Biological Assessment of Silver Lake: 2006

Department of Natural Resources
Cornell University

Jesse M. Lepak and
Clifford E. Kraft

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Acknowledgements:
We thank the E.L. Rose Conservancy for sponsoring this study and providing Cornell researchers with an important opportunity to work collaboratively towards conserving a portion of the northern Pennsylvania landscape. We would also like to personally thank Patty and Billy Bloomer for the use of their boat, trolling motor, property and their extra efforts to make Cornell researchers feel comfortable while conducting sampling efforts.

We would also like to extend our appreciation to Aaron Frey of the Pennsylvania Department of Environmental Protection for consultation regarding the fish consumption advisory information currently being used in Pennsylvania.

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 fishes such as brown and rainbow trout. Concern was raised about habitat availability in previous study years, however, even during the hottest sampling day on record Silver Lake provided a large refuge with temperature and dissolved oxygen levels capable of supporting cold-water pelagic species. Key water chemistry parameters – total phosphorus, chloride, alkalinity and pH – were typical of a relatively unpolluted, oligotrophic system with exceptional water quality.

2) Only a single pumpkinseed sunfish was collected during a minnow trapping survey conducted on June 30th, 2006. 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 have been observed within Silver Lake, including snails, crayfish and the larvae and nymphs of mayflies, caddis flies, midges, dragonflies and damselflies. The high densities of these organisms could explain how Silver Lake supports a dense, diverse and relatively fast-growing fish community.

3) Non-native rock bass were collected during 2006 angling surveys, and these predators contained other fish in their stomachs. Even small rock bass – less than 6 inches in length – were found to consume fish, and it is likely that rock bass are negatively impacting the growth and recruitment of native Silver Lake fish species. In addition, another fish invader, non-native alewife, may be having a negative impact on the lake. 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 since alewife were introduced in the early 1990s. No large-bodied zooplankton were observed in plankton tows collected

in 2006. This finding strongly supports the contention that a growing alewife population has resulted in decreased water clarity in Silver Lake. Based on our findings, local residents decided to stock 150 brown and 150 rainbow trout into Silver Lake. These salmonids are alewife predators and have the potential to restore food web interactions that promote clear water conditions.

4) Two individuals (one large and one small) of each of four fish species commonly angled in Silver Lake (largemouth bass, pumpkinseed sunfish, yellow perch and rock bass) were collected and analyzed for mercury content in 2006. These results showed that some fish in Silver Lake have mercury concentrations exceeding consumption advisory levels set by the Pennsylvania Division of Water Quality Assessment and Standards. Anglers should consult these advisories 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, and 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. Ongoing environmental stewardship fostered by the E.L. Rose Conservancy and the Silver Lake Association should ensure that Silver Lake will continue to provide high quality recreational opportunities for many years to come.

Introduction:

The E. L. Rose Conservancy of Susquehanna County and its past and present members 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 the Conservancy and Cornell University in an effort to understand and subsequently improve the water quality, fisheries and aquatic ecosystem of Silver Lake.

The 2006 field season marked the third year of a cooperative partnership between the E.L. Rose Conservancy and Cornell University in an effort to monitor and manage Silver Lake. The initial focus of Cornell efforts was to assess the biological integrity and nearshore fish community of Silver Lake and review available historical information. Based on the biological assessments and information attained from historical records, Cornell researchers developed two earlier annual reports summarizing future directions for research within the lake (see Appendix A for executive summaries of these previous reports).

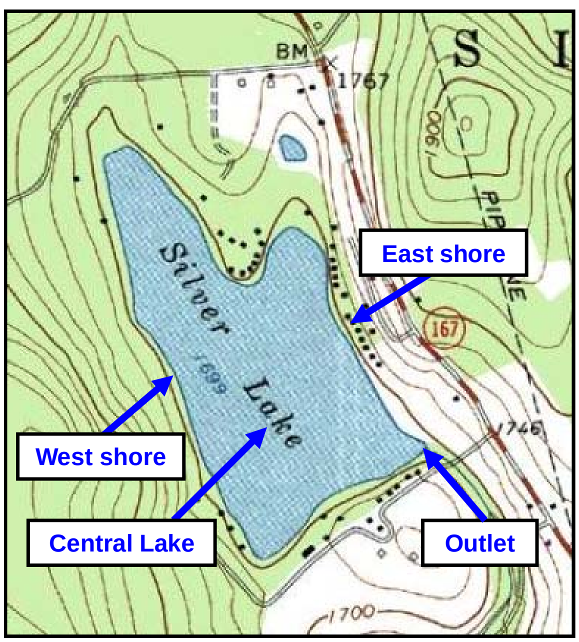
The most important concerns raised by initial lake surveys conducted in 2004 included the oxygen levels in the hypolimnion of Silver Lake and the possibility that nutrient loading may be a problem within the Silver Lake watershed. Based on these findings Cornell researchers focused their 2005 efforts on assessing the offshore fish community and further characterizing the water quality of Silver Lake, with an emphasis on evaluating phosphorus levels, which is the limiting nutrient in most freshwater systems.

During 2006 the Cornell research team included Jesse M. Lepak, a Ph.D. candidate at Cornell University and M.S. student, Jason M. Robinson. Their graduate research efforts have focused on evaluating the effects of non-native fish introductions and food web influences upon mercury contamination in fish, primarily in Adirondack lake ecosystems. Based on this experience they were able to successfully focus on addressing two major goals identified for summer 2006: (1) assessing the impacts of the introduced rock bass and alewife in the Silver Lake ecosystem, 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.

Water Quality:

2005 water chemistry results indicated little cause for concern in Silver Lake, given that samples collected at several lake locations (see Figure 1) on August 27th, 2005 were within acceptable ranges for an oligotrophic (low productivity) freshwater lake (see Table 1). Total phosphorus is an indicator of the productivity of a system and is usually the limiting nutrient in freshwater lakes. Chloride is an indicator of external inputs from runoff such as road salt and other pollutants. Water alkalinity and sulfate content indicate the susceptibility of a lake to acid precipitation. Lake pH – a measure of hydrogen ion concentration, which is a measure of lake acidity – was also measured and found to have a mean value of approximately 7.5, indicating that the lake pH is near neutral and therefore favorable. These results suggest that Silver Lake currently exhibits exceptional water quality and provides good habitat for fish and other organisms.

Figure 1. Silver Lake sampling sites for the August 27th 2005 survey.



	Water Quality Parameter			
	T. Phosphorus (μg/L)	Chloride (mg/L)	Alkalinity (mg/L, $CaCO_3$)	Sulfate (mg/L)
Central Lake	11.8	9.36	8.96	7.75
Central Lake (deep)	14.1	-	-	-
East shore	10.9	9.31	-	-
West shore	12.3	9.37	-	-
Outlet	15.2	9.32	-	-
PADEP 2002-2003	12.0	-	12.0	-

Table 1. Water quality measurement values from the August 27th 2005 survey. Water samples in the central lake location were taken at the deepest location, 1.5 feet below the surface, in the central lake (deep), approximately 30 feet below the surface, the eastern shore off of the Bloomer dock, the western shore, 60 feet beyond leaning tree on the Conservancy property, 18 feet from shore and in the lake outlet, 30 feet from the poplar tree stand in a shallow area.

In 2005, concern was raised about the availability of habitat for cold-water pelagic (offshore) fishes. Several of these species, including brown and rainbow trout, have been previously stocked into Silver Lake and prefer water temperatures below 72 ºF. To evaluate whether suitable trout habitat was available, temperature measurements at a range of depths were taken on June 30th, August 1st and October 12th, 2006 (see Figure 2). The temperature profiles developed from these data are consistent with conditions in other area lakes, showing seasonal variability and summer stratification (i.e. a layer of warm, less dense water floats above a dense, colder water layer). The transition area between these water layers is known as the thermocline, and certain attributes of the thermocline provide information about available habitat for cold-water pelagic species during warmer summer conditions.

Cold-water species such as brown and rainbow trout prefer dissolved oxygen levels above 5 mg/L. Measurements of dissolved oxygen were also taken at a range of depths on June 30th, August 1st and October 12th, 2006 to evaluate the suitability of Silver Lake oxygen conditions for trout survival (see Figure 3). We observed that dissolved oxygen levels were at a maximum near the lake surface and then slowly declined with increasing depth. This is typical of thermally stratified lakes with limited mixing.

2006 temperature and dissolved oxygen profiles developed for Silver Lake were comparable to historic profiles developed in 1946, 1992, 2002, and 2005 (see Figures 4 and 5). For purposes of this comparison, the dates of previous sampling events were matched as closely as possible with 2006 sampling dates, therefore only data collected from mid-July to mid-August were used. Despite inevitable small-scale variations in these profiles, these data suggest that temperature and dissolved oxygen conditions in Silver Lake have been relatively stable for the past five decades.

Figure 2. Silver Lake 2006 temperature profiles. The flattened portions of the lines represent the thermocline.

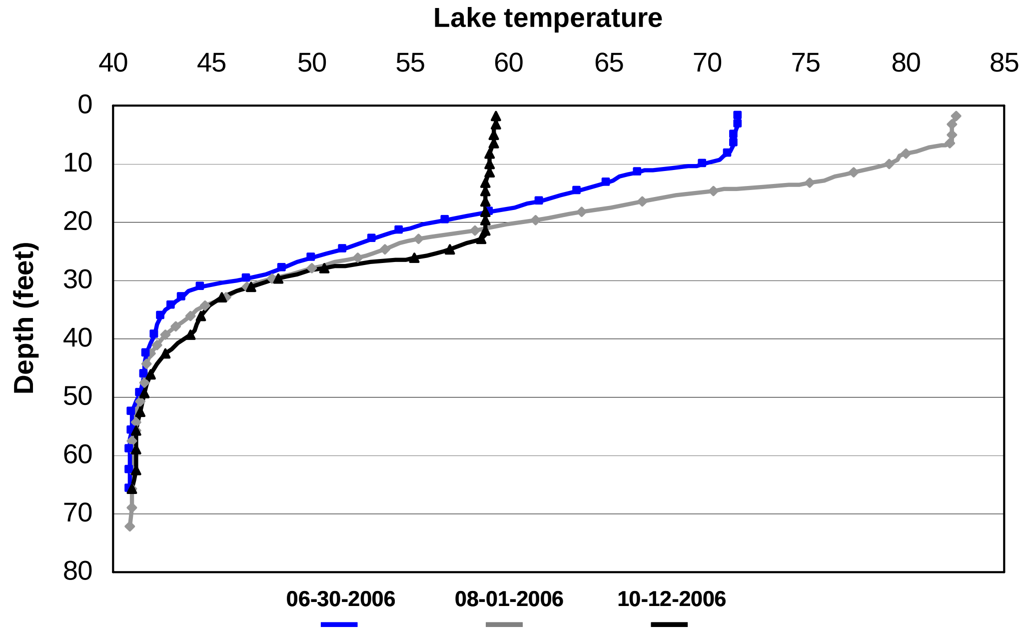


Figure 3. Silver Lake 2006 dissolved oxygen profiles.

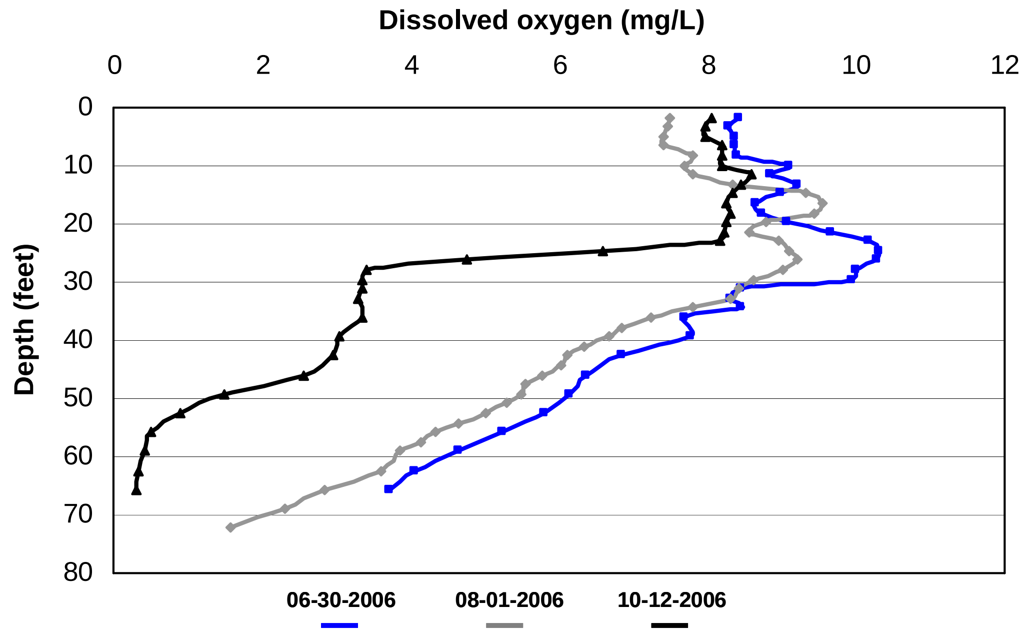


Figure 4. Silver Lake historic temperature profiles. The flattened portions of the lines represent the thermocline.

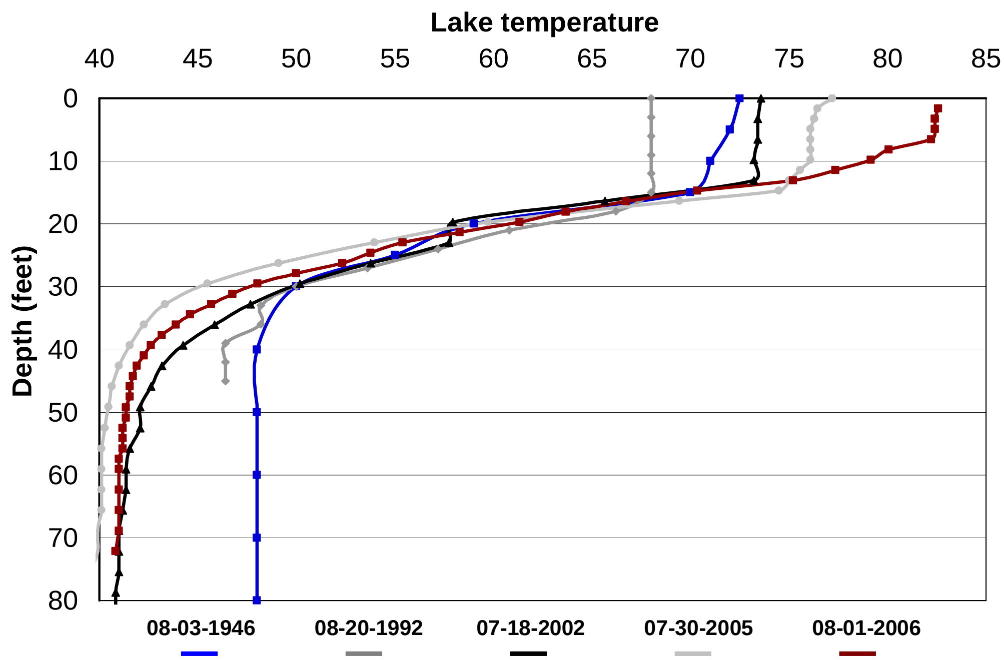
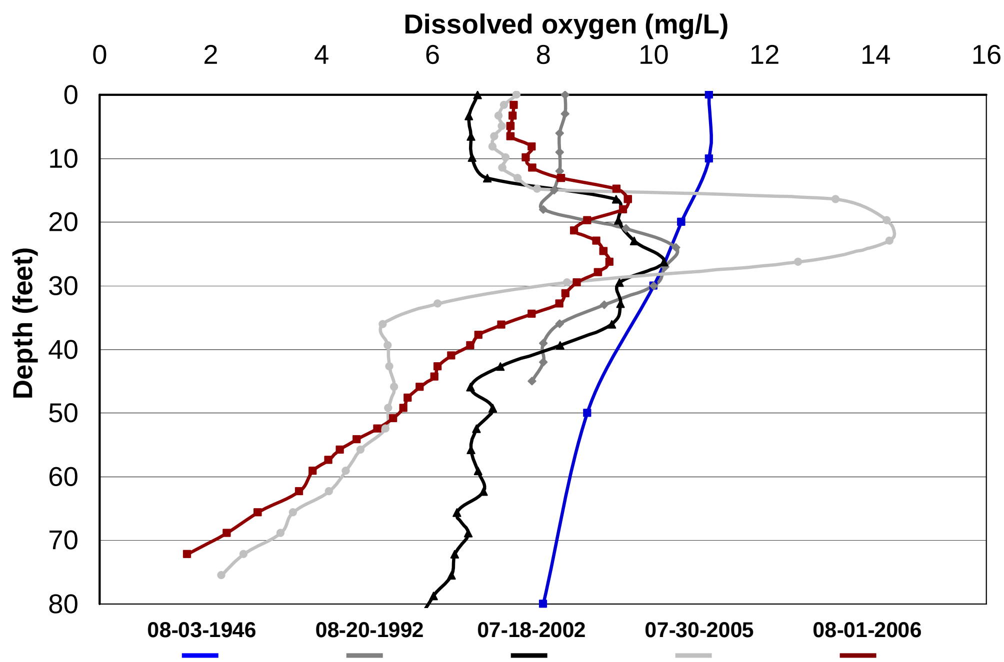


Figure 5. Silver Lake historic dissolved oxygen profiles.



We therefore conclude that despite previously expressed concerns about the temperature and dissolved oxygen conditions within Silver Lake, the lake still provides acceptable conditions to support cold-water fish species throughout the year – even during unusually warm summer conditions. For example, in 2006 we had an opportunity to survey lake thermal conditions on a date (August 1st, 2006) when heat advisories were issued throughout the northeastern United States. The air temperature on that date was approximately 100 ºF and the surface temperature of Silver Lake was the hottest ever documented (82.6 ºF). Nevertheless, the temperature and dissolved oxygen profiles collected that day showed that a large proportion of the water column (37 vertical feet) still provided suitable habitat for cold-water fishes (see Figures 6 and 7). These data suggest that despite extremely warm temperatures, Silver Lake can still support cold-water fish species due to the lake's tendency to develop stable conditions of thermal stratification.

Given the increasing public awareness of global climate change, we recommend that conditions of lake thermal stratification and levels of dissolved oxygen should be monitored within Silver Lake at a minimum of five-year intervals. Such ongoing evaluations will provide a measure of the extent to which changing air temperatures are influencing lake-habitat conditions within Silver Lake and other similar north temperate lake systems.

Figure 6. Silver Lake temperature profile on August 1st, 2006. This date represents the warmest documented surface temperature ever recorded from Silver Lake. Lake depths greater than 15 feet represent suitable habitat for cold-water fish species with respect to temperature.

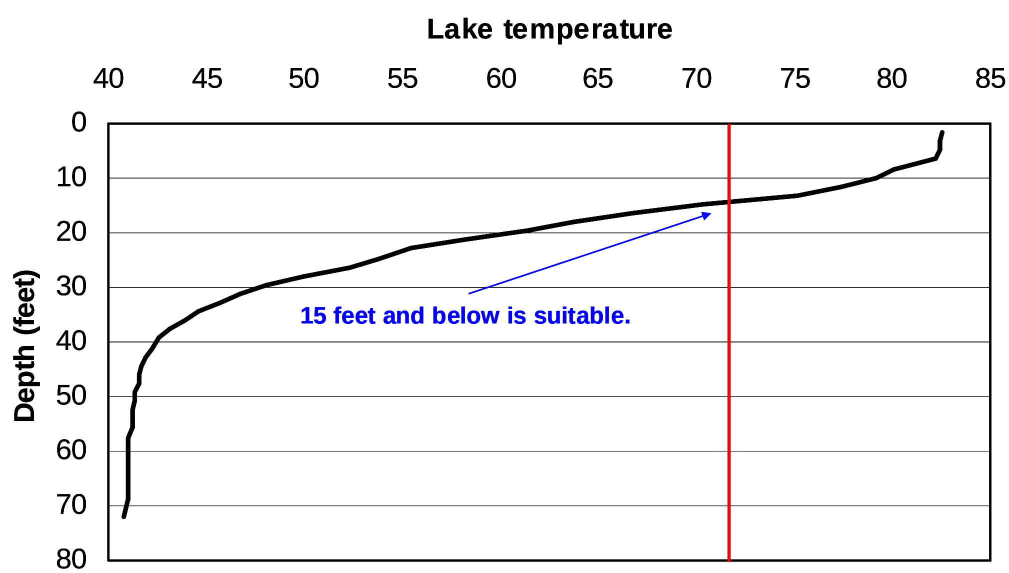
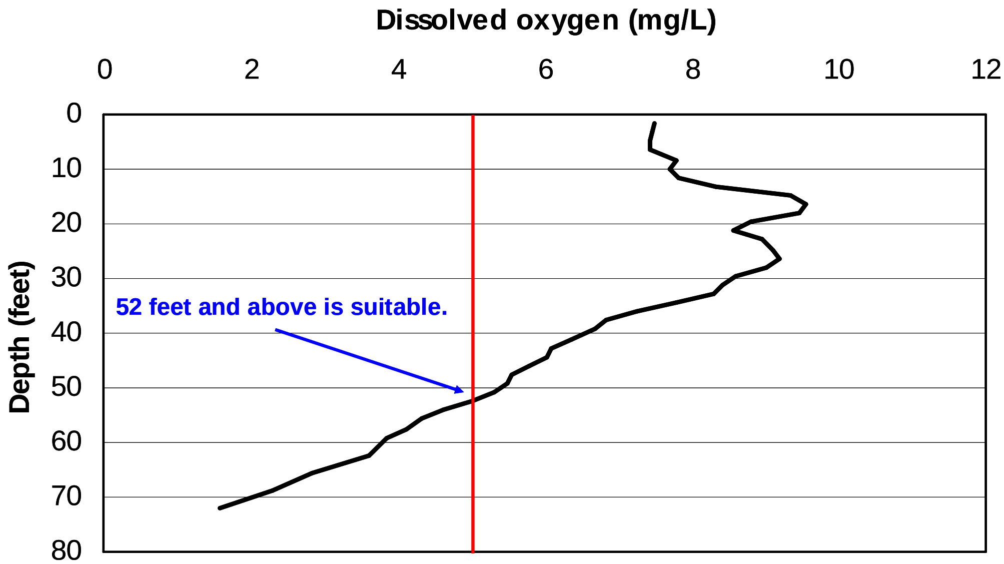


Figure 7. Silver Lake dissolved oxygen profile on August 1st, 2006: the date of the warmest documented surface temperature ever observed in Silver Lake. Lake depths shallower than 52 feet represent suitable habitat for cold-water fish species with respect to dissolved oxygen.



Littoral Zone:

Previous surveys in 2004 and 2005 indicated some cause for concern about the availability of forage fishes that could support the predator fish community within the nearshore environment of Silver Lake. To further evaluate this concern, baited minnow traps were placed within the littoral zone of Silver Lake on June 30th, 2006 in an attempt to capture prey fish and determine the availability of forage species. A single pumpkinseed sunfish was captured after approximately 20 hours of minnow trapping effort, supporting previous observations of limited forage fish availability. In contrast, abundant invertebrate prey items were collected at the same time within the littoral zone by overturning rocks, sifting through nearshore substrate and sampling submerged plants. These invertebrates included an abundance of snails, crayfish and the larvae and nymphs of mayflies, caddis flies, midges, dragonflies and damselflies. High invertebrate densities could explain how the Silver Lake littoral zone can support a healthy community of relatively fast growing fish, including largemouth bass, pumpkinseed sunfish, chain pickerel, yellow perch, brown bullhead and rock bass. It is also important to note that the large amount of natural wood and macrophyte growth within the nearshore zone of Silver Lake provides cover and substrate for invertebrates to feed and breed upon, as well as habitat within which juvenile fish can hide from larger predators.

Introduced Species:

A common problem within many natural ecosystems is the introduction of undesirable, non-native species. The negative impacts of these types of introductions can be far reaching and are often unforeseen. We have documented two such introductions within Silver Lake. Rock bass and alewife had not been observed within Silver Lake prior to 1992 when a survey conducted by the TETHYS Consultants, Inc. of Harrisburg, Pennsylvania first established the presence of both species.

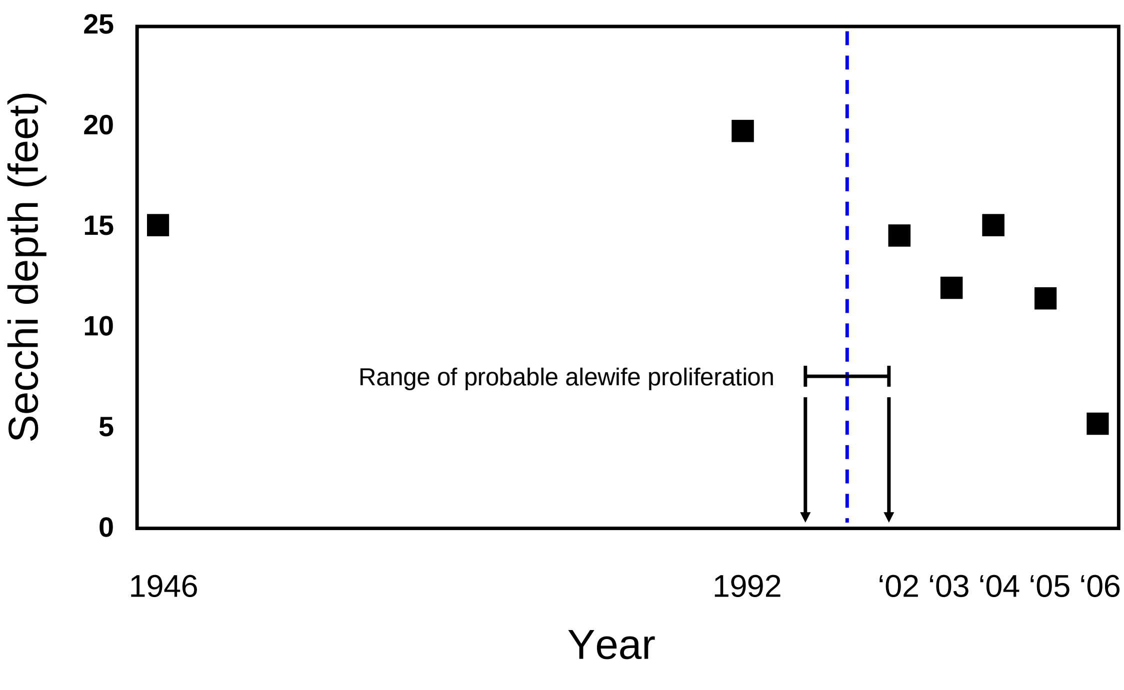
Cornell researchers captured several rock bass during 2006 surveys. The stomach contents of these fish contained many small fish, and even small rock bass – less than 6 inches in length – were piscivorous (i.e. fish were found in their stomachs). Rock bass have been regularly observed to reduce the recruitment of native fishes in other lakes by feeding upon the offspring of other fish and competing with native fish for food and spawning habitat. Rock bass are generally regarded as very effective at invading and dominating the littoral zone of lake systems. At the same time, rock bass offer excellent fishing opportunities for anglers because of their active tendency to feed, which leads to high catchability. They also often reach sizes larger than pumpkinseed sunfish – a related species native to Silver Lake – and are enjoyable to catch. On the other hand, pumpkinseed sunfish are considered to have a more palatable flavor and are preferred by most anglers interested in harvesting and consuming their catch. Eradication of rock bass is likely impossible, so this species is expected to remain a permanent addition within the Silver Lake fish community.

Alewife are the other non-native fish species found in Silver Lake that have been responsible for widespread negative impacts on lake ecosystems into which they have been introduced. These impacts include decreasing native fish abundance, altering food web dynamics and reducing water clarity. Alewife appear to have become the most abundant fish species within Silver Lake, based on visual observations and biological indicators. Alewife populations are known to fluctuate in other lakes, but at present these fish appear to be remaining at relatively high densities in Silver Lake.

The most consistent indication that alewife have become a dominant fish species in Silver Lake is the decrease in water clarity regularly observed since their presumed date of introduction. Alewife preferentially consume large zooplankton (small crustaceans known as Daphnia) that graze upon the phytoplankton responsible for algal blooms in lakes. When the density of phytoplankton increases in the water column of a lake, water clarity decreases due to reduced light penetration. These changes have occurred as a result of alewife introductions in small inland lakes throughout the northeastern United States and lakes as large as Lake Michigan (Sternberger and Miller 2003, Scavia et al. 1986).

Steadily decreasing water clarity has been observed in Silver Lake concurrent with the first observations of alewife in the lake. Water clarity has been regularly measured in Silver Lake with a secchi disk, a weighted disk 8 inches in diameter with four alternately colored black and white quarter portions. To measure water clarity, a secchi disk is lowered into the water column until it can no longer be seen. Measured secchi depths in Silver Lake have declined steadily since 1992 (see Figure 8), and this decline is likely the result of increasing alewife abundance. The mean body size of zooplankton in Silver Lake also provides a metric for determining whether alewife are responsible for decreased water clarity. Alewife reduce the abundance of large zooplankton, and a dominance of small-bodied zooplankton indicates that alewife are present (Sternberger and Miller 2003). Four horizontal zooplankton plankton tows (with a 153 micron mesh net) were taken on August 1st, 2006 and October 12th, 2006 in Silver Lake (two each date) and no large zooplankton were collected in the lake. Instead, the lake zooplankton community was dominated by small copepods. This strongly supports the idea that alewife have reduced the abundance of large-bodied zooplankton within Silver Lake, allowing phytoplankton to proliferate and thereby decrease water clarity. In considering this, it is important to note that Silver Lake phosphorus levels are low and have shown no apparent trend through time, therefore a trend of increasing algae abundance is unlikely to have resulted from increased nutrient inputs.

Figure 8. Silver Lake historic secchi depths. Points represent data collected on the nearest date to June 30th (to avoid seasonal differences). Data collected in 2006 were associated with a flooding event.



Following discussion of potential alewife impacts on Silver Lake water clarity with members of the E.L. Rose Conservancy and the Silver Lake Association, members from both organizations supported a recommendation to stock 150 brown trout and 150 rainbow trout in an attempt to reduce alewife abundance. Brown and rainbow trout are cold-water predators that feed upon alewife. A stocking density of approximately three trout per acre is standard for trout in lakes managed by the Pennsylvania Department of Environmental Protection, the New York Department of Environmental Conservation and the Maine Department of Inland Fisheries and Wildlife. Stocking took place on September 16th, 2006 at the north end of the lake, and stocked fish were approximately 12 and 11 inches in length (brown and rainbow trout, respectively).

We provide the following recommendation regarding an ongoing fish stocking advisory for Silver Lake:

Stocking Advisory:
Predation by salmonid fishes on alewife has been effective in decreasing alewife densities in many lakes, but at a significant financial cost. Neither brown nor rainbow trout are likely to be able to reproduce within Silver Lake due to the lack of appropriate spawning habitat, thus repeated stockings will likely be necessary. Although we generally advocate the re-establishment of native fish communities within lakes, stocking non-native species as a biological control agent can be an appropriate management action. Many trout introductions have occurred within Silver Lake in the past (an incomplete list of previous fish stocking efforts and associated costs is provided in Table 2). Given that trout stocking has repeatedly occurred within this lake, additional stocking will likely benefit the Silver Lake fishery by providing both an alewife control method and a catchable population of trout for anglers. Trout should be stocked at approximately fifteen inches in length to decrease predation by the pickerel and largemouth bass that are found in Silver Lake. Stocking multiple species of predators will provide opportunities to determine whether a particular species is more successful at surviving and feeding upon alewife, at which point the stocking program can be reassessed.

On October 12th, 2006, Cornell researchers conducted an angling survey on Silver Lake and caught two rainbow trout (see Figures 9 and 10). The fish appeared to be in good health with no visible injury or infection. A gastric lavage (i.e. non-lethal stomach pumping) procedure was used to identify prey consumed by these fish and showed that both trout had been recently consuming two-winged fly pupae. In addition, we observed that these and other trout were actively pursuing alewife-imitation lures, indicating that these recently stocked fish were feeding successfully in their new environment. We recommend that water clarity be regularly monitored in Silver Lake and that anglers should maintain annual records of the number and variety of trout captured. Ideally, the stomach contents of these trout should be identified in order to establish whether they are effectively preying upon alewife. Without such information, it will be difficult to determine whether an intermittent stocking program can effectively control the lake's alewife population.

Table 2. Trout stocking in Silver Lake, incomplete list. List provided by Gerry O'Neil.

DATE	YEAR	Fish	Quantity	MaxLength	Total Cost	Cost / Fish
6/11/1959	1959	Rainbow Trout	4	19	$66.25	$16.56
6/11/1959	1959	Rainbow Trout	100	12	$125.00	$1.25
6/11/1959	1959	Rainbow Trout	25	16	$58.75	$2.35
11/1/1971	1971	Rainbow Trout	100	10	$68.20	$0.68
11/1/1971	1971	Rainbow Trout	300	10	$165.00	$0.55
11/15/1974	1974	Rainbow Trout	150	9	$97.50	$0.65
11/15/1974	1974	Rainbow Trout	80	10	$64.00	$0.80
11/15/1974	1974	Golden Trout	25	9	$38.50	$1.54
12/12/1976	1976	Rainbow Trout	450	9	$326.00	$0.72
11/29/1978	1978	Brook Trout	200	9	$200.00	$1.00
11/29/1978	1978	Rainbow Trout	100	9	$117.50	$1.18
10/21/1979	1979	Rainbow Trout	300	12	$464.82	$1.55
10/26/1981	1981	Rainbow Trout	200	11	$387.05	$1.94
10/10/1982	1982	Brown Trout	100	7	$100.00	$1.00
10/10/1982	1982	Rainbow Trout	150	11	$277.50	$1.85
10/10/1982	1982	Rainbow Trout	150	7	$127.50	$0.85
10/10/1982	1982	Brook Trout	100	7	$85.00	$0.85
10/10/1982	1982	Brown Trout	100	7	$100.00	$1.00
11/25/1984	1984	Brown Trout	50	12	$0.00	$0.00
11/25/1984	1984	Rainbow Trout	100	12	$0.00	$0.00
12/7/1986	1986	Rainbow Trout	300	11	$525.00	$1.75
12/7/1986	1986	Brown Trout	25	8	$44.75	$1.79
1/1/1991	1991	Rainbow Trout	200	12	$420.00	$2.10
1/1/1995	1995	Rainbow Trout	85	15	$250.50	$2.95
1/1/1995	1995	Rainbow Trout	200	12	$550.00	$2.75
10/6/1996	1996	Brown Trout	125	14	$340.00	$2.72
10/6/1996	1996	Rainbow Trout	200	14	$500.00	$2.50
11/2/2002	2002	Golden Trout	120	10	$193.50	$1.61
11/2/2002	2002	Kamloop Trout	119	10	$193.50	$1.63
9/6/2003	2003	Rainbow Trout	100	10	$193.95	$1.94
9/6/2003	2003	Golden Trout	100	8	$193.95	$1.94

Figure 9. Cornell graduate student Jesse Lepak with a Silver Lake rainbow trout caught on October 12th, 2006.

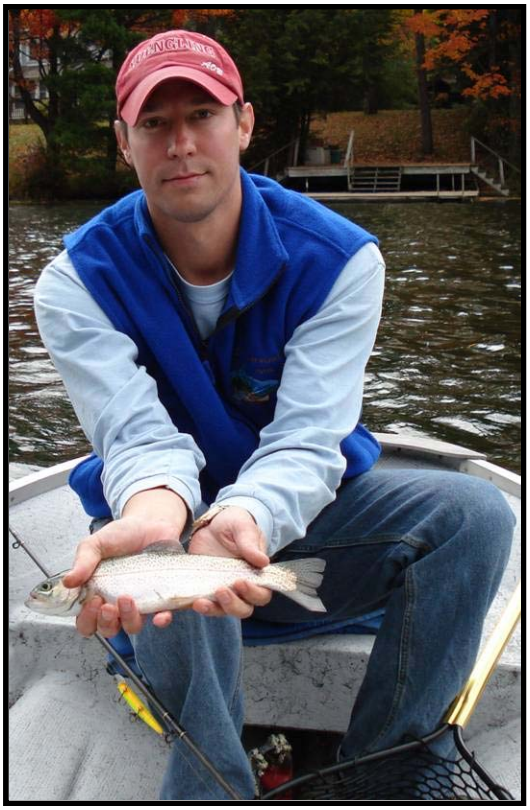


Figure 10. Cornell graduate student Jason Robinson with a Silver Lake rainbow trout caught on October 12th, 2006.

Mercury Contamination:

Mercury contamination is prevalent in fish throughout the United States and is a serious concern to human health. Although mercury contamination in fish has been recognized throughout the eastern U.S., this issue became a more immediate concern for Silver Lake residents after the PADEP evaluated the mercury content of a single largemouth bass from Silver Lake in 2004 and found higher than desirable levels (A. Frey, 2005, personal correspondence). In response to this finding, Cornell researchers collected eight fish commonly caught by anglers in Silver Lake and had them tested for mercury contamination. One large and one small specimen each of largemouth bass, pumpkinseed sunfish, yellow perch and rock bass were collected and tested. These fish were aged using their otoliths – calcified structures found in the skulls of fish that are similar to human inner ear bones – by counting annual growth rings. Mercury concentrations within several of these fish fell within the recommended range for restricted consumption in the mercury health advisory issued by the Pennsylvania Division of Water Quality Assessment and Standards (see Tables 3 and 4). After these results were obtained, an advisory letter was provided to the Silver Lake Association (see Appendix B).

The issue of mercury contamination within Silver Lake should be regularly assessed in the future, and anglers should follow guidelines provided by the State of Pennsylvania fish consumption advisory. To minimize the risk of mercury contamination, most consumption advisories recommend that anglers consume fish of shorter lengths and younger ages. These fish tend to be lower in mercury contamination relative to other fish. Contact the Pennsylvania Division of Water Quality Assessment and Standards for updated information regarding mercury contamination.

Species	Length (inches)	Age	Sex	Mercury (ppm)
Largemouth bass	16 and 5/16	5	Male	1.27
Largemouth bass	12	3	Male	0.23
Rock bass	10 and 1/8	4	Female	0.44
Rock bass	8 and 3/8	3	Male	0.24
Yellow perch	11	4	Male	0.11
Yellow perch	6 and 7/8	3	Immature	0.06
Pumpkinseed sunfish	7 and 1/2	3	Male	0.06
Pumpkinseed sunfish	6 and 1/4	3	Immature	0.02

Table 3. Mercury content of Silver Lake fish captured on June 30th, 2006. Mercury content is shown in parts per million.

MERCURY ADVISORY GROUPS
Based on EPA 9/99 Fact Sheet

ADVICE	Mercury (ppm)
Unrestricted	0 – 0.12
One meal/week	0.13 – 0.25
Two meals/month	0.26 – 0.50
1 meal/month	0.51 – 1.0
6 meals/year	1.1 – 1.90
Do Not Eat	>1.9

Table 4. Mercury advisory values and consumption recommendations issued by the Pennsylvania Division of Water Quality Assessment and Standards. Aaron Frey of the Pennsylvania Division of Water Quality Assessment and Standards provided this information.

Conclusions and Recommendations:

Silver Lake currently sustains exceptional water quality, and efforts to minimize inputs of nutrients and pollutants to the lake should be continued in the future. Periodic monitoring of Silver Lake total phosphorus, chloride, alkalinity, pH, water temperature and dissolved oxygen should be conducted in order to characterize any changes that may occur through time. Maintaining the undeveloped shoreline along the west shore of the lake and the large amount of wood present along that shoreline is important to supporting native fish populations by providing habitat for forage and refuge. High densities of invertebrates in the littoral zone can also be attributed in part to the limited development of the Silver Lake shoreline and can be maintained by preserving the integrity of the lake shoreline.

Recent assessments of the impacts of non-native rock bass and alewife within the Silver Lake ecosystem suggest that both species have had a negative influence upon native fishes within the lake. Unfortunately, both rock bass and alewife are difficult if not impossible to eradicate, so management strategies should be developed that will reduce the impact of these species upon other favorable attributes of Silver Lake. For example, the development and improvement of a stocking program designed to control the alewife population provides an opportunity to limit some of the negative impacts of alewife on Silver Lake water quality. The success of stocking efforts should be evaluated with periodic fish and water quality surveys, and additional introductions of undesirable non-native fish species should not be considered.

Finally, mercury contamination of fish has become ubiquitous in lakes and rivers throughout the United States due to atmospheric deposition. Even relatively pristine systems are susceptible to mercury deposition and as such, precautions should be taken to avoid consumption of fish with elevated mercury concentrations. Some of the larger piscivorous fishes tested from Silver Lake fell within the consumption advisory limits of the Pennsylvania Division of Water Quality Assessment and Standards. Anglers who harvest and consume these species of fish should follow recommendations provided by these advisories.

Silver Lake represents a valuable resource with exceptional water quality and a complex fish community that offers excellent opportunities for anglers. The efforts of the E.L. Rose Conservancy and the stewardship of watershed residents have provided an opportunity to better understand the Silver Lake ecosystem. This understanding has contributed to new initiatives to protect and improve Silver Lake by maintaining water quality and remediating the negative impacts of introduced species. The future of Silver Lake is bright due to the attention and emphasis that local residents have placed on preserving the integrity of this environmental resource.

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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.

Appendix B:

Advisory Letter:

August 10th 2006
Prepared by Jesse Lepak
Department of Natural Resources
Cornell University

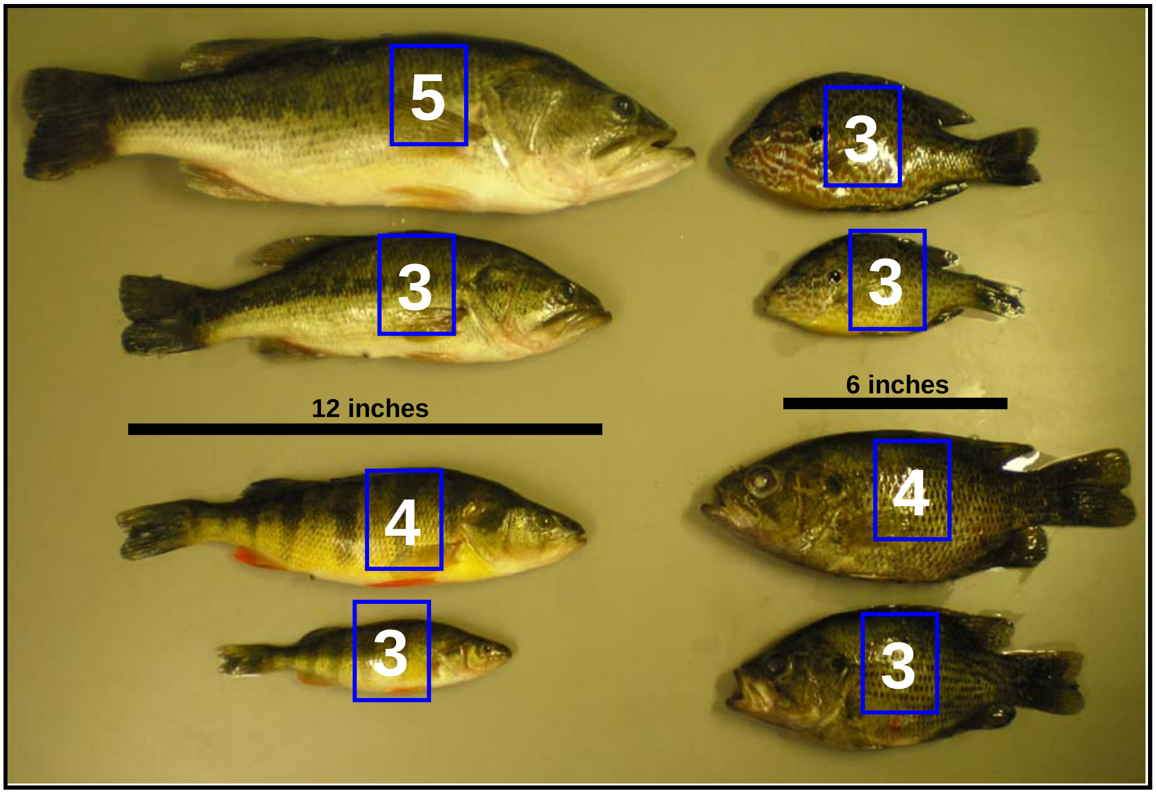
To the Silver Lake, Lake Association,

Fisheries related recommendations for Silver Lake:

This summer, several issues were made apparent regarding the Silver Lake fishery through a study effort conducted by Cornell University researchers. These concerns were discussed briefly at a meeting held on July 29th 2006. After recently receiving data confirming some of these concerns, several recommendations/requests are being put forth in this newsletter to be made available to those with access to the Silver Lake fishery and most importantly those involved in the Lake Association.

1) Cornell researchers have received data regarding eight fish samples that were sent to evaluate mercury concentrations in fish from Silver Lake. As we are not physicians we feel obligated to provide the data associated with the Silver Lake fish as well as the mercury health advisory from the Pennsylvania Division of Water Quality Assessment and Standards (graciously provided by Aaron Frey of the Pennsylvania Division of Water Quality Assessment and Standards). Please note that the advisory groups are based on scale-less, skin on fillets and the Silver Lake fish were tested without skin or scales. The data are provided below:

Species	Length (inches)	Age	Sex	Mercury (ppm)
Largemouth bass	16 and 5/16	5	Male	1.27
Largemouth bass	12	3	Male	0.23
Rock bass	10 and 1/8	4	Female	0.44
Rock bass	8 and 3/8	3	Male	0.24
Yellow perch	11	4	Male	0.11
Yellow perch	6 and 7/8	3	Immature	0.06
Pumpkinseed sunfish	7 and 1/2	3	Male	0.06
Pumpkinseed sunfish	6 and 1/4	3	Immature	0.02



MERCURY ADVISORY GROUPS
Based on EPA 9/99 Fact Sheet

ADVICE	Mercury (ppm)
Unrestricted	0 – 0.12
One meal/week	0.13 – 0.25
Two meals/month	0.26 – 0.50
1 meal/month	0.51 – 1.0
6 meals/year	1.1 – 1.90
Do Not Eat	>1.9

2) A management strategy of removing rock bass from the Silver Lake fishery due to its status as an invasive, non-native species to improve the native fishery was mentioned at the July 29th meeting. Although encouraging anglers to remove rock bass would likely not harm the fishery, the scale of removal that would be necessary to make a significant impact will likely not be achieved given the limited number of anglers and harvest. A thorough and labor intensive effort would be necessary to have any effect on the rock bass population in Silver Lake. An effort such as this would require an appropriate disposal program so as not to attract unwanted wildlife or create any unsanitary conditions. If anglers choose to remove rock bass on their own accord they should be disposed of properly and the Pennsylvania Department of Environmental Protection harvest regulations as they apply to rock bass should be observed at all times.

3) A discussion following the July 29th meeting regarding the catch, harvest and processing of any trout species taken from Silver Lake provided the opportunity for Cornell researchers to extend an invitation to any angler that is comfortable, to save and freeze (in a plastic bag labeled with the date of capture) the head and stomach of any trout harvested. These samples would be picked up by Cornell researchers as soon as possible and would remain perfectly preserved once frozen. This only applies to anglers who intend to keep these fish for their own personal consumption. Cornell researchers do not want to encourage the over-harvest of any trout species, but this harvest and donation practice would be appreciated and would provide additional samples to be analyzed for stomach contents and mercury levels while avoiding unnecessary scientific sampling or bycatch.