Shafer Lake

Van Buren County, T3S, R15W, S19
St. Joseph River watershed, 2010

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Environment

Shafer Lake is an 81-acre natural lake located immediately south of I-94 between the towns of Lawrence and Hartford. The long-axis of the lake is oriented north-to-south, with a length of 0.7 miles and an average width of about 0.2 miles. The shoreline development index (which relates shoreline length to a lake's surface area) for Shafer Lake is 1.50 (Orth 1983). The lake consists of a single basin with a maximum depth of 72 ft. Drop-offs generally are steep, and only 29% of the lake (by surface area) is less than 20 ft deep (Figure 1). Sandy substrates are common along the northern and eastern shorelines, whereas organic substrates predominate in offshore areas and along the western shoreline.

A short, unnamed stream flows into the southern end of Shafer Lake. Water exits this system via the outlet at the northeast corner of the lake and flows approximately 4 miles to the confluence with the Paw Paw River. A low-head dam on the outlet is used to maintain the summer legal lake level of 731.29 ft above sea level.

Shafer Lake is a kettle lake surrounded by end moraines of coarse-textured till. This material is relatively porous, and groundwater is delivered to Shafer Lake by numerous springs. Agriculture (row crops and orchards) and forests are the predominant land uses in the watershed (Figure 2). There is considerable residential and vacation home development along the shoreline. The 2010 habitat survey revealed a dwelling density of 41.5 dwellings/mile (25.8 dwellings/km). Approximately 28% of the shoreline is armored with seawalls or riprap. Large woody structure is scarce, especially along the eastern shoreline where dwelling density is highest. The Michigan Department of Natural Resources (MDNR) boat launch on the southwest corner provides public access to Shafer Lake.

Limnological sampling was conducted near the deepest point in Shafer Lake on August 18, 2010. As expected, the lake was thermally stratified (Figure 3). The epilimnion extended from the surface to a depth of 12 ft. The water temperature was about 80.5 F throughout the epilimnion. The metalimnion (zone of thermal change) extended from 12 ft to 39 ft. Water tempertures declined from 80.5 F at the top to 42.5 F at the bottom of the metalimnion. The cold waters of the hypolimnion extended from 39 ft to the bottom of the lake. The oxygen distribution within Shafer Lake followed a positive heterograde curve, with the highest dissolved oxygen concentrations occuring in the metalimnion (Figure 3). Oxygen supersaturation within the metalimnion is not uncommon, and typically is caused by blooms of stenothermal algae that are adapted to growing well at low temperatures and low light intensities (e.g., Oscillatoria; Wetzel 1983). The dissolved oxygen concentration remained above 3 ppm to a depth of 24 ft. The total alkalinity was 124 mg/L, which is indicative of a hardwater lake with substantial buffering capacity. This conclusion is supported by the slightly alkaline pH values (8.45-8.47) observed in the epilimnion.

The biological productivity of a lake is strongly dependent on its supply of two key nutrients: phosphorus and nitrogen. The ratio of total nitrogen to phosphorus was 38:1 in Shafer Lake in 2010, so

it appears that phosphorus is the limiting nutrient in this system. The total phosphorus concentration was 0.0087 mg/L. The chlorophyll a concentration, which provides an index of algal biomass, was 0.002 mg/L. The phosphorus concentration and Secchi disk depth (15.5 ft) were indicative of an oligotrophic system, whereas the chlorophyll a concentration was more typical of eutrophic lake (Carlson and Simpson 1996). Taken together, the water quality data suggest that Shafer Lake is best classified as a mesotrophic (moderately productive) lake.

Recent quantitative data regarding the abundance and distribution of aquatic plants in Shafer Lake are not available. The Michigan Department of Environmental Quality did not issue any permits for herbicide treatments in this lake during 2007-2009. Due to the steep drop-offs, aquatic vegetation is limited to a narrow band along the shoreline.

History

From 1933 through 1945, bluegills, largemouth bass, and yellow perch were stocked in Shafer Lake (Table 1). Throughout the state, annual stocking programs for these warmwater fish species were discontinued after fisheries managers determined that such programs were unnecessary and could have undesirable effects on the receiving populations (e.g., reduced growth due to increased competition for forage).

Limnological measurements completed in 1950 indicated that Shafer Lake provided suitable environmental conditions for trout management, and an annual rainbow trout stocking program was initiated in 1951. For the first 13 years of this program, trout were stocked at legal size (8 inches or larger). Conservation officers recorded catch and effort data for anglers encountered on Shafer Lake during 1953-1964. These qualitative creel census data revealed that rainbow trout had become an important component of the fishery.

During 1964-1969, a mixture of sub-legal, fall fingerling, spring fingerling, and yearling rainbow trout were stocked in Shafer Lake. Brown trout also were stocked in this system in 1967 and 1968. Few trout were collected during netting and electrofishing surveys conducted in 1966 and 1969. Anglers reported poor fishing for trout, but good fishing for yellow perch during this period.

From 1971 through 1976, approximately 1,500 yearling rainbow trout (19/acre) were stocked in the lake each year. An electrofishing survey was conducted in April 1976 to assess trout survival. Although 25 yearling (recently stocked) fish were captured, no older trout were collected. Anglers also reported that no large trout had been caught in recent years, providing further support for the hypothesis that trout survival was poor in the 1970s. Due to the poor returns, rainbow trout stocking was discontinued for three years. Limnological sampling completed during 1978 suggested that environmental conditions still were suitable for trout survival.

Rainbow trout stocking resumed in 1980. From 1980 through 1991, the annual stocking density varied from 23 yearlings/acre to 37 yearlings/acre. A gill net survey conducted in 1982 yielded six rainbow trout, including two 15-inch fish that had overwintered in the lake. Only one trout was captured during the next gill net survey in 1987. Both of these surveys demonstrated the presence of a strong yellow perch population.

During 1987-1991, a local angler provided MDNR with yearly catch reports for Shafer Lake. His annual rainbow trout catch declined from over 200 fish in 1987 to only 6 fish in 1991. To further assess returns from the rainbow trout stocking program, a sub-sample of the trout stocked in 1991 were marked with Floy tags. Although 625 fish were tagged, only 8 tags were returned by anglers (return rate = 1.3%). Based on the results of this survey, trout stocking was temporarily discontinued.

Rainbow trout stocking resumed again in 1995. From 1995 through 2010, the annual stocking density varied from 30 yearlings/acre to 37 yearlings/acre. A hook-and-line survey in 1995 yielded 33 trout (10-12 inches) in 28 angler hours, and fishing reports were positive during 1995 through 1997. No surveys were conducted and very few angler reports were received during the next decade. In 2009, anglers reported catching many rainbow trout in this system, including fish up to 19 inches. Shafer Lake currently is classified as a Type C trout lake. The lake is open for trout fishing all year, and the minimum size limit for rainbow trout is 8 inches.

Current Status

A fisheries survey was conducted on Shafer Lake during April 6-8, 2010. The primary objective of this survey was to assess the survival and growth of stocked rainbow trout. A secondary objective was to obtain information on the species composition and size structure of the rest of the fish community in Shafer Lake. Fish were captured using fyke nets and gill nets. The total sampling effort was 6 net nights for fyke nets and 3 net nights for gill nets. Total lengths were recorded for all fish captured during the survey. Dorsal fin ray samples also were collected from rainbow trout for age determination. Stocking of yearling rainbow trout in 2010 did not occur until after the netting survey was completed.

Thirty-six rainbow trout were captured during this sampling effort. The total length range for these fish was 11-19 inches (Figure 4). Approximately 55% of the trout collected were age 2 fish from the 2009 stocking event (Figure 5). Age 3 and age 4 fish composed 36% and 9% of the catch, respectively. Annual mortality for rainbow trout from ages 2 to 4 was estimated to be 59% (Figure 6). Mean lengths-at-age were substantially above the state average for age 2 and age 3 rainbow trout (Figure 7). This pattern was less pronounced for age 4 fish, but only 3 individuals from this cohort were included in the sample.

Twenty rainbow trout were captured in the fyke nets, resulting in a catch-per-effort (CPE) of 3.3 fish/net night. The other 16 rainbow trout were collected in the gill nets (CPE = 5.3 fish/net night). The size structures of captured trout varied between gear types (Figure 4). In general, fish captured in fyke nets tended to be larger than those collected in gill nets; however, this difference was not statistically significant (two-tailed t-test, $p = 0.069$).

Ten additional fish species were collected during the netting survey (Table 2). Bluegill (N = 165) was the most abundant species in the catch. Ninety-eight percent of the bluegills captured were of harvestable size. The average length was 7.2 inches, and a few 9-inch bluegills were collected. Yellow perch (N = 126) was the second most abundant game species in the catch. All of the perch captured were of harvestable size. The average length was 10.2 inches, and the maximum length for yellow perch was 13 inches.

Two additional panfish species were represented in the sample: pumpkinseed (N = 44) and black crappie (N = 41). Approximately 64% of the pumpkinseeds and 98% of the black crappies were of harvestable size. Average lengths were 6.3 inches for pumpkinseeds and 9.7 inches for black crappies.

Forty-three largemouth bass were collected during the 2010 survey. Only two of these fish were larger than the minimum size limit of 14 inches. Fish in the 9-10 inch size classes composed 84% of the largemouth bass catch.

Analysis and Discussion

Rainbow trout require water layers with temperatures of 68 F or lower and dissolved oxygen concentrations of at least 3 ppm. During August 2010, such habitat existed at depths of approximately 19-24 ft in Shafer Lake (Figure 3). Although the summer of 2010 was a relatively warm summer, it appears that Shafer Lake still was providing suitable habitat for rainbow trout.

The 2010 netting survey indicated that a considerable number of rainbow trout are able to survive for at least one year in Shafer Lake. This is significant because many trout stocking programs in southwest Michigan lakes have been discontinued due to negligible carryover of stocked fish to successive years. Annual mortality of adult (ages 2-4) rainbow trout in Shafer Lake was similar to that observed for salmonid populations at fixed stream sampling sites throughout Michigan (T. Wills, MDNR Fisheries Division, personal communication) and lower than the mortality estimates reported by Christensen and Moore (2010) for hatchery-reared rainbow trout in two lakes in Washington.

Growth of rainbow trout is excellent in Shafer Lake. By age 3, most of the fish in Shafer Lake have exceeded the state average length for age 4 rainbow trout (Figure 7). The apparent decrease in growth rate between ages 3 and 4 may not be real, as the sample size was so small for age 4 fish. Alternatively, it is not uncommon for fish to shift diets once they reach a certain size. For example, Lynott et al. (1995) studied the diet of rainbow trout of various size classes in Lake Oahe, South Dakota. They found that the dominant prey items were zooplankton for fish smaller than 13 inches, terrestrial insects for fish between 13 inches and 18 inches, and fish for rainbow trout 18 inches or larger. It is possible that the forage fish required to support growth of rainbow trout beyond 18 inches are in short supply in Shafer Lake; however, data are not available to rigorously evaluate this hypothesis.

Both angler reports and the 2010 survey data indicate that Shafer Lake is providing one of the best two-story trout fisheries in southwest Michigan. Without conducting a creel survey, it is not possible to quantitatively assess fishing effort for rainbow trout in this system. Anecdotal information indicates that trout fishing pressure is high relative to other trout lakes in the area. One angler reported observing as many as 10 boats (fishing parties) targeting rainbow trout on Shafer Lake in a single night.

In the last 50 years, a variety of methods have been used to assess the status of the rainbow trout population in Shafer Lake, including spring electrofishing surveys, fall gill net surveys, and hook-and-line surveys. None of these sampling strategies appeared to be as effective for collecting rainbow trout as the techniques utilized during the 2010 survey. Spring is the best time for capturing rainbow trout in lakes, as the fish are more likely to be in shallow water and accessible to sampling gear. By using a combination of gear types (fyke nets and gill nets), it is possible to collect fish in a wide range of water depths. Although gill nets had a slightly higher CPE than fyke nets in 2010, gill nets also are more

size-selective (Hubert 1996). Thus, incorporating fyke nets into the survey provides a more accurate representation of the size structure of the rainbow trout population.

The timing and sampling methods utilized during the 2010 survey were not ideal for assessing the status of the warmwater fish community in Shafer Lake; however, it is possible to draw some general conclusions from the available data. Shafer Lake appears to be providing good fishing opportunities for panfish. The size structures of the bluegill and yellow perch populations were particularly impressive. The presence of 9-inch bluegills and 12-13 inch yellow perch in the catch strongly suggests above average growth for these species. Largemouth bass also are common in this system, but the size structure of the bass population seems to be slanted toward sub-legal fish.

Management Direction

Shafer Lake currently is supporting an excellent rainbow trout fishery with additional fishing opportunities for bluegill, yellow perch, black crappie, and small largemouth bass. The following management goals and actions have been developed primarily to maintain the existing fishery, as little enhancement is required.

The first goal is to maintain or enhance the existing rainbow trout fishery. Annual stocking of 2,500 yearling rainbow trout (31/acre) will continue. For the near future, Eagle Lake strain fish will be stocked in Shafer Lake. Recent studies in several inland lakes have indicated that Michigan strain rainbow trout (i.e., steelhead) have higher survival and better return to the creel than Eagle Lake strain fish (A. Nuhfer, MDNR - Fisheries Division, personal communication). At present, all steelhead are allocated for the Great Lakes, so no fish are available for inland stocking programs. If additional steelhead become available, these will be stocked in Shafer Lake in place of Eagle Lake strain rainbow trout.

The second goal is to protect and rehabilitate habitat for fish and other aquatic organisms. At least three different methods will be used to accomplish this goal. Fisheries Division personnel will continue to review Michigan Department of Environmental Quality permit applications for potential effects on aquatic resources. If a proposed project is likely to degrade the aquatic habitat, Fisheries Division staff will object to the proposal and suggest feasible alternatives. Fisheries Division will work with the Shafer Lake Association and other organizations to educate riparian landowners on the effects of various practices (e.g., large woody structure removal and seawall construction) on aquatic ecosystems. As opportunities arise, Fisheries Division also will provide technical assistance to local units of government interested in establishing ordinances that protect aquatic habitats from pollution or unwise development.

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Table 1.–Fish stocking in Shafer Lake, 1933-2010.

Year	Species	Strain	Life stage	Number	Number/acre	Average length (inches)
1933	Largemouth bass		Fall fingerling	1,000	12	---
1934	Largemouth bass		Fall fingerling	1,000	12	---
1935	Bluegill		Fall fingerling	10,000	123	---
	Largemouth bass		Fall fingerling	800	10	---
	Yellow perch		Fall fingerling	5,000	62	---
1936	Bluegill		Fall fingerling	20,000	247	---
	Largemouth bass		Fall fingerling	300	4	---
1937	Bluegill		Fall fingerling	25,000	309	---
1938	Bluegill		Fall fingerling	45,000	556	---
	Largemouth bass		Fall fingerling	500	6	---
	Yellow perch		Fall fingerling	5,000	62	---
1939	Bluegill		Fall fingerling	50,000	617	---
	Largemouth bass		Fall fingerling	500	6	---
	Yellow perch		Fall fingerling	10,000	123	---
1940	Bluegill		Fall fingerling	20,000	247	---
1941	Bluegill		Fall fingerling	20,000	247	---
	Largemouth bass		Fall fingerling	200	2	---
1942	Bluegill		Fall fingerling	15,000	185	---
	Largemouth bass		Fall fingerling	500	6	---
1943	Bluegill		Yearling	500	6	---
	Largemouth bass		Fall fingerling	500	6	---
1944	Bluegill		Fall fingerling	10,000	123	2.00
	Largemouth bass		Fall fingerling	1,000	12	2.25
1945	Bluegill		Fall fingerling	5,000	62	1.50
	Largemouth bass		Fall fingerling	2,000	25	3.00
1951	Rainbow trout		Legal	4,000	49	8.00
1952	Rainbow trout		Legal	2,000	25	8.00
1953	Rainbow trout		Legal	2,000	25	9.00
1954	Rainbow trout		Legal	2,000	25	9.00
1955	Rainbow trout		Legal	2,000	25	---
1956	Rainbow trout		Legal	2,000	25	---
1957	Rainbow trout		Legal	2,000	25	---
1958	Rainbow trout		Legal	2,000	25	---
1959	Rainbow trout		Legal	2,000	25	---
1960	Rainbow trout		Legal	2,000	25	---
1961	Rainbow trout		Legal	2,000	25	---
1962	Rainbow trout		Legal	1,800	22	---
1963	Rainbow trout		Legal	1,000	12	---
1964	Rainbow trout		Sub-legal	4,000	49	---
1965	Rainbow trout		Sub-legal	5,000	62	---
1966	Rainbow trout		Fall fingerling	5,000	62	---
1967	Brown trout		Fingerling	5,000	62	---
	Brown trout		Yearling	200	2	---

Table 1–Continued.

Year	Species	Strain	Life stage	Number	Number/acre	Average length (inches)
1967	Rainbow trout		Yearling	11,600	143	---
1968	Brown trout		Spring fingerling	4,600	57	---
	Rainbow trout		Spring fingerling	4,926	61	---
	Rainbow trout		Yearling	1,100	14	---
1969	Rainbow trout		Fall fingerling	4,500	56	---
	Rainbow trout		Yearling	200	2	---
1971	Rainbow trout		Yearling	1,500	19	---
1972	Rainbow trout		Yearling	1,500	19	---
1973	Rainbow trout		Yearling	1,500	19	---
1974	Rainbow trout		Yearling	1,500	19	---
1975	Rainbow trout		Yearling	1,500	19	---
1976	Rainbow trout		Yearling	1,500	19	---
1980	Rainbow trout		Yearling	3,000	37	7.60
1981	Rainbow trout	Harrietta	Yearling	2,000	25	6.16
1982	Rainbow trout	Harrietta	Yearling	2,300	28	5.52
1983	Rainbow trout	Harrietta	Yearling	2,500	31	6.52
1984	Rainbow trout	Shasta	Yearling	1,900	23	6.76
1985	Rainbow trout	Shasta	Yearling	2,000	25	7.4
1986	Rainbow trout	Shasta	Yearling	2,690	33	6.92
1987	Rainbow trout	Shasta	Yearling	3,000	37	6.96
1988	Rainbow trout	Shasta	Yearling	3,000	37	6.52
1989	Rainbow trout	Shasta	Yearling	2,790	34	6.68
1990	Rainbow trout	Arlee	Yearling	3,000	37	6.88
1991	Rainbow trout	Arlee	Yearling	2,336	29	7.08
1995	Rainbow trout	Shasta	Fall fingerling	500	6	6.04
	Rainbow trout	Arlee	Yearling	2,770	34	6.84
1996	Rainbow trout	Shasta	Yearling	2,589	32	6.20
1997	Rainbow trout	Shasta	Yearling	2,500	31	6.20
1998	Rainbow trout	Shasta	Yearling	2,430	30	6.20
1999	Rainbow trout	Shasta	Yearling	770	10	6.88
	Rainbow trout	Shasta	Yearling	1,630	20	7.80
2000	Rainbow trout	Shasta	Yearling	2,488	31	6.48
2001	Rainbow trout	Shasta	Yearling	2,500	31	6.28
2002	Rainbow trout	Eagle Lake	Yearling	2,580	32	6.00
2003	Rainbow trout	Eagle Lake	Yearling	2,880	36	6.03
2004	Rainbow trout	Eagle Lake	Yearling	3,000	37	7.46
2005	Rainbow trout	Eagle Lake	Yearling	3,000	37	7.25
2006	Rainbow trout	Eagle Lake	Yearling	2,500	31	6.50
2007	Rainbow trout	Eagle Lake	Yearling	2,900	36	6.40
2008	Rainbow trout	Eagle Lake	Yearling	2,600	32	6.77
2009	Rainbow trout	Eagle Lake	Yearling	2,610	32	6.86
2010	Rainbow trout	Eagle Lake	Yearling	2,600	32	7.23

Table 2.–Numbers, weights, and lengths for fish species collected during the fisheries survey on Shafer Lake, April 6-8, 2010. Fish were captured using fyke nets and gill nets.

Species	Number	Percent by number	Weight (lbs)	Percent by weight	Length range (inches)	Percent legal or harvestable*
Bluegill	165	23.0	46.1	13.2	5-9	98
Yellow bullhead	145	20.2	72.6	20.8	7-14	---
Yellow perch	126	17.5	59.4	17.0	7-13	100
Lake chubsucker	59	8.2	26.4	7.6	7-10	---
Pumpkinseed	44	6.1	9.7	2.8	4-8	64
Largemouth bass	43	6.0	26.3	7.5	8-18	5
Black crappie	41	5.7	22.1	6.3	6-12	98
Rainbow trout	36	5.0	48.7	14.0	11-19	100
Brown bullhead	16	2.2	16.0	4.6	8-14	---
Hybrid sunfish	12	1.7	3.1	0.9	6-7	100
Warmouth	5	0.7	0.9	0.3	5-6	---
Bowfin	2	0.3	18.0	5.2	28-30	---
Total	694		349.3			

* Harvestable size is 6 inches for bluegill, pumpkinseed, and hybrid sunfish, and 7 inches for black crappie and yellow perch.

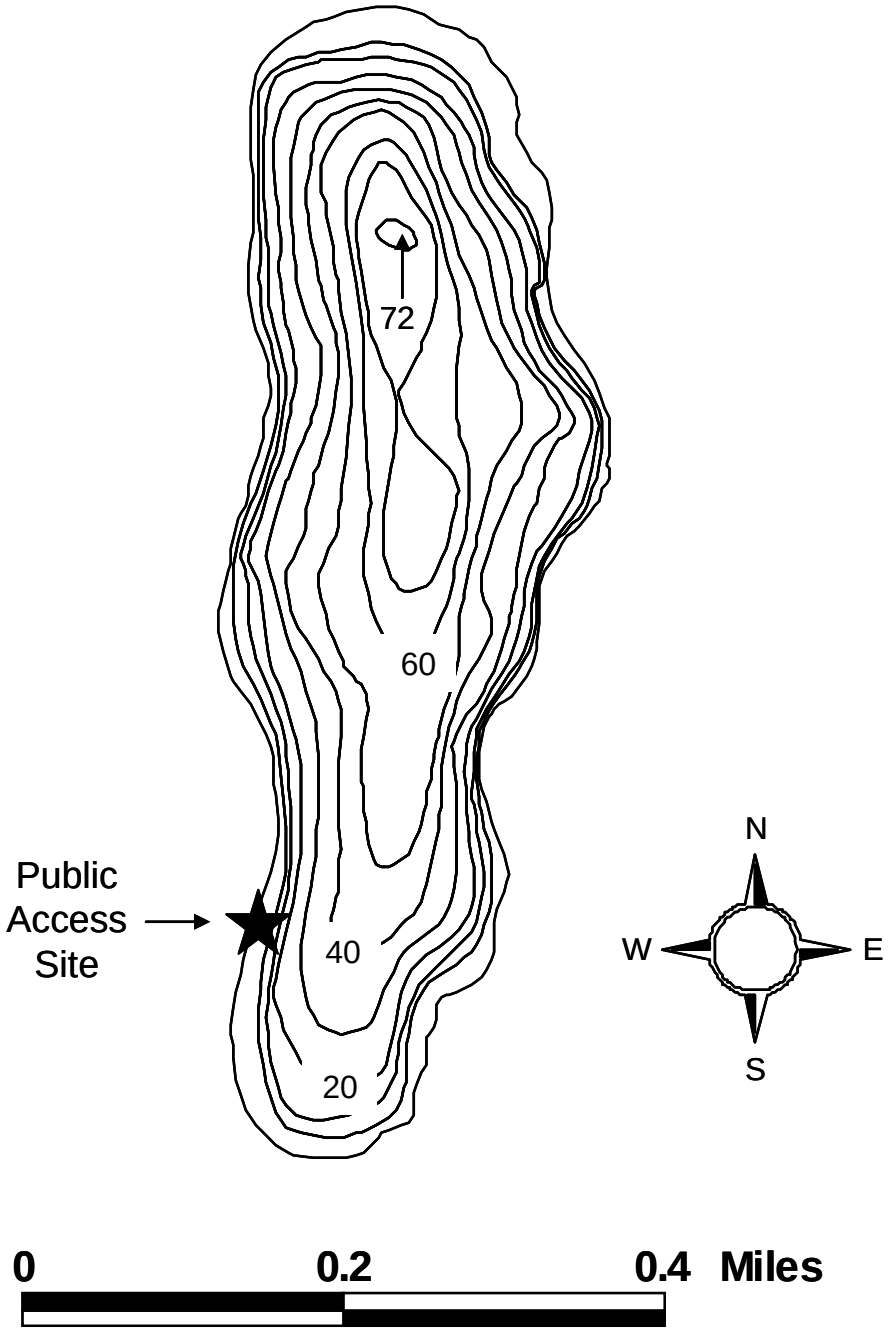
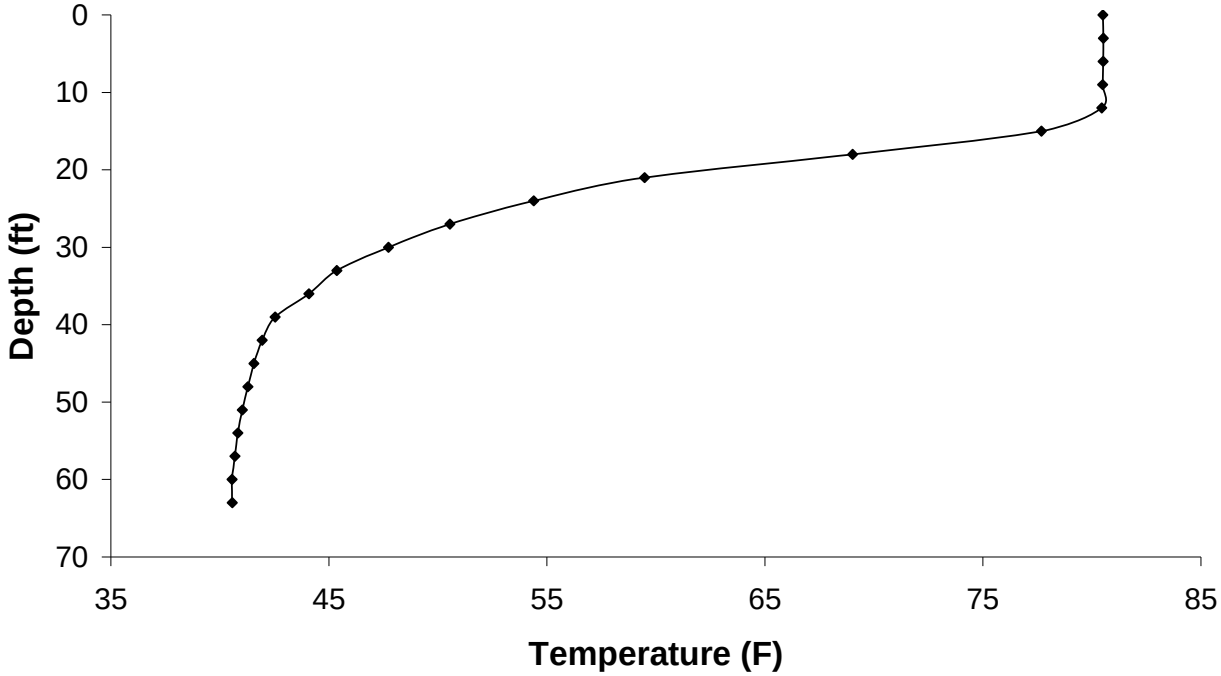


Figure 1.–Bathymetry of Shafer Lake, Van Buren County. Depths are in feet.

Figure 2.–Aerial view of Shafer Lake, showing land use patterns within the watershed. The images from the east and west sides of the view were taken during different seasons. Images from www.bing.com/maps.



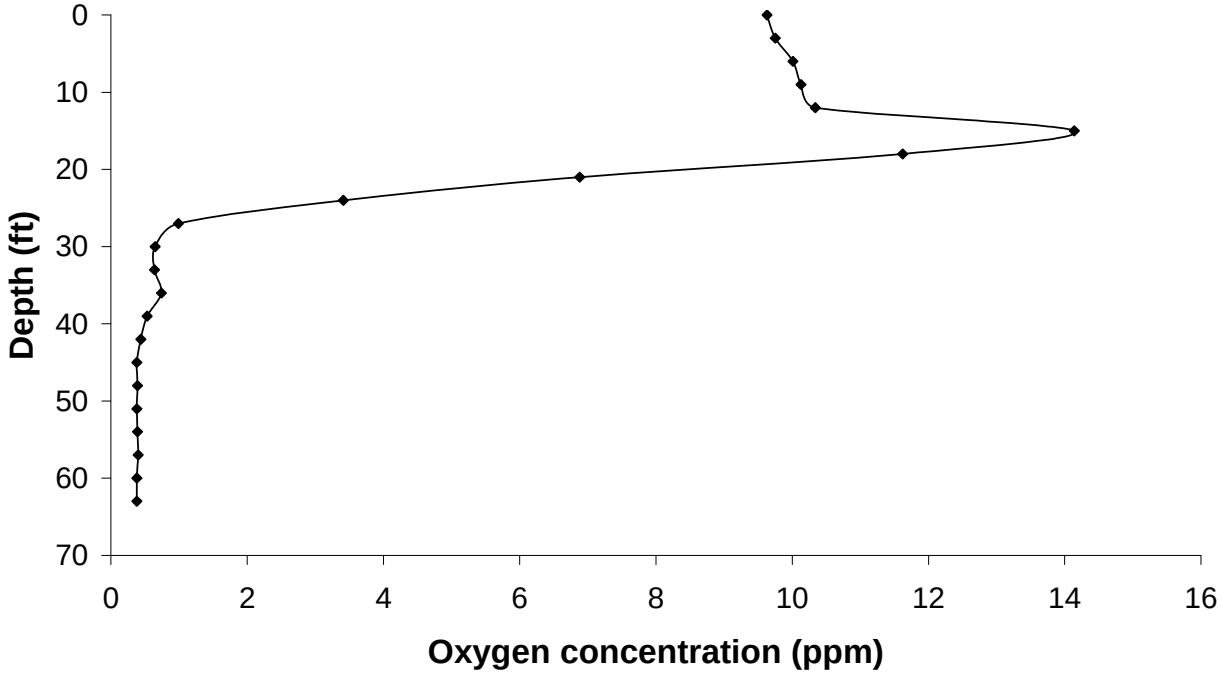
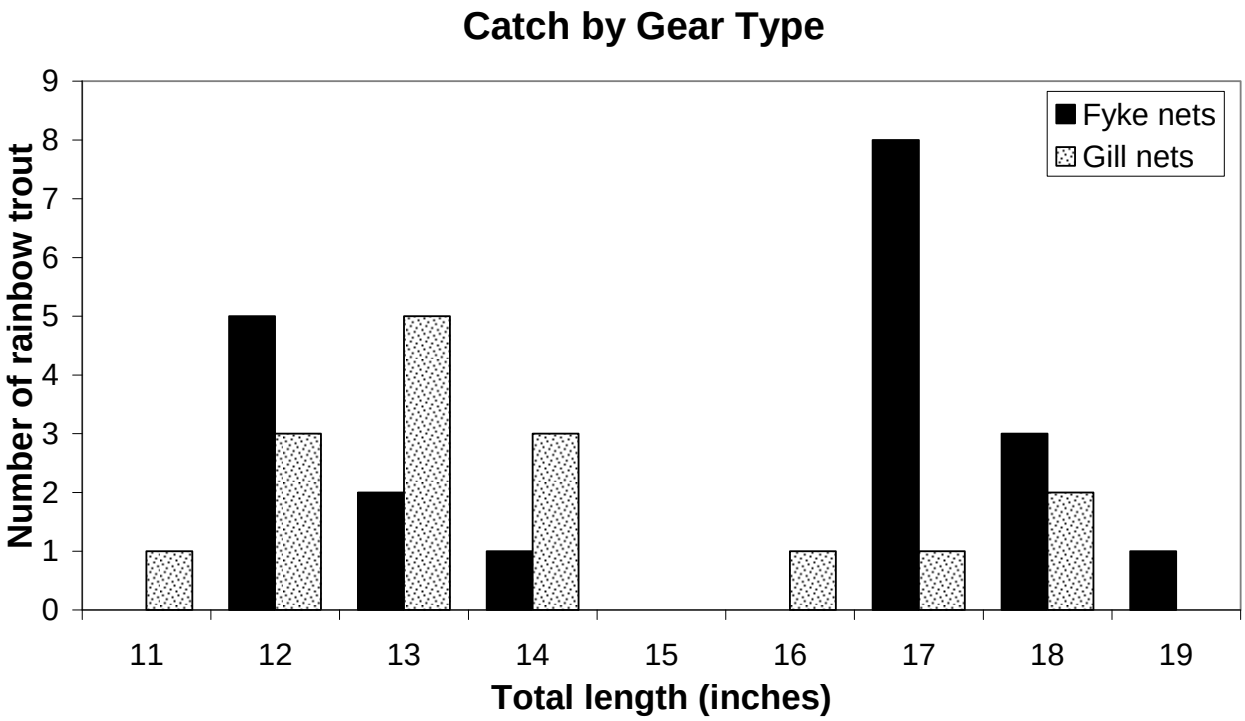


Figure 3.–Temperature and dissolved oxygen profiles for Shafer Lake on August 18, 2010.



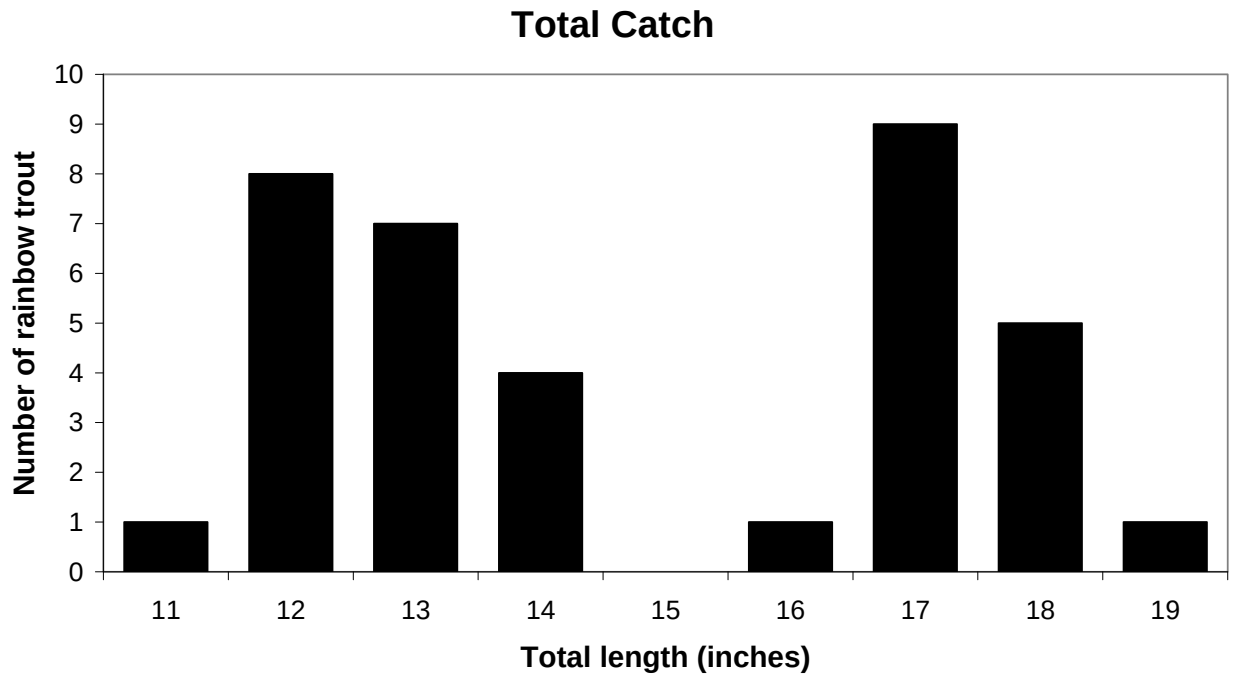


Figure 4.–Length frequency distributions for rainbow trout collected in Shafer Lake with fyke nets and gill nets during April 6-8, 2010.

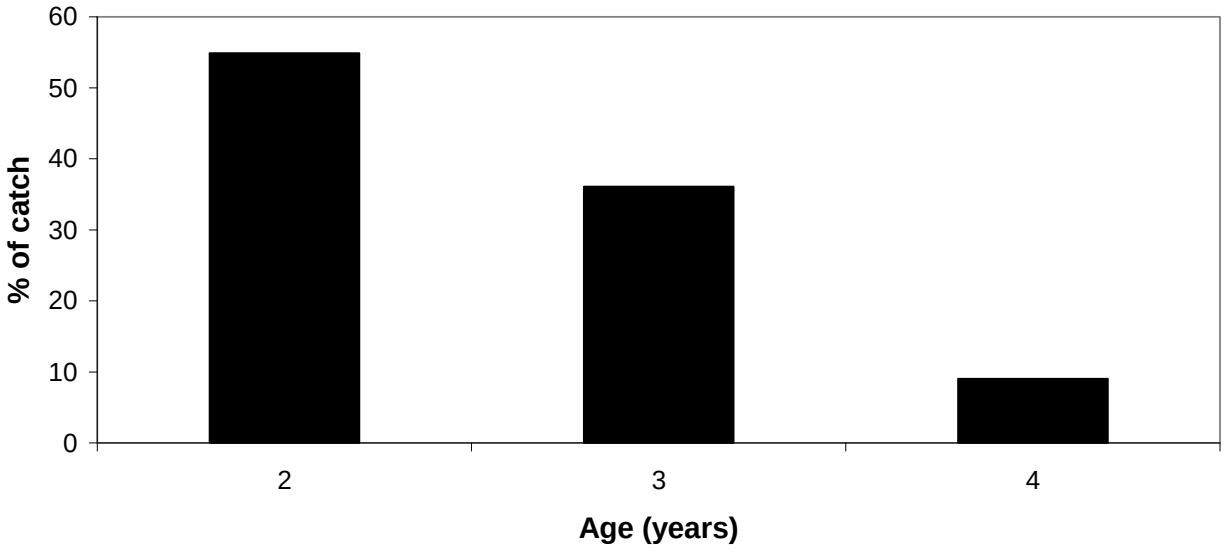


Figure 5.–Age frequency distribution for rainbow trout captured in Shafer Lake during April 6-8, 2010.

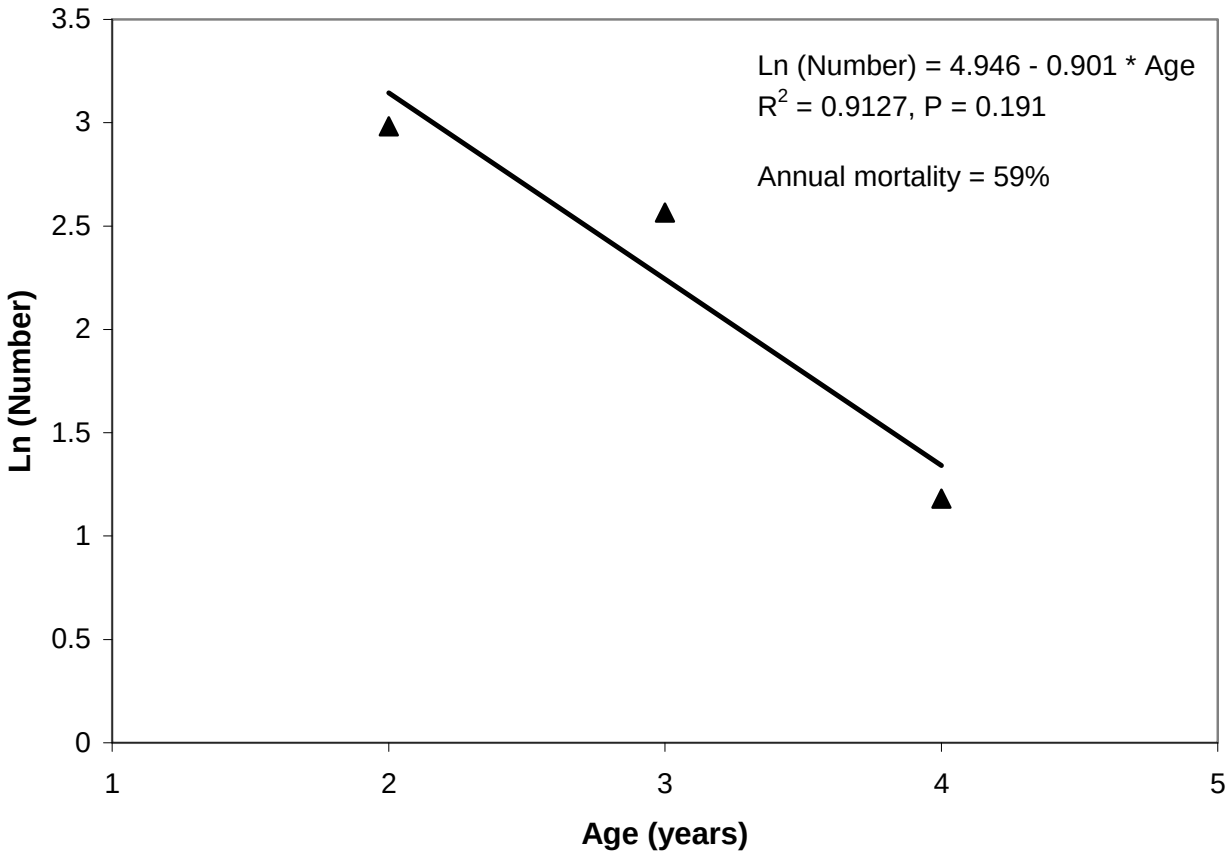


Figure 6.–Observed ln(number) versus age for rainbow trout captured in Shafer Lake during April 6-8, 2010.

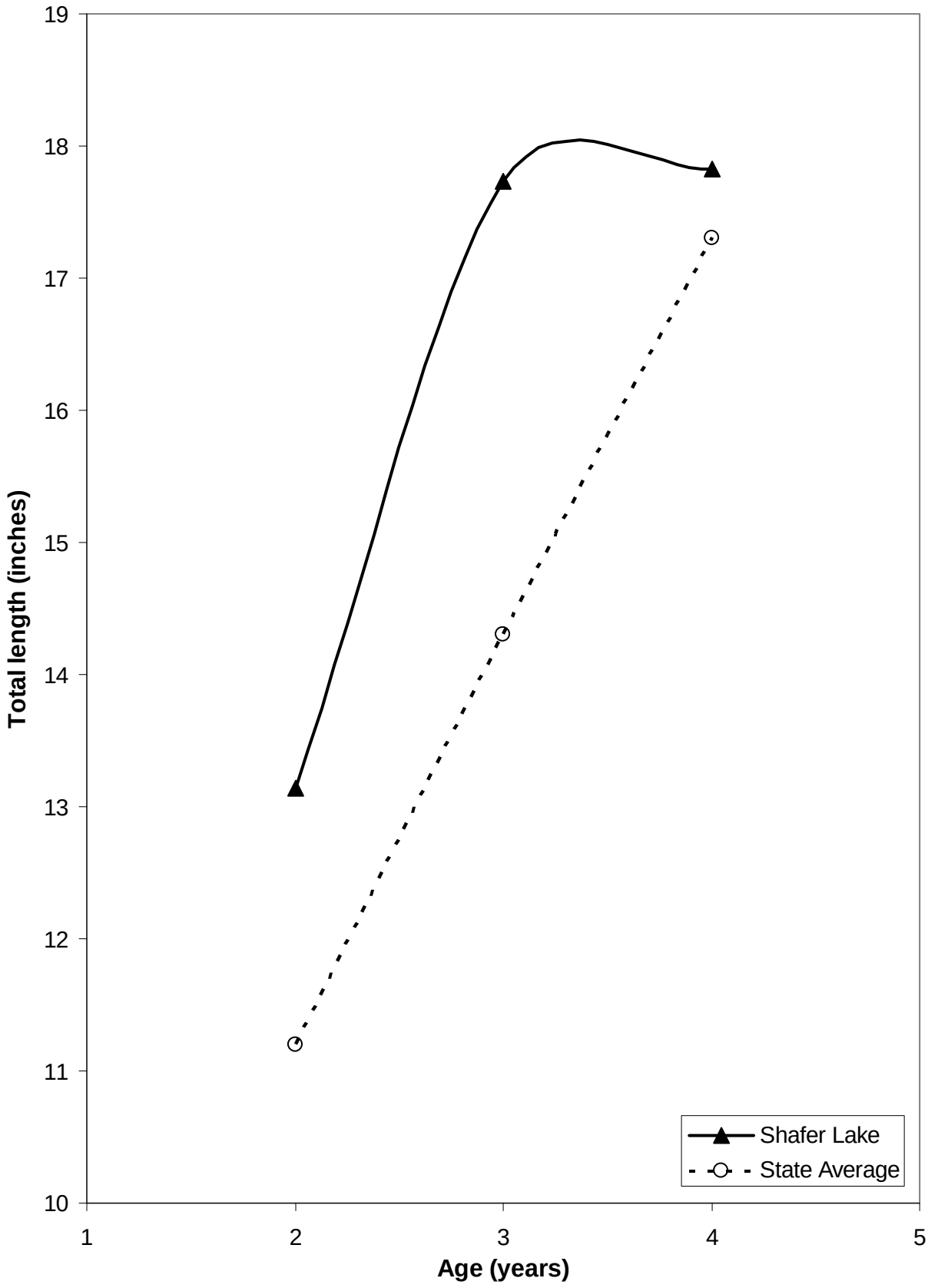


Figure 7.–Growth of rainbow trout in Shafer Lake, as determined from dorsal fin ray samples collected during April 6-8, 2010. State average lengths from Schneider et al. (2000).