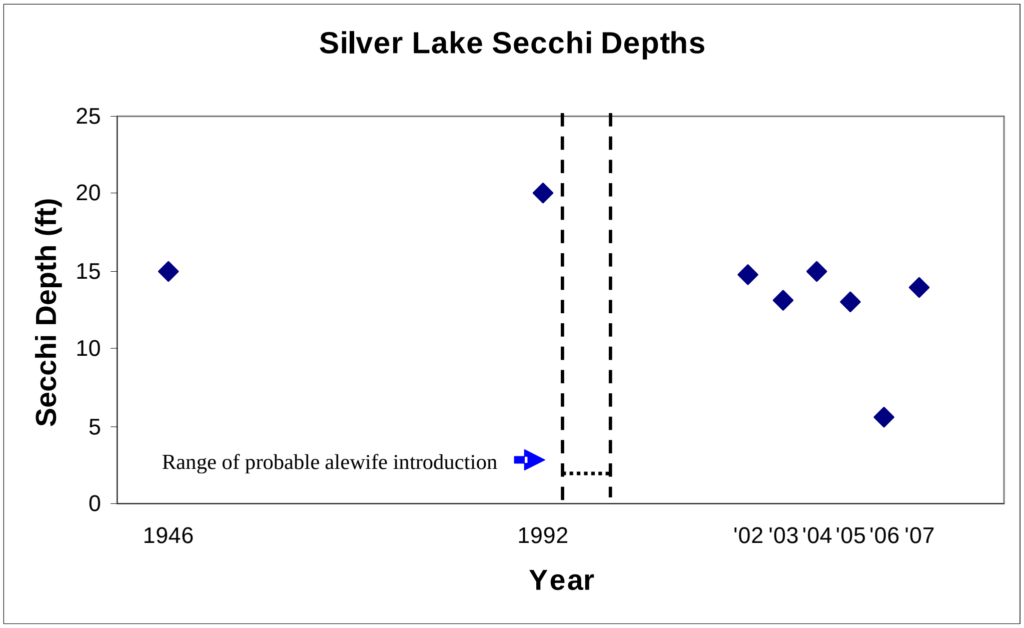


Figure 3. Secchi depths for Silver Lake, 1946, 1992, and 2002 through 2007. Points represent data collected on the nearest date to June 30th to avoid seasonal differences. Data collected in 2006 were associated with a flood event.

Zooplankton Community

The zooplankton (micro-crustaceans and other animals living within the water column) community of Silver Lake was first investigated by Cornell researchers in 2006 (sampled on June 30, August 1, and October 12) and was sampled once again in 2007 (August 15). Samples were collected near mid-lake using a Wisconsin-style plankton net that was lowered to a depth of 20 meters (~66 ft) and slowly lifted vertically to the surface. Preliminary analysis of the 2006 samples found that large-bodied zooplankton were scarce or absent. This finding strongly supported the hypothesis that alewife were the cause of decreasing water clarity in Silver Lake. Alewife preferentially consume large zooplankton that graze upon the phytoplankton (microscopic algae) responsible for algal blooms in lakes. When large-bodied zooplankton are reduced or eliminated by heavy predation, the density of phytoplankton in the water column increases, and water clarity decreases due to reduced light penetration.

The 2006 zooplankton samples contained relatively low numbers of zooplankton overall and were dominated by small-bodied zooplankton, primarily Bosmina and small rotifers, that are ineffective in controlling phytoplankton abundance. In contrast, the 2007 zooplankton samples contained relatively high numbers of zooplankton overall, a greater variety of zooplankton, and, most importantly, greater numbers and variety of large-bodied zooplankton than in 2006 (Table 1). These findings strongly suggest that the stocking of trout in October 2006 is having a positive impact on the zooplankton community by reducing the abundance of alewife and consequently the level of predation on large-bodied zooplankton.

Table 1. Estimated densities of prominent zooplankton groups in Silver Lake based on preliminary analysis of samples collected in 2006 and 2007.

Zooplankton Group	Size (mm)	Estimated Density (No./Liter)			
		6/30/2006	8/1/2006	10/12/2006	8/15/2007
Bosminids	<0.5	9.6	93.1	10.2	324.0
Copepods	<0.7	3.8	0.2	5.5	11.5
Copepods	0.9-1.3	0.4	0.0	0.9	13.0
Daphnia	1.0-1.2	0.0	0.0	0.0	0.9
Rotifers (small)	0.3	10.9	90.4	29.5	11.3
Rotifers (large)	0.5-1.0	0.0	0.0	0.0	45.2

Fish Community

Fish community sampling occurred on October 16, 2007. Floating vertical and sinking horizontal gill nets were set at multiple locations in the lake in an effort to capture both alewife and trout from open-water habitats (Figure 4). Four sets of each net type were made from late morning through early afternoon. In addition, angling was conducted in open water and along about one-half of the lake's shoreline in an effort to capture catchable-size fish (Figure 5). The goals of fish community sampling were to gather length distribution data for alewife and trout, gauge the growth and condition of trout since stocking in September 2006, and analyze the diet of any captured predatory fish to determine what they were eating and if alewife were a component of the diet.

The results of the fish community sampling are provided in Table 2. Gill-net sampling resulted in the capture of only one alewife (a large adult), two brown trout, and one rainbow trout (Figures 6 and 7). All of these fish were captured in the first two net sets in the morning. It appeared that as the sun moved higher in the sky, the nets became more visible to fish in the lake's clear water, and fish were able to avoid capture. However, the few fish captured in the gill nets did provide some useful data for evaluating the success of the trout stocking.

Both species of trout showed excellent growth since stocking and appeared healthy and well fed. Since stocking, the one rainbow trout had increased in length by about 6 inches, and the two brown trout had increased in length by 4 to 5 inches. Although the rainbow trout was longer than either of the brown trout, both brown trout were heavier than the rainbow trout. Given the amount of growth shown by the trout, it is highly likely that fish were a major component of their diet. The rainbow trout contained the remains of a fish in its stomach, but it could not be identified to species. Presumably all of these trout fed primarily on alewife, since this is the only prey species in Silver Lake that would consistently inhabit the cooler, open-water habitats of the lake favored by trout.

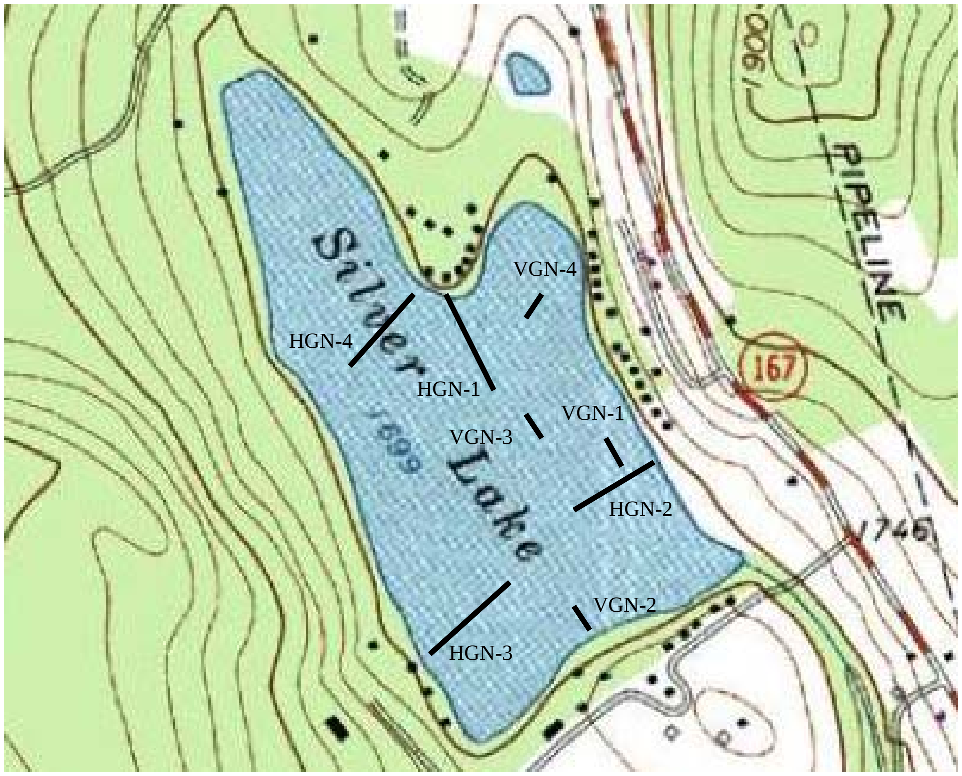


Figure 4. Location of vertical (VGN) and horizontal (HGN) gill net sets in Silver Lake on October 16, 2007.

Figure 5. Areas sampled by angling in Silver Lake on October 16, 2007.

Table 2. Fish catch by gill net and angling in Silver Lake on October 16, 2007.

Sampling Effort	Time (hr)	Species	Length (mm/inches)	Weight (g/lbs)	Stomach Contents
Vertical Gill Net 01	0949-1018	Rainbow trout	440/17.3	716/1.6	Small fish parts
		Brown trout	415/16.3	850/1.9	Empty
Vertical Gill Net 02	1101-1146	No Catch			
Vertical Gill Net 03	1200-1259	No Catch			
Vertical Gill Net 04	1238-1338	No Catch			
Horizontal Gill Net 01	0958-1033	Brown trout	430/16.9	940/2.1	Empty
		Alewife	194/7.6	52/0.1	
		Largemouth bass	202/8.0	93/0.2	Fish parts
Horizontal Gill Net 02	1043-1112	No Catch			
Horizontal Gill Net 03	1123-1205	No Catch			
Horizontal Gill Net 04	1215-1305	No Catch			
Research Angling 01	1230-1250	Largemouth bass	403/15.9	896/2.0	2 alewife (57 mm, 68 mm)
Research Angling 02	1400-1510	Largemouth bass	265/10.4		Empty
		Largemouth bass	265/10.4		Empty
		Largemouth bass	350/13.8		
		Largemouth bass	160/6.3		
		Largemouth bass	132/5.2		
		Largemouth bass	150/5.9		
		Rock bass	230/9.1		

While setting and tending the nets, schools of young-of-year alewife were observed swimming offshore along the surface of the lake from late morning into the afternoon. Larger fish (presumably adult largemouth bass) were seen regularly feeding on these schools of fish. One adult largemouth bass was captured by angling in the vicinity of where these schools were observed, and multiple (3-5) other adult largemouth bass were seen following this fish while it was being brought to the boat. The captured fish was nearly 16 inches long and contained two juvenile alewife in its stomach. These observations of what are presumed to be largemouth bass preying on schools of juvenile alewife indicate that not only are trout feeding on alewife, but other predators in the lake are using this prey resource as well.

Figure 6. Brown trout (top) and rainbow trout (bottom) captured in a gill net from Silver Lake, October 16, 2007.

Figure 7. Brown trout captured in a gill net from Silver Lake, October 16, 2007.

Angling along shoreline areas resulted in the capture of six additional largemouth bass and one rock bass. In addition to the captured fish, two large (>18 inches) largemouth bass, a few juvenile largemouth bass, an adult chain pickerel, a large (~12 inches) rock bass, and several adult pumpkinseed were observed in near-shore waters while angling. The length distribution of largemouth bass indicated that several year classes are represented in the lake, including large adults. This means that there has been regular successful reproduction of bass and ample forage is available for these fish to grow to a large size. A minnow-trapping effort conducted by Cornell researchers in 2006 indicated that forage fish were relatively scarce in near-shore areas. Observations of largemouth bass feeding upon open-water schools of alewife in 2007 suggest that alewife may be providing an important source of forage for bass. Adult largemouth bass may in turn be contributing to control of alewife abundance along with the stocked trout.

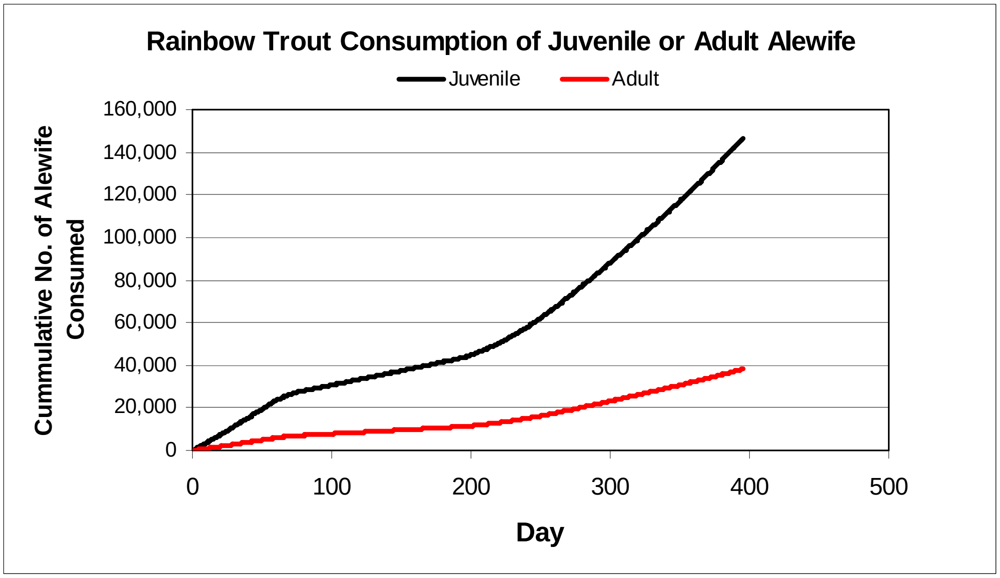
Bioenergetics Modeling

The length and weight data gathered from the few trout collected with the gill nets provided information on the rate of growth of these fish since stocking. This information was used in a bioenergetics model to develop an estimate of how many alewife of a given size the trout would have had to consume to grow to the size at which they were captured. Some general assumptions about the initial weight of the trout, the size and caloric content of the alewife consumed, water temperature, and the percentage of the diet constituted by alewife were made in order to provide input to the model and develop alewife predation estimates.

The bioenergetics model was implemented using two sizes of alewife: juveniles weighing an average of 4 g and adults weighing an average of 15 g. The model estimated the number of alewife a trout of each species of the size stocked in 2006 would consume if it ate only alewife since the time of stocking. This number was then multiplied by the total number of each trout species stocked (150) to arrive at the amount of prey the predator population would have consumed if all stocked individuals survived (Table 3, Figure 8). Thus, the results presented here are an estimate of the maximum numbers of alewife consumed in Silver Lake by stocked trout.

Table 3. Estimated number of juvenile or adult alewife consumed by stocked trout in Silver Lake from September 16, 2006 to October 15, 2007 based on bioenergetics modeling.

Trout Species	**Alewife Size Category**	
	Juvenile (4 g)	**Adult (15 g)**
Rainbow Trout		
Individual	976	254
Population of 150	146,400	38,100
Brown Trout		
Individual	842	217
Population of 150	126,300	32,550
Rainbow and Brown combined		
Population of 300	272,700	70,650



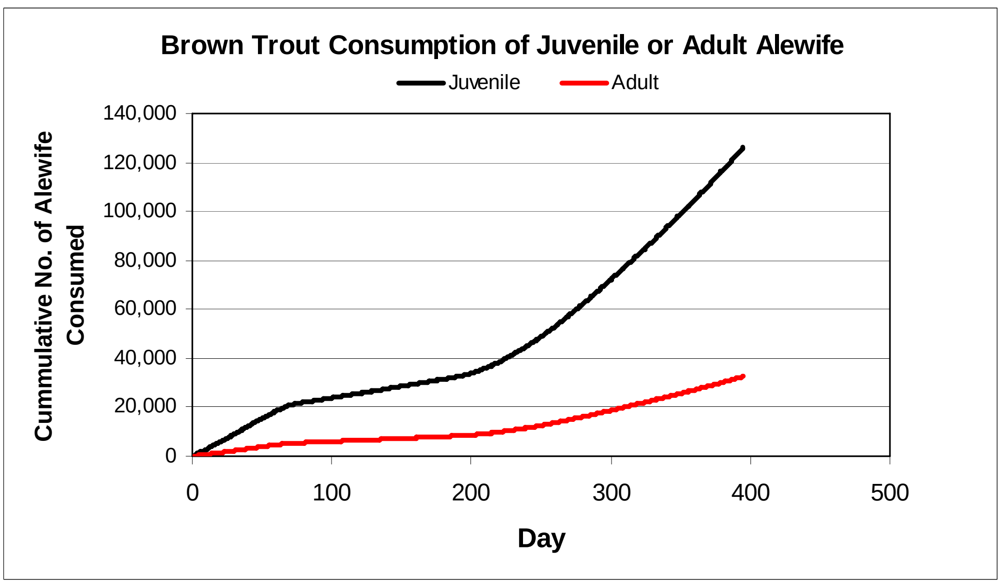


Figure 8 Estimated number of juvenile or adult alewife consumed by stocked rainbow and brown trout in Silver Lake from September 16, 2006 to October 15, 2007, based on a bioenergetics model evaluation.

In reality, the number of alewife consumed would be lower than the model predicted since it is likely that not all of the stocked trout survived to October 15, 2007, and alewife likely were not the sole prey item consumed by trout. Still, the model estimate indicates that the trout stocked in 2006 had the potential to consume more than 70,000 adult alewife or 272,000 juvenile alewife. It is most likely that a combination of juvenile and adult alewife were consumed, thereby representing a substantial level of predation on the alewife population by the stocked trout.

Results of the model indicate that rainbow trout consumed 16-17% more individual alewife than did brown trout. This information is based on growth data from only a few fish, so this conclusion should be considered preliminary. Whether or not further stocking of rainbow trout alone would be more effective than stocking brown trout alone – or a combination of the two species is more effective for controlling alewife – will depend on several variables that merit future evaluation.

Trout Stocking in 2007

Following a recommendation by Cornell researchers, the Silver Lake Lake Association stocked an additional 150 rainbow trout and 150 brown trout into Silver Lake on November 21, 2007. These fish were stocked at the same size (~11 inches for rainbow trout, ~12 inches for brown trout) and density (~3 fish/acre, both species combined) as in September 2006. The purpose of the stocking was to supplement the existing trout populations in the lake, further increasing predation of alewife in order to reduce the impact of alewife on water clarity and the aquatic community as a whole in Silver Lake. Periodic stocking of trout will be necessary in order to maintain trout populations at a level capable of controlling alewife abundance, since neither brown nor rainbow trout are likely to be able to reproduce within Silver Lake due to the lack of appropriate spawning habitat.

Conclusions and Recommendations

Results of investigations conducted in 2007 indicate that Silver Lake is capable of supporting long-term survival of trout, and the stocking of trout in September 2006 is having the desired effect of reducing alewife abundance and the impact of alewife on water clarity and other aquatic resources of Silver Lake. Water temperature and dissolved oxygen levels during summer indicate a large zone of cool, well-oxygenated water capable of supporting trout during the warmest time of the year. Water clarity as measured by secchi depth readings has improved since the stocking of trout. Desirable changes in the zooplankton community, most notably increasing abundance and variety of large zooplankton (Daphnia, large copepods, large rotifers), indicate that alewife abundance has been reduced enough to allow some recovery of large zooplankton. Collections and observations of the fish community indicate that both trout and bass are using alewife as a forage base. Modeling of trout bioenergetics suggests that trout consumption of alewife is likely high, and observed responses of various aspects of the aquatic community suggest that the stocking of trout in September 2006 has resulted in a biologically meaningful reduction in alewife.

Past reports prepared by Cornell University regarding Silver Lake have included several recommendations that are still relevant. These include continuing efforts to minimize inputs of nutrients and pollutants to preserve lake water quality and conducting periodic monitoring of total phosphorus, chloride, alkalinity, pH, water temperature, and dissolved oxygen in order to characterize any changes that may occur through time. Preserving the integrity of undeveloped shoreline and the large amount of wood present along that shoreline should be continued to support native fish populations by providing habitat for forage and refuge. A small evaluation was conducted on Silver Lake fish in 2006 to explore potential concerns regarding mercury contamination in fish. As previously recommended, anglers harvesting fish for consumption should be aware of fish consumption advisory limits published by the Pennsylvania Division of Water Quality Assessment and Standards.

Finally, results of the 2007 investigation of Silver Lake support a recommendation to continue trout stocking as a means of controlling undesirable impacts of alewife within Silver Lake, and this recommendation has already been pursued with the stocking of an additional 300 trout in November 2007. Future monitoring of water clarity, the zooplankton community, and aspects of the fish community (species composition, trout abundance and growth, piscivore diet composition) can be used to measure the long-term effectiveness of the stocking program and potentially identify ways to more effectively implement this effort.

Silver Lake is highly valued for a variety of reasons by watershed residents as evidenced through the efforts sponsored by the E.L. Rose Conservancy to understand, protect, and enhance the Silver Lake ecosystem. These efforts continue to improve our knowledge of the lake and identify means by which the valued resources of the lake can be sustained or improved.

Appendix A

2004 Executive Summary:

Our initial approach towards studying the fish community of Silver Lake included both qualitative biological assessments and a collection and review of historic Silver Lake reports or documents. Two biological assessments of Silver Lake were completed during the summer of 2004, a littoral habitat assessment and a snorkel assessment of the lake's littoral zone. Although approximately 2/3 of the lake's shoreline has been cleared and developed, some degree of woody material continues to accumulate in most of the lake's nearshore areas. In addition, the large portion of the western lake shoreline that has not been developed or cleared most closely represents how the Silver Lake shoreline would have originally appeared prior to human settlement. This shoreline is likely of great importance to the lake's natural function. The nearshore fish community of Silver Lake is thriving and indicative of many lakes and ponds in northeastern Pennsylvania. Given the current reports and resources it is not possible to determine what fish species made up the pre-settlement fish community, but it is clear that historical stocking efforts and non-native fish introductions have occurred throughout the recorded history of Silver Lake. Silver Lake's warmwater fish community (largemouth bass in particular) is comprised of an unusually high proportion of large individuals, making these fish populations both unique and susceptible to overharvest (i.e. removal of large fish). The most important aspect of Silver Lake water quality noted from a review of historic reports is the change in the dissolved oxygen level within the lake's hypolimnion at some point between the 1992 (TETHYS) and 2001 (Dr. John Titus) surveys. This is likely the result of ongoing nutrient loading to Silver Lake, thereby resulting in the production of more algae by comparison with historic levels. It would be beneficial to develop specific goals for both the water quality and fish community management of Silver Lake to ensure that the quality and unique nature of this lake is preserved.

2005 Executive Summary:

The 2005 Silver Lake field evaluations focused on open water habitat conditions and water quality. They also included an investigation of the composition of the fish community, with emphasis on the potential presence of rare native and non-native species.

The 2005 study consisted of monthly (May through September) surveys to collect information on water temperature, dissolved oxygen, nutrient concentrations, and other basic water quality parameters to compare current conditions with those observed in previous efforts. Two fish sampling efforts were undertaken: a June angling survey and an October netting survey.

Results from these surveys showed a lake that is generally oligotrophic (low productivity) with very good water quality and a highly desirable sport fishery capable of supporting both warm and cold-water species. Water quality results indicated that the lake is limited in cold-water fisheries habitat due to warm surface water temperatures and dissolved oxygen concentrations that were below minimally accepted levels.

The unseasonably warm summer of 2005 exacerbated oxygen depletion caused by the buildup of nutrients in the hypolimnion region of the lake and contributed to a limitation in available fish habitat. Nutrient enrichment in the hypolimnion is suspected to have resulted from anthropogenic sources associated with development in the Silver Lake watershed.

Therefore, we recommend nutrient input minimization efforts in the lake watershed, even though phosphorus levels in the epilimnion remain relatively low. Improvements in property management practices and septic system maintenance will be necessary to minimize the loading of excessive nutrients to the lake and maintain current conditions.

Other water chemistry measures were unremarkable and pointed to a lake that is in very good condition. Future monitoring, especially for temperature, dissolved oxygen and phosphorus, is recommended to evaluate ongoing trends in these parameters.

Our lake fishery investigation revealed a system with numerous large warm-water game fish but few forage species in the littoral zone. Of particular importance was the observation of rock bass and alewife that had not been recorded as being present in the lake prior to 1992, indicating that they are new arrivals. Only one cold-water species besides alewife was collected, that being a large brown trout believed to have been stocked into the lake more than nine years ago. This result was surprising given the numerous rainbow trout that have been stocked in Silver Lake. Efforts to identify other rare native or non-native species in the lake were unsuccessful.

The Pennsylvania Department of Environmental Protection reported this year that a single Silver Lake largemouth bass was tested for mercury in 2004 and found to have elevated mercury levels in its tissue. No further actions were taken in light of this observation, pending the results of future sampling for mercury levels in Silver Lake fish.

Finally, we conducted several outreach efforts concurrent with our field investigations to promote the development of constituent-based goal setting, with the ultimate goal of developing a management plan to maintain the high quality of the resources of Silver Lake.

2006 Executive Summary:

The 2006 Silver Lake assessment focused on four objectives: (1) corroboration of data collected during water quality surveys in previous study years, (2) a qualitative assessment of nearshore prey availability, (3) assessing the impacts of introduced rock bass and alewife, and (4) evaluating mercury contamination in four commonly caught Silver Lake fish species.

1) Temperature and dissolved oxygen profiles were developed for Silver Lake during the 2006 field season and showed that Silver Lake contains habitat with the potential to support cold-water pelagic species such as brown and rainbow trout. Concern was raised about this issue in previous study years, however, even on the hottest sampling day on record Silver Lake still offered a large area with temperature and dissolved oxygen levels capable of supporting cold-water pelagic species. Water chemistry surveys measuring total phosphorus, chloride, alkalinity and pH were typical of a relatively unpolluted, oligotrophic system with exceptional water quality.

2) A minnow trapping effort was conducted on June 30th, 2006 and a single pumpkinseed sunfish was collected. Nearshore prey fish appear to be limited in Silver Lake based on this survey,

which was supported by data collected in 2004 and 2005. However, an abundance of invertebrates including snails, crayfish and the larvae and nymphs of mayflies, caddis flies, midges, dragonflies and damselflies exists within Silver Lake. The high densities of these organisms could explain how Silver Lake can support a dense, diverse and relatively fast growing fish community.

3) Non-native rock bass were collected during 2006 angling surveys and they contained several fish in their stomachs. Even small rock bass – less than 6 inches – were consuming fish. It is probable that through competition and predation, rock bass are negatively impacting the growth and recruitment of native Silver Lake fish species. Non-native alewife have been shown to decrease water clarity in small and large lake systems throughout the United States and Canada by altering natural food web interactions. Alewife reduce the abundance of large zooplankton, allowing phytoplankton – organisms that limit light penetration and water clarity in lakes – to become abundant. Silver Lake appears to have experienced a decrease in water clarity as a result of an alewife introduction. Zooplankton were sampled on August 1st, 2006 and October 12th, 2006 in Silver Lake (two each date). No large-bodied zooplankton were collected in any of the samples, which were dominated by small copepods. This finding strongly supports the hypothesis that alewife are the cause of decreasing water clarity in Silver Lake. As a result of these observations, a decision was made to stock 150 brown and 150 rainbow trout into Silver Lake. These salmonids are alewife predators and were stocked as a means of restoring food web interactions that promote clear water conditions. It would be useful to monitor water clarity as a measure of the success of this management action.

4) Two individuals (large and small) of each of four species (largemouth bass, pumpkinseed sunfish, yellow perch and rock bass) commonly angled in Silver Lake were sent for mercury analysis in 2006. These results showed that some fish in Silver Lake fall within the mercury consumption advisory set by the Pennsylvania Division of Water Quality Assessment and Standards. Anglers should consult these advisories and the data provided here to make informed decisions about which fish to harvest and consume.

Silver Lake provides excellent opportunities for recreational activities such as angling, swimming and boating. The Silver Lake ecosystem supports a healthy and diverse community of organisms. Although introduced species have altered some of the natural food web interactions within Silver Lake, this system represents a valuable resource that should be properly protected, managed and monitored by stakeholders. The continuance of environmental stewardship emphasized by the E.L. Rose Conservancy and the Silver Lake, Lake Association should ensure that Silver Lake will offer these types of recreational opportunities in the future.