Hiwassee Reservoir Black Bass Electrofishing Survey

(2000-2002)

Final Report

MOUNTAIN FISHERIES INVESTIGATIONS

Federal Aid in Fish Restoration
Project F-24

Project Type: Survey

Period Covered: 2000-2002

Andrew P. Wheeler
Assistant District 9 Fisheries Biologist

C. Scott Loftis
District 9 Fisheries Biologist

David L. Yow
Mountain Region Warmwater Research Coordinator

North Carolina Wildlife Resources Commission
Division of Inland Fisheries
Raleigh

2003

This publication was funded under the Federal Aid in Sport Fish Restoration Program utilizing state fishing license money and federal grant funds derived from federal excise taxes on fishing tackle and other fishing related expenditures.

Funds from the Sport Fish Restoration Program are used for aquatic education, fisheries research and management, and boating access facilities. The program is administered cooperatively by the N.C. Wildlife Resources Commission and the U.S. Fish and Wildlife Service.

Abstract— We used boat electrofishing to perform a stock assessment of largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieu*, and spotted bass *M. punctulatus* in Hiwassee Reservoir. We used a stratified study design by dividing the reservoir into three longitudinal strata. Largemouth bass electrofishing catch per unit of effort (CPUE) was highest in the upper and middle strata and lower in the lower stratum. The overall mean CPUE by distance (100 m) was 0.9 in the lower stratum, 1.8 in the middle stratum, and 1.6 in the upper stratum. The overall mean CPUE by time (hour) was 12.6 in the lower stratum, 23.7 in the middle stratum, and 22.5 in the lower stratum. Relative stock density analyses revealed that larger fish make up a greater proportion of the largemouth bass population in the lower stratum than the middle and upper strata. Largemouth bass relative weight (W_r) averaged 92.2 in the lower stratum, 93.0 in the middle stratum and 90.2 in the upper stratum. The estimate of instantaneous mortality rate was 0.41 and the estimate of the finite annual mortality rate was 0.34. The Von Bertalanffy growth equation that best fit the data was $L_t = 517.1\ (1\text{-}e^{-0.3351\ (t+0.0603)})$. Smallmouth bass electrofishing CPUE varied across strata and was highest in the lower stratum and lowest in the upper stratum. The overall mean CPUE by distance (100 m) was 2.4 in the lower stratum, 1.4 in the middle stratum, and 0.9 in the upper stratum. The overall mean CPUE by time (hour) was 30.4 in the lower stratum, 17.7 in the middle stratum, and 12.9 in the lower stratum. Relative stock density values were similar across strata. Smallmouth bass W_r averaged 88.8 in the lower stratum, 87.0 in the middle stratum, and 86.0 in the upper stratum. The estimate of instantaneous mortality rate was 1.26 and the estimate of the annual mortality rate was 0.71. The Von Bertalanffy growth equation that best fit the data was $L_t = 429.1\ (1\text{-}e^{-0.4480\ (t+0.0302)})$. Spotted bass electrofishing CPUE was higher in the upper and middle strata than the lower stratum. The overall mean CPUE by distance (100 m) was 0.6 in the lower stratum, 3.1 in the middle stratum, and 1.2 in the upper stratum. The overall mean CPUE by time (hour) was 7.8 in the lower stratum, 40.7 in the middle stratum, and 17.9 in the lower stratum. Relative stock density analyses revealed that larger fish make up a greater proportion of the spotted bass population in the lower stratum than the middle and upper strata. Spotted bass W_r averaged 91.5 in the lower stratum, 94.2 in the middle stratum and 92.7 in the upper stratum. The estimate of the instantaneous mortality rate was 0.91 and the estimate of finite annual mortality rate was 0.60. The Von Bertalanffy growth equation that best fit the data was $L_t = 322.3\ (1\text{-}e^{-0.7735\ (t+0.2423)})$.

Reservoirs in the southern Appalachian region provide diverse recreations opportunities to an increasingly demanding public. As part of its management of fishery resources and angling opportunities on inland waters, the North Carolina Wildlife Resources Commission (NCWRC) surveys sport fish populations. Historically, most of the fish sampling in Hiwassee Reservoir occurred during two time periods. Between 1957 and 1965, the NCWRC sampled the reservoir using a variety of gears including experimental gill nets, trammel nets, and cove rotenone as part of a statewide survey (Tebo 1961; Messer 1966). Then in 1981 and 1982, Davies (1982) sampled with floating gill nets, rotenone, and boat electrofishing.

A current black bass *Micropterus spp.* stock assessment is needed for Hiwassee Reservoir. Previous studies focused heavily on rotenone sampling to produce standing crop estimates for sport fishes. Rotenone sampling is no longer used by the NCWRC; therefore, we need a new survey to act as a benchmark for future investigations. In addition, rotenone catch is more variable than boat electrofishing catch rates and thus, statistically less useful for detecting population trends (Tate et al. 2003). Age estimates in historical collections were based on scales which, unlike otoliths, over age young (≤ age 3) black bass and underage older black bass (Long and Fisher 2001). Furthermore, a new stock assessment is needed because there has been a recent change in the forage fish community.

Blueback herring *Alosa aestivalis* have recently invaded Hiwassee Reservoir and become the primary forage fish. The recent blueback herring introduction into Lake Burton, Georgia has coincided with decreased abundance of black crappie *Pomoxis nigromaculatus*, largemouth bass *Micropterus salmoides*, and white bass *Morone chrysops* (Rabern 2000). In addition, failures in walleye reproduction followed the introduction of a similar species, alewife *A. pseudoharengus*, in several Tennessee reservoirs (Irwin-Larrimore 1989). The blueback herring invasion in Hiwassee Reservoir has coincided with reductions and failures in walleye *Stizostedion vitreum* reproduction (Authors, unpublished data). Although the mechanism by which river herring *A. spp.* reduce sport fish populations is unknown, several possibilities have been suggested including larval fish predation (Irwin-Larrimore 1989) and induced nutrient deficiencies (Vandergoot et al. 2001).

The goal of this study is to perform a stock assessment of the black bass *Micropterus* spp. community in Hiwassee Reservoir. Hiwassee Reservoir contains three species of black bass; largemouth bass, smallmouth bass *M. dolomieu*, and spotted bass *M. punctulatus*. For each species, our specific objectives are to 1) index fish abundance, 2) report the length distribution, 3) estimate fitness, 4) report the age distribution, 5) calculate mortality, and 6) determine the growth rate.

Methods

Hiwassee Reservoir is a 4,318 ha hydropower impoundment operated by Tennessee Valley Authority (TVA). It was impounded in 1940 and is 35.7 km long and has 265.2 km of shoreline (TVA 2003). This reservoir was classified as oligotrophic by a recent North Carolina Department of Environment and Natural Resources basinwide assessment report (NCDENR 2000).

The physical habitat, water chemistry, and productivity of reservoirs generally change along a longitudinal gradient (Siler et al. 1986). Therefore, we investigated Hiwassee Reservoir in three longitudinal strata; lower, middle, and upper sections (Figure 1). Eight, 300-m shoreline electrofishing transects were selected in each strata (Figure 1). Although the transects were not selected randomly, we selected transects that were representative of the habitat within each strata. Surface water temperature (°C) and conductivity (μS) were recorded at each transect during fish sampling.

We used night electrofishing to sample each transect annually between April 29 and May 16 from 2000-2002. Our electrofishing gear included a 5.5 m jon boat, a 7,500 W generator, and a Smith-Root 7.5 GPP that produced 3-4 A of pulsed DC current. One net person collected stunned fish.

All black bass were measured (TL, mm), weighed (g) and released, except for 107 largemouth bass, 105 smallmouth bass, and 66 spotted bass collected in 2000, which were sacrificed for sagittal otoliths. Otoliths with less than two annuli were aged by viewing the otolith whole. Otoliths with two or more annuli were cut in half along the dorsal-ventral axis and the annuli were counted along the dorsal portion of the anterior half. All ages were determined by the same reader using two 'blind' reads.

Data Analysis

We used electrofishing catch rates as an index fish density. Electrofishing catch rates were quantified by mean catch per unit of effort (CPUE) and the precision of these estimates was reported as the standard error of the mean. The length of some transects varied with annual fluctuations in water level. For example, transects in coves were < 300 m long at lower water levels whereas the length of transects along the main channel were likely similar at different water levels. We did not measure the length of the transects every time we sampled but calculated CPUE assuming that transect length (effort) was a constant 300 m. However, to better standardize effort and facilitate future comparisons, we recorded the actual elecrofishing time of each transect and also reported CPUE in units of time (fish / hour).

The length distribution of fish collected was reported both qualitatively and quantitatively. Qualitatively, a length frequency histogram was constructed to visually assess the length distribution. Quantitatively, relative stock density was used to index the proportion of quality (RSD-Q), preferred (RSQ-P), and memorable (RSQ-M) sized fish in the sample (Gablehouse 1984). Standard errors for the RSD estimates were calculated as

$$\sigma_\pi = \sqrt{\frac{\pi\,(1-\pi)}{n}} \qquad (1)$$

where π is the proportion and n is the sample size (Ott 1993).

We used relative weight (W_r) to index fish condition. Relative weight was calculated for largemouth bass and smallmouth bass $\geq$ 150 mm TL using the standard weight (W_s) equations of Wege and Anderson (1978) and Kolander et al. (1993). Relative weight was calculated for all spotted bass $\geq$ 100 mm TL using the W_s equation of Weins et al. (1996). The precision of the estimate of mean W_r was reported as the standard error of the mean.

A catch curve was used to estimate mortality rates. The instantaneous rate of total mortality (Z) was estimated as the slope of the linear regression of $\log_e$ (catch) on age. Young age cohorts that had not fully recruited to the sampling gear were excluded from the regression. In addition, since poorly represented older age cohorts can negatively bias the estimate of Z, older age cohorts represented by < five individuals (Chapman and Robson 1960) were truncated from the analysis when they distorted the linear relationship between $\log_e$ (catch) and age. Linear regressions were considered statistically significant at a Type I error rate (α) of 0.10. The annual mortality rate (A) was calculated from Z using the following relationship from Ricker (1975);

$$A = 1 - e^{-Z}. \qquad (2)$$

Age and length information was also used to estimate describe growth. Growth was expressed using the Von Bertalanffy growth equation (Ricker 1975);

$$L_t = L_\infty\,(1 - e^{-K(t-t_o)}), \qquad (3)$$

where L_t is the predicted total length at a given time, L_∞ is mean maximum total length in the population, K is the growth coefficient, t is time in years, and t_o is the origin. Due to the low sample size of age data for all species, the strata were pooled in mortality and growth rate analyses.

Results

Water Quality

Surface water temperature and conductivity varied little throughout the three year survey or between the strata (Table 1). Mean surface water temperatures ranged 2.9 °C between the highest mean (19.9 °C; 2001, lower strata) and lowest mean (17.0 °C; 2000, upper strata). Mean water conductivity ranged 7.1 µS between the highest mean (28.7 µS; 2002, lower strata) and the lowest mean (21.6 μS; 2000, lower strata). There were no clear trends in conductivity or temperature across the three strata.

Largemouth Bass

We collected 307 largemouth bass during this study. Largemouth bass electrofishing CPUE varied across strata and was highest in the upper and middle strata and lowest in the lower stratum (Table 2). The overall mean CPUE by distance ranged from 1.8 and 1.6 fish per 100 m in the middle and upper strata to 0.9 fish per 100 m in the lowest stratum. The overall mean CPUE by time (h) ranged from 23.7 and 22.5 in the middle and upper strata to 12.6 fish in the lower strata.

We collected largemouth bass ranging in size from 71 to 615 mm TL (Figure 2). Relative stock density analyses revealed that larger fish make up a greater proportion of the largemouth bass population in the lower stratum than the middle and upper strata (Table 2). The mean RSD-Q varied across strata and was highest in the lower stratum (mean 72.2) and lower in the middle (58.5) and upper strata (57.1). The mean RSD-P was also highest in the lower stratum (38.9) and lowest in the middle (24.5) and upper (18.3) strata. The mean RSD-M had an identical trend and was highest in the lower stratum (13.0) and lower in the middle (5.7) and upper (5.1) strata.

Largemouth bass W_r was similar across strata and years. They averaged 92.2 in the lower stratum, 93.0 in the middle stratum and 90.2 in the upper stratum (Table 2).

Largemouth bass in Hiwassee Reservoir are characterized by a wide age distribution. With the exception of age 12, all year classes $\leq$ age 13 were represented in our sample (Figure 5). The regression of $\log_e$ (catch) on age was significant ($F_{1,7} = 14.90$; $P = 0.0084$; Figure 6). The estimate of instantaneous mortality rate was 0.41 and the estimate of finite annual mortality rate was 0.34. The mean lengths at age are shown in Table 5. The Von Bertalanffy growth equation that best fit the data was

$$L_t = 517.1\,(1-e^{-0.3351\,(t+0.0603)}). \qquad (3)$$

This equation is shown in Figure 7 and explained 97.9% of the variation in the relationship between age and total length of largemouth bass.

Smallmouth Bass

We collected 338 smallmouth bass during this study. Smallmouth bass electrofishing CPUE varied across strata and was highest in the lower stratum and lowest in the upper stratum (Table 3). The overall mean CPUE by distance (100 m) was 2.4 in the lower stratum, 1.4 in the middle stratum, and 0.9 in the upper stratum. We found an identical relationship between CPUE by time and strata. Catch per unit effort by time (h) was highest in the lower stratum (30.4), lower in the middle stratum (17.7), and lowest in the upper stratum (12.9).

We collected smallmouth bass ranging in size from 69 to 440 mm TL (Figure 3). Relative stock density values were similar across strata (Table 3). The mean RSD-Q was 26.1 in the lower stratum, 26.2 in the middle strata, and 29.5 in the upper strata. The mean RSD-P was 10.9 in the lower stratum, 4.9 in the middle stratum, and 6.8 in the upper stratum. The mean RSD-M was 1.7 in the lower stratum, 1.6 in the middle stratum, and 0.0 in the upper stratum.

Smallmouth bass W_r were similar across strata and years. They averaged 88.8 in the lower stratum, 87.0 in the middle stratum, and 86.0 in the upper stratum (Table 3).

Smallmouth bass in Hiwassee Reservoir are characterized by a narrow age distribution. We collected no smallmouth bass greater than age 5 (Figure 5). The mortality analysis resulted in a significant ($F_{1,3} = 15.06$; $P = 0.0605$) regression of $\log_e$(catch) on age (Figure 6). The estimate of Z was 1.26 and the estimate of A was 0.71. The mean lengths at age are shown in Table 5. The Von Bertalanffy growth equation that best fit the data was

$$L_t = 429.1\,(1-e^{-0.4480\,(t+0.0302)}). \tag{4}$$

This equation is shown in Figure 7 and explained 98.2% of the variation in the age and growth relationship of smallmouth bass.

Spotted Bass

We collected 350 spotted bass during this study. Spotted bass electrofishing CPUE was highest in the upper and middle strata and lowest in the lower stratum (Table 3). The overall mean CPUE by distance (100 m) was lowest in the lower (0.6) and upper (1.2) strata and higher in the middle strata (3.1). The overall mean CPUE by time had a similar trend across strata. Catch per unit effort by time (h) was lowest in the lower stratum (7.8), and higher in the upper (17.9) and middle strata (40.7).

We collected spotted bass ranging in size from 68 to 348 mm TL (Figure 4). Relative stock density analyses revealed that larger fish make up a greater proportion of the spotted bass population in the lower stratum than the middle and upper strata. The mean RSD-Q varied across strata and was highest in the lower stratum (mean 26.9) and lower in the middle (22.1) and upper strata (11.8). The mean RSD-P was also highest in the lower stratum (3.8) and lowest in the middle (0.7) and upper strata (5.9). The mean RSD-M's were 0.0 because no fish of memorable size were collected.

Spotted bass W_r were similar across strata and years. They averaged 91.5 in the lower stratum, 94.2 in the middle stratum and 92.7 in the upper stratum (Table 4).

Spotted bass in Hiwassee Reservoir are characterized by a narrow age distribution. We collected no spotted bass older than age 5. The mortality analysis resulted in a significant ($F_{1,3} = 13.13$; $P = 0.0685$) regression of $\log_e$(catch) on age (Figure 6). The estimate of instantaneous mortality rate was 0.91 and the estimate of finite annual mortality rate was 0.60. The mean lengths at age are shown in Table 5. The Von Bertalanffy growth equation that best fit the data was

$$L_t = 322.3\,(1-e^{-0.7735\,(t+0.2423)}). \tag{5}$$

This equation is shown in Figure 6 and explained 98.6% of the variation in the age and growth relationship of spotted bass.

Discussion

The black bass assemblage in Hiwassee Reservoir differs along a longitudinal gradient in the reservoir. Largemouth bass were the most abundant species in the upper strata, spotted bass were the most abundant in the middle strata, and smallmouth bass were most abundant in the lower strata. Siler et al. (1986) suggested several reasons for spatial heterogeneity in reservoir fish communities including, trophic interactions, and species specific habitat, behavioral, or physical preferences. More recently, Janssen (1992) and Sammons and Bettoli (2002) documented differences in the distribution of largemouth bass, smallmouth bass, and spotted bass in southeastern U.S. reservoirs based on local habitat differences.

Our sampling likely targeted largemouth bass and was likely less representative of smallmouth bass and spotted bass. Largemouth bass strongly associate with cover in littoral areas and are therefore very vulnerable to shoreline electrofishing. Spotted bass and smallmouth bass may be less associated with littoral areas and less sedentary. For example, in other wildlife district nine reservoirs, such as Lake Glenville, large smallmouth bass are frequently collected in bottom set gill nets below the effective depth of boat electrofishing gear (authors, personal observation). If older smallmouth bass and spotted bass are less vulnerable to our collection techniques then our mortality rate estimates may be overestimated.

Of the three black basses, largemouth bass are most successful in Hiwassee Reservoir. Largemouth bass have better condition, survival rates, and growth than the other species. Although reservoir fishing for smallmouth bass is an experience somewhat unique to mountain reservoirs in North Carolina, largemouth bass provide the most potential for anglers to catch preferred and memorable fish in Hiwassee Reservoir and should be the focus of our black bass management activities.

There is no evidence that the blueback herring invasion has negatively impacted the black bass species in Hiwassee Reservoir. The absence of missing year classes and consistency of the descending arms of the age structures suggest historically consistent recruitment for all species. Although we only aged fish in 2000, the length frequencies also suggest recruitment of all species in 2001 and 2002. In addition, the consistency of the mortality and growth curves suggest that these relationships have not changed since before the blueback herring invasion. However, we do not have reliable historical data to examine whether blueback herring may have changed species densities, condition, or composition.

Current North Carolina fishing regulations for Hiwassee Reservoir set the minimum length limit at 12 inches for largemouth bass, smallmouth bass and spotted bass and allows 2 fish under the limit to be harvested daily. The Von Bertalanffy growth equation predicts that largemouth bass recruit to the minimum length limit at 2.6 years; spotted bass at 4.0 years; and smallmouth bass at 2.8 years. At the estimated mortality rates, 49% of largemouth bass, 94% spotted bass, and 90% of smallmouth bass die before they reach the minimum length limit.

Future research should evaluate the impact of using one lenght limit for three species with differeing growth and mortality. Given the size potential and low mortality rate of largemouth bass, a more restrictive minimum length limit may protect fish longer and allow them to reach a larger size before harvest. Conversely, given the low percentage of smallmouth bass and spotted bass that recruit to the minimal length limit, increasing the harvest by further liberalizing (or removing) bag and size restrictions may improve the yield of theses species. Furthermore, the high mortality rates and slow growth of spotted bass and smallmouth bass suggest that their growth potential may be restricted by intraspecific competition for the limited food resources of an oligotrophic system. Thus, an additional benefit of reducing the abundance of these species is that the remaining fish may survive and grow better.

References

Chapman, D. G., and D. S. Robson. 1960. The analysis of a catch curve. Biometrics 16:354-368.

Davies, J. H. 1982. Hiwassee Reservoir survey. North Carolina Wildlife Resources Commission, Division of Inland Fisheries, Raleigh.

Gablehouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Goodrich, B. C. 2002. Dietary composition and habitat preferences of blueback herring, *Alosa aestivalis*, including observations on their role in the trophic ecology of Lake Chatuge NC/GA. M.S. thesis. University of Tennessee, Knoxville. 82 pages.

Irwin-Larrimore, E. R. 1989. Alewife and threadfin shad ecology in Dale Hollow Reservoir, Tennessee. M.S. thesis. Tennessee Technology University, Cookeville. 66 pages.

Janssen, F. W. 1992. Ecology of three species of black bass in the shoals reach of the Tennessee River and Pickwick Reservoir, Alabama. M. S. Thesis. Auburn University, Alabama. 82 pages.

Long, J. M., and W. L. Fisher. 2001. Precision and bias of largemouth, smallmouth, and spotted bass ages estimated from scales, whole otoliths, and sectioned otoliths. North American Journal of Fisheries Management 21:636-645.

Kolander, T. D., D. W. Willis, and B. R. Murphy. 1993. Proposed revision of the standard weight (W_s) equation for smallmouth bass. North American Journal of Fisheries Management 13:398-400.

Messer, J. B. 1966. Mountain reservoirs 1965 surveys. North Carolina Wildlife Resources Commission, Division of Inland Fisheries, Raleigh.

NCDENR. 2000. Basinwide assessment report. Hiwassee River. North Carolina Department of the Environment and Natural Resources, Division of Water Quality. Raleigh, NC. Available online: http://www.esb.enr.state.nc.us/Basinwide/HIW2000.pdf (July 2003).

Ott, R. L. 1993. An introduction to statistical methods and data analysis. 4th edition. Duxbury Press, Belmont, California.

Rabern, A. 2000. Lake Burton annual report 1999. Fisheries Section, Wildlife Resources Division, Georgia Department of Natural Resources.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin 191 of the Fisheries Research Board of Canada. 383 pages.

Sammons, S. M., and P. W. Bettoli. 1999. Spatial and temporal variation in electrofishing catch rates of three species of black bass (*Micropterus spp.*) from Normandy Reservoir, Tennessee. North American Journal of Fisheries Management 19:454-461.

Siler, J. R., W. J. Foris, and M. C. McInterny. 1986. Spatial heterogeneity in fish parameters within a reservoir. Pages 122-136. *in* G. E. Hall and M. J. Van Den Avyle, editors. Reservoir fisheries management: strategies for the 80's. Reservoir Committee, Southern Division American Fisheries Society, Bethesda, Maryland.

Tate, W. B., M. S. Allen, R. A. Meyers, and J. R. Estes. 2003. Comparison of electrofishing and rotenone for sampling largemouth bass in vegetated areas of two Florida lakes. North American Journal of Fisheries Management 23:181-188.

Tebo, L. B. 1961. Inventory of fish populations in lentic waters. North Carolina Wildlife Resources Commission, Division of Inland Fisheries, Raleigh.

TVA. 2003. Reservoir operations study-draft programmatic environmental impact statement. Volume II - appendices. Knoxville, TN.

Vandergoot, C. S., D. C. Honeyfield, and P. W. Bettoli. 2001. An investigation of reproduction and early mortality syndrome and Tennessee walleye populations. Final Report, Tennessee Technology University, Cookeville. 37 pages.

Wege, G. J., and R. O. Anderson. 1978. Relative weight (W_R): a new index of condition for largemouth bass. Pages 79-91 *in* G. D. Novinger and J. G. Dillard, editors. New approaches to the management of small impoundments. American Fisheries Society, North Central Division, Special Publication 5, Bethesda, Maryland.

Weins, J. R., C. S. Guy, and M. L. Brown. 1996. A revised standard weight (W_s) equation for spotted bass. North American Journal of Fisheries Management 16:958-959.

TABLE 1.—Sample dates, mean temperature (°C), and mean conductivity (μS), for sampling upper, middle, and lower strata of Hiwassee Reservoir. The standard deviation of the estimate is shown in parentheses. [A]Conductivity was not measured from the upper strata in 2002.

Year	Strata	Sample Dates	Temperature	Conductivity
2000	Upper	5/01	17.0 (0.4)	23.0 (1.4)
	Middle	5/02	17.9 (0.5)	23.4 (0.7)
	Lower	5/03, 5/16	19.7 (1.3)	21.6 (2.2)
2001	Upper	4/30	19.5 (1.0)	27.9 (1.0)
	Middle	5/01	19.7 (0.2)	25.6 (0.2)
	Lower	5/01, 5/02	19.9 (0.8)	26.3 (0.8)
2002	Upper	4/29	18.5 (0.3)	[A]
	Middle	4/29, 4/30	18.8 (0.2)	28.7 (1.2)
	Lower	4/30, 5/01	17.8 (0.3)	26.7 (2.7)

TABLE 2.—The number collected (N), catch per unit effort in distance and time, relative stock density for quality (Q), memorable (M), and trophy (T) size fish, and mean relative weight (W_r) of largemouth bass collected during this survey. Standard errors are shown in parenthesis.

			Catch per Unit Effort		Relative Stock Density			
Year	Strata	N	N/100m	N/hr	Q	P	M	W_r
2000	Low	27	1.1 (0.5)	18.0 (8.4)	80.8 (7.9)	57.7 (9.9)	15.4 (7.2)	95.2 (1.8)
	Mid	48	2.0 (1.0)	20.6 (8.7)	50.0 (8.7)	23.5 (7.4)	8.8 (4.9)	92.1 (1.6)
	Upp	41	1.7 (0.5)	22.0 (7.0)	48.4 (9.1)	25.8 (8.0)	9.7 (5.4)	89.5 (0.9)
2001	Low	15	0.6 (0.1)	10.0 (2.1)	66.7 (14.2)	25.0 (13.1)	16.7 (11.2)	90.6 (1.8)
	Mid	34	1.4 (0.5)	27.3 (8.5)	70.6 (7.9)	32.4 (8.1)	5.9 (4.1)	95.9 (1.3)
	Upp	38	1.6 (0.5)	27.5 (8.2)	62.2 (8.1)	16.2 (6.1)	5.4 (3.8)	92.7 (1.3)
2002	Low	20	0.8 (0.3)	10.0 (3.8)	62.5 (33.3)	18.8 (10.1)	6.3 (6.3)	88.8 (1.4)
	Mid	48	2.0 (0.8)	23.2 (9.7)	55.3 (8.2)	18.4 (6.4)	2.6 (2.6)	91.7 (0.9)
	Upp	36	1.5 (0.7)	18.1 (6.9)	60.0 (9.1)	13.3 (6.3)	0.0	88.2 (1.3)
All	Low	62	0.9 (0.2)	12.6 (3.1)	72.2 (6.2)	38.9 (6.7)	13.0 (4.6)	92.2 (1.1)
	Mid	130	1.8 (0.4)	23.7 (5.0)	58.5 (4.8)	24.5 (4.2)	5.7 (2.3)	93.0 (0.7)
	Upp	115	1.6 (0.3)	22.5 (4.2)	57.1 (5.0)	18.3 (3.9)	5.1 (2.2)	90.2 (0.7)

TABLE 3.—The number collected (N), catch per unit effort in distance and time, relative stock density for quality (Q), memorable (M), and trophy (T) size fish and mean relative weight (W_r) of smallmouth bass collected during this survey. Standard errors are shown in parenthesis.

			Catch per Unit Effort		Relative Stock Density			
Year	Strata	N	N/100m	N/hr	Q	P	M	W_r
2000	Low	57	2.4 (0.7)	29.2 (7.2)	27.5 (6.3)	9.8 (4.2)	0.0	88.5 (1.0)
	Mid	27	1.1 (0.4)	11.8 (4.8)	16.7 (7.8)	4.2 (4.2)	0.0	87.3 (1.6)
	Upp	22	0.9 (0.3)	11.1 (3.1)	33.3 (11.4)	11.1 (7.6)	0.0	85.0 (2.2)
2001	Low	44	1.8 (0.4)	26.6 (5.5)	27.2 (7.9)	9.1 (5.1)	3.0 (3.0)	89.5 (1.0)
	Mid	18	0.8 (0.2)	12.8 (3.3)	29.4 (11.4)	0.0	0.0	85.7 (2.0)
	Upp	22	0.9 (0.3)	17.0 (5.8)	20.0 (9.2)	0.0	0.0	86.4 (1.6)
2002	Low	75	3.1 (1.2)	35.5 (13.3)	22.9 (7.2)	14.3 (6.0)	2.9 (2.9)	88.5 (0.9)
	Mid	55	2.3 (0.5)	28.6 (6.0)	35.0 (10.9)	10.0 (6.9)	5.0 (5.0)	87.4 (1.3)
	Upp	18	0.8 (0.2)	10.6 (3.2)	50.0 (22.4)	16.7 (16.7)	0.0	87.3 (1.5)
All	Low	176	2.4 (0.5)	30.4 (5.2)	26.1 (4.0)	10.9 (2.9)	1.7 (1.2)	88.8 (0.6)
	Mid	100	1.4 (0.3)	17.7 (3.1)	26.2 (5.7)	4.9 (2.8)	1.6 (1.6)	87.0 (0.9)
	Upp	62	0.9 (0.2)	12.9 (2.4)	29.5 (7.0)	6.8 (3.8)	0.0	86.0 (1.1)

TABLE 4.—The number collected (N), catch per unit effort in distance and time, relative stock density for quality (Q), memorable (M), and trophy (T) size fish, and mean relative weight (W_r) of spotted bass collected during this survey. Standard errors are shown in parenthesis.

			Catch per Unit Effort		Relative Stock Density			
Year	Strata	N	N/100m	N/hr	Q	P	M	W_r
2000	Low	10	0.4 (0.3)	4.1 (2.3)	14.3 (14.3)	0.0	0.0	89.0 (3.1)
	Mid	48	2.0 (0.7)	21.5 (6.5)	25.6 (6.7)	0.0	0.0	93.6 (1.3)
	Upp	10	0.4 (0.3)	4.4 (3.4)	25.0 (16.4)	0.0	0.0	95.8 (2.6)
2001	Lower	15	0.6 (0.4)	8.2 (4.7)	36.4 (15.2)	0.0	0.0	95.8 (2.0)
	Mid	57	2.4 (0.6)	46.3 (13.1)	10.8 (5.2)	0.0	0.0	93.5 (1.1)
	Upp	25	1.0 (0.4)	21.2 (9.4)	8.7 (6.0)	4.3 (4.3)	0.0	91.9 (1.2)
2002	Low	21	0.9 (0.3)	11.1 (3.7)	25.0 (16.4)	12.5 (12.5)	0.0	89.5 (2.0)
	Mid	115	4.8 (1.7)	54.4 (18.4)	26.8 (6.0)	1.8 (1.8)	0.0	94.7 (1.0)
	Upp	49	2.0 (0.5)	28.1 (6.3)	10.0 (6.9)	10.0 (6.9)	0.0	92.5 (1.1)
All	Low	46	0.6 (0.2)	7.8 (2.1)	26.9 (8.9)	3.8 (3.8)	0.0	91.5 (1.4)
	Mid	220	3.1 (0.7)	40.7 (8.0)	22.1 (3.6)	0.7 (0.7)	0.0	94.2 (0.6)
	Upp	84	1.2 (0.3)	17.9 (4.3)	11.8 (4.6)	5.9 (3.3)	0.0	92.7 (0.8)

TABLE 5.—Mean total length (TL, mm) at age, standard error of the mean, and sample size for the largemouth bass (LMB), smallmouth bass (SMB), and spotted bass (SPB) that were aged during this survey. No age-12 fish were collected.

	Age	1	2	3	4	5	6	7	8	9	10	11	13
LMB	Mean TL	155.8	283.4	312.4	362.1	379.0	456.5	460.0	427.5	490.0	590.0	545.0	578.0
	S.E.	8.6	5.8	17.3	19.9	1.0	13.7	12.6	22.5				
	N	25	48	7	8	2	8	3	2	1	1	1	1
SMB	Mean TL	148.2	247.3	321.0	362.3	325.0							
	S.E.	9.9	3.9	15.2	7.7								
	N	17	70	8	9	1							
SPB	Mean TL	132.7	235.1	277.7	309.2	306.5							
	S.E.	14.6	3.9	9.9	7.0	6.5							
	N	11	41	6	6	2							

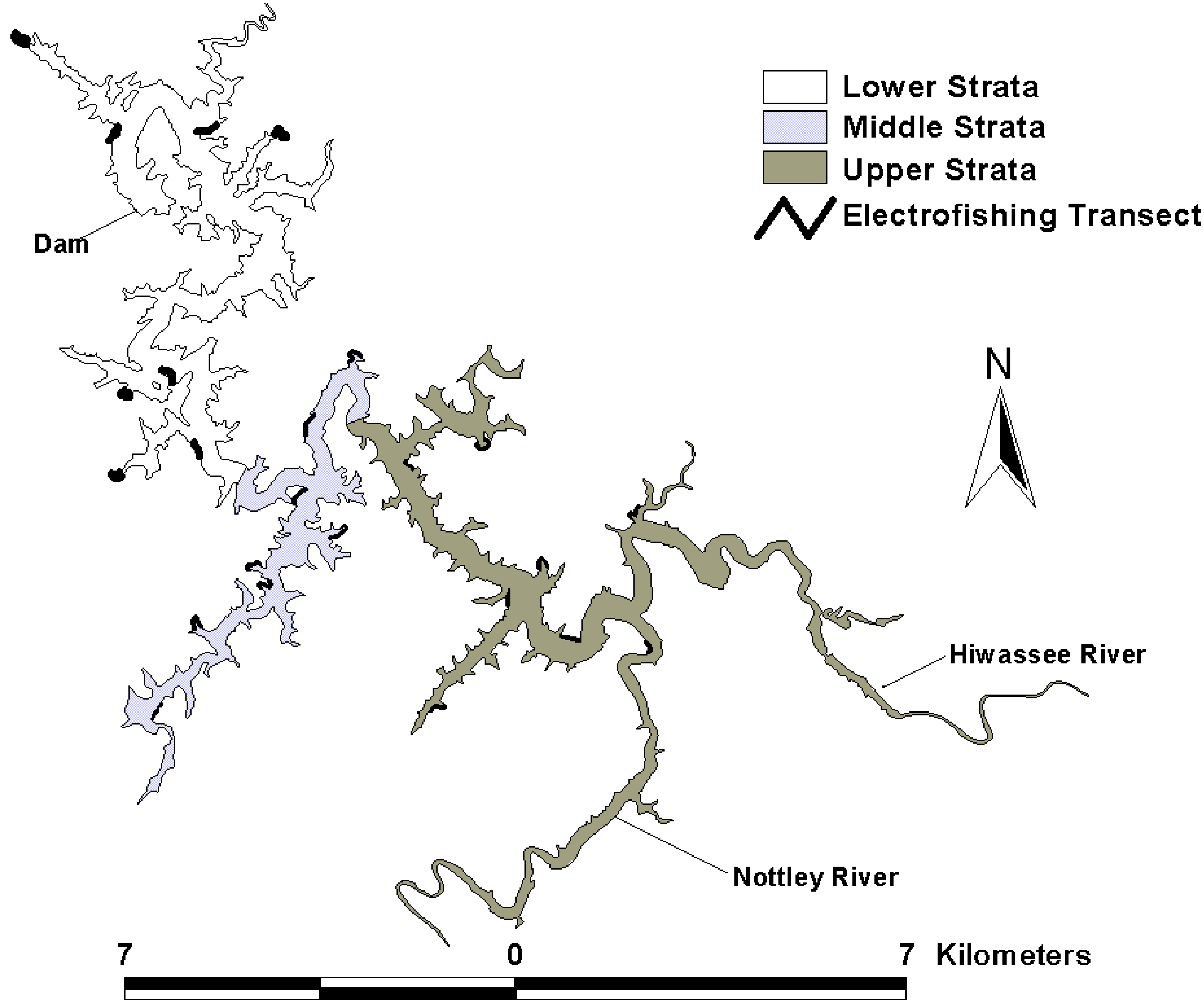

FIGURE 1.—Map of Hiwassee Reservoir showing the three strata and 24 shoreline elecrofishing transects used in this study, 2000-2002.

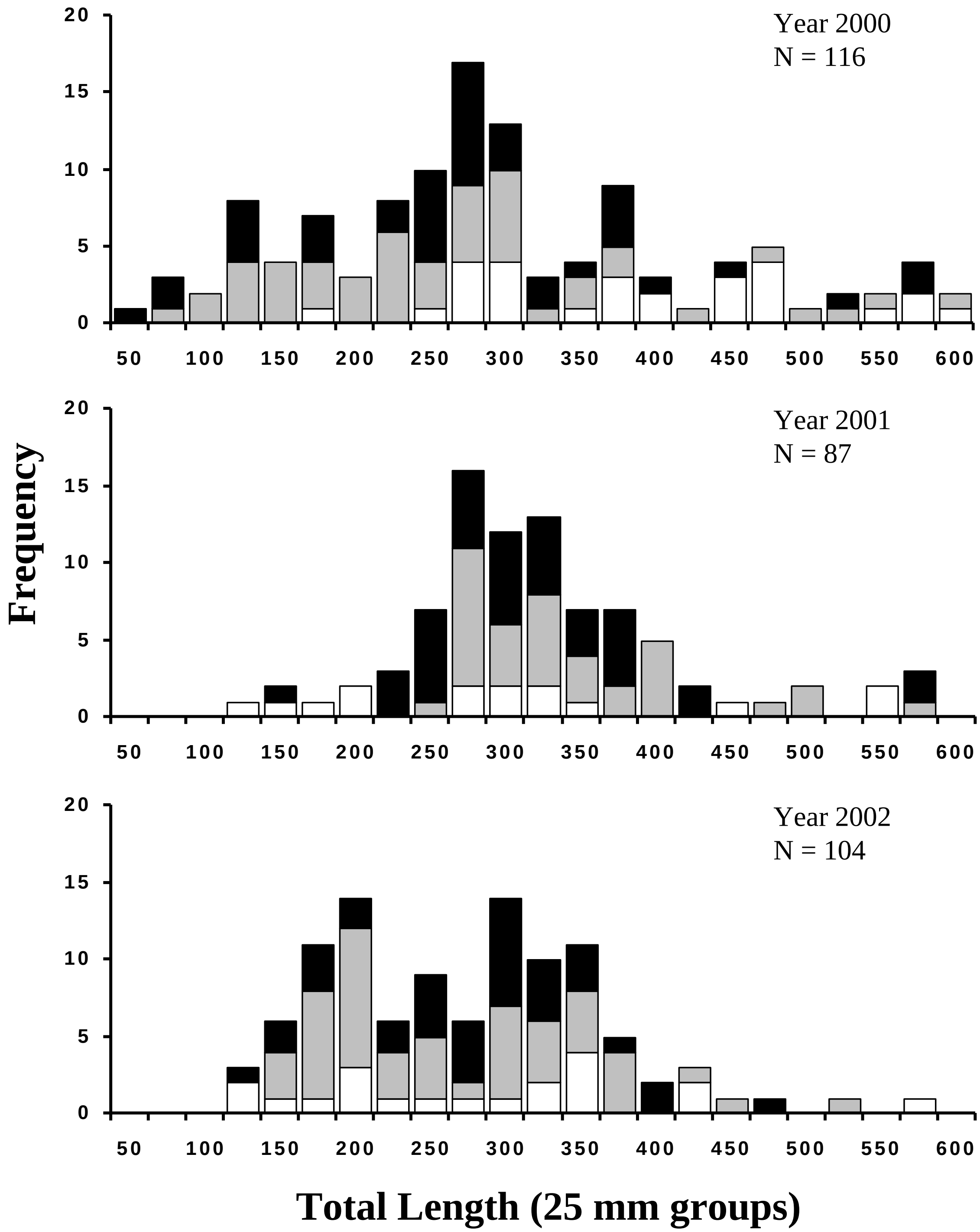

FIGURE 2.— The length-frequency distribution of largemouth bass collected during this survey. The frequency of the upper, middle, and lower strata fish are shown separately by the black, gray, and white bars respectively.

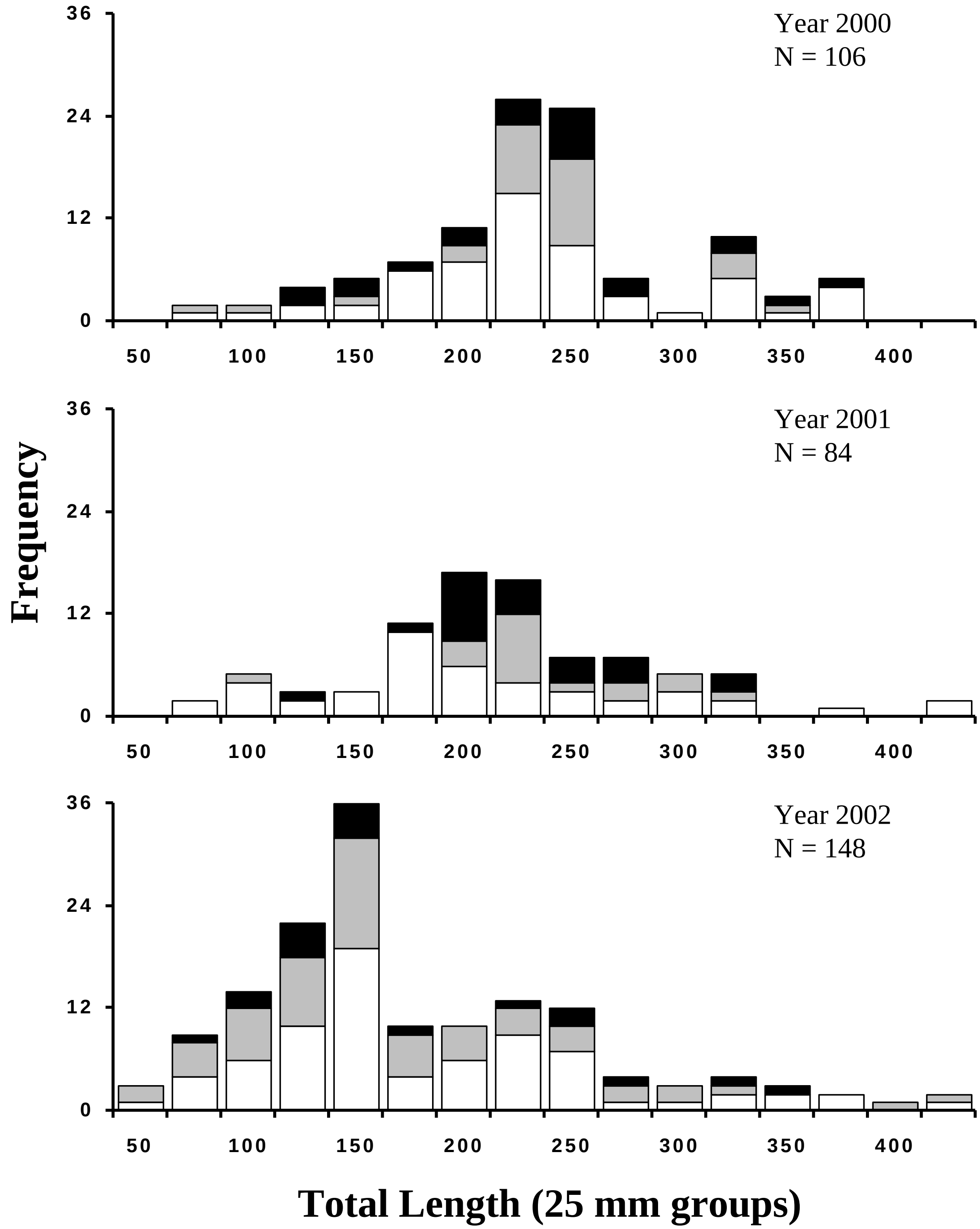

FIGURE 3.—The length-frequency distribution of smallmouth bass collected during this survey. The frequencies of the upper, middle, and lower strata fish are shown separately by the black, gray, and white bars respectively.

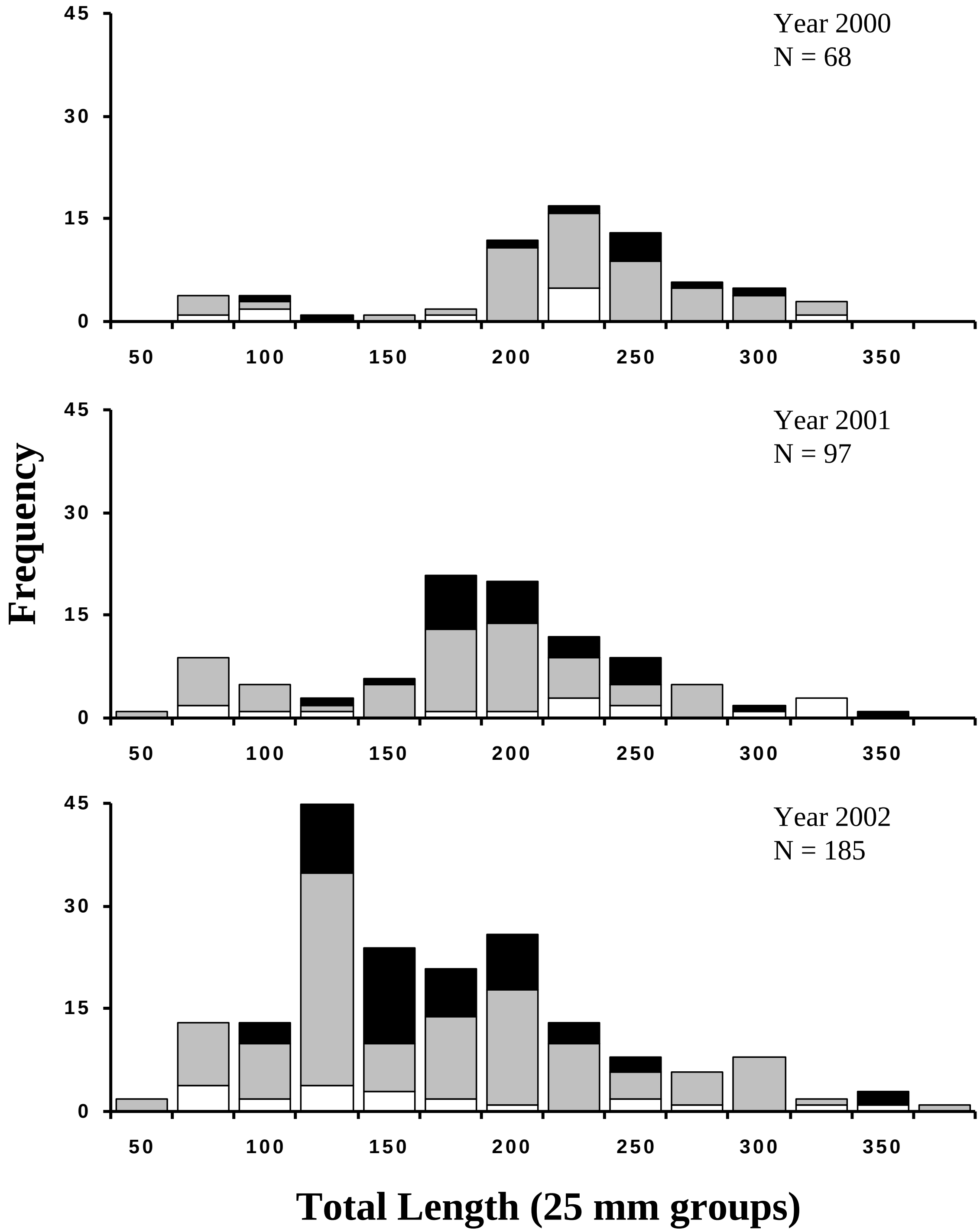

FIGURE 4.—The length-frequency distribution of spotted bass collected during this survey. The frequencies of the upper, middle, and lower strata fish are shown separately by the black, gray, and white bars respectively.

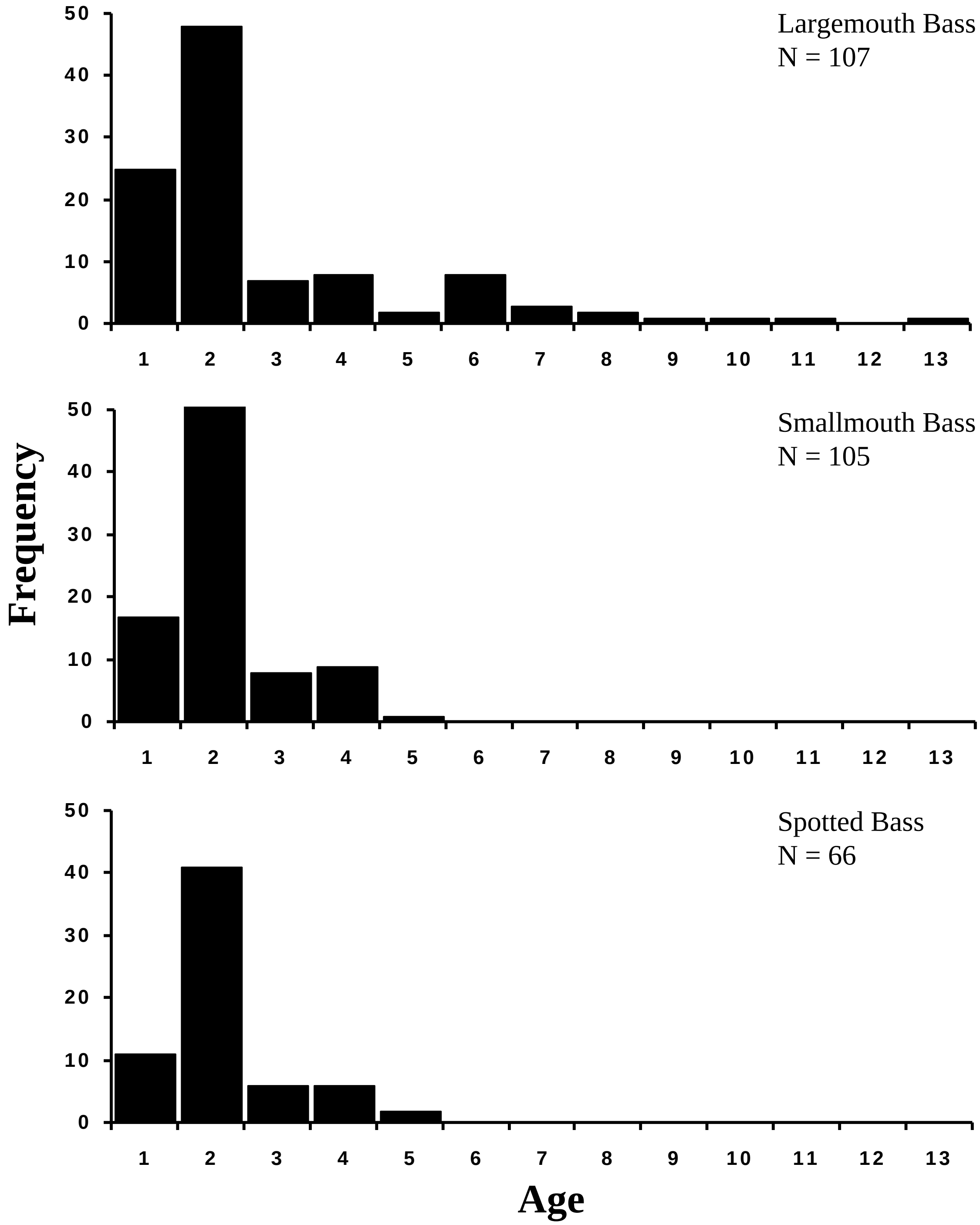

FIGURE 5.—Age-frequency distributions for largemouth bass, smallmouth bass, and spotted bass collected during this survey.

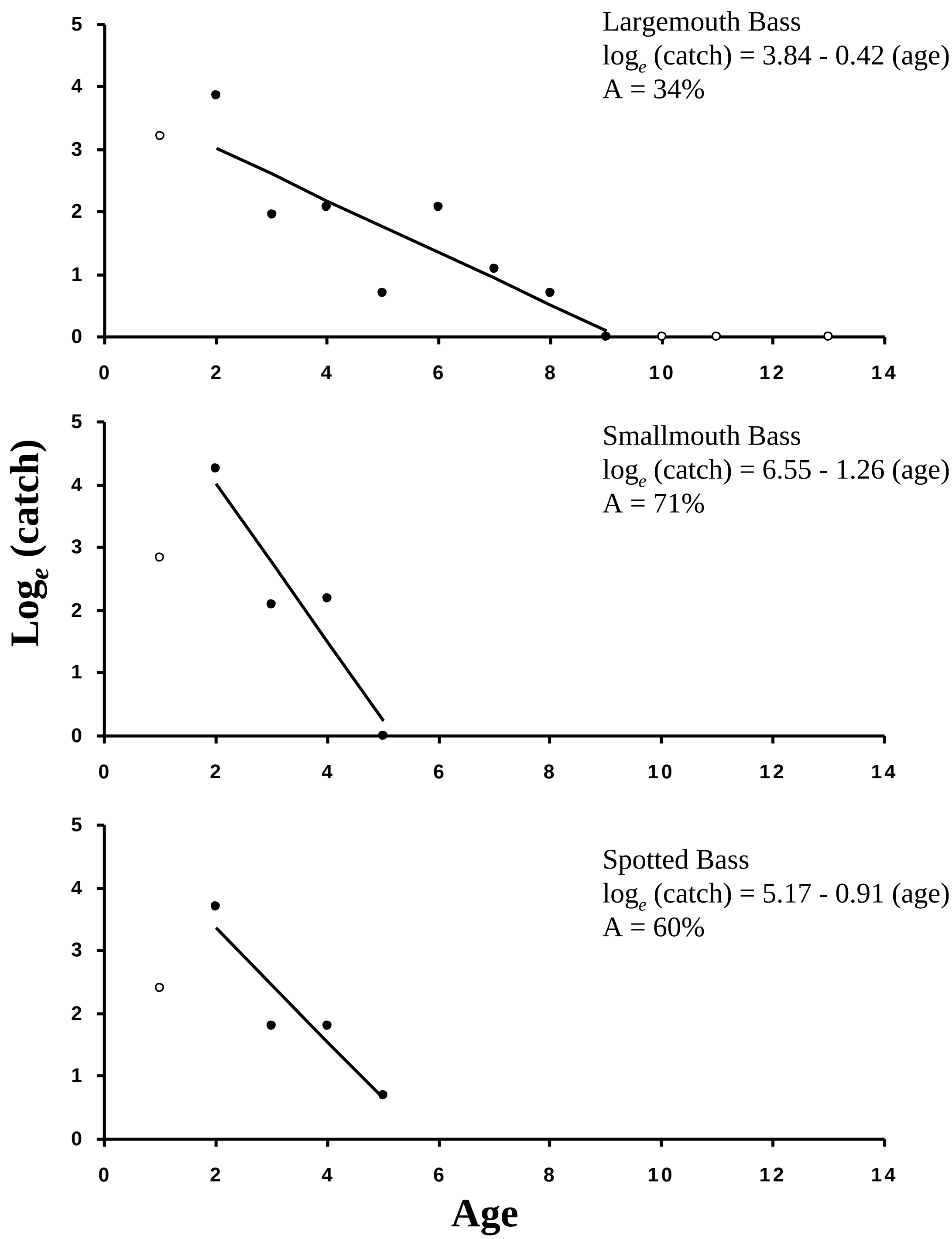

FIGURE 6.—Catch curve regressions and annual mortality rate estimates (A) for largemouth bass, smallmouth bass, and spotted bass collected during this survey. Open circles represent age classes not used in the regression because they had not fully recruited to the gear or were represented by few individuals and biased the regression.

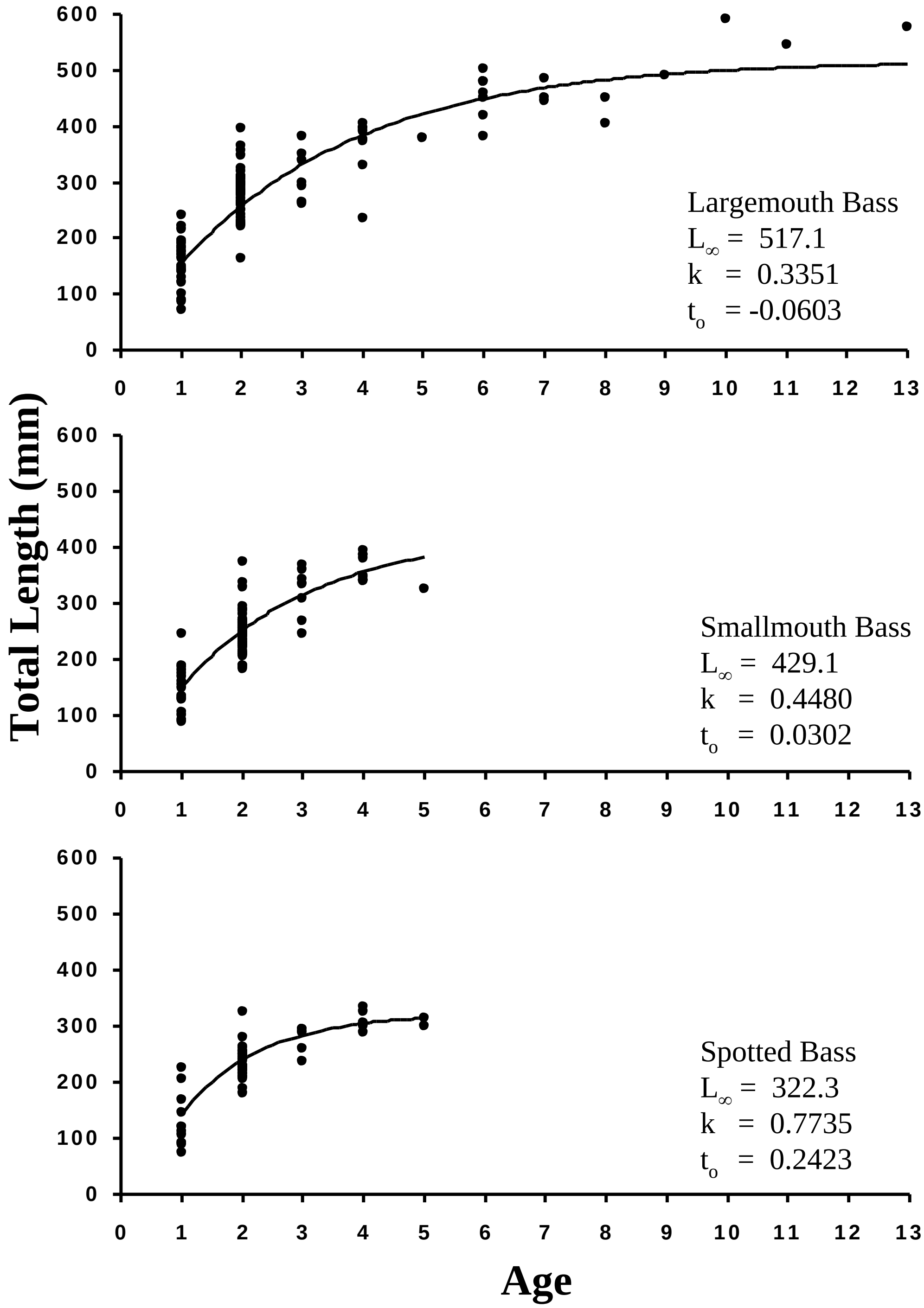

FIGURE 7.—Von Bertalanffy growth equations for largemouth bass, smallmouth bass, and spotted bass collected during this survey.