MOSS LAKE BLACK BASS SURVEY (2008 – 2010)

FINAL REPORT

MOUNTAIN FISHERIES INVESTIGATIONS

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Abstract.—A shoreline electrofishing survey of largemouth *Micropterus salmoides* and spotted bass *Micropterus punctulatus* was conducted at Moss Lake in April 2008, 2009, and 2010. A total of 91 largemouth bass and 70 spotted bass were collected during the survey. Mean annual catch rates of black bass were low, ranging from 10.0 fish/hr in 2010 to 43.1 fish/hr in 2008 for largemouth bass and 14.3 fish/hr in 2010 to 25.4 fish/hr in 2009 for spotted bass. Largemouth bass total lengths ranged from 166 to 532 mm (mean = 352; SE = 8.5), and spotted bass lengths ranged from 65 to 450 mm (mean = 233; SE = 12.7). Mean proportional size distributions of quality length (PSD) for largemouth bass was 77, mean PSD-P was 46, and mean PSD-M was 8, with no trophy length (≥630 mm) largemouth bass observed. Spotted bass mean values were PSD of 65, PSD-P of 27, and PSD-M of 5, again with no trophy length (≥510 mm) spotted bass observed. Largemouth bass annual mean relative weight (W_r) values ranged from 82 in 2009 and 2010 to 88 in 2008, while spotted bass annual W_r values ranged from 74 in 2010 to 82 in 2008. Twelve largemouth bass and six spotted bass age classes were observed, with age-2 fish representing the dominant age-class for both species. Spotted bass growth was more rapid than largemouth bass growth, with von Bertalanffy growth model predictions of 2.7 years for spotted bass to attain harvestable size of 305 mm and 3.5 years to attain 356 mm, whereas largemouth attained harvestable size of 356 mm in 4.6 years. Largemouth bass estimated annual mortality was 22%. Black bass populations in Moss Lake consisted of multiple year-classes consisting of quality-sized fish in poor condition. The largemouth bass population was characterized by slow growth, low mortality, and inconsistent young-of-the-year recruitment, whereas the spotted bass population reflected initial rapid growth and consistent young-of-the-year recruitment.

Moss Lake, also known as Kings Mountain Reservoir, is located in Cleveland County, North Carolina and serves as the water supply reservoir for the City of Kings Mountain. Constructed in 1963, the reservoir covers 730 ha at full pool, and the drainage area is characterized by rolling hills and rural land use (NCDENR 2001). With a mean Secchi depth of 2.6 m and hypoxic conditions during summer months occurring at 6 to 7 m, Moss Lake has been classified as oligotrophic by NCDENR (2001).

Moss Lake currently supports a variety of sport fishes including largemouth bass *Micropterus salmoides*, spotted bass *Micropterus punctulatus*, crappies *Pomoxis spp*., and sunfishes *Lepomis spp*. During 1987, the North Carolina Wildlife Resources Commission (NCWRC) began annual hybrid striped bass *Morone saxatilis x chrysops* stockings to create a pelagic fishery, following establishment of threadfin shad *Dorosoma petenense*, introduced by NCWRC in 1961–1997, and gizzard shad *D. cepedianum*, presumably introduced by anglers in the late 1970s (Goudreau 1993a). Subsequent forage surveys (NCWRC, unpublished data) documented establishment of alewife *Alosa pseudoharengus* and blueback herring *A.aestivalis*.

Periodic largemouth bass population assessments at Moss Lake were primarily conducted using boat-electrofishing, seine-haul, and gill-net gears (Goudreau 1993a). In the early 1990s, anglers petitioned NCWRC staff to investigate the largemouth bass population at Moss Lake due to poor perceived fishing success. Limited habitat availability, coupled with turbid water conditions, precluded NCWRC biologists from obtaining adequate population assessment numbers; consequently, largemouth bass size or creel limits were not adjusted (Goudreau 1993a). The absence of desirable largemouth bass habitat was consistently emphasized as contributing to low largemouth bass survey numbers at Moss Lake during historic investigations (Goudreau 1993a).

Because largemouth bass surveys have not been conducted at Moss Lake since the early 1990s, NCWRC fisheries biologists decided to assess current black bass populations to investigate angler reports of increased spotted bass catch and continued poor fishing success for largemouth bass.

Methods

Field Collections.—Largemouth bass and spotted bass were collected during April 2008–2010 using a boat mounted Model 7.5 GPP Electrofisher (Smith-Root, Inc., Vancouver, Washington) set at 1,000 V-DC and 120 pulses per second to produce a 3- to 4-A field. Sample sites consisted of five 300-m fixed shoreline transects scattered throughout Moss Lake representing a variety of habitats (Figure 1). All largemouth and spotted bass collected were kept in a plastic bag labeled by site, placed on ice, and returned to the Marion State Fish Hatchery. Fish were weighed (g), measured for total length (TL, mm), and sexed, and sagittal otoliths were removed and stored in plastic vials for age determination. Fish were considered immature if the gonads were not developed.

Catch-per-unit-effort.—Relative abundance was indexed by catch-per-unit-effort (CPUE) of electrofishing pedal-time and expressed as number of fish collected per pedal-hour (Hubert and Fabrizio 2007).

Size Structure and Condition.—Length-frequency histograms were constructed and stock indices were calculated for largemouth and spotted bass populations by year (Neumann and Allen 2007). Proportional size distribution (PSD) and relative stock density values of preferred (PSD-P) and memorable (PSD-M) sized bass were calculated for each population as described by Gabelhouse (1984) as modified by Guy et al. (2007). Relative weight (W_r) was used to index fish condition and was calculated for largemouth bass $\geq$150 mm TL and spotted bass $\geq$100 mm TL using the standard weight (W_s) equations described by Wege and Anderson (1978) and Wiens et al. (1996).

Age, Growth, and Mortality.—Otoliths were mounted on fully-frosted cytological microscope slides using cyanoacrylate glue and sectioned transversely through the dorsoventral plane into two 0.5-mm sections using a Buehler Isomet low speed diamond wheel saw (Allen et al. 2003). Sections then were mounted onto glass microscope slides using Shandon synthetic mountant (Thermo Scientific, Waltham, Massachusetts), and annuli were counted using a compound microscope by two independent readers (Hoyer et. al. 1985; Heidinger and Clodfelter 1987). If no assigned age could be agreed upon between readers, the otolith was discarded.

Annulus formation was assumed to occur early during the black bass growing season, with each annulus indicating a new growth year (DeVries and Frie 1996). However, early spring collections of temperate fishes may occur before the most recent annulus becomes clearly visible; Taubert and Tranquilli (1982) observed annulus formation for largemouth bass between April and June in Lake Sangchris, Illinois. To account for the assumed absence of a visible annulus for year of collection, an additional year was added to visible annuli counts. Age-distribution histograms displaying black bass age-classes were constructed for each survey year.

Fisheries Analyses and Simulation Tools (FAST) V. 2.1 software (Slipke and Maceina 2001) was used to assess largemouth bass and spotted bass growth fitting the von Bertalanffy growth model (von Bertalanffy 1938). This model consists of three parameters (K, L_∞, and t_0) where K = Brody growth coefficient, L_∞ = asymptotic length, and t_0 = theoretical time when length equals zero.

Time (years) estimates to reach current North Carolina largemouth bass (356 mm TL) and spotted bass (305 mm TL) harvestable size were calculated to evaluate growth, as it relates to current minimum-length regulations. Additionally, time estimates to reach current North Carolina largemouth bass harvestable size were calculated for spotted bass to evaluate relative growth comparisons between black bass populations using the following von Bertalanffy equations:

$$\text{Largemouth bass: 356 mm TL} = L_{\infty} \text{ mm TL} * \left(1 - e^{-K(\text{age} - t_0)}\right),$$

$$\text{Spotted bass: 356 mm TL} = L_{\infty} \text{ mm TL} * \left(1 - e^{-K(\text{age} - t_0)}\right).$$

Instantaneous (Z) and annual (A) mortality rates were estimated using linearized catch curves (Ricker 1975). The first age-class was removed if it was not abundant in the age-frequency as described by Miranda and Bettoli 2007), and older age-classes were removed if they contained fewer than 5 fish (Ricker 1975; Van Den Avyle and Hayward 1999). Estimates of annual mortality were derived by pooling successive data years to reduce the erratic recruitment influence and scatter points around the catch curve (Allen 1999), and to permit annual mortality estimation of older age-classes (Miranda and Bettoli 2007). Annual mortality (A) was estimated using $A = 1 - S$, where $S = e^{-Z}$.

Results and Discussion

Catch-per-unit-effort.—A total of 91 largemouth bass and 70 spotted bass were collected at Moss Lake during the 3-year survey period (Figure 2; Table 1). Mean annual catch rates of black bass were low, ranging from 10.0 fish/hr (SE = 4.4) in 2010 to 43.1 fish/hr (SE = 9.6) in 2008 for largemouth bass and 14.3 fish/hr (SE = 8.2) in 2010 to 25.4 fish/hr (SE = 11.6) in 2009 for spotted bass (Table 1). Cumulative black bass catch rates ranged from 24.3 fish/hr (SE = 4.5) in 2010 to 59.6 fish/hr (SE = 6.6) in 2008 (Table 2). Current mean largemouth bass catch rates at Moss Lake were similar to the catch rate of 47.6 fish/hr reported during the 1993 Moss Lake survey (Goudreau 1993a) and to values observed on the Catawba River arm of Lake James, where largemouth bass catch rates ranged from 38.9 fish/hr in 2004 to 59.9 fish/hr in 2006 (Rash 2006). However, black bass catch rates at Moss Lake were substantially lower than those reported for other Catawba River impoundments; Goudreau (1993b) reported a significantly higher mean largemouth bass catch rate of 106.4 fish/hr at Lake Rhodhiss, and mean annual catch rates of largemouth bass at Lake Hickory averaged 89 fish/hr between 2004 and 2007 (Hodges 2007).

Size Structure and Condition.—Largemouth bass lengths (Figure 2; Table 1) ranged from 166 to 532 mm (mean = 352; SE = 8.5). Proportional size distributions of quality (PSD) length largemouth bass ranged from 64 to 87 (mean = 77; SE = 6.7) among transects sampled; preferred length values (PSD-P) ranged from 31 to 57 (mean = 46; SE = 7.8), memorable length values (PSD-M) ranged from 2 to 14 (mean = 8; SE = 3.5), and no trophy length largemouth bass (≥630 mm) were observed (Table 1). Largemouth PSD and PSD-P values were higher than those reported by Goudreau (1993a) during the 1993 Moss Lake survey (PSD = 58; PSD-P = 12), likely due to various gear types used for historic fish collections. However, largemouth bass size-structural values were similar to those reported by Goudreau (1993b) at Lake Rhodhiss, where mean PSD and PSD-P values were 77 and 44, respectively. Largemouth bass PSD values were also similar to recent values from upper Catawba reservoirs; however, the PSD-P value was higher than the mean PSD-P values of 33 for both Lake Hickory (Hodges 2007) and Lake James (Rash 2006). Approximately 53% of largemouth bass collected at Moss Lake during this survey were harvestable size (≥356 mm), which is higher than the proportion (40%) observed in Lake James (Rash 2006).

Spotted bass lengths (Figure 2; Table 1) ranged from 65 to 450 mm (mean = 233; SE = 12.7). Proportional size distributions of quality length spotted bass ranged from 59 to 71 (mean = 65; SE = 3.5), PSD-P from 14 to 36 (mean = 27; SE = 6.8), and one memorable length fish was collected reflecting a PSD-M value of 5; no trophy length spotted bass (≥510 mm) were observed (Table 1).

Largemouth bass annual mean relative weight (W_r) values ranged from 82 in 2009 (SE = 1.3) and 2010 (SE = 2.5) to 88 (SE = 0.8) in 2008, while spotted bass annual W_r values ranged from 74 (SE = 1.8) in 2010 to 82 (SE = 2.1) in 2008 (Figure 3). Increased W_r values reflected by preferred and memorable length largemouth and spotted bass may be explained by pre-spawn gonadal development (Ney 1999); however, mean W_r values reflected by largemouth and spotted bass at Moss Lake generally were poor regardless of length-class (Figure 3). Low largemouth bass condition values observed during this survey were similar to values reported during the 1993 Moss Lake survey, where mean W_r values for 100-mm length-classes ranged from 86 to 90 (Goudreau 1993a), and slightly lower than those observed in 1990 in Lake Rhodhiss, where mean W_r values for 50-mm size classes ranged from 84.0 to 94.0 (Goudreau 1993b). In addition, annual mean W_r values obtained during the current survey were much lower than mean values from the more recent 3-yr studies at Lake James (Rash 2006) and Lake Hickory (Hodges 2007). Rash (2006) reported a 98 annual mean W_r value for largemouth bass in Lake James, while Hodges (2007) reported annual mean relative weights for largemouth bass in Lake Hickory ranging from 90 to 95.

Age, Growth, and Mortality.—Twelve largemouth bass and six spotted bass age classes were observed, with age-2 fish representing the dominant age class for both species during the survey period (Figure 4). Although spotted bass appeared to have recruited to the sampling gear at age 1 during 2008, both species were considered fully recruited to the sampling gear at age 2 (Figure 4). Rash (2006) observed similar results at Lake James, where largemouth bass recruited to the sampling gear at age 2.

The von Bertalanffy growth curves,

$$\text{Largemouth bass: TL} = 539.5 * \left(1 - e^{-0.219(\text{age}+0.982)}\right),$$

$$\text{Spotted bass: TL} = 485.4 * \left(1 - e^{-0.426(\text{age}-0.379)}\right),$$

best fit our data and explained 99% of the variation in total length at age for largemouth bass and spotted bass (Figure 5). Moss Lake spotted bass growth was more rapid than largemouth bass growth, as the von Bertalanffy growth model predicted 2.7 years for spotted bass to attain harvestable size (305 mm) and 3.5 years to attain 356 mm, while largemouth attained harvestable size (356 mm) in 4.6 years (Figure 5). Goudreau (1993a) reported faster largemouth bass growth at Moss Lake during historic surveys, as fish attained harvestable size in 4 years; however, ages were assigned using scale impressions, and likely underestimated true age (Beamish and McFarlane 1987; Isely and Grabowski 2007). Largemouth bass growth at Moss Lake was slower than rates observed at Lakes Hickory (Hodges 2007) and James (Rash 2006), where fish attained harvestable size at ages 4 and 3, respectively. Although slower largemouth bass growth at Moss Lake was observed during this survey compared to historical and contemporary regional reservoir surveys, the estimated asymptotic maximum length for largemouth bass was 540 mm, which was higher than estimates of 476 mm for Lake Hickory (Hodges 2007) and 464 mm for Lake James (Rash 2006).

Instantaneous (Z) and annual (A) mortality estimates were only calculated for largemouth bass (Figure 6), due to unmet catch-curve assumptions (catch at age) for spotted bass (Miranda and Bettoli 2007). Largemouth bass were assumed fully recruited to the sampling gear at age 2, and age 6 was the oldest age class with at least five representatives. Estimated instantaneous mortality was 0.25; thus, estimated annual mortality rate was 22%.

Annual mortality estimate observed during this survey was lower than the estimate (A = 30%) calculated for Moss Lake largemouth bass during historic surveys, as fish were assumed fully recruited to the sampling gear at age 1, and age 4 was the oldest age class with at least five representatives (Goudreau 1993a); again as with growth estimates, the use of scales for age determination in the 1993 study likely influenced resulting mortality estimates. However, the annual mortality rate calculated during this survey was lower than that calculated for the 2001 largemouth bass cohort in Lake Hickory (Hodges 2007), and the total annual mortality estimate of 35% for largemouth bass in Lake James (Rash 2006). Furthermore, Beamesderfer and North (1995) reported mortality rates for 698 populations of largemouth bass in North American and found annual mortality averaged 35%. Thus, our estimated total annual mortality rate of 22% is lower than national average for largemouth bass.

Conclusions

The largemouth bass population in Moss Lake reflected multiple year classes consisting of quality-sized fish in poor condition. In addition, the largemouth bass population was characterized by slow growth and low mortality; thus, implementation of fisheries regulations to restrict harvest likely would be ineffective (Myers et al. 2008). Spotted bass appeared to grow much faster than largemouth bass at Moss Lake, and consistent young-of-the-year (YOY) recruitment observed during the current survey suggests a well-established spotted bass population. Therefore, increasing the current minimum-size limit for spotted bass at Moss Lake to 356 mm would eliminate potential species identification issues (compliance) among anglers and law enforcement personnel, especially if largemouth and spotted bass hybridize as is the case at Lake Norman (NCWRC unpublished data). Additionally, increasing the spotted bass minimum-size limit to 356 mm would simplify statewide black bass regulations among reservoirs that contain viable spotted and largemouth bass fisheries.

Largemouth bass in this survey reflected a larger predicted asymptotic maximum length than black bass populations at Lakes Hickory and James; however, largemouth bass growth at Moss Lake appears to be slower than in other reservoirs in the region. Catch rates indicated low-density, high-quality black bass populations, and mortality estimates suggest that low numbers of largemouth bass are lost annually. Therefore, it is possible that interspecific competition with other piscivores (spotted bass, hybrid striped bass) is limiting the initial growth of largemouth bass at Moss Lake. Furthermore, potential suboptimal forage (gizzard shad) may be restricting growth of early age fish. Age-frequency and length-frequency distributions indicate consistent absence of YOY and age-1 largemouth bass collections, while YOY and age-1 spotted bass were collected annually. Introduced spotted bass may be influencing largemouth bass recruitment by outcompeting current spawning and juvenile rearing habitats, which appear to be very limited at Moss Lake. Sampling locations were characterized by sparse cover, and black bass were typically collected from the few locations within transects where woody cover was present.

Therefore, limited cover, oligotrophic conditions, and a poor forage base, coupled with an emerging spotted bass population, may be impairing the quality of the largemouth bass population at Moss Lake. Periodic repeated sampling would be required to further assess trends in black bass population dynamics.

Recommendations

1) Continue to manage the Moss Lake largemouth bass population under current statewide regulation.

2) Increase the current spotted bass minimum-size limit at Moss Lake to 356 mm (5-fish daily creel) with a two-fish-under-356-mm exemption to match current statewide largemouth bass regulations.

3) Conduct periodic electrofishing surveys at Moss Lake to monitor black bass population dynamics over time.

4) Investigate opportunities to enhance littoral and off-shore black bass habitat at Moss Lake.

5) Investigate supplemental forage stocking opportunities at Moss Lake.

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TABLE 1.—Catch statistics for largemouth bass (LMB) and spotted bass (SPB) collected during electrofishing surveys at Moss Lake, North Carolina, April 2008–2010. Catch (N), effort (pedal-hrs), catch-per-unit effort [CPUE (fish/hr)] with associated standard error (SE), total length range, median total length, proportional size distribution (PSD), PSD-preferred (P), and PSD-memorable (M) values with 95% confidence intervals in parentheses are shown by sample year.

Year	Species	N	Effort	CPUE (SE)	Range (mm)	Median (mm)	PSD	PSD-P	PSD-M
2008	LMB	47	1.09	43.1 (9.6)	166-512	323	64 (51-78)	31 (18-45)	2 (0-7)
2009	LMB	30	1.26	23.8 (5.1)	251-532	381	87 (75-99)	57 (39-74)	7 (0-16)
2010	LMB	14	1.40	10.0 (4.4)	241-521	386	79 (57-100)	50 (24-76)	14 (0-16)
2008	SPB	18	1.09	16.51 (3.4)	93-376	169	71 (38-100)	14 (0-40)	
2009	SPB	32	1.26	25.4 (11.6)	91-450	230	59 (39-80)	32 (12-51)	5 (0-13)
2010	SPB	20	1.40	14.3 (8.2)	65-371	268	64 (39-89)	36 (11-61)	

TABLE 2.—Cumulative catch statistics for black bass collected during electrofishing surveys at Moss Lake, North Carolina, April 2008–2010. Catch (N), effort (pedal-hrs), catch-per-unit effort [CPUE (fish/hr)] with associated standard error (SE), total length range, and median total length, are shown by sample year.

Year	N	Effort	CPUE (SE)	Range (mm)	Median (mm)
2008	65	1.09	59.6 (6.6)	93-512	302
2009	62	1.26	49.2 (5.9)	91-532	381
2010	34	1.40	24.3 (4.5)	65-521	341

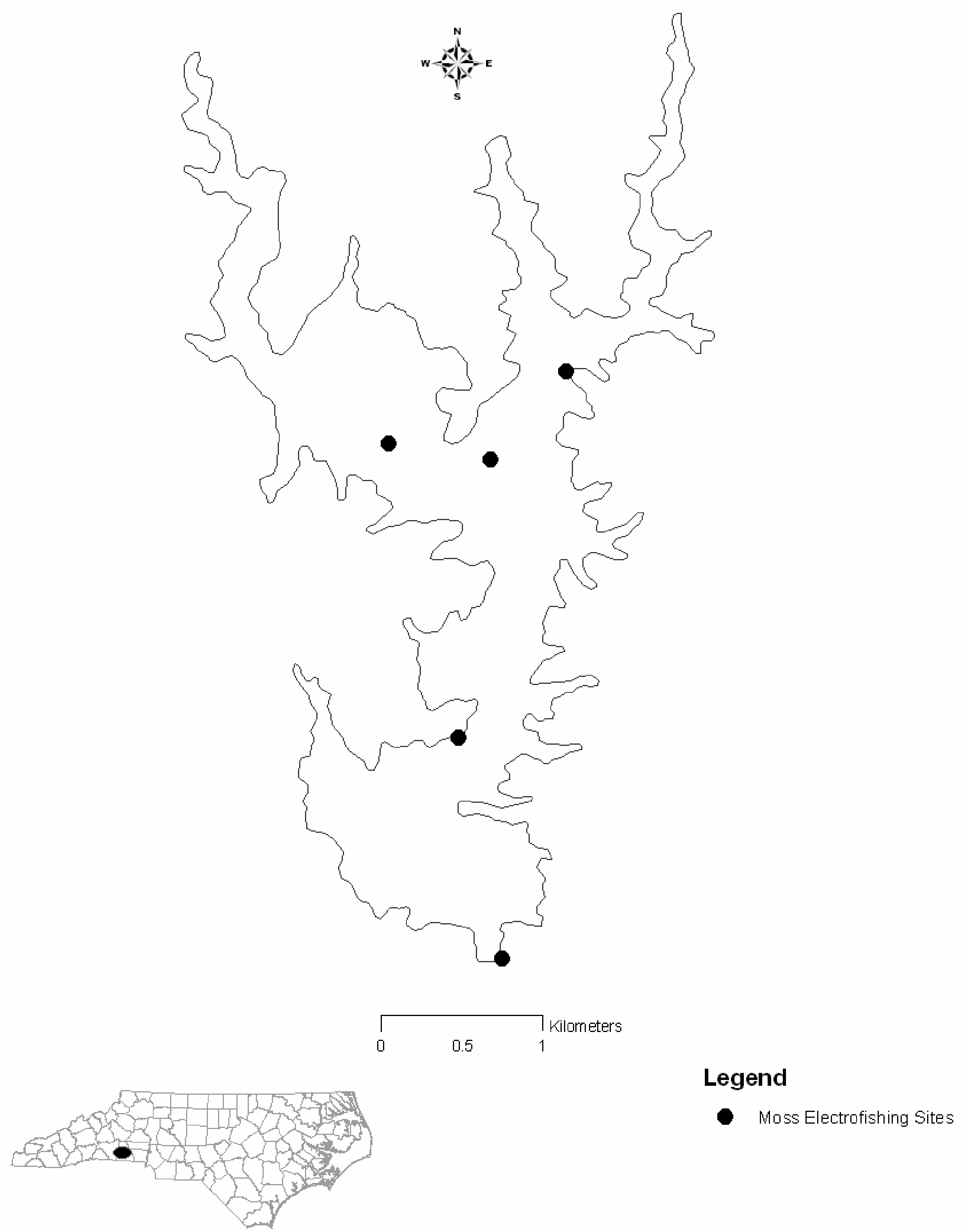

FIGURE 1.—Map of Moss Lake, North Carolina, with April 2008–2010 sampling locations. Sites located on map in open water are island transects.

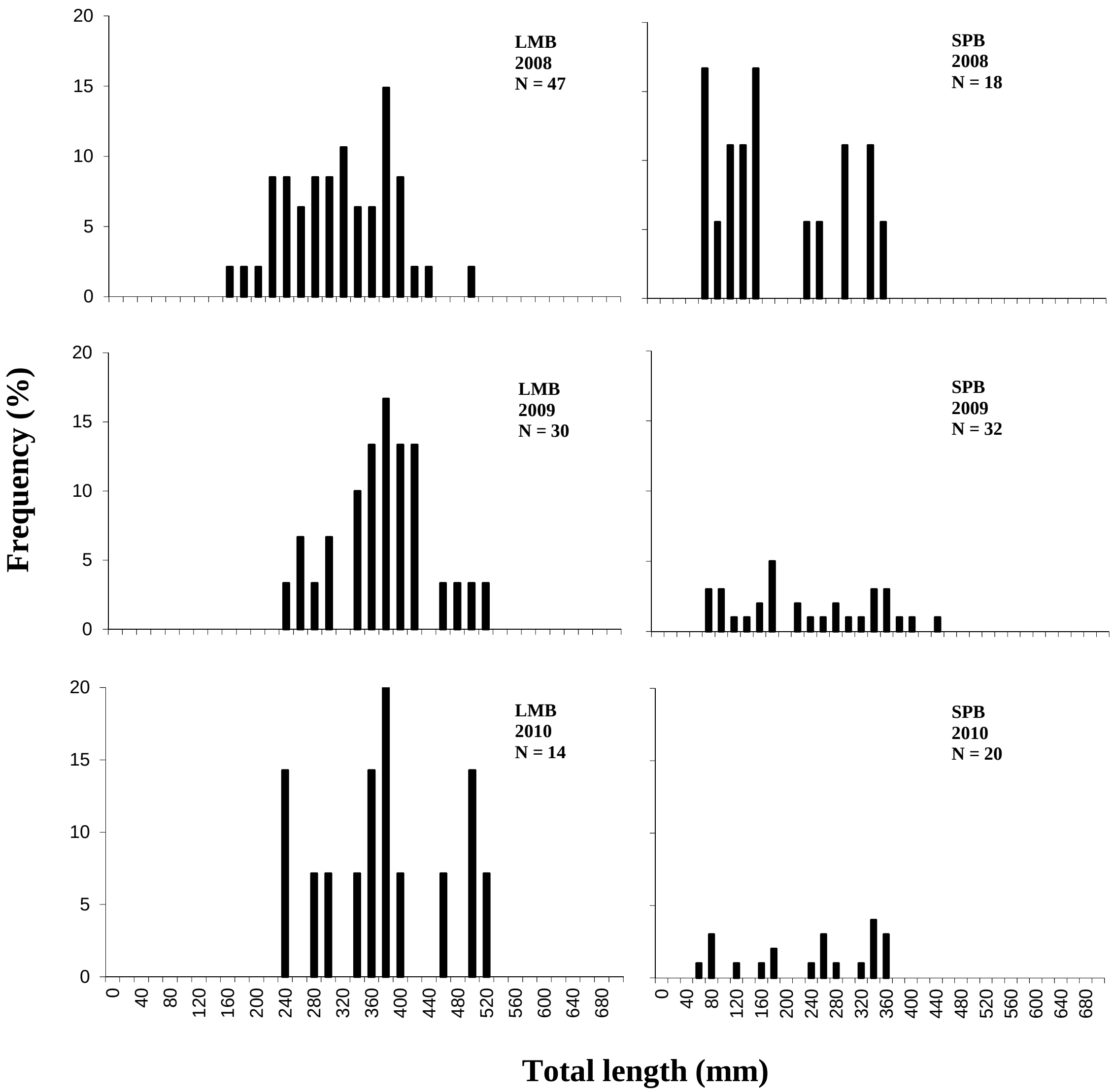

FIGURE 2.—Length-frequency distributions for largemouth bass (LMB) and spotted bass (SPB) collected during electrofishing surveys at Moss Lake, North Carolina, April 2008–2010.

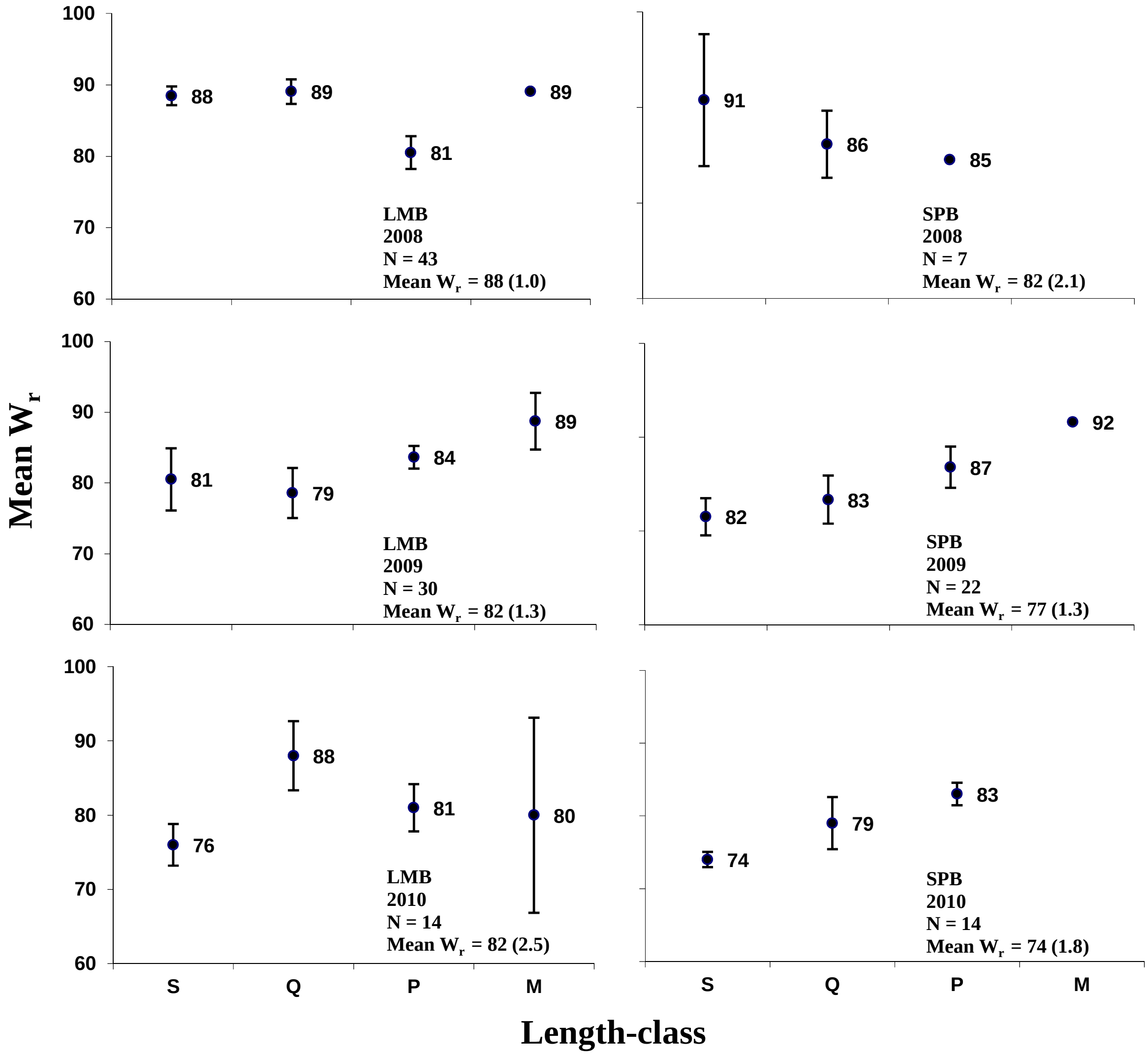

FIGURE 3.—Mean relative weight (W_r) values for stock (S), quality (Q), preferred (P), and memorable (M) size largemouth bass (LMB) and spotted bass (SPB) collected during electrofishing surveys at Moss Lake, North Carolina, April 2008–2010. Standard error bars associated with length-class mean values are shown, and standard errors for annual mean W_r values are listed in parentheses.

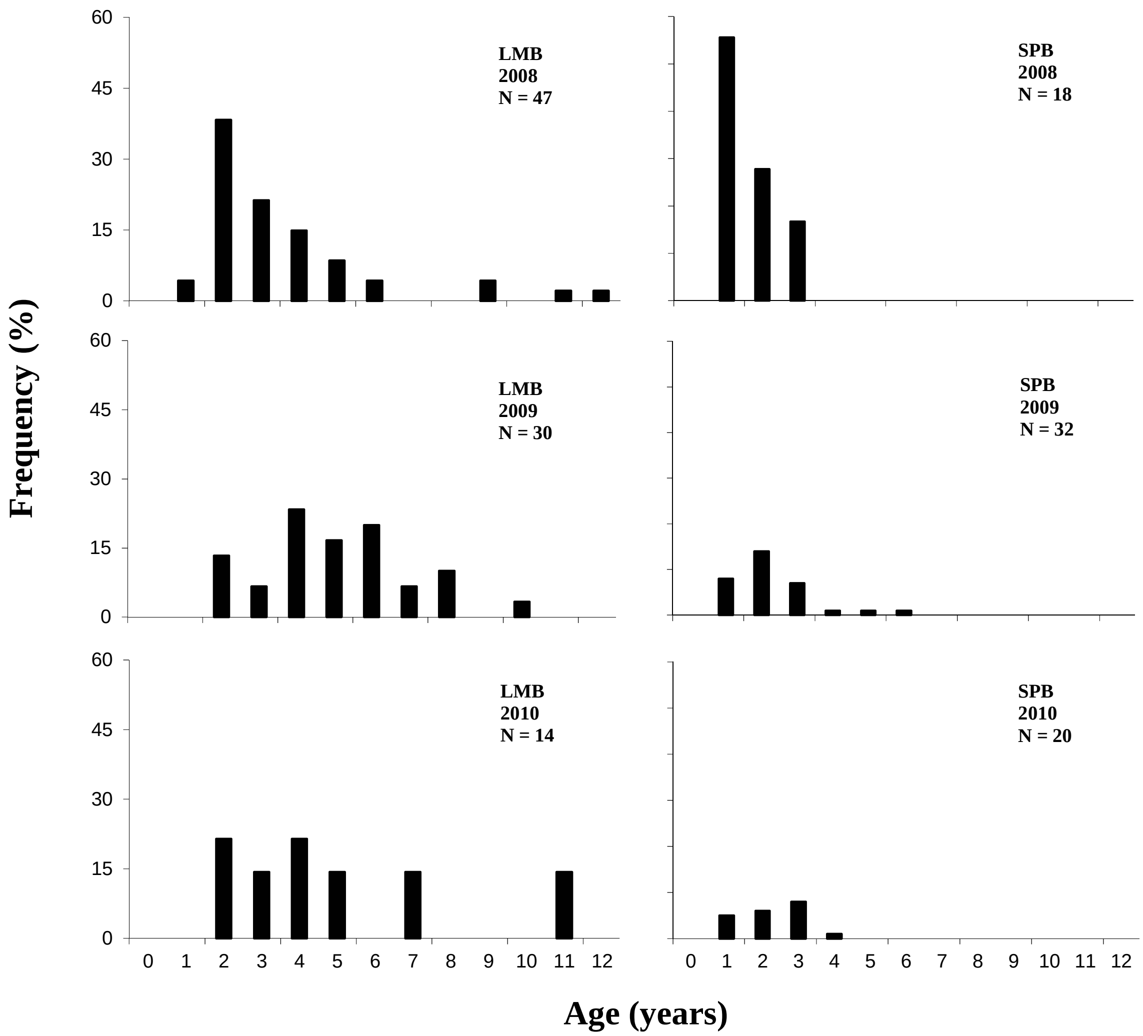

FIGURE 4.—Age distributions for largemouth bass (LMB) and spotted bass (SPB) collected during electrofishing surveys at Moss Lake, North Carolina, April 2008–2010.

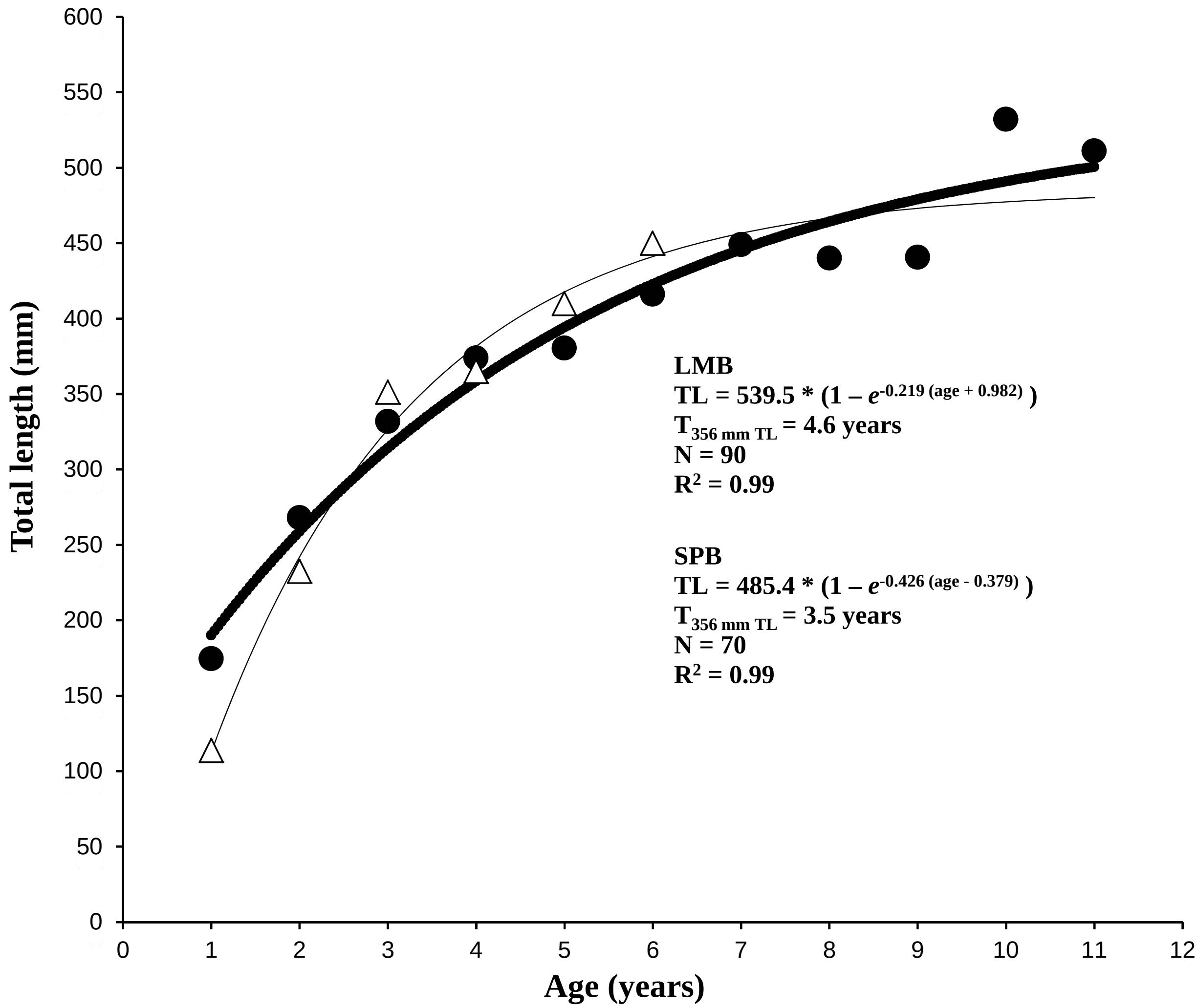

FIGURE 5.—von Bertalanffy growth curves for largemouth bass (LMB) and spotted bass (SPB) collected during electrofishing surveys at Moss Lake, North Carolina, April 2008–2010. Predicted times (T) to reach 356 mm total length (TL) are shown for each species. Growth plots show observed (LMB = black circles; SPB = white triangles) and predicted (LMB = thick line; SPB = thin line) values.

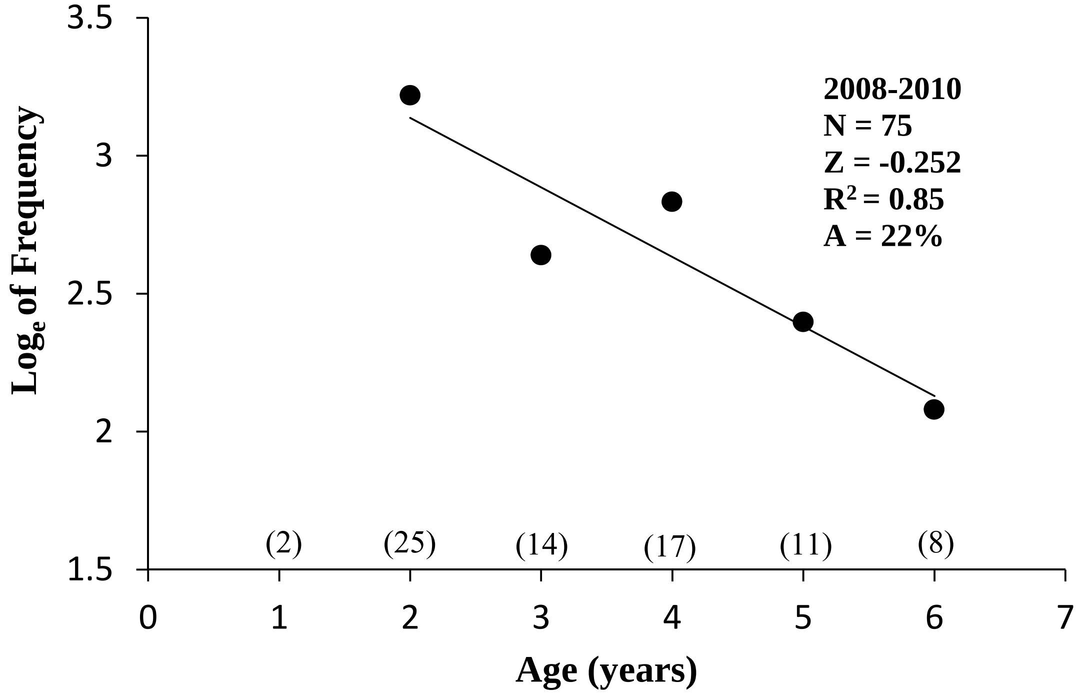

FIGURE 6.—Catch curve for largemouth bass collected during electrofishing surveys at Moss Lake, North Carolina, April 2008–2010. Numbers in parentheses indicate the number of fish caught at each age. The estimate of annual (A) mortality is given based on three consecutive years.