# A BIOLOGICAL SURVEY OF

# SILVER LAKE

by

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INTRODUCTION

Silver Lake is located in Susquehanna County, lies at an elevation of 1728 feet above sea level and has an area of about 120 acres. It is a deep, cool-water lake with no contributing streams. It is a natural lake and is fed largely from bottom springs which must be rather large judging from the amount of flow of the lake outlet. The rise and fall of water level is slight and probably is caused as much by the rise and fall of the water table of the surrounding region as by change in rate of flow of the contributing springs or by any surface drainage which may enter the lake during heavy storms. The slopes surrounding the lake are in main heavily forested with mixed hard and soft woods and the forest floor has a heavy layer of humus. This condition must keep surface drainage to a minimum.

The exposed rock of this region is primarily a Devonian sandstone of the Catskill formation. This rock is very low in soluble mineral content, in fact, it is for this reason that over most of northeastern Pennsylvania an excellent grade of clear, soft, drinking water is available.

The lack of silt and debris from tributary streams, the lack of any appreciable amount of surface drainage into the lake and the soft, mineral-free character of the water from the contributing springs all tend to produce a lake with very clear, clean water and with a rather sparse growth of vegetation. The only visible source of replenishment of the mineral content of the waters of the lake is from slow decay of large trees which occasionally fall into the lake from the surrounding banks.

## HISTORY

The angling success in this lake as well as the fish plantings present a varied and somewhat confused picture. According to members of the Association, lake trout were at one time fairly common - the last one being taken about 15 years ago. It is believed also that land-locked salmon and cut-throat trout were planted in the past. Neither of these species has ever been taken by angling. Pike perch (wall-eyed pike) were planted in 1945 with no apparent results. Plantings of the past few years were:

| | | |
|---|---|---|
| 1942 - | 10,000 | small-mouth bass ? (Georgia) |
| 1943 - | 16,000 | large-mouth bass (3" - 4") |
| 1943 - | 4,000 | bluegill sunfish (1") |
| 1944 - | 100 | large-mouth bass (4" - 6") |
| 1945 - | ? | pike perch (20" - 22") |

Success of the angling effort has been expressed as follows:

Small-mouth bass - good five years ago, poor now.
Large-mouth bass - only a few reported caught.
Pickerel - fairly good in past, only about 10 this year.
Yellow perch - fewer catches than in past - fish average smaller.
Eels - fairly common in past - only few now.
Bullheads - probably produce better fishing results than any other species at present time.

## PHYSICAL CONDITIONS

Color and visibility. The color of the water of Silver Lake may be termed "white". The average of Secchi disc readings showed a visibility of 15 feet. This extreme clearness of the water, although it has a beautiful appearance and is fine for swimming, is generally not the type in which maximum fish production is obtained. The reasons for this will be pointed out later.

Type of bottom. An Eckman dredge was used to determine the nature of the bottom. In the deeper areas the bottom was composed of mud with some clay and traces of sand. In shallower waters the bottom was much the same with perhaps a little more sand. This type of bottom represents a relatively stable (not putrescent) condition and one which is poor in suspended detritus and organic materials. It furthermore explains why oxygen relations near the bottom are so high.

Depths and temperatures. A map showing depth contours had already been prepared by members of the Association. The findings of the writers checked very well with the map. The greatest depth found was 88 feet. A considerable portion of the lake is greater than 40 feet in depth. Because of these depths there occur in this lake, in the summer, three distinct layers of water. The uppermost layer (epilimnion) extends from the surface down to about 15 feet, the middle layer (thermocline) from 15 to 30 feet, and the lower layer (hypolimnion) from 30 feet to the bottom. The extent of these three layers is determined by taking temperatures at various levels. In general the upper layer represents warmer, lighter water which is mixed by wind action and has a fairly uniform temperature. The middle layer shows increasingly colder temperatures as greater depths are reached. Because this layer is heavier than the one above, it is not mixed by the wind and thus presents thermal stratification. The deepest layer is cold but nearly uniformly so, there being no rapid drop in temperature as greater depths are reached. The water in this layer is the coldest found in the lake and because it is the heaviest, there is no mixing of this water with water of the higher levels in summer. The table below shows the approximate extent of each of these layers as determined by depth and temperature readings.

| Depth in feet | Temperature °F. | |
|---|---|---|
| 0 (surface) | 72.5 | |
| 5 | 72.0 | epilimnion |
| 10 | 71.0 | |
| 15 | 70.0 | |
| 20 | 59.0 | |
| 25 | 55.0 | thermocline |
| 30 | 50.0 | |
| 40 | 48.0 | |
| 50 | 48.0 | |
| 60 | 48.0 | hypolimnion |
| 70 | 48.0 | |
| 80 | 48.0 | |

These three layers of water are present, more or less as described above, until late fall. At this time colder air temperatures cool the surface waters. These cooling (and heavier) surface waters sink and are replaced by warmer (and lighter) waters. The whole process is repeated until, theoretically, the entire lake has attained the same temperature from top to bottom. This period is known as the fall overturn. Because of the circulation of the water during this period and the low temperature, the water picks up a maximum load of dissolved oxygen. Due to this supply of oxygen the lake waters are able to maintain life during the winter even beneath the ice.

As the ice melts in the spring, convection currents are again set up and the whole lake once more becomes uniform in temperature. This is the spring overturn and at this period the lake again takes on a supply of dissolved oxygen. During summer the thermocline is established as mentioned above.

This annual cycle, as found in lakes of this depth, is of considerable biological importance. Both the summer and winter periods may be considered stagnation periods. During summer the thermocline effectively "locks" the lower waters so there can be no direct circulation. During winter the lake is locked beneath the ice. In many deep lakes during both summer and winter there is frequently an almost complete lack of dissolved oxygen in deeper waters. This is especially true when large amounts of decaying organic materials are present. It is because of this lack of dissolved oxygen that the deep waters of some lakes are uninhabitable by fish during the summer stagnation period, and that suffocation beneath the ice sometimes occurs during winter.

It will be gratifying to the members of the Association to learn that dissolved oxygen conditions in Silver Lake during summer are very good even in the deepest areas (see Chemical Conditions). This means, presumably, that the entire lake can be utilized by fishes during the summer stagnation. It seems quite likely that the same is true during winter stagnation.

Another factor is of importance in dealing with the depth of the lake. Waters deeper than 50 feet produce relatively small amounts of food. In fact it is the most shallow waters - probably less than 25 feet - which are the major food producers. The food-production area of Silver Lake is rather limited. It is obvious, therefore, that while the entire lake is suitable for holding certain species of fish, a limited area only can be relied on to produce food for fish. This is one of the most significant problems of Silver Lake.

## CHEMICAL RELATIONS

One of the prime requirements for fish life is sufficient dissolved oxygen. The amount of this gas in the water is affected by temperature, agitation of the surface, the presence of green plants and the amount of decaying material in the water. Normally, cold water carries more dissolved oxygen than does warmer water, agitation by the wind adds oxygen to the water, green plants in the presence of sunlight give off oxygen to the water and oxygen is consumed by the decomposition of organic material and by animal respiration.

A series of water samples were taken for the purpose of determining the amount of dissolved oxygen. In general it may be stated that any value above five parts per million is suitable for fish life. Results of analysis of samples from the surface to the bottom in the deepest area are given below:

| Depth in feet | Dissolved oxygen (parts per million) |
|---|---|
| 0 (surface) | 11.0 |
| 10 | 11.0 |
| 20 | 10.5 |
| 30 | 10.0 |
| 50 | 8.8 |
| 80 | 8.0 |

In addition analyses were made from samples collected at various other points on the lake. Results were similiar to those above. It is thus apparent that oxygen conditions are suitable throughout the lake during the summer. As explained before, these good conditions are due probably to the lack of any appreciable amount of decaying organic material in the lake.

Tests were made for free carbon dioxide in the water. The true effects of this gas are not well understood since high carbon dioxide is frequently accompanied by low oxygen. At no place sampled on the lake was there an excessive amount of free carbon dioxide. The highest reading found was 6.4 parts per million. Values as low as 1.6 parts per million were found. These values are known to be satisfactory.

Colorimetric tests were used to determine the hydrogen-ion (pH) concentration of the water. A rather constant reading of pH = 6.7 was found. This is slightly acid.

It can be safely stated that gaseous relations are satisfactory in Silver Lake in the summer and they probably present no problem during any period of the year.

## VEGETATION

The vegetation of the lake, as would be expected, is rather sparse and slow of growth. Filamentous algae appear in some abundance about any submerged tree trunks or brush. In water from about 30 to 45 feet in depth a rather abundant growth of a small species of Fontinalis occurs. This is a fine moss-like plant making a matted growth three or four inches high on the bottom.

In shallow water (4 to 10 feet) there are occasional beds of *Potamogeton natans*, common spatterdock *Nymphaea advena*, white water lily *Castalia tuberosa* and a small amount of *Myriophyllum* and *Elodea*. At no place is the vegetation thick enough to produce much protective cover for young fish. Emergent vegetation along the shores of the lake is represented by an aquatic sedge *Dulichium arundinaceum* which is rather abundant, a few patches of pickerel weed *Pontederia cordata* and a few of American bur reed, *Sparganium americanum*.

The deep hole (50 to 100 feet) in the center of the lake is practically free of vegetation due to the lack of sunlight.

The functions of vegetation in the lake may be listed as follows:

1. Provide cover for the young of some species of game fish

as perch, pickerel and large mouth bass and the young of species of forage fish if they can be successfully introduced. The fallen trees and brush along the shores of part of the lake fill this function to some extent.

2. Dead and living parts of plants produce food for small organisms such as protozoans, crustaceans and insects which in turn serve as food for small fish.

3. Weed beds produce favorable spawning sites for perch and pickerel. Also if forage fish are introduced as food for bass and pickerel, it may be a species which prefers weed beds for spawning.

It would be of value to encourage aquatic vegetation in this lake. Brush shelters spaced around the lake in the shallow areas might also be valuable.

## FISH PRESENT AND THEIR ABUNDANCE

Considerable time was spent in patrolling by boat and seining in the shallow waters to determine the abundance of the various species of fish present in the lake. In such clear water fish were frightened by both the net and the boat. However, it is felt that a fair indication of the fishes present was obtained by these methods and by still fishing.

Common sunfish, *Lepomis gibbosus* were observed more frequently than any other species. This was perhaps due to the fact that this species inhabits shallow waters where it is readily seen. None of the young of this year were seen. No blue gill sunfish of any size were seen.

Yellow perch, *Perca flavescens* are considered as being common in the lake. Several were taken by angling and numerous schools of this year's young were seen.

Common bullheads, Ameiurus nebulosis were taken by angling. This species is probably not as common as the perch. No young were seen although young were reported as seen earlier in the summer.

Large-mouth bass, Huro salmoides are perhaps the most abundant of the larger game fish found in the lake. Only a few of this species have been taken by angling this year. However, inspection of the shallows along the wooded shore showed at least 24 nests, probably largely belonging to this species. The largemouth bass is one of the very few species in the lake which is producing young successfully. More young of this species were seen than of any other species excepting yellow perch.

The pickerel must be disappearing from the lake. None were seen although they are normally fairly easy to observe. It is possible that, if proper food relations were established, the pickerel might again produce good fishing.

It cannot be truthfully stated that other game species such as lake trout, cut-throat trout and pike perch have entirely disappeared from the lake. However, it can be logically assumed that, if present at all their numbers are so small as to be of little importance.

Conspicuously absent from the lake were minnows of any kind. This is a definite obstacle to the maximum production of game fish in Silver Lake.

## SPAWNING AREAS

Certain of the shoal areas are well suited to the spawning of large-mouth bass. It is the male of this species which scours out the nest, and guards both eggs and young.

Perch probably spawn near the weed beds in the shallow areas. They do not make nests. Perch guard neither the eggs nor the young, but desert their eggs after hanging them in strings on submerged vegetation.

Nesting sites for sunfish are prevalent along the shores in shallow water. This species excavates a nest and guards it to some extent.

Bullheads spawn on the bottom and the parent guards the eggs as well as the young for a time.

Typically the pike perch is a stream spawning species. Therefore it should not be planted in lakes with no inlets, such as Silver Lake. Occasionally this species spawns in lakes but it is not known with what success. Ultimately this species should disappear from the lake if it has not already done so.

Lake trout spawn on shoals usually deeper than 15 feet. Such shoals are numerous in Silver Lake.

It is apparent that spawning areas are available for the species present in the lake. A major consideration, then, is not where can the fish spawn, but what happens to the young after hatching.

## THE FOOD PROBLEM

Probably no factor affecting fish life is less appreciated by the average angler than that of food. The amount of food and hence fish in a body of water depends, basically, upon the fertilizing elements in the water such as nitrogen, phosphorous and potassium. These elements may reach the water from the surrounding land, through decomposition of organic material in the water or, as practised in certain small waters, by artificial fertilization.

When the necessary fertilizers are present in the proper amounts, they produce enormous quantities of plankton (tiny, free-floating plants and animals). Plankton serve as food for all young fishes and for insects which in turn are eaten by large fishes.

In order for any species of fish to reach maturity there must be sufficient food of the proper types present at all times. The case of the large-mouth bass may be used as an illustration. This species requires plankton organisms as its first food. During the first summer it passes gradually from this plankton-feeding stage to one in which the diet consists of fishes smaller than itself. For the rest of its days the bass feeds almost exclusively on various species of fishes. If plankton is not available, the young bass will starve before reaching the fish-eating stage. If forage fish are not available the bass resorts to cannibalism. This results in only a few large bass which might be readily depleted by angling.

The name of this lake is significant for "Silver Lake" denotes clear, sparkling water. Such clear water is not usually the type which produces large amounts of plankton and studies at the lake showed this to be true.

Insect life was found to be more plentiful than was at first supposed. At nearly every place where bottom samples were taken, a plentiful supply of the tubes of midge larvae was found. The young of many species of fishes as well as some adults feed extensively on this insect larva. Nymphs of dragon flies were fairly common in the shallow weedy areas. One of the larger burrowing mayflies is quite abundant in the lake and probably serves as an important food item. Many cast skins of nymphs of this form were found scattered over the surface. The fishes collected were opened and the contents of the stomachs analyzed. All of the insect organisms mentioned above were found in stomachs.

A forage fish may be defined as any fish which may serve as food for a larger, carnivorous fish. There is a definite lack of forage fish in Silver Lake. None of the various species of minnows which usually serve this purpose were observed.

Large-mouth bass seem to be the predominating carnivorous species of fish present. One can only speculate on what forage fish serve as food for adult bass. So far as can be seen, bass must utilize perch, sunfish and bass for food. At present the numbers of these three do not seem to warrant a large population of adult bass. If lake trout and pike perch are also present, this aggravates the food situation since both of these species are carnivorous as adults. Undoubtedly bass eat each other in this lake, which can account for poor results of plantings. The lack of young sunfish in the lake is evidence that they have been eaten--probably by bass or perch.

In summing up the food situation in this lake the following points seem reasonable. The lake is not naturally a fertile one and hence does not support a heavy growth of plankton. The amount of plankton present may be called good, however, for this type of lake. At present predation and cannibalism are so high in the lake that no single species has an opportunity to produce any appreciable number of catchable fish. There can be no hope of supporting a large population of any one or several carnivorous species until the supply of forage fish is raised considerably. To stock more carnivorous fishes under present conditions would be wasted effort. The first step toward producing good angling in Silver Lake is the introduction of one or more suitable species of forage fish.

## GROWTH

A collection of fish scales was made and then examined by microscope to determine the ages of various species at known lengths. Unfortunately the number of specimens taken was so small that a clear picture of growth could not be obtained for any species. From the limited data it appears that yellow perch require 3 or 4 years to reach 7 inches, 6 or 7 years to reach 9 inches and 9 or 10 years to reach 11 inches. Common sunfish require 3 or 4 years to reach 5 inches and 5 or 6 years to reach 6.5 inches. Large-mouth bass can attain a length of 14.5 inches in 4 to 5 years.

The growth of the species studied in this lake is only fair. In the case of yellow perch there is at least an indication that growth is slow after 4 years. Thus while a limited population may obtain a fair growth here, a heavy population probably could not under the present conditions. The lake has seemingly struck a balance between the number of carnivorous fishes and their food. As long as the food supply is as it is now there would perhaps never be a much heavier population of carnivorous fishes.

## CONCLUSIONS

As a result of the survey the following conclusions seem justified:

1. This is a cool, deep lake. Very little surface water enters the lake. The source is almost entirely from bottom springs.

2. A thermocline exists in the lake in summer but presents no problem as far as oxygen deficiency is concerned. Gaseous relations are excellent. This is due to the lack of any considerable amount of decaying organic material. Even the deepest waters can

be utilized by the deep-dwelling species of fishes.

3. The bottom slopes so rapidly that only a relatively small area of shallow water exists. This limits the production of rooted aquatic vegetation.

4. Plankton production is only fair and could probably be increased by fertilization in the shallow areas. Insects of various species are fairly common and serve as food for such fish as sunfish, perch and bullheads. Extreme food competition exists among adult carnivorous fishes and these species must be feeding upon each other. The lack of forage fish constitutes the major limiting factor to the production of game fish in the lake.

5. Spawning areas seem suitable for the species of fishes it is desired to maintain.

## RECOMMENDATIONS

The following recommendations are preliminary in nature. When they have been met a further examination of the lake should be made - at least of the food supply. Once food conditions are suitable it will be time to consider the introduction of game species.

1. No further plantings of game fish should be made for a period of two years or until a suitable food supply has been established in the lake.

2. The plankton production of the lake can probably be increased by fertilizing. Results from fertilizing in lakes are less well known than in smaller ponds. Although the writers cannot guarantee results from fertilizing the lake, it is their opinion that it would be of considerable value. Only the shallow areas should be fertilized. The procedure to be used may be obtained