Long Lake

St. Joseph County, T06S, R12W, S7
St. Joseph River watershed, 2009

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Environment

Long Lake is a 211-acre natural lake located 6 miles west of the city of Three Rivers. As the name suggests, this is a long, narrow lake with a shoreline development index of 1.83 (Orth 1983). Long Lake has a maximum depth of 41 ft. Drop-offs vary from gradual at the west end of the lake to steep along the south central portion of the shoreline (Figure 1). About 18% of the lake (by surface area) is less than 5 ft deep, and 58% of the lake is less than 20 ft deep. Sandy substrates are common along the shoreline, whereas organic substrates predominate in offshore areas. Patches of gravel are present on the shoals near the center (in terms of longitude) of the lake.

No tributaries flow into this lake, and there are no natural outlets. In 1983, a year-round legal lake level of 887.0 ft was established for Long Lake. When the water elevation on Long Lake exceeds this level, water is pumped from Long Lake to Clear Lake through an underground culvert. The St. Joseph County Drain Commission prohibits transfer of water from Long Lake to Clear Lake when the water elevation on Clear Lake exceeds 874.75 ft.

Long Lake is surrounded by deposits of ice-contact outwash sand and gravel. These materials are relatively porous, and groundwater is delivered to Long Lake via numerous springs. Much of the watershed has been developed for agriculture, but forests and wetlands predominate in the eastern portion of the basin (Figure 2). There is considerable residential and vacation home development along the shoreline. The 2009 habitat survey revealed a dwelling density of 50.7 dwellings/mile (31.4 dwellings/km). Approximately 35% of the shoreline is armored with seawalls or riprap. Large woody structure is scarce, except along the undeveloped shoreline at the eastern end of the lake. The DNRE boat launch at the west end provides public access to Long Lake.

Limnological sampling was conducted at the deepest point in Long Lake on August 18, 2009. As expected, the lake was thermally stratified (Figure 3). The epilimnion extended from the surface to a depth of 12 ft. The water temperature within the epilimnion was relatively uniform, ranging from 79.0 F to 79.3 F. The metalimnion (zone of thermal change) extended from 12 ft to the bottom of the lake. Water temperatures in the metalimnion declined from 79.0 F at 12 ft to 53.1 F at 39 ft. The oxygen distribution within Long Lake followed a clinograde curve, with the highest dissolved oxygen concentrations occurring near the surface (Figure 3). The dissolved oxygen concentration remained above 3 ppm to a depth of 23 ft. The total alkalinity was 98 mg/L, which is indicative of a moderately hardwater lake (Shaw et al. 2004).

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 >50:1 in Long Lake in 2009, so it appears that phosphorus is the limiting nutrient in this system. The total phosphorus concentration was 0.011 mg/L. The chlorophyll a concentration, which provides an index of algal biomass, was 0.0039 mg/L. The water was relatively clear, with a Secchi disk depth of 15.5 ft. Based on this information, Long Lake is considered a borderline oligotrophic-mesotrophic lake (low to moderate productivity; Carlson and Simpson 1996).

Recent quantitative data regarding the abundance and distribution of aquatic plants in Long Lake are not available. For many years, riparian landowners have hired private companies to complete weed treatments on this lake. During the most recent treatment, the target organisms were Eurasian watermilfoil, curlyleaf pondweed, coontail, native pondweeds, and algae (Table 1).

History

The first fisheries survey of Long Lake was conducted in 1887. Yellow perch, bluegills, rock bass, bullheads, and shiners were captured during this initial assessment. In 1927, researchers captured bluegills, pumpkinseeds, yellow perch, largemouth bass, bullheads, and lake chubsuckers in Long Lake. Bluegills and largemouth bass were stocked annually during 1934 through 1945 (Table 2). Yellow perch also were stocked periodically during the 1930s.

Anglers reported good fishing for largemouth bass, bluegills, yellow perch, and black crappies during the late 1940s. Conservation officers recorded catch and effort data for anglers encountered on Long Lake during 1953-1963. These qualitative creel census data indicated that bluegills composed most of the harvest, followed by pumpkinseed, yellow perch, largemouth bass, and black crappies.

During the early 1960s, angler reports suggested that the fish community in Long Lake was dominated by small, slow-growing panfish. A fisheries survey conducted in 1963 corroborated these reports. To reduce panfish abundance (and ultimately improve panfish growth), the lake was treated with rotenone in October 1965. Division personnel estimated that this treatment removed 80% of the panfish population. Largemouth and smallmouth bass were stocked in Long Lake after the rotenone treatment. Rainbow trout also were stocked during 1965-1971 to provide a short-term fishery while the warmwater fish community was recovering.

By the early 1970s, small panfish once again composed the bulk of the fish community in Long Lake. In another effort to reduce panfish abundance, the lake was treated with Antimycin A in May 1974. Fisheries Division personnel estimated that this treatment removed about 40% of the bluegills and pumpkinseeds, 50% of the yellow perch, 25% of the black crappies, and 1% of the largemouth bass in the lake.

Tiger muskellunge (sterile hybrids of northern pike and muskellunge) were stocked in Long Lake from 1974 through 1991 (Table 2). The primary objective of this stocking program was to create a trophy tiger muskellunge fishery, with the secondary objective of controlling panfish abundance. (To assist with this second objective, a manual removal of 2,400 lb [11.4 lb/acre] of small bluegills and pumpkinseeds was completed in 1980.) Fisheries surveys and angler reports indicated that the lake supported a popular tiger muskellunge fishery during the 1980s. Some large tiger muskellunge were reported by anglers, but growth typically was below average. The stocking program ended when the Division's tiger muskellunge rearing program was discontinued in 1991. No improvement in panfish size structure was observed during this period, and anglers continued to report an overabundance of small bluegills. Bluegill lengths-at-age were well below average throughout the 1980s (mean growth indices = -1.6 to -1.3).

A new muskellunge stocking program was initiated in 1999 to create additional opportunities for catching trophy fish. Northern strain muskellunge were stocked in 1999 and 2000, and Iowa strain muskellunge were stocked in 2004, 2005, and 2009. Unlike tiger muskellunge, these fish were fertile. Thus, there is the potential for natural reproduction of muskellunge in Long Lake.

Current Status

A variety of methods were used to evaluate the fish community and the fishery in Long Lake during the 2009 open water season. Fish were captured with trap nets, fyke nets, and gill nets in May and electrofishing gear in June (Table 3). Total lengths were recorded for all fish. For game fish species, dorsal fin ray or scale samples were collected from 10 fish per inch group for age determination. A creel survey also was conducted to collect additional information regarding fishing effort, harvest, and catch rates for various game fish species in Long Lake. From April 25 through October 31, the creel clerk made boat and shore angler counts and interviewed anglers on Long Lake during one weekend day and one or two weekdays each week. A total of 348 angler interviews were completed during the creel survey.

Fourteen fish species were collected during the 2009 netting and electrofishing surveys (Table 4). Bluegill (N = 744) was the most abundant species, composing 50% of the catch by number and 37% of the catch by weight. Seventy-four percent of the bluegills were of harvestable size. Size structures of bluegill populations can be challenging to interpret because each gear type exhibits some degree of size selectivity. In an effort to minimize the subjectivity associated with analyses of bluegill catch data, Schneider (1990) developed a standardized scoring system for interpreting length-frequency distributions of bluegills collected with various types of sampling gear. The size score for the Long Lake bluegill population was 5.4 (good-excellent) based on the trap net sample and 4.2 (satisfactory-good) based on the electrofishing sample (Schneider 1990).

The mean growth index for bluegills was 0, indicating average growth for a Michigan bluegill population. (Note: Schneider et al. [2000] calculated different state average lengths for January-May and June-July. During the 2009 survey, spine and scale samples were collected in May and June. The January-May lengths were used to calculate growth indices for fish captured during the spring netting effort, and the June-July average lengths were used to calculate growth indices for fish captured during the electrofishing effort. The individual growth indices were averaged to obtain the mean growth indices.) However, there was considerable variation in lengths-at-age for individual bluegills (Figure 4). Based on the length-at-age data, it appears that some fast-growing bluegills reach harvestable size at age 3, whereas other individuals do not reach harvestable size until age 6

Eight year classes of bluegills were collected (Figure 5). Age 3 fish were particularly abundant, composing 40% of the bluegill catch. Annual mortality was estimated to be 58% for adult bluegills (ages 3-8; Figure 6).

Bluegills composed 85% of the total harvest during the 2009 creel survey (Table 5). For April through October, the bluegill harvest estimate was 13,578 fish. An additional 10,812 bluegills were caught and released, so it appears that anglers only had to release 0.8 undersized fish for every "keeper." During June-August, the bluegill harvest per angler hour (CPH) for Long Lake was 0.84. For comparison, bluegill CPH values for other southwest Michigan lakes have ranged from 0.07 to 0.97 (Table 6; Z. Su, MDNRE Fisheries Division, unpublished).

Eighty-two pumpkinseeds were collected during the fish community survey. The mean growth index was +0.4, and 56% of the pumpkinseeds captured were of harvestable size. Although six year classes were represented, age 3 fish made up more than 70% of the catch (Figure 5). Pumpkinseeds (N = 1,668) composed 10% of the total harvest during the creel survey. Approximately seven pumpkinseeds were harvested for every fish that was released.

Two other panfish species were collected during the netting and electofishing efforts: yellow perch (N = 133) and black crappie (N = 69). Harvestable fish composed 83% and 88% of the yellow perch and black crappie catch, respectively. Cumulatively, these two species made up 4% of the total harvest during the 2009 creel survey. For both species, anglers harvested more fish than they released.

Numerically, largemouth bass (N = 126) were the most abundant predators in the netting and electrofishing catch. Only four of the bass captured were larger than 12 inches, and only two fish were larger than 14 inches. Nine year classes were represented in the sample. Mean lengths-at-age for largemouth bass were about average for ages 1-3, but were well below average for older fish (Figure 7). Annual mortality of bass ages 4 to 7 was estimated to be 53% (Figure 8).

The creel results indicate that 3,788 largemouth bass were caught during April-October, 2009. The bass fishery in Long Lake is almost entirely a catch-and-release fishery, and only 0.2% of these fish were harvested. The largemouth bass catch rate in Long Lake was lower than the median value for lakes in southwest Michigan (Table 6).

Five muskellunge were captured during the netting survey. The length range for these fish was 36 to 45 inches. Four fish were Northern strain muskellunge from the 1999 and 2000 stockings. The other fish was from the 2004 year class and probably was an Iowa strain muskellunge. Lengths-at-age for Long Lake muskellunge generally were below the state average (Figure 9).

The estimated muskellunge catch during April-October 2009 was 115 fish (Table 5). Only five of these fish were harvested. The muskellunge catch per angler hour was 0.0084 for the entire survey period and 0.0086 for May-September. This catch rate falls within the middle of the range recorded for Michigan's muskellunge waters (Figure 10). Anglers reported total lengths for 14 muskellunge during the creel survey. Three fish (21%) were of legal size, and the largest muskellunge was 45 inches (Figure 11).

Analysis and Discussion

Long Lake supports a well-balanced fish community. Predators (largemouth bass, muskellunge, and grass pickerel) composed 36% of the biomass, benthivores (pumpkinseed, bluntnose minnow, lake chubsucker, and bullheads) composed 6%, and pelagic planktivores-insectivores made up 58% of the biomass during the 2009 survey. Schneider (2000) suggested that predators typically compose 20-50% of the biomass in lakes with desirable fish communities. Based on this standard, Long Lake appears to have a healthy predator-prey ratio.

Bluegill is the primary game fish species in Long Lake, accounting for 85% of the total harvest during the 2009 open water season (Table 5). The netting, electrofishing, and creel survey data all indicate that Long Lake supports a strong bluegill fishery. Bluegills are abundant, and anglers do not have to sort through many smaller fish to catch their limit of "keepers."

Annual mortality of bluegills was 58%, which is in the middle of the range reported by Schneider (2000) for Michigan bluegill populations and very similar to that observed in nearby Clear Lake (Gunderman 2010). A population estimate was not obtained, so it was not possible to generate estimates of fishing mortality and natural mortality. Given that 64 bluegills/acre were harvested during the creel survey, it seems logical to assume that fishing mortality composes a substantial percentage of total annual mortality in this system.

The improvement in the size structure of the bluegill population has been dramatic during the last 20 years. The reasons for this improvement are not completely understood. The muskellunge stocking program has increased the predation pressure, which may have reduced bluegill abundance and intraspecific competition for forage. Predators only composed 5% of the biomass during the 1988 survey, compared to 36% in 2009. Now that the size structure has improved, fishing mortality serves as an additional mechanism for controlling bluegill abundance.

The wide variation in lengths-at-age for bluegills suggests the use of different foraging strategies. Morphological variation and habitat segregation within bluegill populations has been reported in other systems (Spotte 2007). In Long Lake, the slow-growing individuals may forage primarily in aquatic vegetation, whereas the fast-growing individuals may spend more time in the pelagic zone preying on zooplankton.

In terms of fish harvested, pumpkinseed was the second most important species in Long Lake. Most pumpkinseeds probably were caught incidentally by anglers targeting bluegills. The released fish-harvested fish ratio may have been higher than indicated by the creel data, as many released pumpkinseeds are misidentified as bluegills. There are two plausible explanations for the observed age structure. The relative scarity of age 4 and older pumpkinseeds could be the result of high fishing mortality, as most pumpkinseeds reach harvestable size late in the fourth year or early in the fifth year of life. Another possibility is that the observed age structure was produced by variable recruitment, and the peak at age 3 indicates that an exceptionally large year class was produced in 2006.

Black crappie and yellow perch are small components of the open water fishery in Long Lake. The size structures of the perch and crappie populations were acceptable, and these species support targeted fisheries during certain times of the year (e.g., spring for crappies and winter for yellow perch). The black crappie harvest per angler hour was about average for lakes in southwest Michigan (Table 6).

The catch rate for largemouth bass in Long Lake was slightly below average for lakes in this region, and was noticeably lower than the catch rate in Clear Lake (Table 6). Legal-sized bass are rare in this system. Annual mortality in Long Lake was 53%, which is slightly below the median (58%) of the annual mortality values reported by Allen et al. (2008) for North American largemouth bass populations and similar to mortality estimates for bass populations in Clear and Shavehead lakes (Gunderman 2010; Gunderman 2009). The poor size structure of the largemouth bass population in Long Lake appears to be the result of poor growth rather than high mortality. On average, largemouth bass in Michigan lakes reach 14 inches at age 5. In Long Lake, largemouth bass do not reach this size until age 9 (Figure 7).

The reasons for the poor growth of largemouth bass in this system are not known. The lake does not have an abnormally high predator-prey ratio, and forage does not appear to be scarce. Poor growth of bass also has been observed in nearby Corey, Pleasant, and Clear lakes, so it is likely that habitat is partially responsible for the observed growth pattern. However, the mean lengths at age for adult largemouth bass in these systems were substantially greater than those for Long Lake bass. Another possible explanation is that the threat of predation by muskellunge is altering the foraging behavior of largemouth bass. Largemouth bass from other southwest Michigan lakes with muskellunge (e.g., Campau and Murray lakes) have exhibited below average growth, yet the mean lengths-at-age for bass in these systems still were much greater than those observed for Long Lake bass.

The low muskellunge catch during the 2009 netting survey can be attributed to the timing of the sampling effort. The best time to capture muskellunge is during spawning, which typically occurs in early April (about one month before the 2009 netting effort). Thus, the creel survey provides a better indication of the quality of the muskellunge fishery in this system. The muskellunge catch per angler hour in Long Lake is considered acceptable. Creel surveys have been completed for three muskellunge lakes in the Southern Lake Michigan Management Unit: Campau, Murray, and Long lakes. The catch rate in Long Lake was higher than that observed for Campau Lake, but substantially lower than in Murray Lake (Figure 10). This corroborates the angler reports received at the Plainwell DNRE Office, which generally suggest that Long Lake supports a decent, but not extraordinary, muskellunge fishery.

The available length-at-age data suggest that Long Lake muskellunge are growing more rapidly than fish in Campau, Murray, and Hudson (Lenawee County) lakes, but slower than muskellunge in Thornapple Lake (Barry County). Due to the small sample size (N = 5), these data must be interpreted with caution. Long Lake is capable of producing muskellunge larger than 42 inches, as evidenced by the three legal-sized fish reported during the creel survey.

There appears to be little, if any, natural reproduction of muskellunge in Long Lake. All of the muskellunge captured during the netting survey were traced back to years when stocking occurred. Ages were not determined for muskellunge reported during the creel survey. Given the length range of most captured muskellunge (31-45 inches), it is plausible that all of these fish were of hatchery origin. If there was substantial natural reproduction in this system, the expectation was that several fish in the 20-30 inch range would have been reported by anglers. The only fish smaller than 30 inches was a 13-inch individual reported in October. This may have been a wild fish, but it also is possible that it was a stocked muskellunge from the September 29, 2009 stocking event or a misidentified grass pickerel.

The sample size was too small to discern any differences in survival or growth of Northern strain and Iowa strain muskellunge. Only one Iowa strain fish was captured during the netting survey, but several of the smaller fish reported during the creel survey may have been Iowa strain muskellunge.

Management Direction

Three fisheries management goals have been developed for Long Lake. Goal 1: Protect and rehabilitate habitat for fish and other aquatic organisms. Goal 2: Maintain the popular muskellunge fishery in this water body. Goal 3: Maintain a healthy predator-prey ratio within the fish community.

At least three different methods will be used to accomplish the first goal. Fisheries Division personnel will continue to review MDNRE - Water Resources Division 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 Long Lake Association and other organizations to educate riparian landowners on the effects of various practices (e.g., chemical weed treatments 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 (e.g., bans on phosphorus fertilizer for residential use) that protect aquatic habitats from pollution or unwise development.

The second and third goals are interrelated. Muskellunge are the dominant predators in Long Lake, composing 24% of the total biomass during the 2009 survey. As there appears to be minimal natural reproduction in this system, muskellunge abundance can be controlled by adjusting the stocking density. To achieve goals 2 and 3, stocking should continue on a biennial schedule. In the past, stocking density has varied from 2 fall fingerlings/acre to 4 fall fingerlings/acre. For future stocking events, the recommended density is 2 fall fingerlings/acre (Dexter and O'Neal 2004). This strategy should maintain the existing muskellunge fishery without overtaxing the forage base in Long Lake.

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Table 1.–Aquatic herbicide treatments in Long Lake, May-June 2007. Data from treatment reports provided to the Department of Natural Resources and Environment – Water Bureau by the permittee.

Date	Herbicide	Rate of application	Total amount	Target species
May 30	Copper sulfate	2.6 lb/acre-ft	16.5 lb	Algae
	Reward (diquat dibromide)	1.5 gal/acre	4.9 gal	Curlyleaf pondweed
	Hydrothol 191 (amine salts of endothall)	1 gal/acre	7 gal	
	Cygnet Plus	0.5 gal/acre	1.6 gal	Adjuvant
	Komeen	1.5 gal/acre	4.9 gal	Eurasian water-milfoil
	Aquathol K (dipotassium salts of endothall)	1.5 gal/acre	10.5 gal	Mixed pondweeds
June 22	Reward (diquat dibromide)	1.5 gal/acre	0.8 gal	Coontail
	Komeen	1.5 gal/acre	0.8 gal	

Table 2.–Fish stocking in Long Lake, 1934-2009. N = Northern strain and I = Iowa strain.

Year	Species	Life stage	Number	Number/acre	Average length (inches)
1934	Bluegill	Fall fingerling	35,000	166	---
	Largemouth bass	Fall fingerling	1,000	5	---
	Yellow perch	Fall fingerling	10,000	47	---
1935	Bluegill	Fall fingerling	30,000	142	---
	Largemouth bass	Fall fingerling	1,000	5	---
	Yellow perch	Fall fingerling	15,000	71	---
1936	Bluegill	Fall fingerling	25,000	118	---
	Largemouth bass	Fall fingerling	1,000	5	---
1937	Bluegill	Fall fingerling	40,000	190	---
	Largemouth bass	Fall fingerling	1,000	5	---
1938	Bluegill	Fall fingerling	80,000	379	---
	Largemouth bass	Fall fingerling	1,500	7	---
	Yellow perch	Fall fingerling	15,000	71	---
1939	Bluegill	Fall fingerling	80,000	379	---
	Largemouth bass	Fall fingerling	2,500	12	---
	Yellow perch	Fall fingerling	15,000	71	---
1940	Bluegill	Fall fingerling	15,000	71	---
	Bluegill	Yearling	1,500	7	---
	Largemouth bass	Fall fingerling	2,000	9	---
	Largemouth bass	Yearling	1,500	7	---
1941	Bluegill	Fall fingerling	50,000	237	---
	Largemouth bass	Fall fingerling	1,000	5	---
1942	Bluegill	Fall fingerling	20,000	95	---
	Largemouth bass	Fall fingerling	1,000	5	---
1943	Bluegill	Fall fingerling	10,000	47	---
	Largemouth bass	Fall fingerling	1,000	5	---
1944	Hybrid sunfish	Fall fingerling	20,000	95	2.00
	Largemouth bass	Fall fingerling	2,000	9	3.00
1945	Bluegill	Fall fingerling	15,000	71	2.00
	Largemouth bass	Fall fingerling	4,500	21	4.00
1965	Bluegill	Adult	250	1	---
	Largemouth bass	Fall fingerling	2,000	9	---
	Rainbow trout	Yearling	10,000	47	---
	Smallmouth bass	Yearling	2,600	12	---
1966	Largemouth bass	Adult	345	2	---
	Largemouth bass	Fry	20,000	95	---
1968	Rainbow trout	Yearling	5,000	24	---
1969	Rainbow trout	Spring fingerling	4,500	21	---
1971	Rainbow trout	Yearling	4,500	21	---
1974	Tiger muskellunge	Fry	5,960	28	---
1975	Tiger muskellunge	Fall fingerling	952	5	---
1977	Tiger muskellunge	Fall fingerling	2,000	9	---
1978	Tiger muskellunge	Fall fingerling	2,000	9	---

Table 2.–Continued.

Year	Species	Life stage	Number	Number/acre	Average length (inches)
1980	Tiger muskellunge	Fall fingerling	2,000	9	6.80
1981	Tiger muskellunge	Fall fingerling	1,000	5	6.36
1982	Tiger muskellunge	Fall fingerling	1,900	9	6.08
1983	Tiger muskellunge	Fall fingerling	800	4	7.36
1983	Tiger muskellunge	Fall fingerling	200	1	7.80
1984	Tiger muskellunge	Fall fingerling	1,400	7	7.24
1985	Tiger muskellunge	Fall fingerling	800	4	6.24
1986	Tiger muskellunge	Fall fingerling	182	1	11.92
1986	Tiger muskellunge	Fall fingerling	818	4	7.88
1987	Tiger muskellunge	Spring fingerling	31,500	149	1.76
1987	Tiger muskellunge	Fall fingerling	1,200	6	11.16
1988	Tiger muskellunge	Fall fingerling	1,000	5	10.2
1989	Tiger muskellunge	Fall fingerling	1,800	9	9.12
1990	Tiger muskellunge	Fall fingerling	1,400	7	9.24
1991	Tiger muskellunge	Fall fingerling	2,000	9	10.32
1999	Muskellunge (N)	Fall fingerling	506	2	11.88
2000	Muskellunge (N)	Fall fingerling	500	2	11.60
2004	Muskellunge (I)	Fall fingerling	760	4	12.72
2005	Muskellunge (I)	Fall fingerling	760	4	11.80
2009	Muskellunge (N)	Fall fingerling	367	2	8.72

Table 3.–Sampling effort during the fish community survey on Long Lake, May-June 2009. Each net night equals one overnight set of one net.

Sampling Period	Gear	Effort
May 4-7	Trap net	6 net nights
May 4-7	Fyke net	6 net nights
May 4-7	Graded-mesh gill net	4 net nights
June 17	Electrofishing	30 minutes

Table 4.–Numbers, weights, lengths, and growth indices for fish species collected during the fish community survey on Long Lake, May-June, 2009. Fish were captured using trap nets, fyke nets, gill nets, and electrofishing gear.

Species	Number	Percent by number	Weight (lbs)	Percent by weight	Length range (inches)	Percent legal or harvestable[1]	Growth index[2]
Bluegill	744	49.6	160.8	36.8	1-8	74	0
Yellow perch	133	8.9	35.5	8.1	3-11	83	+0.1
Warmouth	130	8.7	16.5	3.8	2-7	25	---
Largemouth bass	126	8.4	51.6	11.8	4-18	2	-2.3
Pumpkinseed	82	5.5	15.9	3.6	3-8	56	+0.4
Black crappie	69	4.6	34.8	8.0	6-13	88	+0.5
Hybrid sunfish	17	1.1	4.1	0.9	4-7	82	---
Lake chubsucker	7	0.5	3.3	0.7	7-10	---	---
Yellow bullhead	6	0.4	3.2	0.7	7-12	---	---
Muskellunge	5	0.3	106.5	24.4	36-45	60	---
Brown bullhead	5	0.3	4.0	0.9	8-14	---	---
Bluntnose minnow	5	0.3	0.0	0.0	1-2	---	---
Grass pickerel	3	0.2	0.5	0.1	7-10	---	---
Blackchin shiner	3	0.2	0.0	0.0	1-2	---	---
Golden shiner	2	0.1	0.2	0.0	6-6	---	---
Total	1,337	436.9					

[1] Harvestable size is 6 inches for bluegill, pumpkinseed, rock bass, hybrid sunfish, and warmouth, and 7 inches for black crappie and yellow perch.

[2] Average deviation from the state average length at age. Mean growth indices <-1 indicate below average growth, indices between -1 and +1 indicate average growth, and indices >+1 indicate growth is faster than the state average.

Table 5.–Angler survey estimates for Long Lake (Z. Su, MDNR Fisheries Division, unpublished). Survey period was April 25 through October 31, 2009. Two standard errors are given in parentheses. NA = estimates not available and CPH = catch per angler hour.

Species	CPH	April	May	June	July	August	September	October	Season
HARVEST									
Largemouth bass	0.0004	0	0	0	0	0	6	0	6
	(0.0008)	(0)	(0)	(0)	(0)	(0)	(12)	(0)	(12)
Yellow perch	0.0337	0	0	33	30	119	163	115	460
	(0.0263)	(0)	(0)	(38)	(36)	(141)	(193)	(243)	(345)
Bluegill	0.9949	0	3,943	2,244	3,196	1,965	2,166	65	13,578
	(0.4138)	(0)	(3,216)	(1,662)	(2,626)	(1,509)	(1,172)	(99)	(4,864)
Pumpkinseed	0.1222	0	303	145	1,049	162	9	0	1,668
	(0.1328)	(0)	(308)	(175)	(1,722)	(257)	(18)	(0)	(1,777)
Black crappie	0.0211	0	0	121	160	7	0	0	288
	(0.0187)	(0)	(0)	(156)	(192)	(13)	(0)	(0)	(248)
Muskellunge	0.0004	0	5	0	0	0	0	0	5
	(0.0008)	(0)	(11)	(0)	(0)	(0)	(0)	(0)	(11)
TOTAL HARVEST	1.1727	0	4,252	2,542	4,435	2,252	2,343	180	16,004
	(0.4543)	(0)	(3,231)	(1,679)	(3,146)	(1,537)	(1,188)	(263)	(5,196)
RELEASED									
Largemouth bass	0.2771	11	373	705	856	791	978	68	3,782
	(0.1369)	(21)	(438)	(570)	(1,079)	(578)	(911)	(81)	(1,688)
Yellow perch	0.0116	0	5	22	58	17	0	55	158
	(0.0094)	(0)	(11)	(34)	(69)	(35)	(0)	(90)	(124)
Bluegill	0.7923	0	2,632	1,860	2,630	2,129	1,298	263	10,812
	(0.3000)	(0)	(2,148)	(NA)	(1,539)	(1,966)	(785)	(276)	(3,397)
Pumpkinseed	0.0172	0	65	16	0	70	84	0	235
	(0.0165)	(0)	(124)	(33)	(0)	(144)	(106)	(0)	(220)
Black crappie	0.0184	0	0	15	123	83	30	0	251
	(0.0163)	(0)	(0)	(30)	(169)	(116)	(61)	(0)	(216)
Muskellunge	0.0080	0	31	0	64	0	12	2	110
	(0.0073)	(0)	(39)	(0)	(84)	(0)	(24)	(5)	(96)
Green sunfish	0.0019	0	0	26	0	0	0	0	26
	(0.0026)	(0)	(0)	(35)	(0)	(0)	(0)	(0)	(35)
TOTAL RELEASED	1.1265	11	3,106	2,644	3,732	3,090	2,403	389	15,374
	(0.3645)	(21)	(2,196)	(NA)	(1,891)	(2,057)	(1,209)	(301)	(3,766)
TOTAL CATCH	2.2993	11	7,358	5,186	8,167	5,342	4,746	569	31,378
	(0.6762)	(21)	(3,906)	(NA)	(3,671)	(2,568)	(1,695)	(400)	(6,417)
ANGLER HOURS		151	2,415	2,266	3,636	2,947	1,931	304	13,647
		(82)	(1,815)	(1,119)	(1,302)	(1,213)	(741)	(222)	(2,884)
ANGLER TRIPS		91	702	1,189	1,784	1,289	886	198	6,138
		(40)	(510)	(578)	(1,0330	(658)	(398)	(171)	(1,511)

Table 6.–Angler survey estimates for Long, Clear, Shavehead, Birch, Campau, Paw Paw, Murray, and Gull lakes (Z. Su, MDNR Fisheries Division, unpublished). Survey durations were variable. To facilitate comparisons between lakes, only data for June-August are reported in the table.

Lake	County	Year	Bluegill Harvest/Hr	Black Crappie Harvest/Hr	Largemouth Bass Catch/Hr*	Angler Hours/Acre
Long	St. Joseph	2009	0.837	0.033	0.266	41.9
Clear	St. Joseph	2009	0.972	0.008	0.422	42.3
Shavehead	Cass	2007	0.119	0.038	0.557	24.7
Birch	Cass	2007	0.313	0.056	0.981	28.1
Campau	Kent	2005	0.070	0	0.251	41.2
Paw Paw	Berrien	2005	0.438	0.025	0.052	11.2
Murray	Kent	2005	0.554	0.002	0.512	49.3
Gull	Kalamazoo	2002	0.681	0.001	0.252	9.5

* Includes harvested and released fish

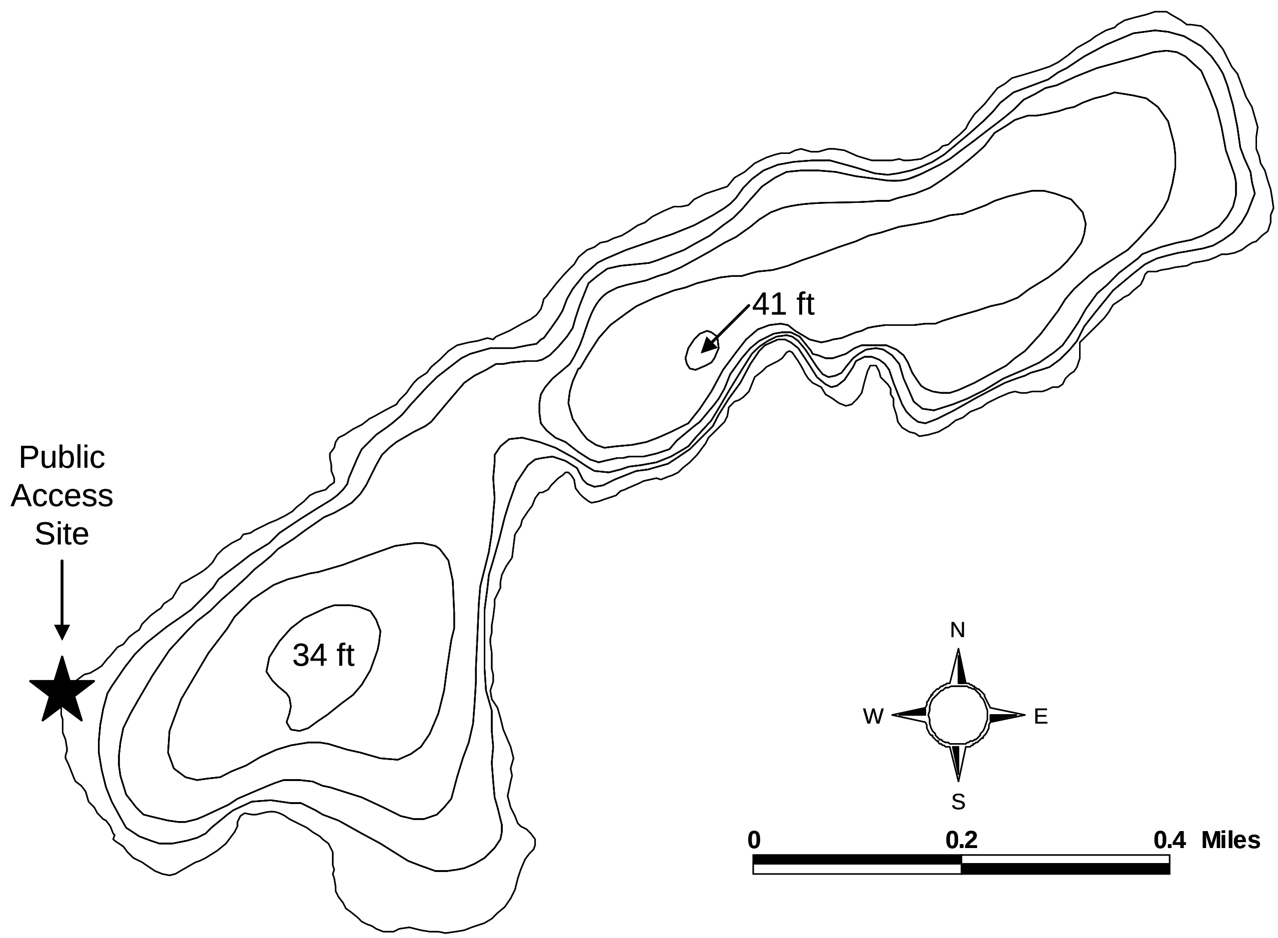

Figure 1.–Bathymetry of Long Lake, St. Joseph County.

Figure 2.–Aerial view of Long Lake, showing land use patterns within the watershed. Image from Microsoft© Virtual Earth™ (www.bing.com/maps).

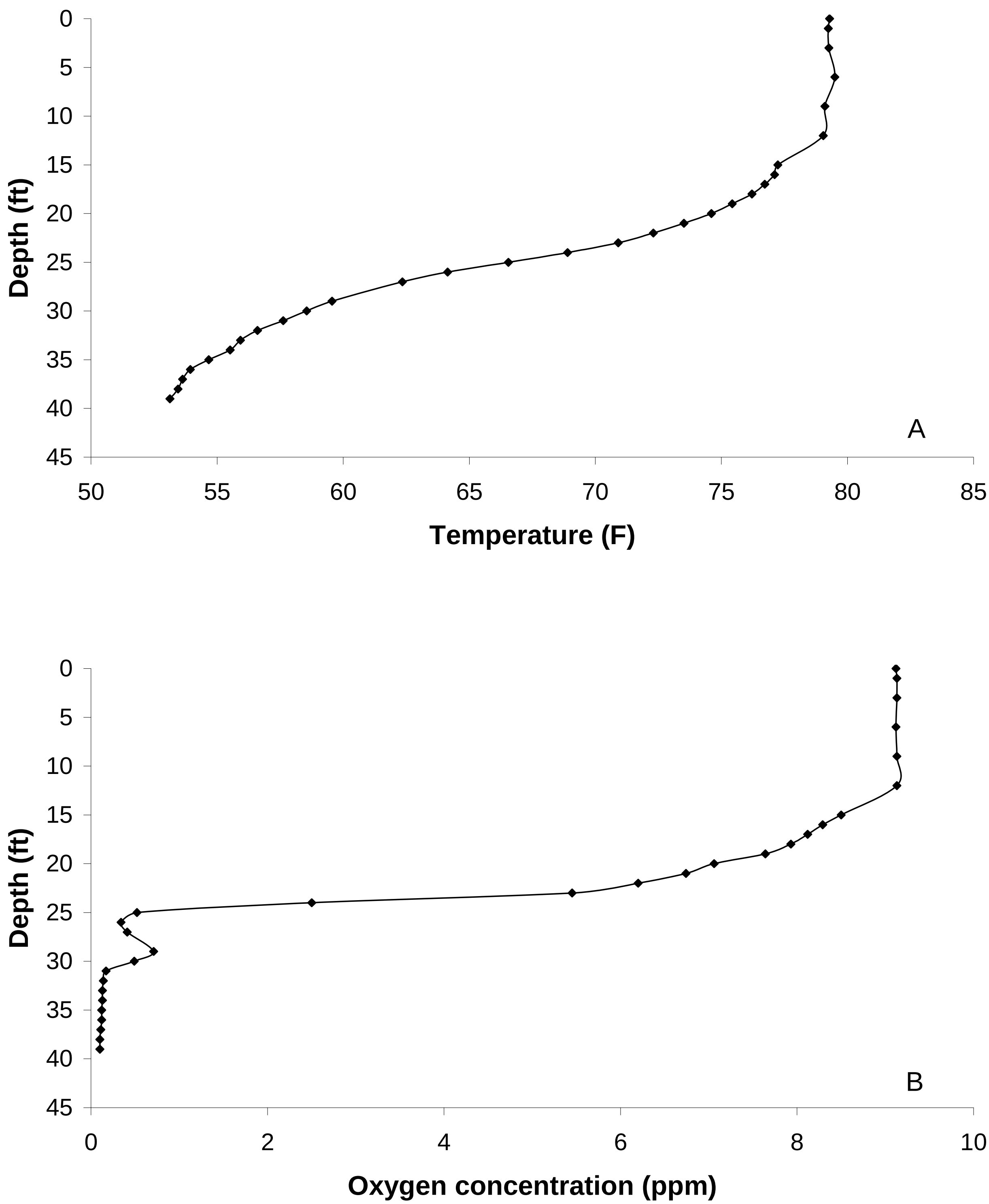

Figure 3.–Temperature (A) and dissolved oxygen (B) profiles for Long Lake on August 18, 2009.

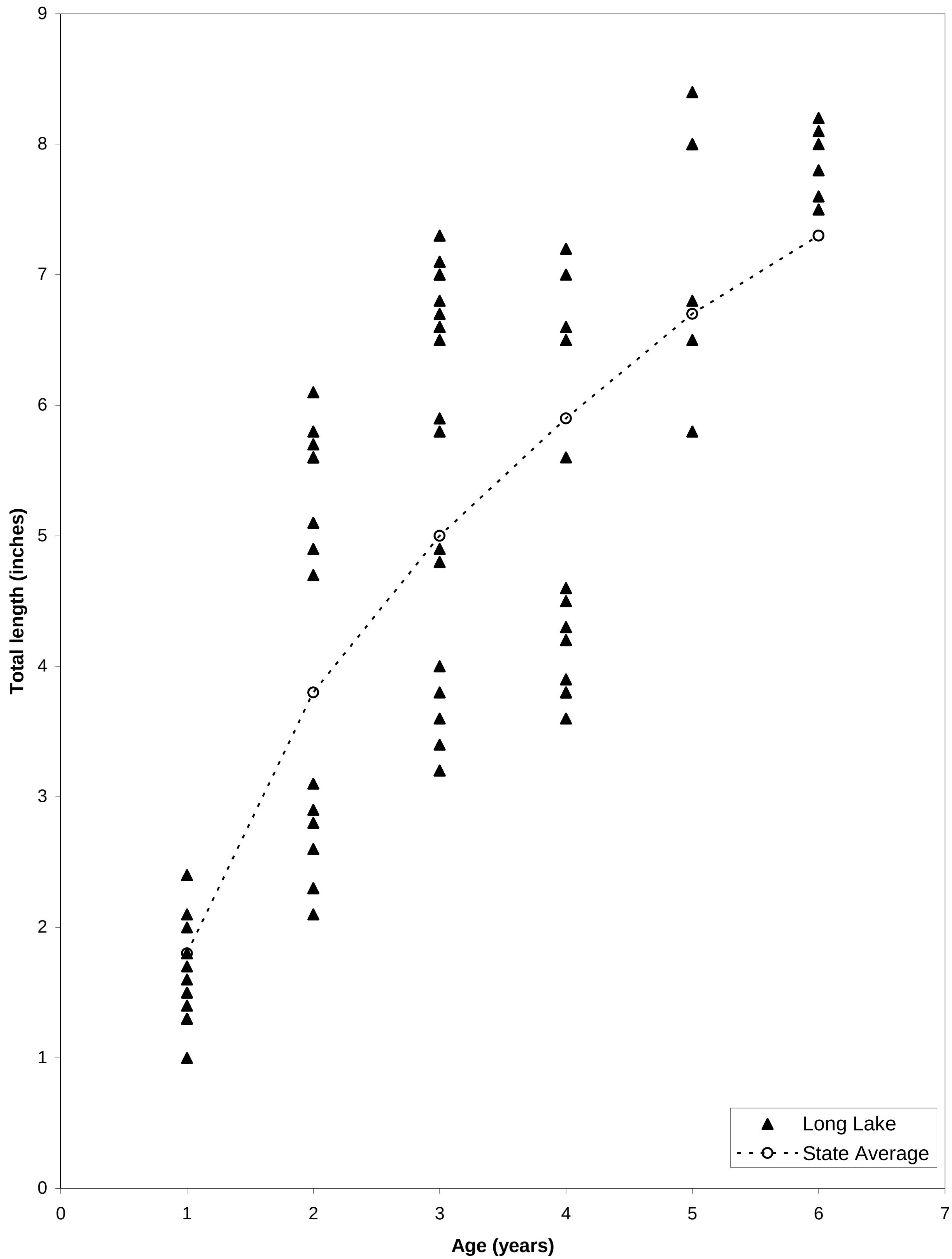

Figure 4.–Growth of bluegill in Long Lake, as determined from scale and spine samples collected during May-June 2009. State average lengths from Schneider et al. (2000). State averages for January-May are depicted, as most of the bluegills were collected during May.

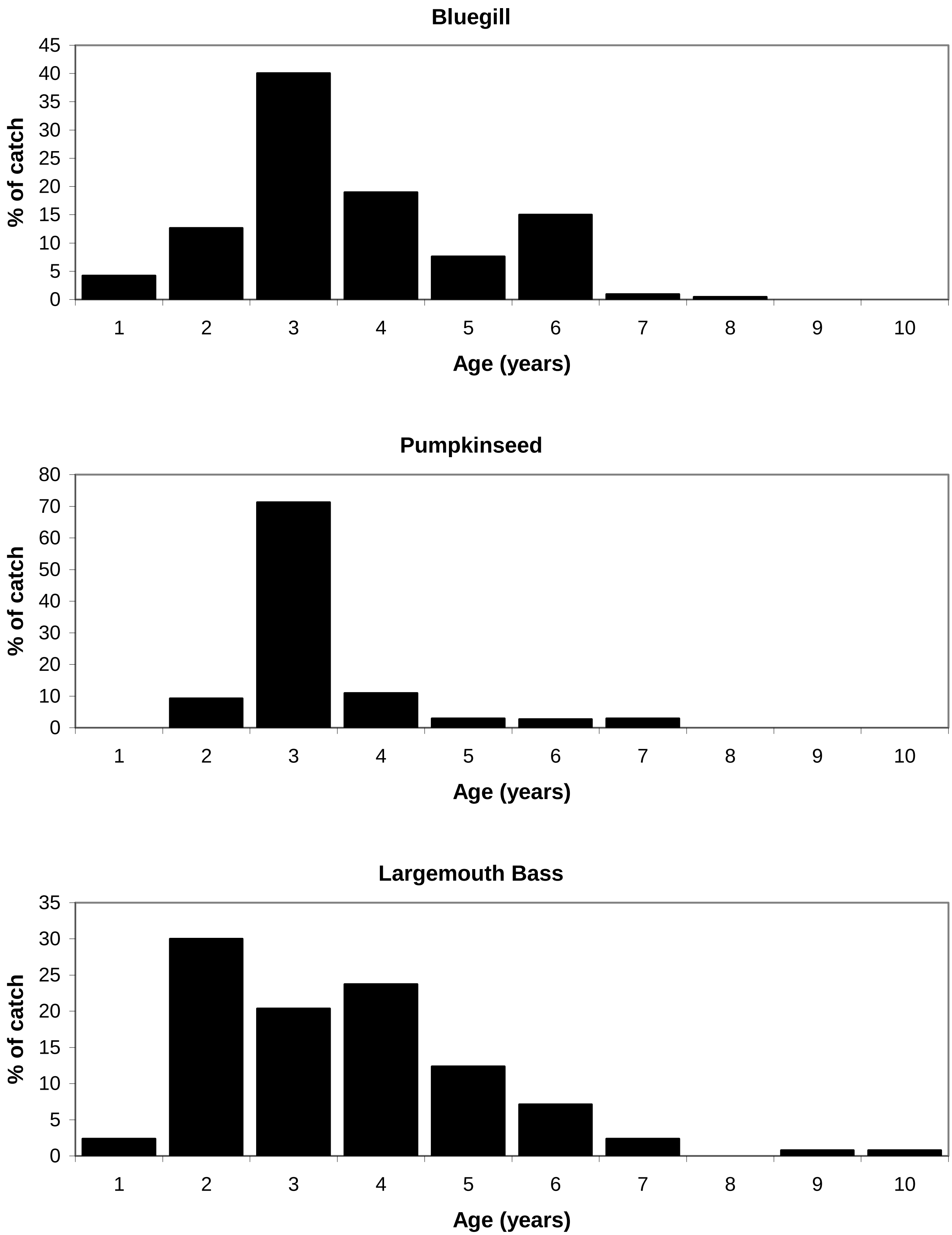

Figure 5. – Age-frequency distributions for bluegill, pumpkinseed, and largemouth bass captured in Long Lake during May-June 2009.

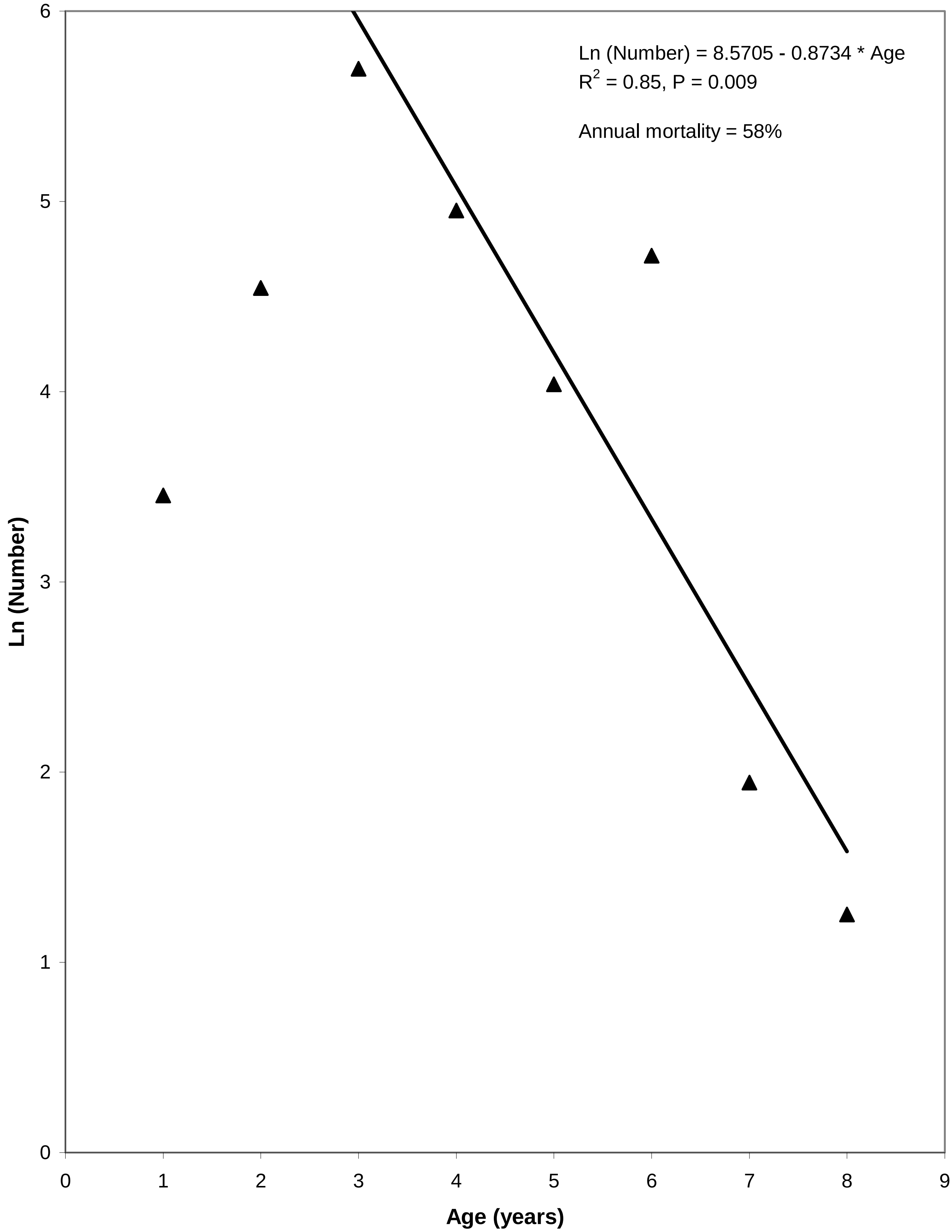

Figure 6.–Observed ln(number) versus age for bluegill captured in Long Lake during May-June 2009.

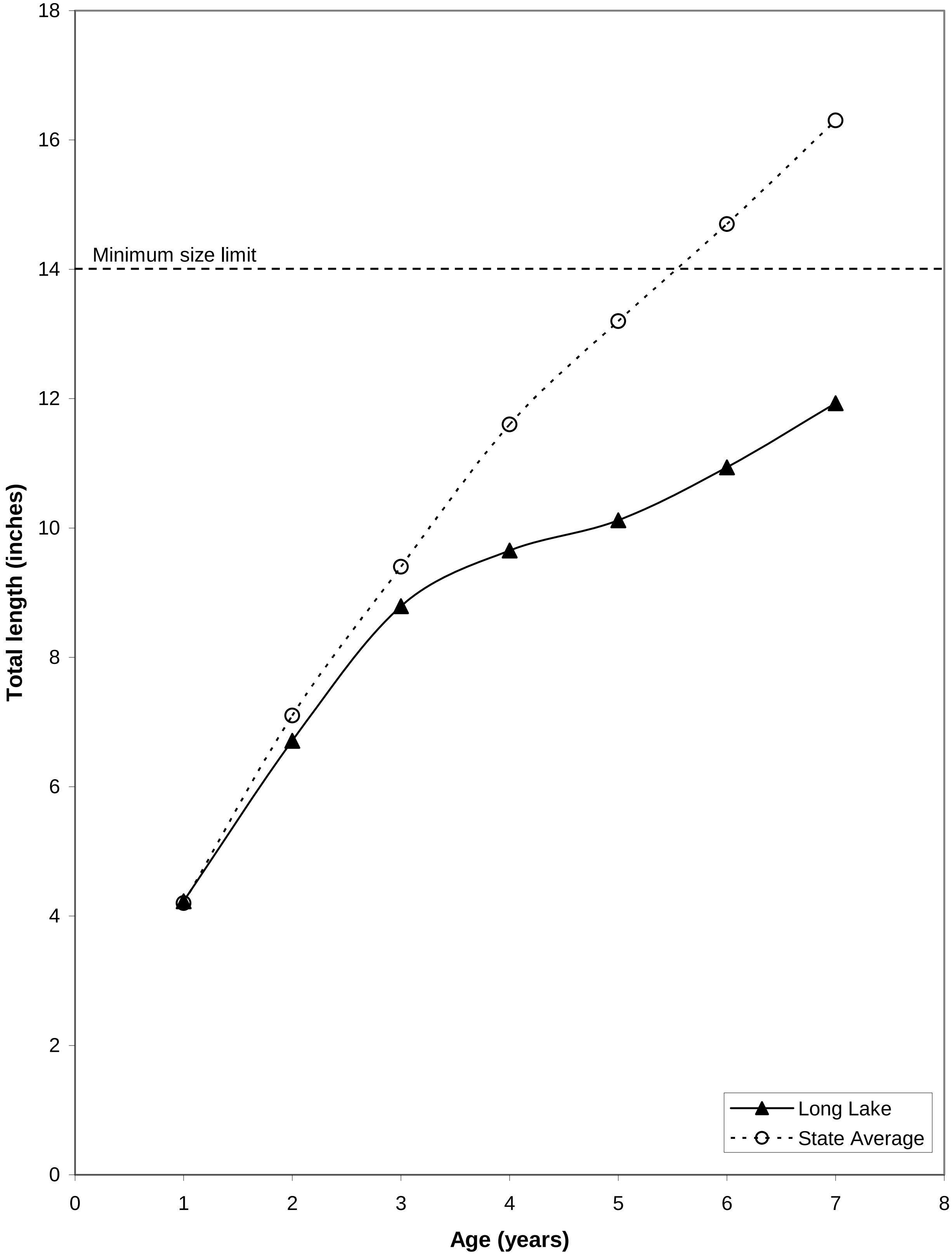

Figure 7.–Growth of largemouth bass in Long Lake, as determined from scale and spine samples collected during May-June 2009. State average lengths from Schneider et al. (2000). State averages for January-May are depicted, as most of the samples were collected during May.

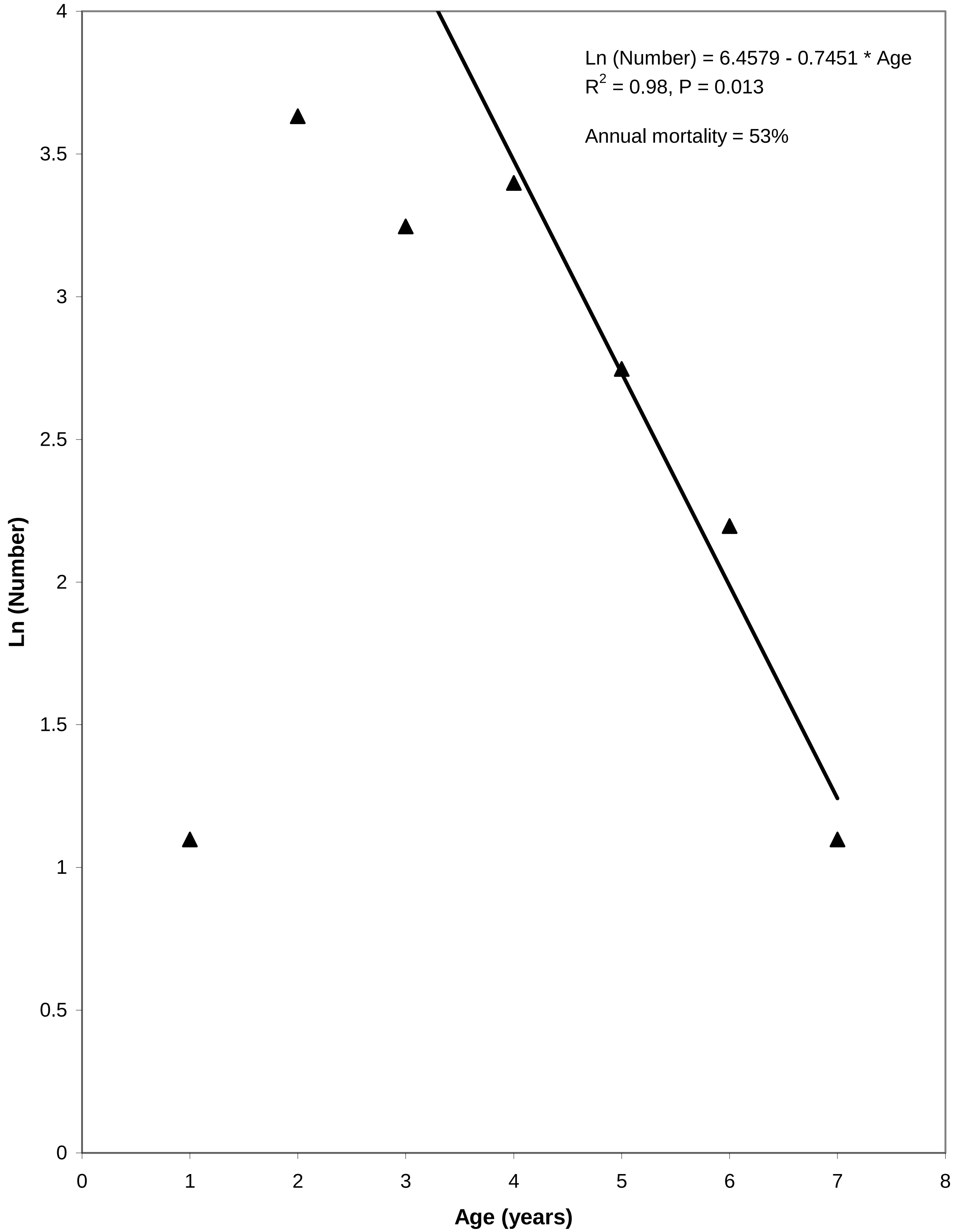

Figure 8.–Observed ln(number) versus age for largemouth bass captured in Long Lake during May-June 2009.

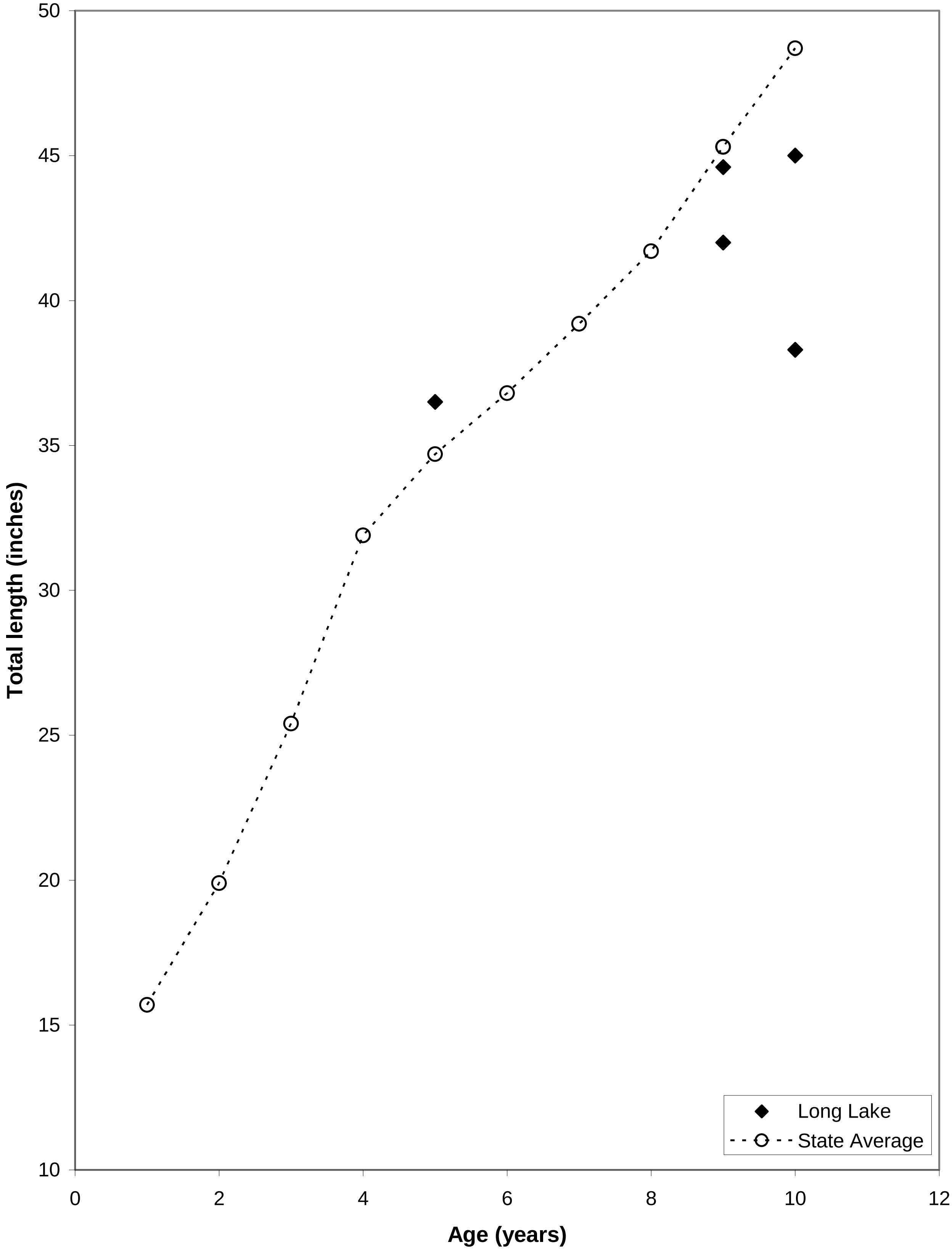

Figure 9.–Growth of muskellunge in Long Lake, as determined from dorsal fin ray samples collected during May 2009. State average lengths from Schneider et al. (2000).

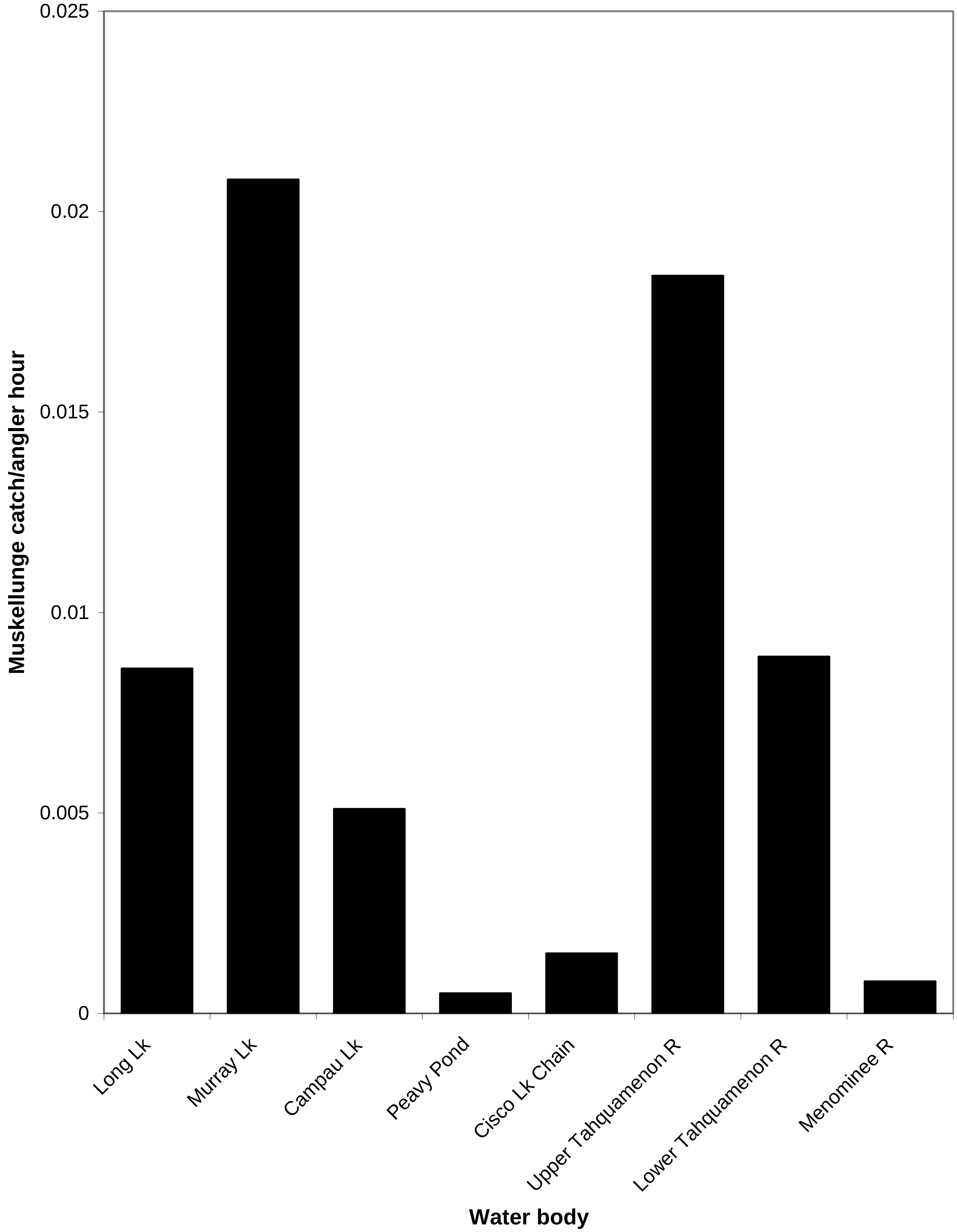

Figure 10.–Muskellunge catch (harvest + release) per angler hour estimates for several muskellunge waters in Michigan (Z. Su, MDNRE Fisheries Division, unpublished). Survey durations were variable. To facilitate comparisons between waters, only data for May-September are represented in the figure.

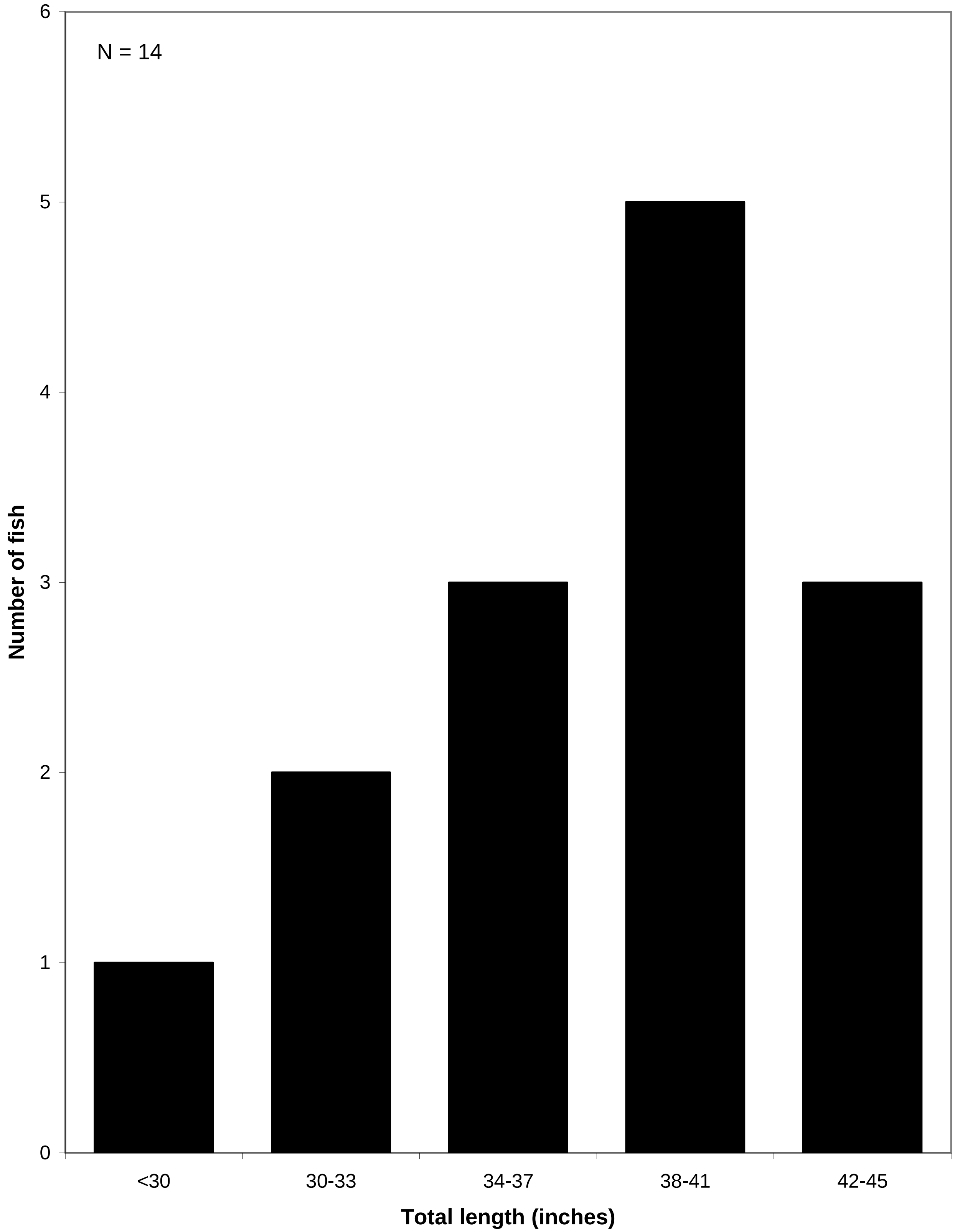

Figure 11.–Length frequency distribution for muskellunge caught by anglers during the Long Lake creel survey. In most instances, the angler measured the fish. For one fish (total length = 34 inches), the angler estimated the total length. Survey period was April 25 through October 31, 2009.