Population characteristics of riverine smallmouth bass in Tennessee, simulated effects of length limits, and management recommendations.

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Abstract

We described population characteristics of riverine smallmouth bass in Tennessee and used modeling software to identify harvest restrictions that would maximize PSD and RSD14, and secondarily, maximize yield. From 1995 through 2000, we collected 3,185 smallmouth bass from 72 locations and determined age using otoliths. Population data were summarized into four categories: a statewide average, administrative regions within Tennessee Wildlife Resources Agency (2, 3, and 4), growth rate (slow, medium, and fast), and size (stream and river). Predicted von Bertalanffy growth functions were similar among levels within each category, suggesting that there was little growth variability within the state. For the statewide population the predicted total length at age was 106, 166, 218, 261, 298, 329, 356, 379, 398, and 415 mm for ages 1 to10. Due to low sample sizes in most locations, relative stock indices were only reported for 20 populations. Mean PSD, RSD14, RSD17, and RSD20 was 34, 13, 3, and < 1, respectively. In river populations (n =12), annual mortality (age 2+ and older) ranged from 15 to 55% ($\bar{x}$ = 38%) and recruitment variability ranged from 22 to 105 % ($\bar{x}$ = 55%). Annual mortality was significantly higher in Region 2 rivers (51%) compared to Region 4 rivers (32%). We used growth parameters estimated for the statewide population, a range of conditional fishing mortality (*cf*) rates (5 to 50%), and a range of conditional natural mortality (*cm*) rates (10 to 50%) to simulate the effects of 256-, 305-, 356-, and 406-mm minimum length limits and protected length ranges (slot limits) from 305-356, 305-381, and 356-432 mm. Under the circumstances where regulations were effective ($cm \leq 30$ %, $cf \geq 20$ %), the 356-mm minimum length limit appeared to be the best regulation for the average smallmouth bass fishery in Tennessee's streams and rivers.

Introduction

Each year in Tennessee about 150,000 people fish in warmwater streams and rivers (Jakus et al.1999) and smallmouth bass (*Micropterus dolomieu*) are an important component of these fisheries. Smallmouth bass streams are widespread and located in several physiographic regions resulting in varied habitats and productivity. Like many recreational fisheries, stream anglers have a variety of expectations about the number and size of bass that should be available for harvest. Despite these complexities, Tennessee Wildlife Resources Agency (TWRA) has historically taken a simple approach to regulations for stream bass populations. Between 1947 and 1997 the statewide creel limit was set at 10 bass (*Micropterus* spp.) per day. In 1997, this limit was reduced to 5 bass per day.

We wanted to evaluate the current statewide regulation and consider length restrictions for these fisheries.   Length restrictions have been widely used to improve bass fishing in streams and rivers (i.e. Paragamian 1984b; Fajen 1975a, 1981; Lyons et al. 1996; Slipke et al. 1998) and Tennessee's stream anglers have indicated support for such regulations (Jakus et al. 1999). However, basic data typically used to evaluate potential regulations, such as bass population characteristics and creel data was lacking.

A review by DeJaynes (1991) synthesized literature on riverine smallmouth bass populations. Relevant research on growth, survival, recruitment, and management recommendations for smallmouth bass are from populations in Alabama (Slipke et al. 1998), Arkansas (Filipek et al. 1995; Kilambi et al. 1997), Iowa (Paragamian 1984a, 1984b; Kalishek and Wade 1992), Missouri (Fajen 1975a, 1975b, 1981; Covington et al.1983; Roell 1993), Oklahoma (Fisher et. al 1997), Virginia (Kauffman 1985; Austen and Orth 1988; Smith and Kauffman 1991), West Virginia (Austen and Orth 1988, VDGIF 2001), and Wisconsin (Paragamian and Coble 1975; Forbes 1989; Lyons et al. 1996). Anderson and Weithman (1978) considered growth rates and proposed proportional stock density (PSD) for smallmouth bass in balanced populations. Beamesderfer and North (1995) summarized vital statistics for 409 smallmouth bass populations in North America (mostly reservoir populations) and predicted the effects of fishing regulations under various conditions. Population statistics were not available for riverine smallmouth bass populations in Tennessee.

Only one creel survey (Condo and Bettoli 2000) has been conducted on Tennessee warmwater streams and rivers in recent decades. Additional surveys to describe riverine bass fisheries across the state could not be conducted in a timely manner to address our needs. Given this data gap, we chose to rely on recently developed modeling software (Slipke and Maceina 2000) to consider a variety of new regulations under varying exploitation rates. Early versions of this model have been used to model sauger (Maceina et al. 1998), and crappie fisheries (Sammons et al. 2000).

Our first objective was to describe the size structure, growth, annual mortality and recruitment of smallmouth bass populations in Tennessee streams and rivers. Our second objective was to predict how these populations would respond to a variety of length restrictions using population modeling software.

PART 1. POPULATION PARAMETERS

Study Areas

Smallmouth bass are found in most streams and rivers in Tennessee east of Kentucky Lake, where they inhabit medium to fast moving waters with good clarity (Etnier and Starnes 1993, Figure 1). Local TWRA biologists in each of Tennessee's four administrative regions (Figure 1) surveyed smallmouth bass populations in streams and rivers which were known, or suspected to have, smallmouth bass fisheries. Between 1995 and 2000, we sampled 72 smallmouth bass populations in streams and rivers across the state (Table 1, Figure 2). These waters probably represented a majority (~75 %) of Tennessee's river fisheries and a small portion (~20 %) of stream fisheries. We have assumed that this sample adequately represented the statewide spectrum of stream smallmouth bass fisheries.

Methods

Smallmouth bass collections and analysis

Smallmouth bass samples were collected between June and September primarily with electrofishing gear, although a few streams were surveyed by explosives and angling (Table 1). Fish collected by angling were only used to supplement length at age estimates. Sample sites were chosen to maximize the likelihood of capturing bass (prime habitat and shocking conditions) while allowing for relatively easy access for personnel and equipment.

In wadeable streams (less than ~1 m deep) we used a DC electrofishing tow barge with three anodes or multiple backpack shocking units. Two or three 200-m sites were usually sampled on each wadeable stream. On larger rivers, we used boat mounted electrofishing units that provided at least 4 amps of DC current at 120 pulses per second through fixed droppers on the front of the boat. Typically 10-20 timed sites were electrofished on each river survey. Only 3 locations were sampled by explosives, these sites included pools (about 2-3 m) that were too deep to be sampled by wading and were inaccessible by boat..

We measured total length (± 1 mm) and weight (± 1 g), and extracted sagittal otoliths from each bass. Otoliths were sectioned along the transverse axis, polished with 600 grit sandpaper, and submerged under water where annuli were counted using a stereo microscope and a fiberoptic light source. Each annulus indicates the beginning of a new growth season in temperate latitudes (DeVries and Frie 1996). For example, if we counted 2 annuli then that fish was assigned an age of 2+ years (age 2+).

Classification of populations

We used four data classifications for analyses. First, all populations were grouped into one statewide category. Second, populations were categorized according to TWRA administrative regions because management recommendations within the TWRA are often first considered on this scale. Only five smallmouth bass populations were surveyed in Region 1 and smallmouth bass streams are relatively similar between Region 1 and 2. Additionally two of the major smallmouth bass rivers, the Duck and Buffalo rivers, flow through Regions 1 and 2. Therefore, Region 1 streams were grouped with Region 2 for comparisons among regions.

The third classification was based on growth rates, which grouped populations as slow, medium and fast. This classification was needed because models based on statewide or regional averages may not address varied growth conditions. We compared growth rates based on mean total length at age 3+ and 4+. We chose two age groups to lessen the odds of an unrepresented year class precluding that population from the analysis. We considered ages 3+ and 4+ because these ages are fully recruited the gear, they represent more years of growth compared to age 2+, and these ages were commonly represented in most of the populations surveyed. Populations were ranked by mean total length at ages 3+ and 4+, and populations without either estimate were not included. . For streams that were sampled in multiple years we first averaged mean length at age among years prior to ranking. If a population ranked in the slowest quartile for either age (< 232 mm for age 3+, < 263mm for age 4+) then that population was classified as slow. If a population ranked in the fastest quartile for either age(> 261 mm for age 3+, > 314 mm for age 4+) then that population was classified as fast. Populations that did not rank as fast or slow at either age were classified as medium.

The last classification was based on the size of the water body. With a few exceptions, large rivers where sampling was conducted by boat were classified as rivers, and smaller water bodies were classified as streams.

Size structure of populations

We described the size structure of populations where 30 or more smallmouth bass were collected by plotting 25-mm total length frequency distributions and calculating proportional size indices following Gabelhouse (1984) (Table 2). PSD (or RSD11) was calculated as the percent of stock length bass (> 180 mm or 7 inches) that are of quality length (> 280 mm or > 11 inches). RSD14, RSD17, and RSD20 are calculated as the percent of stock length bass that are greater than 356, 432, and 508 mm, respectively. Proportional stock indices were first averaged among years for multiple year data, then they were compared among levels of classification using Tukey's test ($\propto$ = 0.05).

Growth

To determine the relationship between total length and weight for each level of classification, we used linear regression of the $\log_{10}$ transformations of both variables to predict $\log_{10}$(weight) from $\log_{10}$(total length). We used a general linear model procedure (SAS) to predict $\log_{10}$(weight) from $\log_{10}$(total length), classification level, and the interaction term to determine if the slopes of length-weight relationships were similar within each level of classification.

We calculated mean total length for each age collected in each population (Appendix A). When populations were sampled in multiple years, we calculated mean total length for each age based on all bass of that age regardless of the sample year. Not all ages were collected from each population, and we did not estimate mean total length at age for missing ages. All mean total length at age calculations were unweighted.

Average growth rates were estimated among populations within each of the classifications. First, mean total length at age data for each population were again averaged by age to calculate a statewide mean (of means) for each age. Within the statewide category the sample size for each mean total length at age was the number of populations where bass of that age were collected. We used the same procedure to calculate average growth rates among populations within each region, growth class, and water size.

Growth rates within each level of classification (statewide, region, growth class, water size) were described by von Bertalanffy growth equations (von Bertalanffy 1938). Mean total length estimates for age-0+ bass were not included because we believe that these estimates were positively biased due to poor collection efficiencies for small bass (< 60 mm). Because bass were collected in the latter half of the growing season we arbitrarily added 0.6 to each age to represent the number of growth years at collection in the von Bertalanffy function. For example the mean total length data for age 1+ fish were entered into the model as age 1.6, and the additional 0.6 years represents growth during the year of collection. All represented age groups 1.6 and over were included to model the von Bertalanffy equation using the Gauss- Newton Method, a nonlinear least squares iterative program (SAS version 6.2).

We arbitrarily set L_∞ at 508 mm for all populations during the modeling of the von Bertalanffy growth curves. Exploratory analyses of each classification level using von Bertalanffy models predicted reasonable L_∞ estimates ranging from 449 to 517 mm, and one unrealistic estimate of 762 mm for the Region 3 classification. We suspected that estimates of L_∞ below 508 mm were slightly low because larger fish are occasionally observed in these locations. For this reason we believe it was appropriate to adjust the L_∞ to realistic length for this modeling exercise and we feel confident that 508-mm (20-inch) fish do occur in smallmouth bass populations across the state.

We compared the asymptotic 95 % confidence intervals of the von Bertalanffy equation parameters among levels within each category to determine significant differences among levels.

Mortality

We estimated annual mortality for populations where we collected 30 or more age-2+ and older individuals. We used FAST's weighted regression routine for catch curves to estimate annual mortality (Slipke and Maceina 2000) from age 2+ to the oldest age captured in that population. Estimated annual mortality was averaged among years for multiple year data, then compared annual mortality among levels of classification using Tukey's test ($\propto = 0.05$).

Recruitment

We assessed recruitment variability by calculating a coefficient of variation for recruitment (REC-CV) for each population using samples where more than 30 bass age-2+ and older were collected. This method, which is based on catch curve regression statistics, was developed by Maceina and Slipke (in preparation) and uses the following equation to predict REC-CV:

$$\text{REC-CV} = 32 + 0.864(\text{Age Range}) - 129.3\,(R^2) + 66.8(\log_{10}(\text{AM})),$$

where Age Range was the range in years of the catch curve regression. R^2 was the coefficient of determination of the regression line for the catch curve, and AM was the estimated annual mortality for the regression. The above model explained 77.4 % of the recruitment variability in simulated populations which covered a wide range fishing and natural mortality rates (Maceina and Slipke, in preparation). An assumption of this model is that density-dependent mortality does not occur after the time of recruitment into the fishery and that both fishing and natural mortality are constant among age classes after a year class enters the fishery. REC-CV estimates were first averaged among years for multiple year data, then REC-CV was compared among levels of classification using Tukey's test ($\propto = 0.05$).

Results

Collection totals and classifications

A total of 3,185 smallmouth bass was collected from the 72 populations and 82 % of these fish were collected in Regions 2 and 4 (Table 1). Weight data were not available for two individuals, therefore only 3,183 bass were used in the length-weight relationships. Otoliths samples were not collected from 179 bass resulting in age determinations for 3,006 individuals.

Region 1 and 2 samples combined totaled 1,318 bass representing 37 populations. Region 3 surveys collected 304 bass representing 13 populations. Sixty-seven percent of the bass collected in Region 3 were from the Collins River. Region 4 surveys collected 1,564 bass representing 22 populations (Table 1).

Growth rate classifications were assigned to 57 populations: 16 slow, 22 medium, and 19 fast (Table 3). Region 2 populations were most commonly assigned to the medium and fast categories, whereas Region 3 and 4 populations tended to fall into the slow to medium categories.

River collections represented 21 populations and a total of 2,331 bass. Stream collections included 51 populations and a total of 854 bass (Table 1).

Size structure of populations

Length frequency distributions and proportional stock indices were reported for 20 populations. Bass in the 100- to 300-mm categories were most abundant with relatively few fish over 350 mm (Figure 3).

Proportional stock indices were calculated for 20 populations (Table 4). PSD ranged from 13 to 72 (mean = 34), and RSD14 ranged from 0 to 40 (mean= 13). RSD17 ranged from 0 to 11 (mean= 3), and bass of trophy length were represented in only two samples: Clinch River and Shoal Creek (Table 4). There were no significant differences between proportional stock indices among levels within any of the classifications.

Growth

The linear relationships predicting weight from total length (using $\log_{10}$ transformed data) for each classification were all significant ($P < 0.001$) (Table 5). The slopes of these lines ranged from 2.9 to 3.1 with intercepts ranging from -5.19 to - 4.77. Lower slope estimates were observed in the Region 3 and slow growth classifications, higher slopes were observed in the Region 4 and fast growth classifications. Interaction terms for the regression models were significant among all levels of classification indicating that the slopes of the length-weight regressions lines were significantly different among levels of classification.

The von Bertalanffy growth function for the statewide classification predicted that it took smallmouth bass 7 years to reach preferred size (14 inches) (Figure 4). Among regions, Region 2 and 4 populations had similar growth rates whereas Region 3 populations grew slower (Figure 5). Region 3 bass took 8.3 years to grow to preferred size, compared to 6.8 and 6.7 years for bass in Regions 2 and 4, respectively. Surprisingly, populations categorized as having medium and fast growth produced preferred-size bass in 6.6 and 6.3 years, respectively (Figure 5). However, populations categorized as slow did grow somewhat slower, taking 8.0 years to reach preferred size. There was no difference between estimated growth curves for stream and river populations (Figure 5).

Comparing the asymptotic 95 % confidence intervals around each level's predicted growth curve revealed that none of the levels within any of the classifications had significantly different growth equations (Table 5). However, comparisons involving Region 3 and slow growth populations slightly overlapped other levels within each category, suggesting that these levels were only marginally similar to others.

Annual Mortality

Annual mortality for ages 2+ and older were calculated for 12 river populations (Table 7). Annual mortality could be calculated for only one stream population, therefore statistical comparisons between streams and rivers could not be made and results were limited to river populations.

Among river populations annual mortality ranged from 15 to 55% with a mean of 38%. The highest estimate of annual mortality was for the populations in Buffalo rivers of Region 2 (55 %) and the lowest estimate of annual mortality (15 %) was for the Holston River population (below Fort Patrick Henry Dam) (Table 7). Annual mortality was significantly higher in Region 2 (mean = 51 %) compared to Region 4 (mean = 32 %), however there were no differences in annual mortality among rivers with respect to growth rate classification.

Recruitment

REC-CV (recruitment variability) was estimated for 12 rivers. Mean REC-CV was 55% and ranged from 22 to 105% (Table 7). Only one Region 3 population and one stream population was represented in this analysis, precluding further statistical analyses involving these levels. Region 4 rivers exhibited a much wider range of REC-CV than Region 2 rivers, but values did not significantly differ. There were no differences in REC-CV among growth classifications.

Discussion

Perhaps the best way to sample different types of smallmouth bass populations on a statewide scale would have been to randomly choose populations and stratify the selection according to the availability of that type. That design was not possible for this study because we were concurrently collecting the required inventory data. Our arbitrary sampling approach may have created a biased depiction of smallmouth bass population parameters due to unbalanced representation of resource types. However, because we tended to survey the prominent smallmouth bass fisheries, management recommendations based on these data will be applicable to the state's most important fisheries.

Relatively few smallmouth bass were collected in Region 3, therefore our depiction of this region may be biased by low sample size. Many of the Region 3 streams surveyed are known for their smallmouth bass fisheries. Low catch rates of smallmouth bass may have resulted from low gear efficiency, low smallmouth bass abundance, sample habitat selection, or a combination of these factors. Survey crews in Region 3 rely on only two backpack shocking units in rocky streams that are wider than 8 meters and under these circumstances bass can be difficult to capture. However, in some locations high catch rates of spotted bass *Micropterus punctulatus* and coosa bass *M.*

coosa suggested adequate sampling efficiency and low smallmouth bass abundance. Regardless of the reason for low sample sizes, additional surveys in this region are warranted to supplement this study. Relatively few stream-size waters in Region 4 were surveyed, which may be a source of bias. However, small streams in Region 4 are not well known for smallmouth bass fisheries (as compared to Region 2 and 3), therefore an argument could be made that smallmouth bass populations in smaller fisheries were sampled relative to their abundance or importance.

The size of fish collected by electrofishing gears are typically positively biased for larger fish (Reynolds 1996). Roell (1993) reported that 180-mm smallmouth bass may not be fully recruited to boat electrofishing surveys on Missouri rivers, which would result in positively biased estimates of PSD. We suspect that electrofishing large rivers may actually be negatively biased towards trophy bass, especially during daytime shocking. In our study and all of the literature we referenced, electrofishing probably results in similar biases affecting estimates of the population's size structure. Therefore, we feel that data can be fairly compared within this study and among others.

Length frequency distributions (Figure 3) and proportional stock indices (Table 4) indicated that many of the populations we surveyed had a low abundance of quality-size and larger bass. According to Anderson and Weithman (1978) given our levels of mortality and growth the expected PSD for Tennessee populations should be, conservatively, 40 or greater. However, only about a third of our PSD estimates were over 40 (Table 7). Based on Beamesderfer and North's (1995) growth criterion for unexploited populations, our statewide class has the potential to have PSD values from 40 to 70, and these populations would be highly sensitive to fishing pressure and length limit regulations.

Our PSD estimates ranged widely and about 50% were between 20 and 40 (mean = 34). These values were similar to those reported for populations in some of the major Arkansas fisheries with 254-mm minimum length limits (Filipek et al. 1995). Paragamian (1984a) reported PSD estimates of 20 to 30 % for the Maquoketa River, Iowa, which was a heavily fished population (total annual mortality was 71 %, 50 % of which was harvest). In later years under catch-and-release management, the PSD increased to 80 on the Maquoketa River (Kalishek and Wade

1992). An unexploited stream in the Ozark region of Arkansas had a PSD of 41 (Reed and Rabeni 1989). Slipke et al. (1998) reported a PSD of 72 for the Shoals Reach of the Tennessee River, Alabama, which has a 356-mm minimum length limit and anglers that commonly practice 'catch-and-release'. No difference in PSD was observed in a 305-mm minimum length zone compared to a no length limit zone of the New River (WV and VA) in both zones PSD was extremely low ranging from 2 to 5 (Austen and Orth 1988).

Growth rates of smallmouth bass populations were considered on several levels, yet there were no differences among the predicted von Bertalanffy curves. Considering that our study covered a variety of ecoregions across the state this is a surprising result. Comparisons of growth curves for individual populations would detect significant differences between the extreme populations (Fiss, unpublished data). However, all individual curves would fall within the confidence intervals for at least one of our levels of classification, and the purpose of this study was to identify differences among broad categories.

Our quartile approach to categorize growth rates among populations did not produce significantly separate populations with respect to growth. Confidence intervals for the slow growth category were only slightly overlapped by the confidence intervals of the medium and fast growth categories, suggesting that we might have detected a difference had our data been less variable. At this early point in our inventory of Tennessee's smallmouth bass populations we recommend a cautious approach to describing the growth rate of Tennessee populations by using the statewide curve and the slow growth curve to represent a range of growth conditions. This suggestion is supported by Beamesderfer and North's (1995) age at quality length criterion for describing a population's productivity (of which growth rate is a major component). They would categorize our three growth categories as only two productivity levels (medium and low, using their terminology), because both of our fast and medium levels were within their range for medium productivity populations.

There was a disparity between our total length at age estimates and those reported in the literature and we believe this was due to different in aging techniques. Compared to mean total length at age based on scale data in other states (Table 8), our estimates were similar through age 3 and then increasingly lower than average as age increased (Figure 6 - Graph A). Scales tend to underestimate the age of older fish (Beamish and McFarlane 1987) which would result in an over estimation of mean total length for older fish. Although otoliths were used to validate a portion of the scale data reported for the Arkansas populations (Filipek et al. 1995), the only studies that relied solely on otoliths for age determination were Slipke et al. (1998) and VDGIF (2001). Mean length at age data reported for Virginia rivers (VDGIF 2001) based on otolith aging techniques were more comparable to our data (Table 8, Figure 6 - Graph B).

Growth rates for smallmouth bass from the Shoals Reach of the Tennessee River in Alabama (Slipke et al. 1998) were much higher than we observed in Tennessee's streams and rivers. The fast growth rates observed by Slipke et al. (1998) can be attributed to an abundance of shad (*Dorosoma spp.*) in the diet of smallmouth bass in this tailwater population (Hubert 1977). The growth rate of smallmouth bass in the Shoals Reach of the Tennessee River was more similar to growth rates observed in Tennessee reservoir populations than river and stream populations (Figure 7). Smallmouth bass in Tennessee reservoirs also rely on shad for forage.

Our highest estimate of annual mortality (55%) was observed on the Buffalo River. Although this river is a popular fishery, we have no data to estimate the contribution of exploitation on annual mortality. Annual mortality on the nearby Duck River (mean 53 %) was also high and in this case, the exploitation was very low because Condo and Bettoli (2000) reported very low fishing pressure and concluded that fishing mortality, although not measured, must be low.

Annual mortality could only be estimated in one stream (Garrison Fork Creek = 29 %). Low sample sizes prevented estimation of annual mortality in all the other streams. However, many of these small samples did include old bass (age 6 - 12) (Appendix A) suggesting that mortality rates were probably not very high in those populations. We could not determine whether or not a lack of old bass in other samples was due to high mortality in the population or a poor sample size.

Annual mortality rates for riverine smallmouth bass reported in the literature typically represent adult mortality rates. With the exception of Slipke et al. (1998) (annual mortality = 49%), the use of scales to determine ages may have positively biased all of the following mortality rates.

Unexploited populations in Missouri had 11 and 16 % annual mortality (Fajen 1975a; Reed and Rabeni 1989). Among reports for exploited populations in Missouri, Arkansas, Virginia, Iowa, Wisconsin and Alabama total mortality was typically above 35 % and as high as 84 % (Fajen 1975b; Filipek et al. 1995; Kilamba et al. 1997; Covington et al.1983; Austen and Orth 1988; Kauffman 1983; Paragamian 1984a; Forbes 1989; Paragamian and Coble 1975; Slipke et al. 1998).

REC-CV were highly correlated (r = -0.97) to the coefficient of determination of the catch curve so the calculation of REC-CV may seem redundant. However, the REC-CV values were more useful than the coefficient of determination because REC-CV values can be incorporated directly into FAST models (Part 2 of this report).

We suspect that variations in seasonal stream discharges were a major factor influencing recruitment of smallmouth bass in Tennessee rivers. Variable recruitment is common in riverine smallmouth bass populations and is often influence by river discharge (Mason et al. 1991; Reynolds and O'Bara 1991; Sallee et al. 1991; Lukas and Orth 1995; Slipke et al. 1998). Although recruitment variability averaged about 55 % among rivers, the maximum value (105 %) should also be considered when modeling the potential effects of recruitment variability.

PART 2. FAST MODELS

In part one of this report we characterized the population dynamics of smallmouth bass populations in Tennessee. In this section we use those estimates to predict and compare the effects of a variety of length restrictions on Tennessee's smallmouth bass fisheries. Our goal was to identify regulations that would maximize PSD and RSD14, and secondarily, we considered the effects on yield. This criteria basically evaluates improvements made to the middle range of a smallmouth bass population's size structure and should not be used to evaluate benefits to the trophy component of the fishery.

Methods

We used the FAST Dynamic Pool model (Slipke and Maceina 2000) to predict PSD, RSD14 and yield. Each model was run for 30 years with fixed recruitment of 100,000 age-0 fish. Annual mortality from age 0 through age 2 was fixed at 80 % for all simulations. Therefore, recruitment to age-2 was also fixed (64,000 fish). Longevity was fixed at 15 years.

We modeled a broad spectrum of conditions including variations of mortality (beyond age 2), growth, and regulations (Table 9). Several combinations of conditional natural and fishing mortality rates were incorporated into the model to approximate total annual mortality ranging from approximately 10 to 70 %. We considered conditional natural mortality (*cm*) from 10 to 50 % with conditional fishing mortality (*cf*) varying from 5 to 50 % (Table 9). These condition mortality rates (*cf* and *cm*) are used by the model in a manner that accounts for compensatory mortality. Some combinations of *cf* and *cm* in our modeling exercise simulate annual mortality rates that were much higher than annual mortality rates we observed in Tennessee populations. We simulated these higher annual mortality rates to simulate what might happen if fishing pressure, or natural mortality, or both increased.

We predicted the effects of four minimum length limits and three protected length ranges (PLR)(Table 9). In a survey of Tennessee's smallmouth bass anglers (TWRA, unpublished data) only about 2 % of the anglers that harvest bass keep fish less than 254 mm. Therefore we will consider a 254-mm minimum length limit as an approximation of a "no minimum" length limit. In minimum size limits models, we did not consider the effects hooking mortality for fish below the length limit.

The Dynamic Pool model is specifically designed to simulate conditions under a minimum length limit, therefore we had to approximate conditions under a PLR scenario. To accommodate simulation of PLRs in the Dynamic Pool model we modified the conditional fishing mortality rates for the ages in and around the PLR (as suggested by Slipke and Maceina 2000). In all PLR simulations we arbitrarily set *cf* at: zero for fish less than 254 mm in length in all PLR simulations, a given value (X) for the ages from 254 mm through the approximate age at the bottom of the PLR, X/10 in the PLR, and X/2 above the PLR. Fish within the PLR would experience mortality due to catch-and-release angling and one-tenth of *cf* would be a fair estimation of hooking mortality. We reduced *cf* by half for fish above the PLR because in Tennessee we typically limit harvest above the PLR to one fish. In the case of smallmouth bass the regulations that we were considering would allow only one fish above the PLR and a possible five fish below the PLR.

Although the Dynamic Pool model would allow us to model using variable recruitment rates and recruitment rates for smallmouth bass did vary, we chose to run fixed recruitment models to compare length regulations. This greatly simplified comparisons among regulations and allowed us to focus on differences attributed to growth and survival without the distraction of the recruitment variability. To demonstrate the effects of recruitment variability on PSD, RSD14, and yield we simulated the effects of 254-mm and 356-mm minimum length limits, and 50 and 100 % REC-CV using the statewide population with *cm* at 20 % and *cf* at 50 %.

Results

The predicted values of PSD and RSD14 for slow and statewide populations under similar model parameters and regulations were nearly identical (Figure 8). Yield predictions were slightly lower from models using the slow growth populations compared to the statewide population (Figure 8). Under a given set of mortality conditions, whichever length regulation maximized PSD, RSD14, or yield for the statewide population was also best for the slow growth population. The remainder of the reported results pertain directly to the statewide population because both populations had such similar predictions.

By comparing the PSD, RSD14, and yield among a variety of *cm* and *cf* (Figures 9-12) we observed a number of trends in these data. At low *cf* (5 and 10 %) there were only small differences in the effects of regulations on PSD, RSD14, and yield. At very low levels of *cm* (10 %) and *cf* greater than 20 % yield was substantially higher under 305- and 356-mm minimum length restrictions compared to the 254-mm minimum length restriction (an approximation of the current regulations: no length limit)(Figure 9). However, at nearly every other combination of *cm* and *cf* the 254-mm minimum length resulted in the lowest PSD and RSD14 values and the highest yield (Figures 9-12). The 356-mm and 406-mm minimum lengths limit generally produced the highest PSD and RSD14 values. The 406-mm minimum length limit consistently produced the lowest yield.

In general, the PLRs regulations were inferior to the 356- and 406-mm minimum length limits. Under high mortality conditions (*cm* =30 and 50%, *cf* = 50%) yield was higher using the PLRs. However under these same conditions PLRs resulted in lower PSD and RSD14 compared to the 356- and 406-mm minimum length limits and were not much better than no length limit scenario.

PSD and RSD14 were inversely correlated to *cm* and as *cm* increased the difference among the effects produced by regulations decreased. In other words, as natural mortality increased the abundance of larger fish in the population decreased and the differences among regulations' ability to maintain larger fish in the population decreased. Regulations had little affect on PSD or RSD14 when *cm* was 50 (Figure 12). Yield was also inversely related to *cm*, however the differences among regulations' ability to affect yield was greater as *cm* increased (Figures 9-12).

According to our FAST Dynamic Pool model predictions, recruitment variability can greatly effect the year to year variability of PSD, RSD14 and yield (Figure 13). In this example with 50 % recruitment variability, and regardless of the length limit, the model predicted that PSD values could change by over 20 units in just a few years. Large variations were also observed in RSD14 and yield. This example had moderate natural mortality (*cm* =20 %) and high fishing mortality (*cf* = 50 %) making the regulation more effective. As a result, the higher minimum length limit (356-mm) slightly reduced the variability of PSD and RSD14. Over the 15 year period with 100 % recruitment variability, the coefficient of variability (CV) of PSD and RSD14 was 82 and 147 %, respectively, for the 254-mm minimum length limit compared to 55 and 84 % for the 356-mm minimum length limit. In the same model with 100 % recruitment variability the CV of yield was similar between regulations (34 and 36 % for the 254-mm and 356-mm minimum length limits, respectively). Although we only report one scenario to demonstrate the affects of recruitment variability, several additional models including PLR regulations, were examined and the effects observed in Figure 13 are typical within the ranges of our variables.

Discussion

This modeling exercise suggests that the current lack of length restrictions on smallmouth bass fisheries always minimizes the abundance of larger bass (PSD and RSD14) and, in most cases (*cm* >10%), maximizes yield. This effect would be most pronounced in populations with low natural mortality and high fishing mortality. In populations with high natural mortality the length regulations we modeled would have little affect on the abundance of larger bass, however high minimum length restrictions would substantially decrease yield.

Under the circumstances where regulations were effective ($cm \leq 30$ %, $cf \geq 20$ %), the 356-mm minimum length limit appeared to be the best regulation for the average smallmouth bass fishery in Tennessee's streams and rivers. Typically the 406-mm minimum length limit resulted in slightly better PSD and RSD14 values, however in some cases it produced substantially less yield than the compared to the 356-mm minimum length limit (e.g., Figure 10). For this reason, combined with higher angler acceptance for a lower length limit (TWRA, unpublished data), the 356-mm length limit appeared to be a good compromise.

Lyons et al. (1996) reported that a 356-mm minimum length limit generally improved the size structure in Wisconsin streams. Minimum length limits as low as 305-mm have been used to improve smallmouth bass fisheries in Missouri and Iowa (Fajen 1981; Paragamian 1984b). However, a 305-mm minimum length limit did not improve the fisheries on the Shenandoah River, Virginia (Kauffman 1985), and New River, Virginia (Austen and Orth 1988), and in both cases the authors blamed high mortality rates (mostly natural) for the failure. Our models also suggested that at high mortality rates (*cm* = 50 %) length restrictions would be ineffective. Smith and Kauffman (1991) reported that a 279- to 330-mm PLR improved the catch rates and growth of smallmouth bass on the Shenandoah River, suggesting that density-dependent factors had to be addressed to improve this fishery.

The Dynamic Pool model assumed that growth and mortality rates were not density dependent. This is a reasonable assumption because in streams and rivers density-independent factors (floods, droughts, etc.) typically override density-dependent factors (Van Den Avyle and Hayward 1999). If density-dependent growth or mortality were substantial in these populations, then our predicted results for the minimum length restrictions would be positively biased and the predictions based on the PLRs would be negatively biased. Even with density-dependent factors influencing the populations, we would expect each minimum length limit to have the same ranking among the minimum length limit regulations with respect to PSD, RSD14 and yield. However, we would expect that the PLR regulations may be more effective (possibly better than minimum length limits) because PLR regulations are designed to correct problems associated with density-dependent factors (Noble and Jones 1993).

A lack of substantial differences between predicted PSD, RSD14, and yield between the statewide and slow populations suggests that there is no need to consider different regulations for populations in Tennessee streams and rivers based on growth rates. Within the range of growth rates we measured, mortality rates would have a much greater influence on which regulations may be appropriate for a particular stream or region. Additional research is needed to estimate fishing and natural mortality for smallmouth bass populations in stream and river fisheries.

If a length regulation was imposed on a smallmouth bass population with highly variable recruitment, it would be difficult for the public and managers to perceive the effectiveness of the regulation. For example, a 356-mm minimum length limit may improve the fishery, but it may take several years to document the improvements because variability due to recruitment could easily mask any effect of the regulation (Figure 13). Other variability (changes in fishing pressure, environmental factors, etc.) could similarly add variability. As suggested by Lyons et al. (1996) and Slipke et al. (1998), managers will need to establish control fisheries (no regulation changes) and monitor the experiment for a several years to isolate the effects of a given regulation.

PART 3. MANAGEMENT RECOMMENDATIONS

Based on our assessment of smallmouth bass populations and our modeling exercise using the FAST Dynamic Pool model, there are opportunities to use length restrictions to improve fisheries in Tennessee's streams and rivers. Populations that have low natural mortality rates and high fishing pressure have the greatest chance for improvement. The best length restriction to consider would be a 356-mm minimum length limit. Of course, higher minimum length limits could be even more effective at increasing the abundance of large bass, but they would drastically reduce the yield from these fisheries. There are a number of anglers that enjoy harvesting smallmouth bass, therefore the 356-mm minimum length limit, which allows more harvest, appears to be the best compromise.

We suggest testing a 356-mm minimum length limit on heavily-fished fisheries where total annual mortality is greater than 35 %. If fishing mortality is a large enough component of the annual mortality, then we should observe positive effects on the fishery. If we observe negative effects such as a decrease in condition or an increase in natural mortality of the protected ages, then the next step would be to consider PLR regulations for those fisheries.

Even under the best circumstances it will be difficult to measure the effects of new regulations. Ideally, reference areas should be established within the same watershed. It may be impossible to find reference areas for some waters (especially large rivers), therefore we should attempt to collect multiple samples from these waters prior to changing regulations.

These management recommendations are based on the average Tennessee population of smallmouth bass under modeled conditions that made several assumptions about these populations. They are certainly the best data we have to date, however this study should not preclude managers from collecting more information on smallmouth bass populations and considering other alternatives for individual fisheries. For example, if a manger was interested in developing a trophy smallmouth bass fishery, then the criteria used in this evaluation may not be adequate.

This study identified three basic research needs for Tennessee. First, as mentioned above, if TWRA establishes length regulations, then we should monitor the effects. Second, in the populations we examined, mortality rates were more important than growth rates in predicting the outcome of proposed regulations, yet our database had relatively little information on mortality rates. Therefore, we need estimates of both fishing and natural mortality to identify our best opportunities to improve fisheries. Third, we need more surveys of bass populations in streams and rivers of Region 3 and streams in Region 4 to make sure that these resources have been adequately represented by the statewide averages.

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Table 1. Streams and rivers surveyed by TWRA biologists from June through October, 1995 - 2000. Size indicates river (R) or stream (S). Gears used to collect bass included boat electrofishing (BT), backpack electrofishing (BP), tow barge electrofishing (TW), explosives (EX), and angling (AN). The numbers of smallmouth bass collected and otoliths examined are also noted.

Water Surveyed	Size	County	TWRA Region	Survey Year	Number of Sites Surveyed	Gear Types	Number of Bass Collected	Number of Otoliths Aged
Big Richland Creek	S	Humphreys	1	1996	1	BP/AN	3	3
Horse Creek	S	Hardin	1	1998	3	TW	1	1
Lick Creek	S	Perry	1	1998	2	TW	5	5
Standing Rock Creek	S	Stewart	1	1998	3	TW	24	24
White Oak Creek	S	Humphreys	1	1996	2	BP/EX/AN	28	28
						Total =	61	61
Beans Creek	S	Coffee	2	1998	2	TW	3	3
Beaverdam Creek	S	Hickman	2	1999	2	TW	3	3
Big Bigby Creek	S	Lewis	2	1999	2	TW	13	13
Big Swan Creek	S	Hickman, Lewis	2	1997	2	TW	10	10
Buffalo River	R	Lawrence	2	1995	1	EX	1	1
Buffalo River	R	Lewis, Perry, Wayne	2	1996	9	BT	134	134
Buffalo River	R	Lewis, Perry, Wayne	2	1998	9	BT	128	128
Duck River	R	Maury (TVA sample)	2	1995	unknown	BT	17	16
Duck River	R	Bedford, Hickman, Humphreys, Marshall, Maury	2	1996	23	BT	102	102
Duck River	R	Bedford, Hickman, Humphreys, Marshall, Maury	2	1998	30	BT	115	115
East Fork Mulberry Creek	S	Lincoln, Moore	2	1997	2	TW	38	38
East Fork Stones River	R	Cannon, Rutherford	2	1997	8	BT/TW	93	93
East Fork Stones River	R	Cannon, Rutherford	2	1999	3	BT	45	45
Elk River	R	Giles, Lincoln	2	1997	15	BT	26	26
Elk River	R	Giles, Lincoln	2	1999	10	BT	74	74
Factory Creek	S	Wayne	2	1997	2	TW/AN	11	11
Forty-eight Creek	S	Wayne	2	1998	2	TW	6	6
Fountain Creek	S	Wayne	2	1997	2	TW	16	16
Garrison Fork Creek	S	Bedford	2	1998	2	TW	59	59
Green River	S	Wayne	2	1995	22	BP/AN	25	25
Harpeth River	R	Cheatham, Williamson	2	1997	9	BT/TW	28	28
Harpeth River	R	Cheatham	2	1999	7	BT/TW	44	44
Jones Creek	S	Dickson	2	1999	2	TW	6	6
Knob Creek	S	Maury	2	1995	1	BP	10	10
Leipers Creek	S	Maury	2	1998	2	TW	4	4
Lick Creek	S	Maury	2	1995	3	BP	3	3

Table 1. Continued. Streams and rivers surveyed by TWRA biologists from June through October, 1995 - 2000. Size indicates river (R) or stream (S). Gears used to collect bass included boat electrofishing (BT), backpack electrofishing (BP), tow barge electrofishing (TW), explosives (EX), and angling (AN). The numbers of smallmouth bass collected and otoliths examined are also noted.

Water Surveyed	Size	County	TWRA Region	Survey Year	Number of Sites Surveyed	Gear Types	Number of Bass Collected	Number of Otoliths Aged
Lick Creek	S	Hickman	2	1998	2	TW	5	5
Little Bigby Creek	S	Maury	2	1999	2	TW	18	18
Little Harpeth River	S	Williamson	2	1999	2	TW	32	32
Long Fork Creek	S	Macon	2	1997	3	TW	25	25
Mill Creek	S	Davidson, Williamson	2	1997	2	TW	30	30
Red River	R	Montgomery, Robertson	2	1999	9	BT/BP	33	33
Richland Creek	S	Giles	2	1998	2	BP	4	4
Rutherford Creek	S	Maury	2	1999	2	TW	6	6
Shoal Creek	S	Lawrence	2	1999	7	BT/TW	31	31
South Harpeth River	S	Williamson	2	1996	2	BP	20	20
South Harpeth River	S	Williamson	2	1998	1	TW	5	5
Stones River	R	Rutherford	2	1997		TW	5	5
Sycamore Creek	S	Cheatham	2	1997	2	TW	5	5
Turnbull Creek	S	Dickson, Williamson	2	1997	2	TW	21	21
Yellow Creek	S	Dickson	2	1999	2	TW	2	2
						Total =	1257	1256
Blackburn Fork	S	Jackson	3	1995	2	BP	1	1
Caney Fork River	R	White	3	1998	6	BT	13	1
Charles Creek	S	Warren	3	1997	1	BP	5	5
Collins River	R	Warren	3	1998	15	BT	200	200
Daddy's Creek	S	Cumberland	3	1998	3	BP	8	8
Dry Fork	S	Dekalb	3	1996	1	BP	1	1
Flat Creek	S	Overton	3	1996	1	BP	4	4
Hickory Creek	S	Warren	3	1997	1	BP/TW	1	1
Hills Creek	S	Warren	3	1996	1	BP	1	1
Isham Spring	S	Grundy	3	1995	1	BT	1	1
Roaring River	S	Jackson	3	2000	4	BP	11	10
Smith Fork	S	Dekalb, Wilson	3	1998	2	TW	11	11
Smith Fork	S	Dekalb, Wilson	3	2000	3	BP	46	30
White Oak Creek	S	Morgan	3	1996	2	BP	1	1
						Total =	304	275

Table 1. Continued. Streams and rivers surveyed by TWRA biologists from June through October, 1995 - 2000. Size indicates river (R) or stream (S). Gears used to collect bass included boat electrofishing (BT), backpack electrofishing (BP), tow barge electrofishing (TW), explosives (EX), and angling (AN). The numbers of smallmouth bass collected and otoliths examined are also noted.

Water Surveyed	Size	County	TWRA Region	Survey Year	Number of Sites Surveyed	Gear Types	Number of Bass Collected	Number of Otoliths Aged
Beech Creek	S	Hawkins	4	1996	1	BP	8	8
Big Creek	S	Hawkins	4	1995	1	BP	6	6
Big Creek	S	Hawkins	4	1997	1	BP/TW	15	15
Big War Creek	S	Hancock	4	1995	1	BP	13	13
Citico Creek	S	Monroe	4	1997	1	BT	9	9
Doe River	R	Carter	4	1996	1	BP	22	22
Dunn Creek	S	Sevier	4	1996	1	BP	2	1
French Broad River	R	Cocke, Knox, Seveir	4	2000	24	BT	91	91
Hinds Creek	S	Anderson	4	1996	1	BP	1	1
Holston River (below FPH)	R	Grainger, Jefferson, Knox	4	2000	13	BT	122	122
Indian Creek	S	Claiborne	4	1995	1	BP	17	17
Little Pigeon River	S	Sevier	4	2000	5	BT	14	14
Little River	R	Blount	4	1996	2	BP	10	10
Little River	R	Blount	4	1997	2	BT	11	11
Nolichucky River	R	Washington	4	1996	1	AN	7	7
Nolichucky River	R	Cocke, Greene, Hamblen, Washington, Unicoi	4	1998	31	BT	153	153
North Fork Clinch River	R	Hancock	4	1995	1	BP	5	5
North Fork Holston River	R	Hawkins, Sullivan	4	1997	1	BT	20	20
North Fork Holston River	R	Hawkins, Sullivan	4	1998	6	BT	115	115
Pigeon River	R	Cocke	4	1995	5	BT	11	11
Pigeon River	R	Cocke	4	1996	5	BT	68	62
Pigeon River	R	Cocke	4	1997	5	BT/AN	130	125
Pigeon River	R	Cocke	4	1998	5	BT	67	67
Pigeon River	R	Cocke	4	2000	6	BT	137	0
Powell River	R	Claiborne, Hancock	4	1999	31	BT	257	257
South Fork Holston River	R	Hawkins	4	2000	10	BT	14	14
Stony Fork	S	Campbell	4	1996	1	BP	12	12
Watuaga River	R	Johnson	4	1996	1	BP/EX	17	17
West Prong Pigeon River	R	Sevier	4	1997	1	BT	7	7
Wilhite Creek	S	Sevier	4	1996	1	BP	1	1
						Total =	1564	1415
						Grand total =	3185	3006

Table 2. Minimum total lengths used for calculating proportional stock indices for smallmouth bass (Gabelhouse 1984).

Length Category	Total Length (cm)	Total Length (inches)
Stock	18	7
Quality	28	11
Preferred	35	14
Memorable	43	17
Trophy	51	20

Table 3. Growth rates of populations based on mean total length at capture for age 3+ and 4+ fish. Populations that had mean total lengths (for either age) in 25th percentile, and above 75th percentile were classified as slow and fast, respectively. The remaining populations with classified as medium growth. Sixteen populations were not classified because no age 3+ and 4+ bass were collected.

SLOW		MEDIUM		FAST	
Population	TWRA Region	Population	TWRA Region	Population	TWRA Region
Little Bigby Creek	2	Lick Creek	1	Big Richland Creek	1
Elk River	2	Standing Rock Creek	1	White Oak Creek	1
Caney Fork River	3	Beaverdam Creek	2	Big Bigby Creek	2
Charles Creek	3	Buffalo River	2	Big Swan Creek	2
Collins River	3	East Fork Mulberry Creek	2	Duck River	2
Flat Creek	3	East Fork Stones River	2	Forty-eight Creek	2
Beech Creek	4	Factory Creek	2	Fountain Creek	2
Big Creek	4	Garrison Fork Creek	2	Green River	2
Big War Creek	4	Harpeth River	2	Knob Creek	2
Doe River	4	Jones Creek	2	Leipers Creek	2
Indian Creek	4	Long Fork Creek	2	Lick Creek	2
Little River	4	Mill Creek	2	Little Harpeth River	2
North Fork Holston River	4	Red River	2	Richland Creek	2
Stony Fork	4	Rutherford Creek	2	Shoal Creek	2
Watuaga River	4	Sycamore Creek	2	South Harpeth River	2
West Prong Pigeon River	4	Hickory Creek	3	Turnbull Creek	2
		Roaring River	3	Smith Fork	3
16 populations		Clinch River	4	French Broad River	4
		Nolichucky River	4	Holston River (below FPH)	4
		Pigeon River	4		
		Powell River	4	19 populations	
		Wilhite Creek	4		
		22 populations			

Table 4. Estimated proportional stock indices for smallmouth bass populations (N>30).

Population	Region	Year	Growth	Size	Total Number Collected	Total Number Stock Size	PSD	RSD14	RSD17	RSD20
Buffalo River [a]	2	96, 98	Medium	River	262	125	13.5	6.5	1.5	0
Duck River [a]	2	96, 98	Fast	River	217	173	28	6.5	1	0
East Fork Stones River [a]	2	97, 99	Medium	River	138	95	21	8	0.5	0
Elk River	2	1999	Slow	River	74	21	22	6	0	0
Garrison Fork Creek	2	1998	Medium	Stream	59	38	39	18	3	0
Harpeth River	2	1999	Medium	River	44	18	28	11	0	0
Little Harpeth River	2	1999	Fast	River	32	23	61	17	0	0
Mill Creek	2	1997	Medium	Stream	30	28	43	14	4	0
Mulberry Creek	2	1997	Medium	Stream	38	26	50	23	8	0
Red River	2	1999	Medium	River	33	15	13	0	0	0
Shoal Creek	2	1999	Fast	Stream	31	18	72	28	11	6
Collins River	3	1998	Slow	River	200	140	29	8	1	0
Smith Fork Creek	3	2000	Fast	River	46	24	29	4	0	0
Clinch River	4	1999	Medium	River	277	51	21	6	1	1
French Broad River	4	2000	Fast	River	91	38	16	13	5	0
Holston River (below FPH)	4	2000	Fast	River	122	40	50	40	10	0
Nolichucky River	4	1998	Medium	River	153	77	32	12	1	0
North Fork Holston River	4	1998	Slow	River	115	74	41	9	1	0
Pigeon River [a]	4	96-98, 00	Medium	River	393	145	40	16.3	5	0
Powell River	4	1999	Medium	River	257	128	27	7	2	0

[a] Totals are for all years combined. Proportional stock indices reported are averages among years and not pooled data.

Table 5. Estimated length-weight relationships of smallmouth bass collected from June through October, 1995 - 2000. Number in parentheses is the standard error of the estimate.

	$\log_{10}(\text{grams}) = \mathbf{a} + \mathbf{b}[\log_{10}(\text{mm})]$			
Classification	**a**	**b**	R^2	n
Statewide	- 5.058	3.0678	0.99	3,183
	(0.012)	(0.005)		
Region 2 (and 1)	- 5.189	3.126	0.99	1,316
	(0.019)	(0.008)		
Region 3	- 4.768	2.935	0.98	304
	(0.053)	(0.023)		
Region 4	- 5.007	3.044	0.99	1,563
	(0.015)	(0.007)		
Slow growth	- 4.878	2.987	0.99	613
	(0.031)	(0.014)		
Medium growth	- 5.057	3.067	0.99	1,761
	(0.016)	(0.007)		
Fast growth	- 5.164	3.114	0.99	740
	(0.020)	(0.008)		
Unclassified growth				69
Streams	- 5.089	3.080	0.99	669
	(0.022)	(0.010)		
Rivers	- 5.050	3.064	0.99	2,514
	(0.014)	(0.006)		

Table 6. Estimated parameters for the von Bertalanffy growth equations for smallmouth bass. L_∞ was fixed at 508 mm for all classifications. Asymptotic 95 % confidence intervals are in parentheses.

	$L_t = \mathbf{L_\infty} (1 - e^{-\mathbf{k}(t-\mathbf{t_0})})$			
Classification	(mm) $\mathbf{L_\infty}$	**k**	(years) $\mathbf{t_0}$	R^2
Statewide	508	0.16208	- 0.44997	0.99
		(0.14892, 0.17523)	(-0.88190, -0.018053)	
Region 2 (and 1)	508	0.15760	- 0.81888	0.99
		(0.13325, 0.18194)	(-1.65742, 0.01966)	
Region 3	508	0.13626	- 0.52335	0.99
		(0.10432, 0.16819)	(-1.78212, 0.73542)	
Region 4	508	0.18334	0.18155	0.99
		(0.15635, 0.21032)	(-0.46829, 0.83139)	
Slow growth	508	0.15194	0.11382	0.99
		(0.13728, 0.16660)	(-0.35361, 0.58125)	
Medium growth	508	0.17605	- 0.27014	0.99
		(0.16229, 0.18980)	(-0.63588, 0.09561)	
Fast growth	508	0.16888	- 0.83368	0.99
		(0.13728, 0.20049)	(-1.83920, 0.17184)	
Streams	508	0.15344	- 0.66940	0.99
		(0.12599, 0.18088)	(-1.63654, 0.29774)	
Rivers	508	0.17121	- 0.20690	0.99
		(0.15129, 0.19112)	(-0.78247, 0.36867)	

Table 7. Estimated total annual mortality for age 2+ and older (AM %), coefficient of determination for estimation of annual mortality (AM r^2), maximum age collected, and recruitment variability (REC-CV) for smallmouth bass populations where over 30 age-2+ and older fish were collected.

Population	**Region**	**Year**	**Growth**	**Size**	**AM %**	**AM r^2**	**max age**	**REC-CV**
Buffalo River - Mean	2	1996, 1998	Medium	River	55.0	0.897	7, 7	36.3
Duck River - Mean	2	1996, 1998	Fast	River	52.5	0.860	7,8	41.3
East Fork Stones River	2	1997	Medium	River	44.3	0.931	7	26.0
Elk River	2	1999	Slow	River	53.7	0.822	9	47.3
Collins River	3	1998	Slow	River	28.8	0.608	12	59.5
Clinch River	4	1999	Medium	River	39.4	0.965	11	21.6
French Broad River	4	2000	Fast	River	39.2	0.292	7	105.0
Holston River (FPH)	4	2000	Fast	River	14.7	0.355	14	74.4
Nolichucky River	4	1998	Medium	River	31.6	0.572	8	63.4
North Fork Holston River	4	1998	Slow	River	34.4	0.739	8	44.3
Pigeon River - Mean	4	1996 -1998	Medium	River	25.3	0.383	8, 10, 15	83.9
Powell River	4	1999	Medium	River	38.8	0.624	7	61.7
Garrison Fork Creek	2	1998	Medium	Stream	28.6	0.478	10	74.4

Table 8. Predicted total length at age based on von Bertalanffy equations (Table 6) for each level of classification in this study and mean total length at age reported for riverine populations throughout the range. Citations in boldface type represents studies that reported using otoliths to determine age.

State	Source	Population	Age 1	2	3	4	5	6	7	8	9	10
TN	**(This study)**	Statewide	106	166	218	261	298	329	356	379	398	415
		upper 95 CI	143	201	251	292	327	356	380	401	418	433
		lower 95 % CI	71	132	184	229	267	301	329	354	375	394
		Region 2 (and1)	127	182	230	270	305	335	360	381	400	416
		Region 3	95	148	194	234	269	299	326	349	369	387
		Region 4	71	144	205	256	298	333	362	387	407	424
		Slow	64	127	180	227	266	300	330	355	376	395
		Medium	102	167	222	268	307	340	367	390	409	425
		Fast	135	193	242	283	318	348	373	394	411	426
		Streams	115	171	219	260	295	325	351	374	393	409
		Rivers	95	160	215	261	300	332	360	383	403	420
AL	**(Slipke et al. 1998)**	Shoal Reach, TN River	179	261	337	414	454	511				
AR	(Filipek et al. 1995)	Buffalo River	137	201	252	308	389	428	456	496		
	"	Crooked River	149	206	255	331	380	415				
	"	Piney Creek		168	211	262	305	363	411			
	"	Big Piney River	120	185	218	245	280	342				
	"	Mulberry River	78	141	201	252	289	344				
	"	Cossatot River	73	120	159	206						
	"	Caddo River	87	161	212	262	317	376				
IA	(Paragamian 1984a)	Maquoketa River	102	180	259	325	388	427	470	490	488	511
MO	(Fajen 1959)	Big Buffalo Creek	79	152	206	249	284	328	393	407		
	(Reed and Rabeni 1989)	Big Buffalo Creek	78	134	183	233	278	321	354	376		
	(Lowry 1953)	White River	64	144	201	231	269	326	349	376		
	(Fajen 1972)	Huzzah Creek	81	155	226	274	333	391	437	460		
	(Funk 1975)	Courtois Creek	79	150	213	272	330	381	419	442		
	(Covington 1982)	Current River	92	151	195	236	276	315	366	408		
OK	(Orth et al. 1983)	Glover Creek	91	160	215	246	299	341				
	(Fisher et al. 1997	Glover Creek	91	168	239	299	360					
	"	Baron Fork Creek	89	161	228	282	357	388				
	(Stark and Zale 1991)	Baron Fork Creek	95	187	242	273	296					
	"	Mountain Fork Creek	120	203	258	297	341	411				
IL	(Carlander 1977)	Illinois River	90	177	242	310						
VA	(Smith and Kauffman 1991)	Shenandoah River	103	191	245	354	395	414				
	(Austen and Orth 1988)	New River		107	176	236	281					
	(VDGIF 2001)	Shenandoah River	103	138	211	277	359	391		411		
		S Fk Shenandoah River	100	150	181	222	294	332	313	325	347	
		N Fk Shenandoah River	93	152	169	228	310	360	388	378	435	443
		James River (lower)	105	191	255	320	390	423	461	434	378	
		James River (upper)	101	176	215	263	320	384	416	413	458	
		Rappahannock River	90	168	203	259	379		387	408		
		Staunton River	83	155	236	274	319	377		429	426	
		New River	81	155	211	272	305	319	362	390	403	
		Jackson River	99	149	205	245	255	281	306	291	308	322
		Maury River	102	164	215	248	252	293				363
WV	(Austen and Orth 1988)	New River		96	187	244	331					
WI	(Forbes 1989)	Galena River		173	239	302	368	394	424	445		

Table 9. Input variables adjusted for each iteration of the FAST Dynamic Pool model.

Variable	Values
Population Classification	Statewide: length/weight $a = -5.058$, $b = 3.0678$
	von Bertalanffy $L_{\infty} = 508$, $k = 0.16208$, $t_0 = -0.44997$
	Slow: length/weight $a = -4.878$, $b = 2.987$
	von Bertalanffy $L_{\infty} = 508$, $k = 0.15194$, $t_0 = 0.11382$
cm	10, 20, 30, 50 %
cf	5, 10, 20, 30, 50 %
Regulation	254-mm minimum length limit (approximation of no length limit)
	305-mm minimum length limit
	356-mm minimum length limit
	406-mm minimum length limit
	305-356 protected length range
	305-381 protected length range
	356-432 protected length range

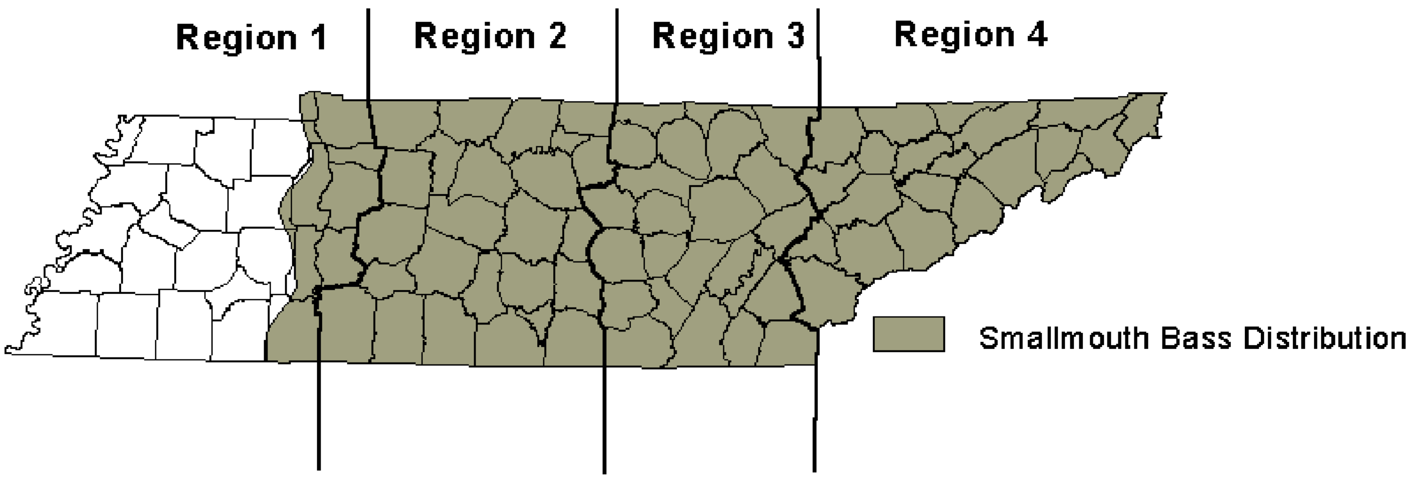
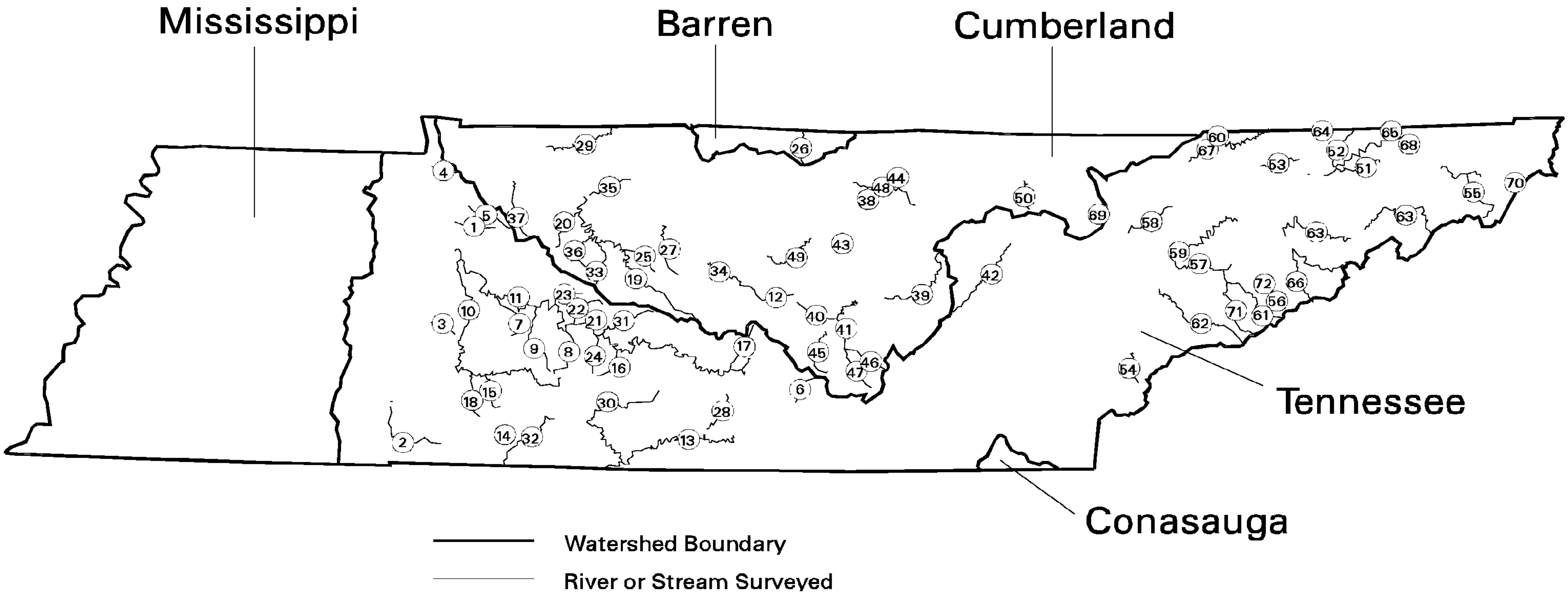


Figure 1. Distribution of smallmouth bass in Tennessee (From Etnier and Starnes 1993) and TWRA administrative Regions.



Label	River Name	Label	River Name	Label	River Name	Label	River Name
Region 1				**Region 3**		56	Dunn Creek
1	Big Richland Creek	19	Harpeth River	38	Blackburn Fork	57	French Broad River
2	Horse Creek	20	Jones Creek	39	Caney Fork River	58	Hinds Creek
3	Lick Creek	21	Knob Creek	40	Charles Creek	59	Holston River (below FPH))
4	Standing Rock Creek	22	Leipers Creek	41	Collins River	60	Indian Creek
5	White Oak Creek	23	Lick Creek	42	Daddy's Creek		61Little Pigeon River
		24	Little Bigby Creek	43	Dry Fork	62	Little River
Region 2		25	Little Harpeth River	44	Flat Creek	63	Nolichucky
6	Beans Creek	26	Long Fork Creek	45	Hickory Creek		64North Fork Clinch River
7	Beaverdam Creek	27	Mill Creek	46	Hills Creek	65	North Fork Holston River
8	Big Bigby Creek	28	Mulberry Creek (East Fork)	47	Isham Spring	66	Pigeon River
9	Big Swan Creek	29	Red River	48	Roaring River	67	Powell River
10	Buffalo River	30	Richland Creek	49	Smith Fork	68	South Fork Holston River
11	Duck River	31	Rutherford Creek	50	White Oak Creek	69	Stony Fork
12	East Fork Stones River	32	Shoal Creek			70	Watauga River
13	Elk River	33	South Harpeth River	**Region 4**		71	West Prong Little Pigeon River
14	Factory Creek	34	East Fork Stones River	51	Beech Creek	72	Wilhite Creek
15	Forty-eight Creek	35	Sycamore Creek	52	Big Creek		
16	Fountain Creek	36	Turnbull Creek	53	Big War Creek		
17	Garrison Fork Creek	37	Yellow Creek	54	Citico Creek		
18	Green River			55	Doe River		

Figure 2. Locations where smallmouth bass were collected in 1995 - 2000.

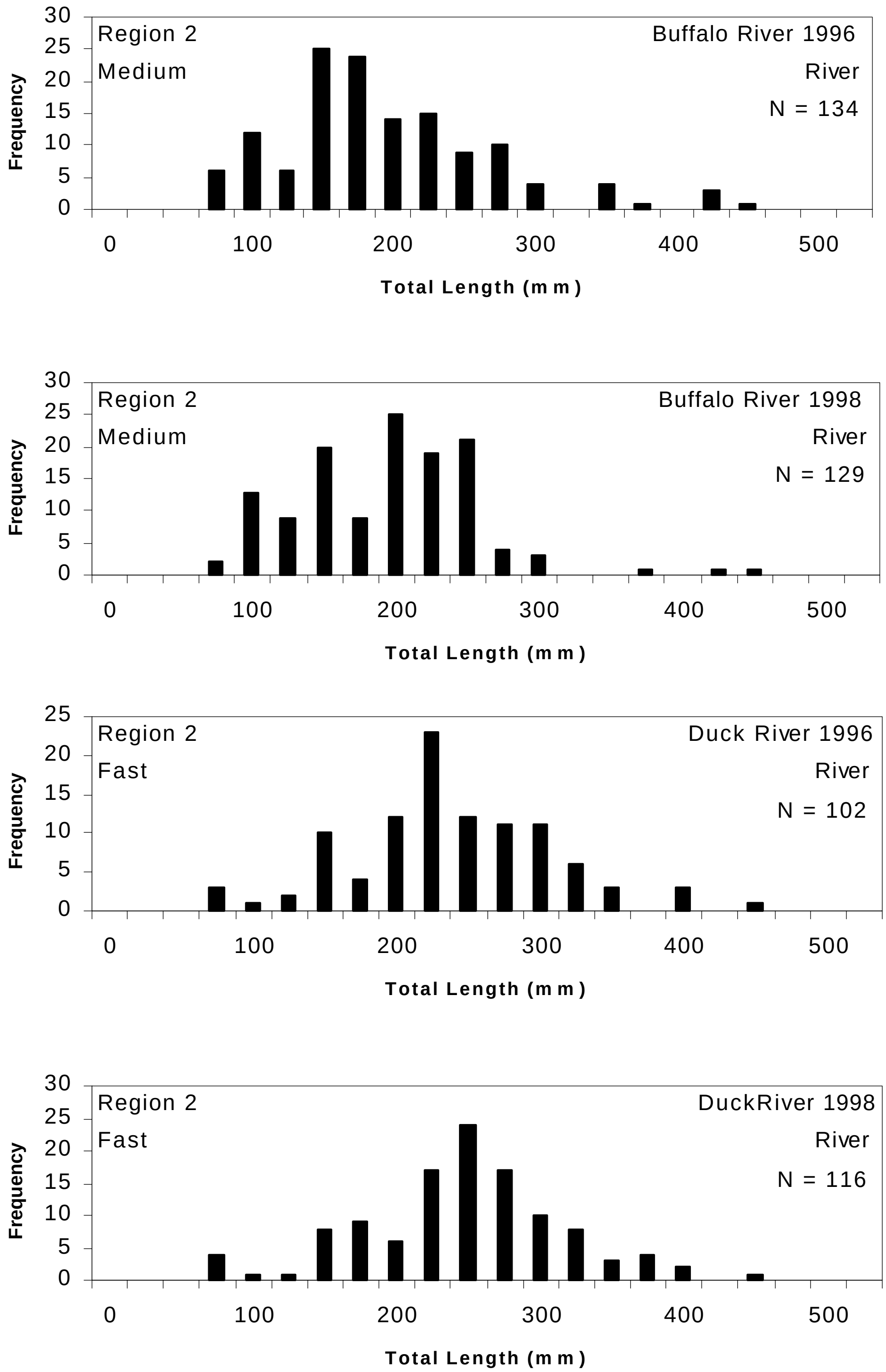


Figure 3. Length frequency (25 mm) of smallmouth bass collected from the indicated location.

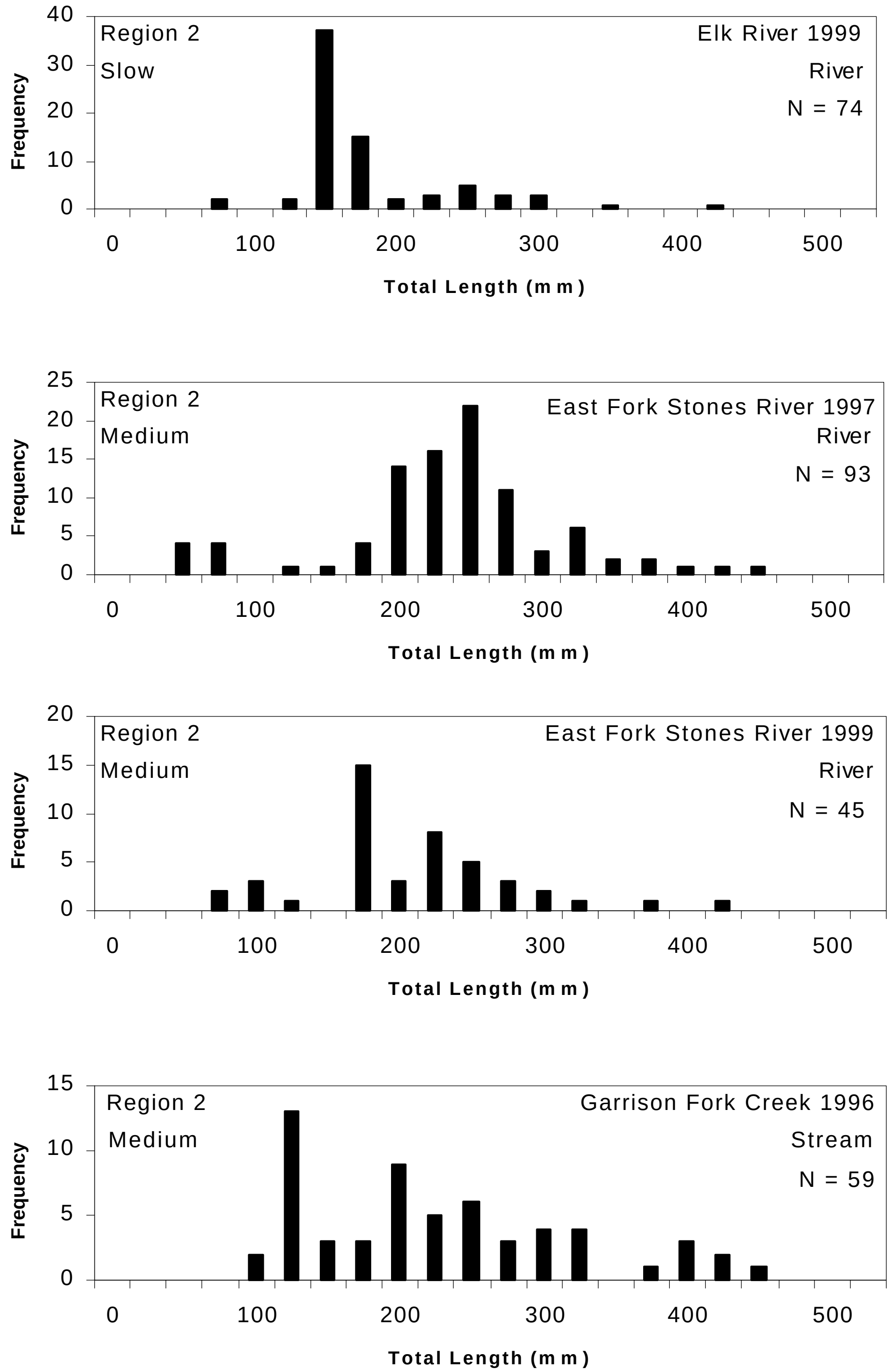


Figure 3. Continued. Length frequency (25 mm) of smallmouth bass collected from the indicated location.

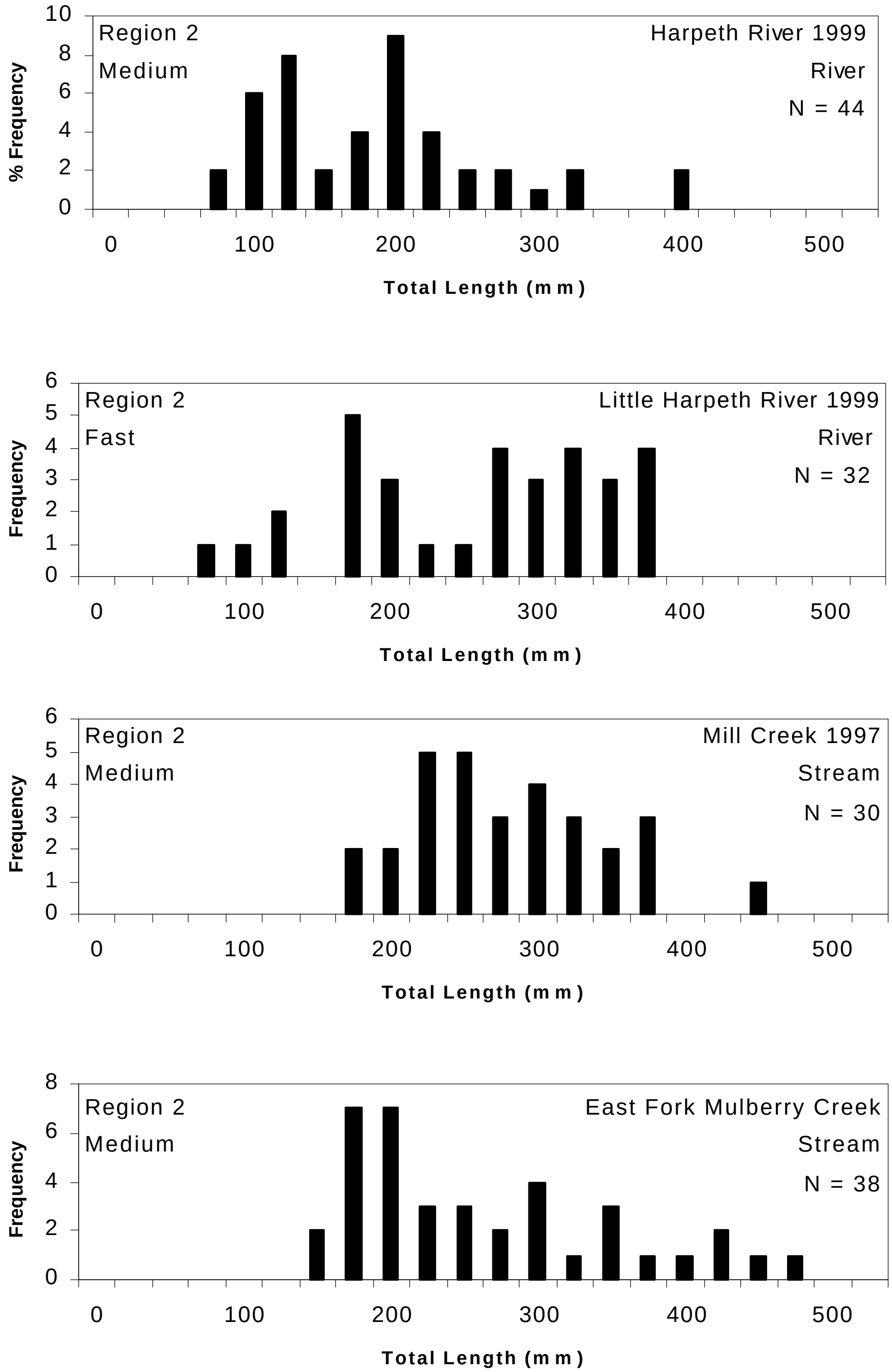


Figure 3. Continued. Length frequency (25 mm) of smallmouth bass collected from the indicated location.

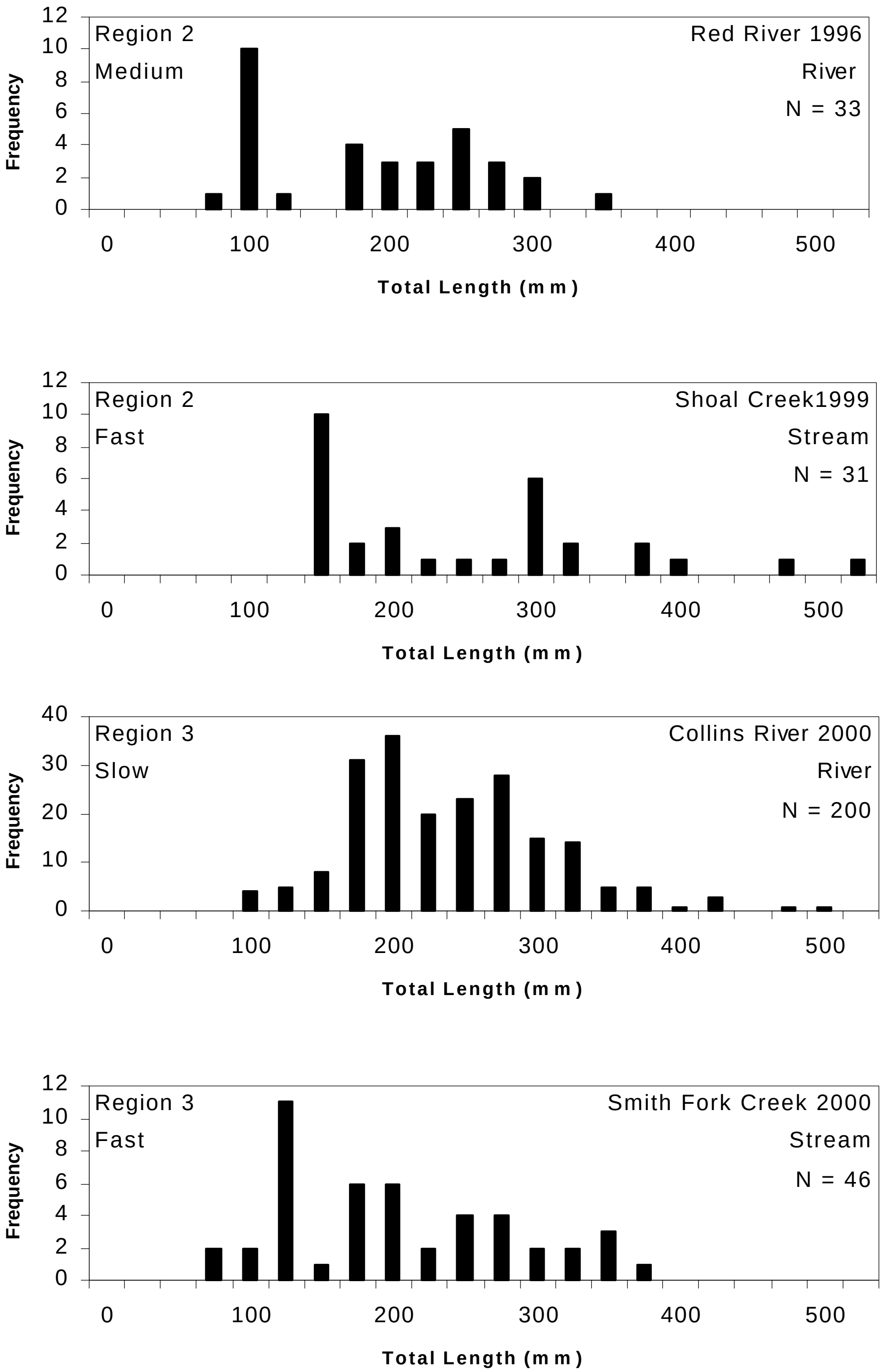


Figure 3. Continued. Length frequency (25 mm) of smallmouth bass collected from the indicated location.

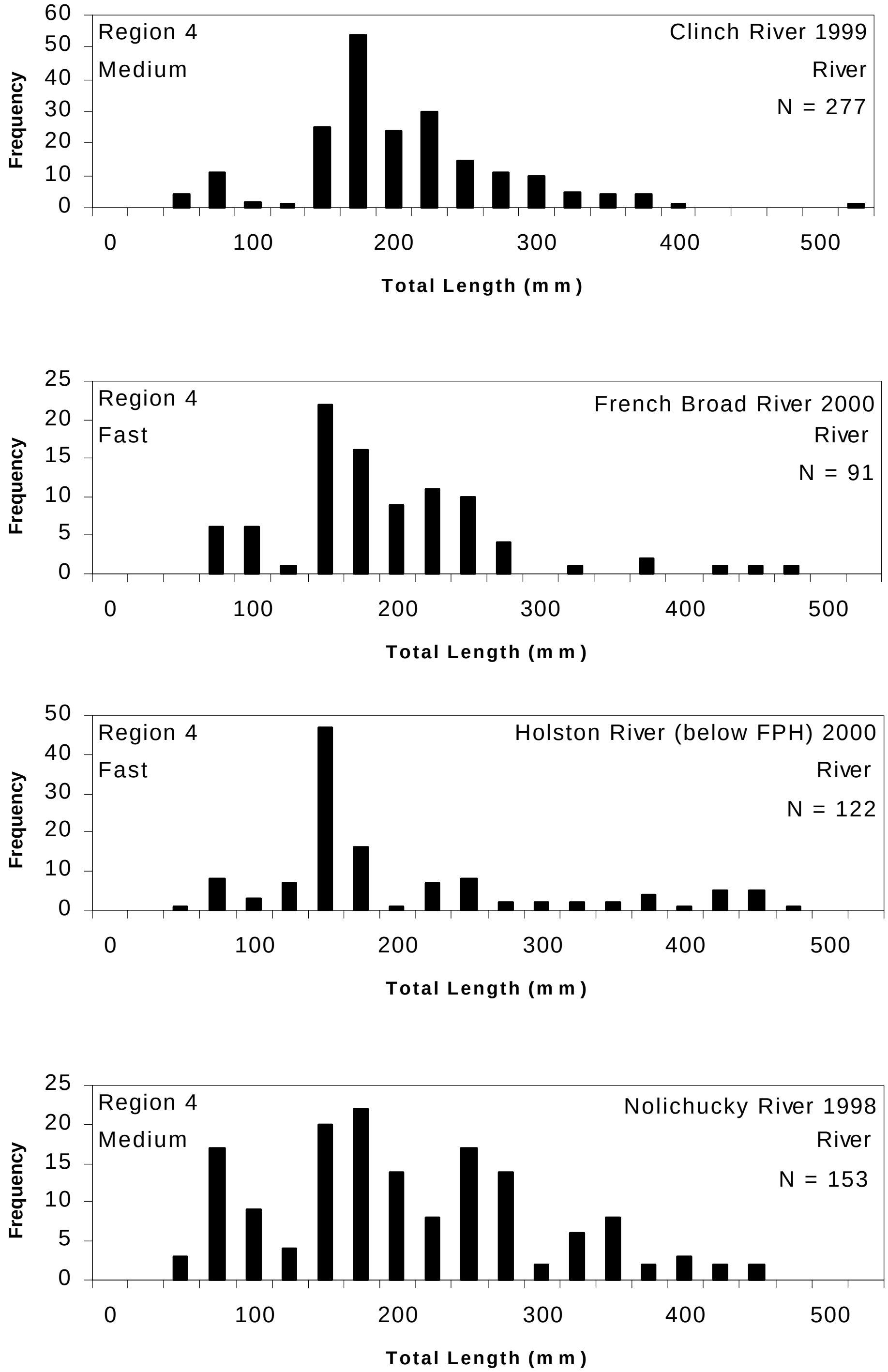


Figure 3. Continued. Length frequency (25 mm) of smallmouth bass collected from the indicated location.

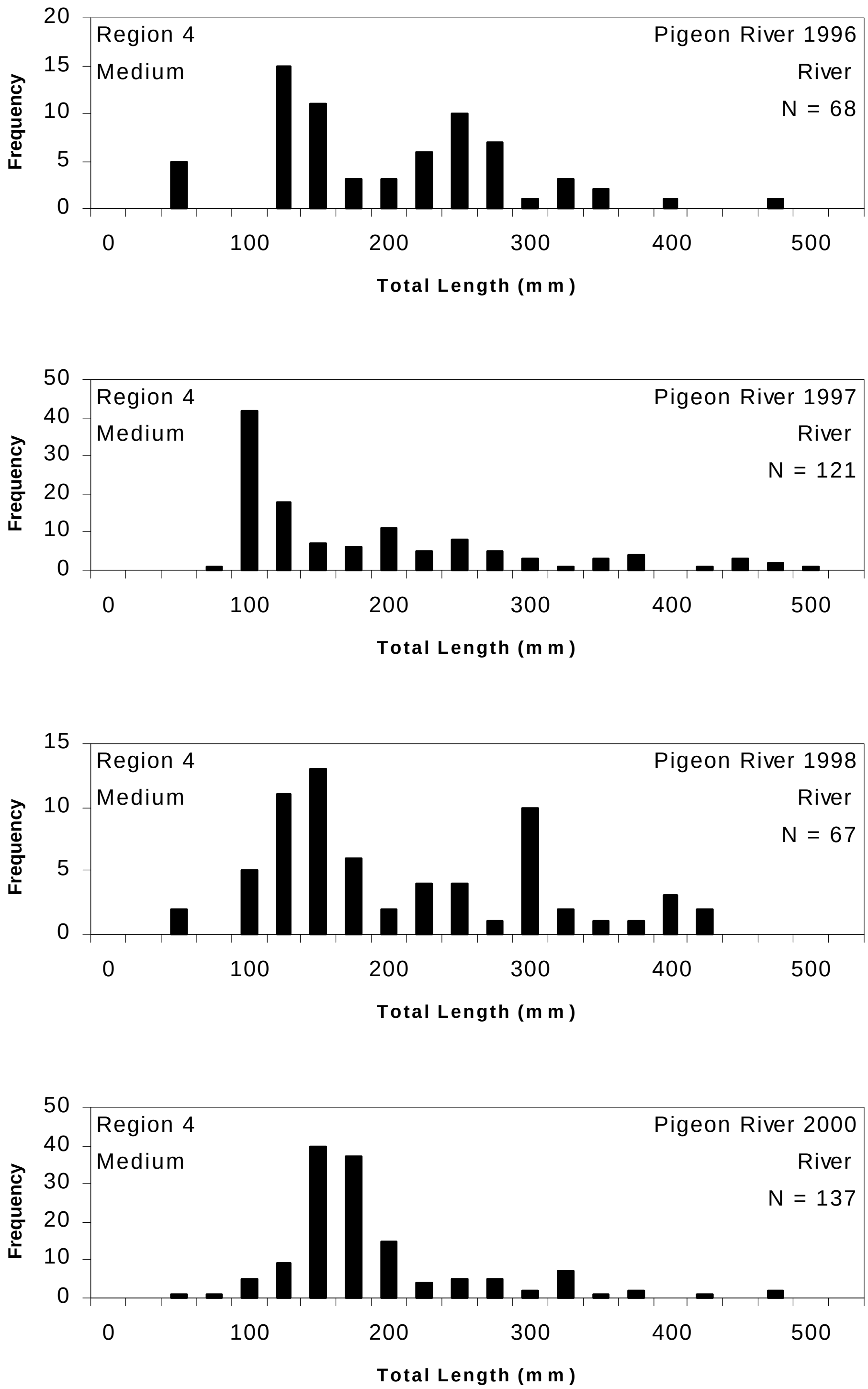
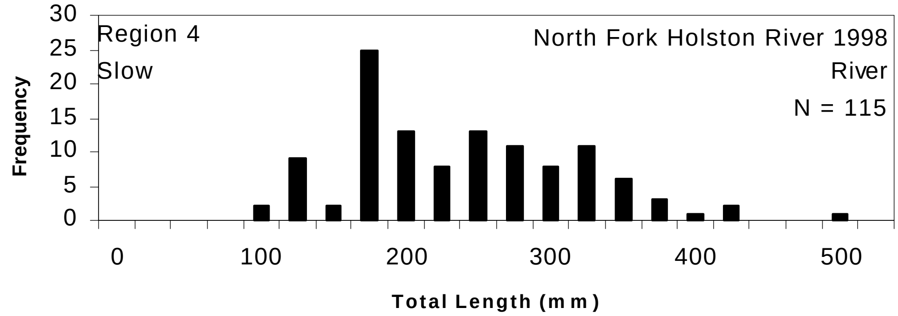


Figure 3. Continued. Length frequency (25 mm) of smallmouth bass collected from the indicated location.



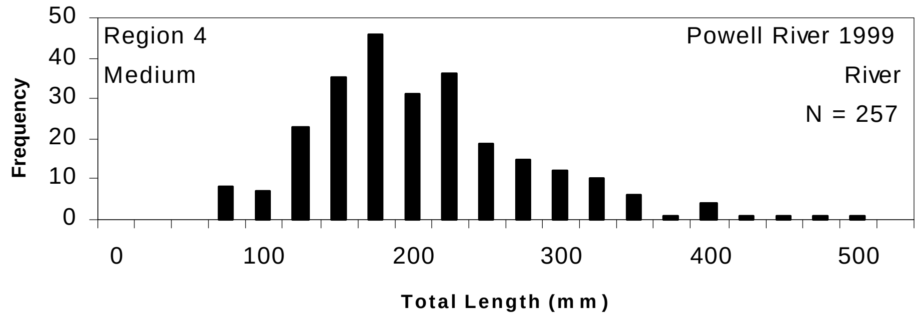


Figure 3. Continued. Length frequency (25 mm) of smallmouth bass collected from the indicated location.

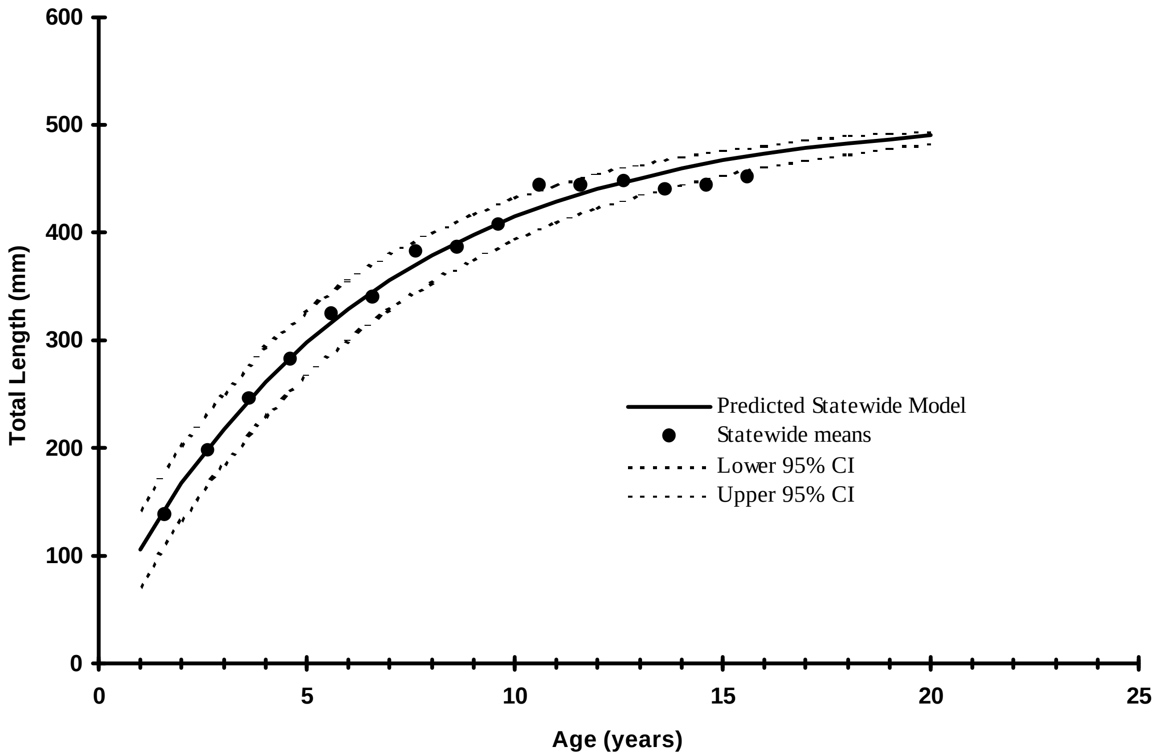


Figure 4. The von Bertalanffy growth function (solid line) based on statewide mean total length at age (circles) for smallmouth bass collected in Tennessee. Dashed lines represent the upper and lower asymptotic 95 % confidence intervals of the growth function.

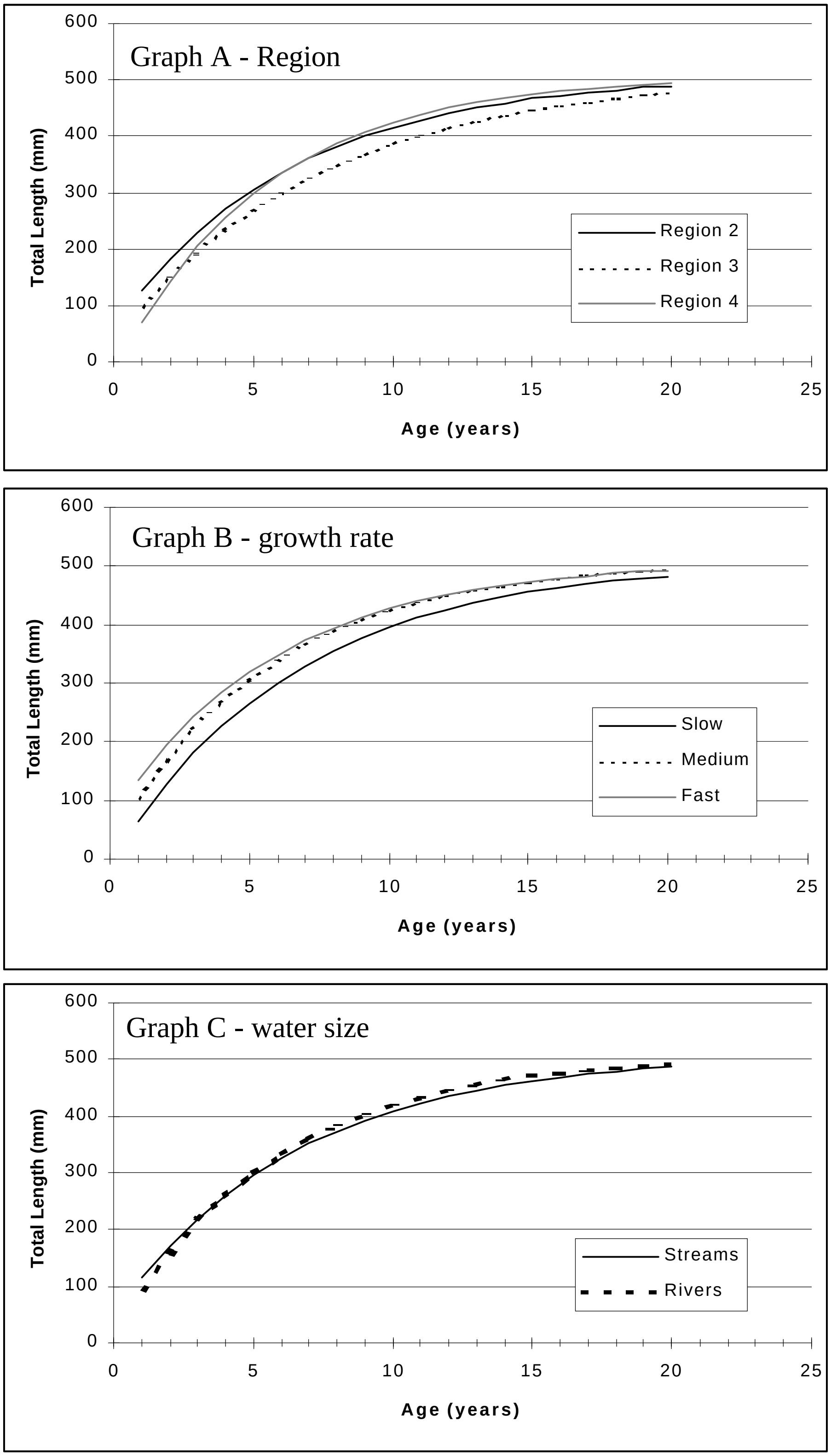
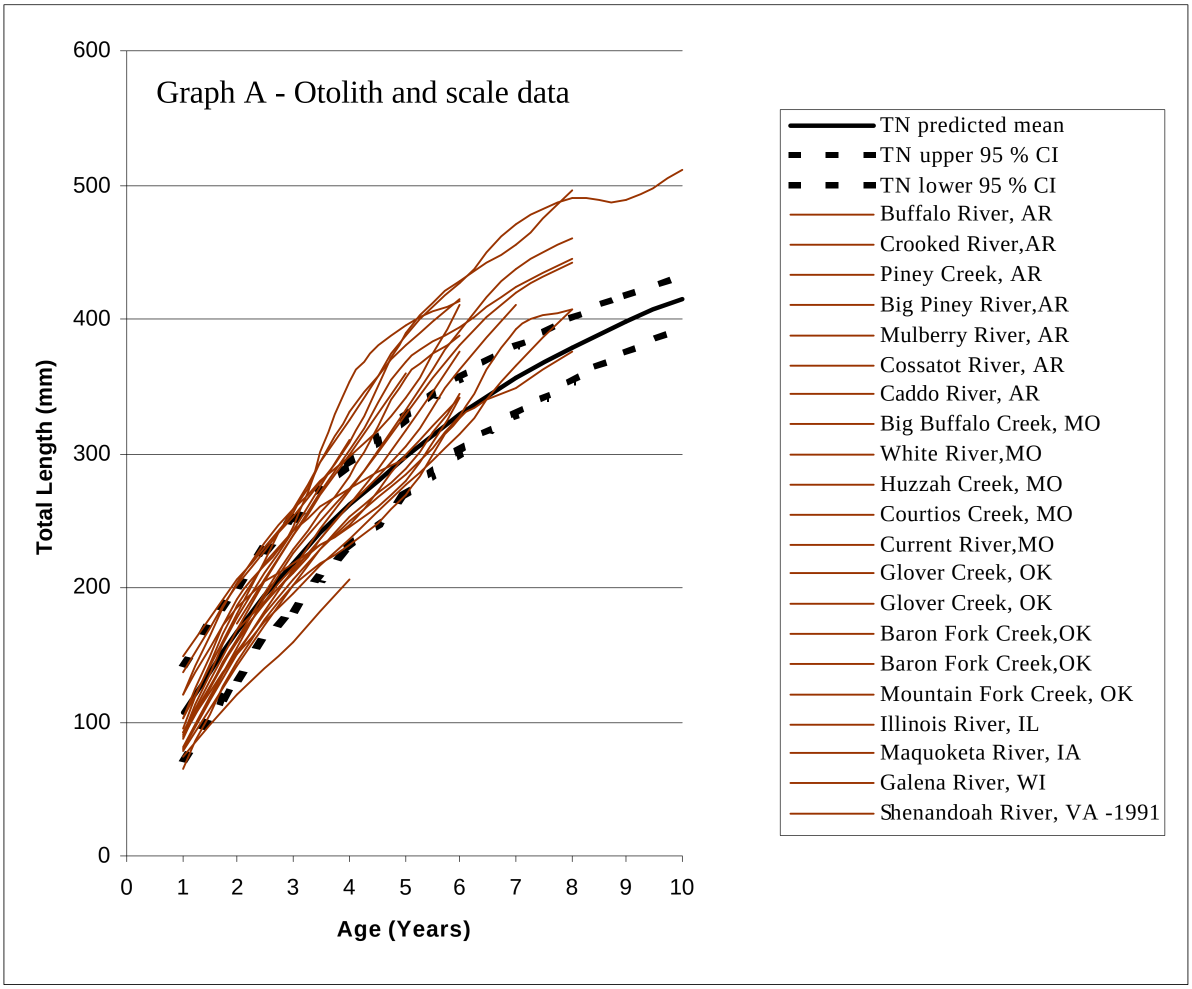


Figure 5. The von Bertalanffy growth functions based on mean total length at age for each level of classification: A) by Region, B) by growth rate, and C) by water size.



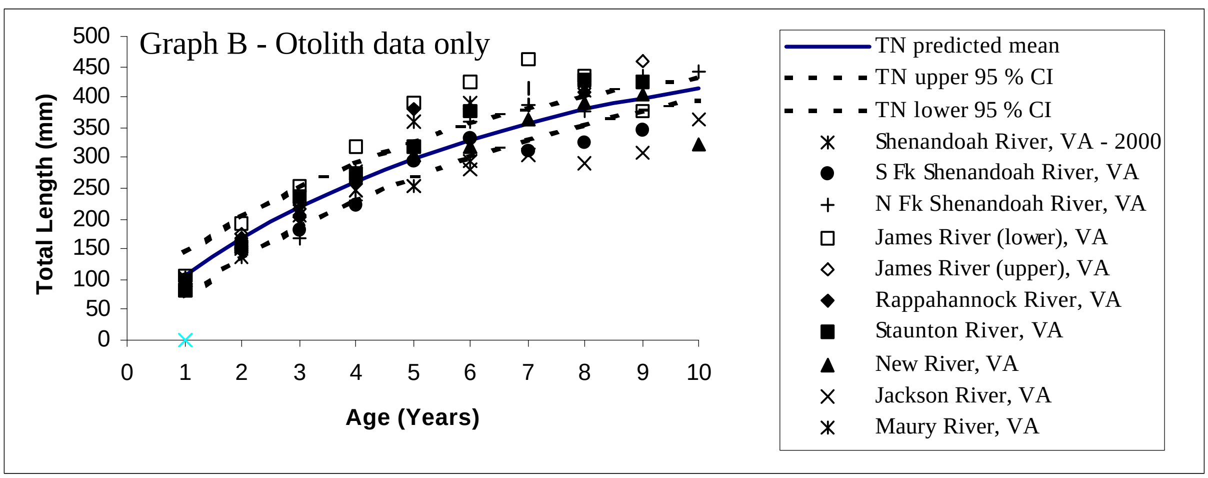


Figure 6. **Graph A**- The von Bertalanffy growth curve for the Tennessee statewide population (ages based on otolith data) with 95 % asymptotic confidence intervals, and mean total length at age for smallmouth bass in other studies (all ages based on scale data; see Table 8 for citations). **Graph B** - The von Bertalanffy growth curve for the Tennessee statewide population with 95 % asymptotic confidence intervals, and mean total length at age for smallmouth bass in Virginia rivers (VDGIF 2001).

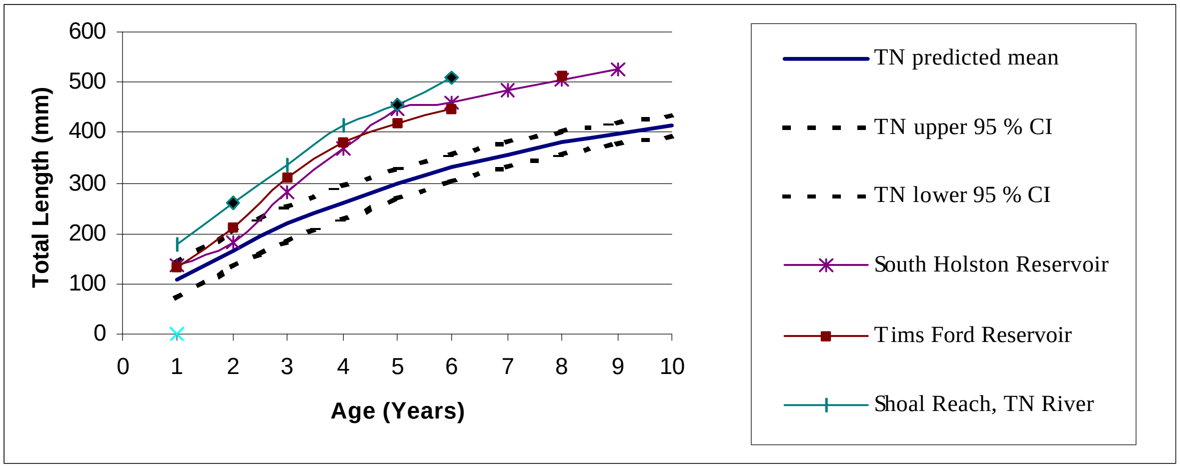


Figure 7. The von Bertalanffy growth curve for the average statewide population and 95 % asymptotic confidence intervals, and mean total length at age for smallmouth bass from selected Tennessee reservoirs (TWRA, unpublished data) and the Shoals Reach of the Tennessee River, Alabama (Slipke et al. 1998).

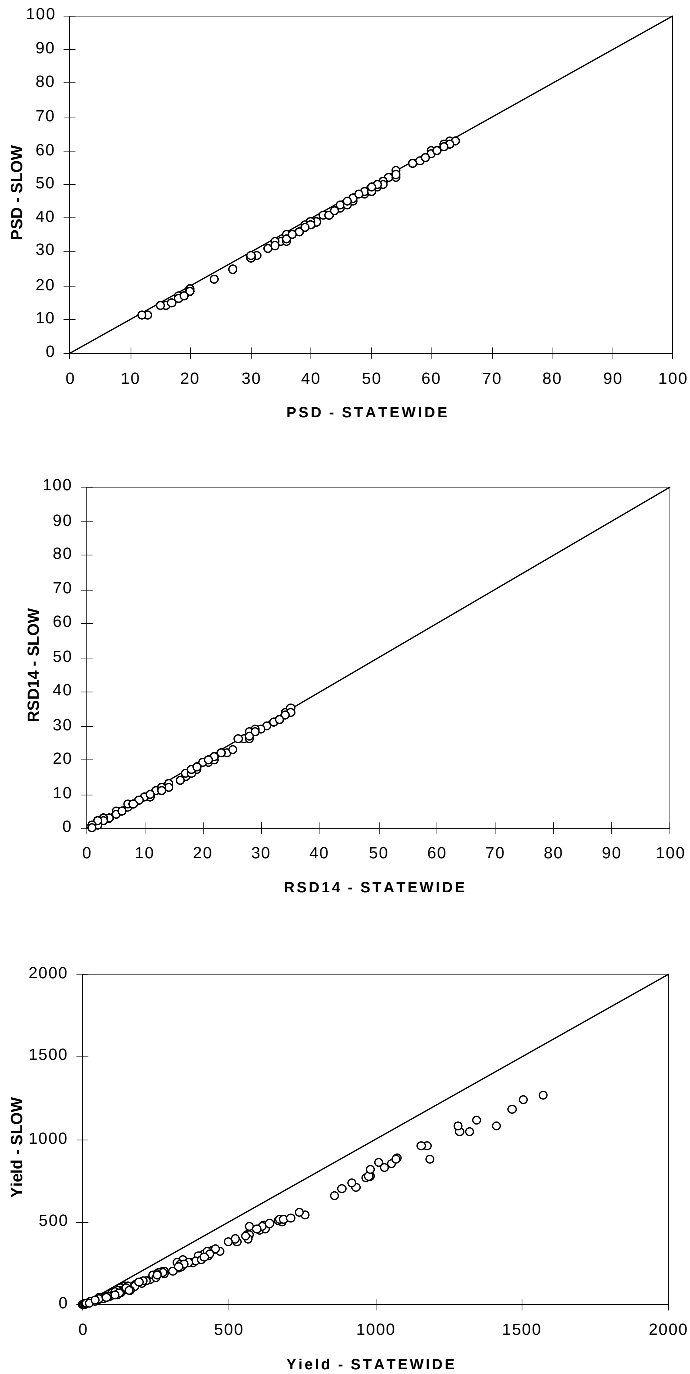


Figure 8. Comparison of predicted PSD, RSD14, and yield for the statewide and slow growth categories of smallmouth bass populations given equal conditions of *cm* (10, 20, 30, 50 %), *cf* (5, 10, 20, 30, 50 %), and length restrictions (254-, 305-, 356-, 406-mm minimum lengths, and protected length ranges of 305-356, 305-381, and 356-432 mm). The solid line (y = x) indicates identical values.

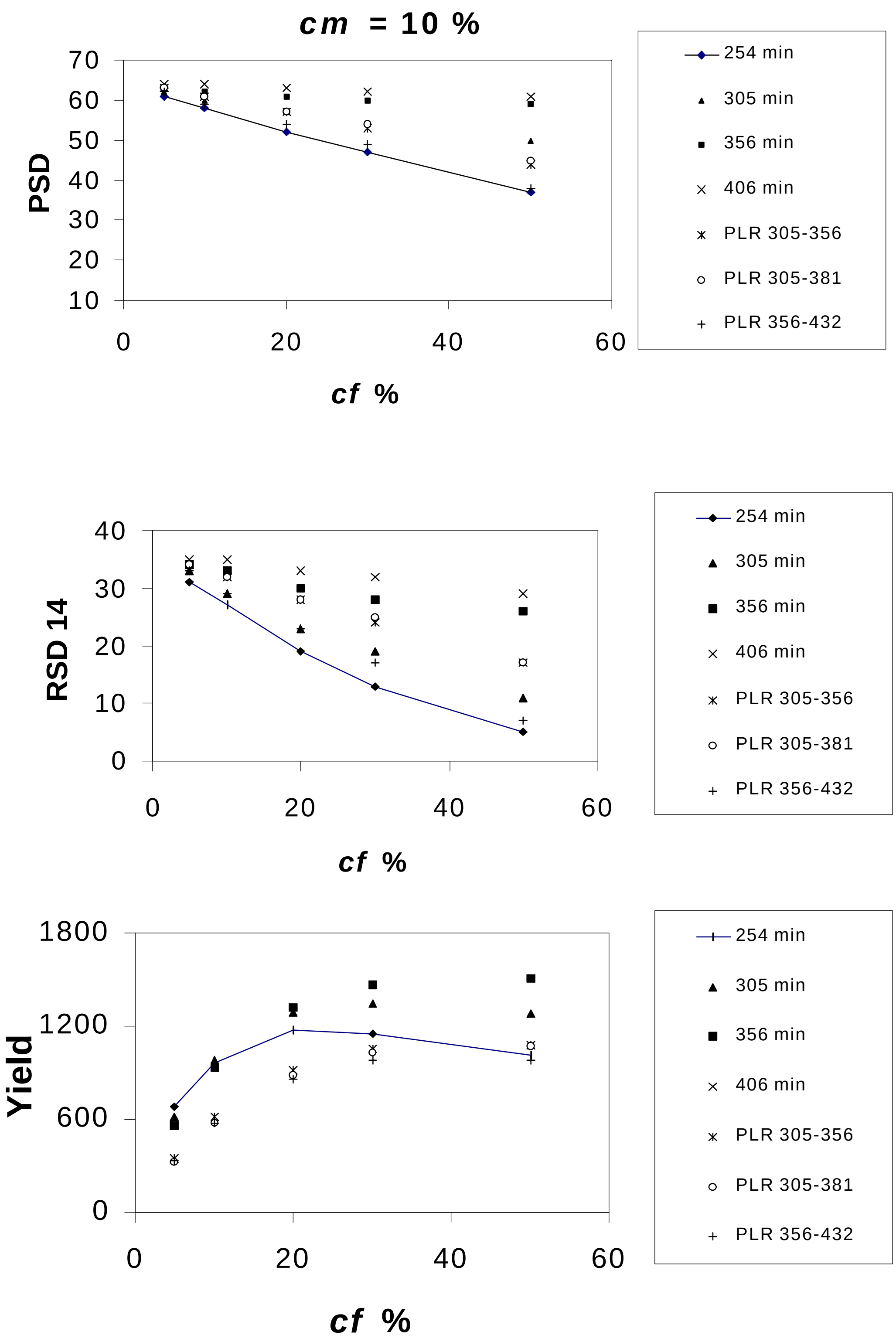


Figure 9. Predicted PSD, RSD14, and yield given a conditional mortality rate (*cm)* of 10 % over a range of conditional fishing mortality rates (*cf*), and a variety of length restrictions for the statewide smallmouth bass population. The 254-mm regulation (solid line) is an approximation of a “no minimum length limit” as few bass less than 254 mm are harvested by anglers.

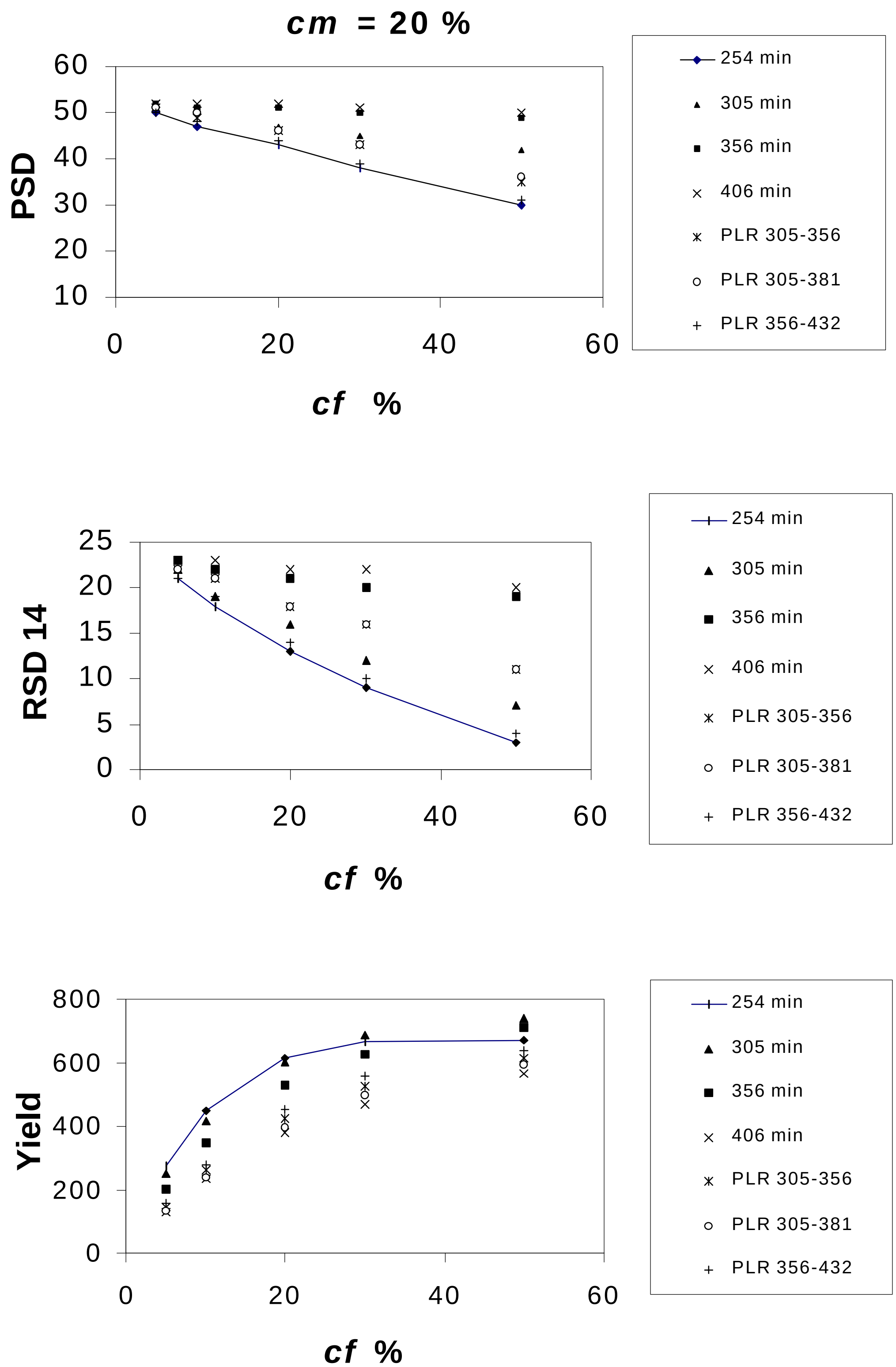
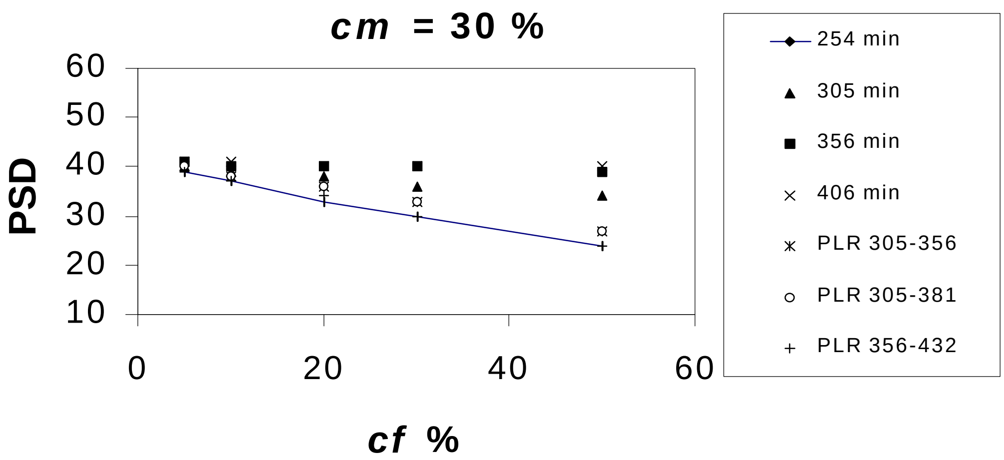
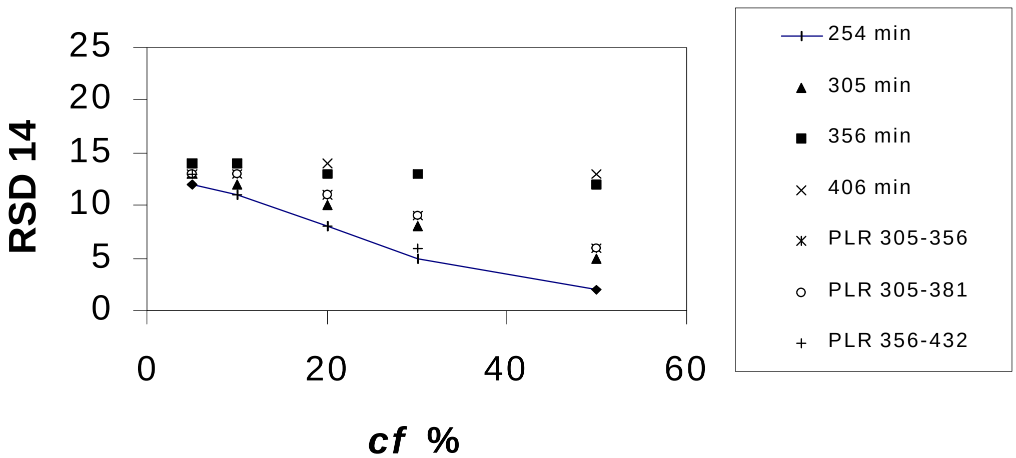


Figure 10. Predicted PSD, RSD14, and yield given a conditional mortality rate (*cm*) of 20 % over a range of conditional fishing mortality rates (*cf*), and a variety of length restrictions for the statewide smallmouth bass population. The 254-mm regulation (solid line) is an approximation of a “no minimum length limit” as few bass less than 254 mm are harvested by anglers.





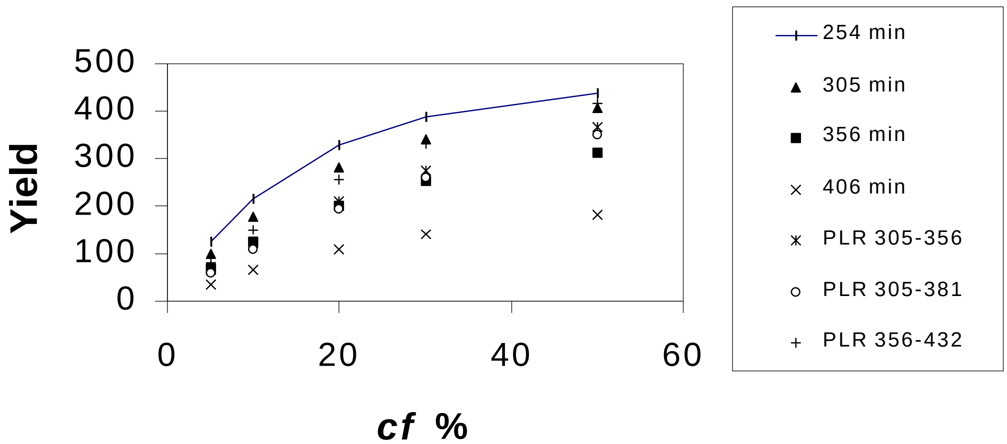


Figure 11. Predicted PSD, RSD14, and yield given a conditional mortality rate (*cm)* of 30 % over a range of conditional fishing mortality rates (*cf*), and a variety of length restrictions for the statewide smallmouth bass population. The 254-mm regulation (solid line) is an approximation of a “no minimum length limit” as few bass less than 254 mm are harvested by anglers.

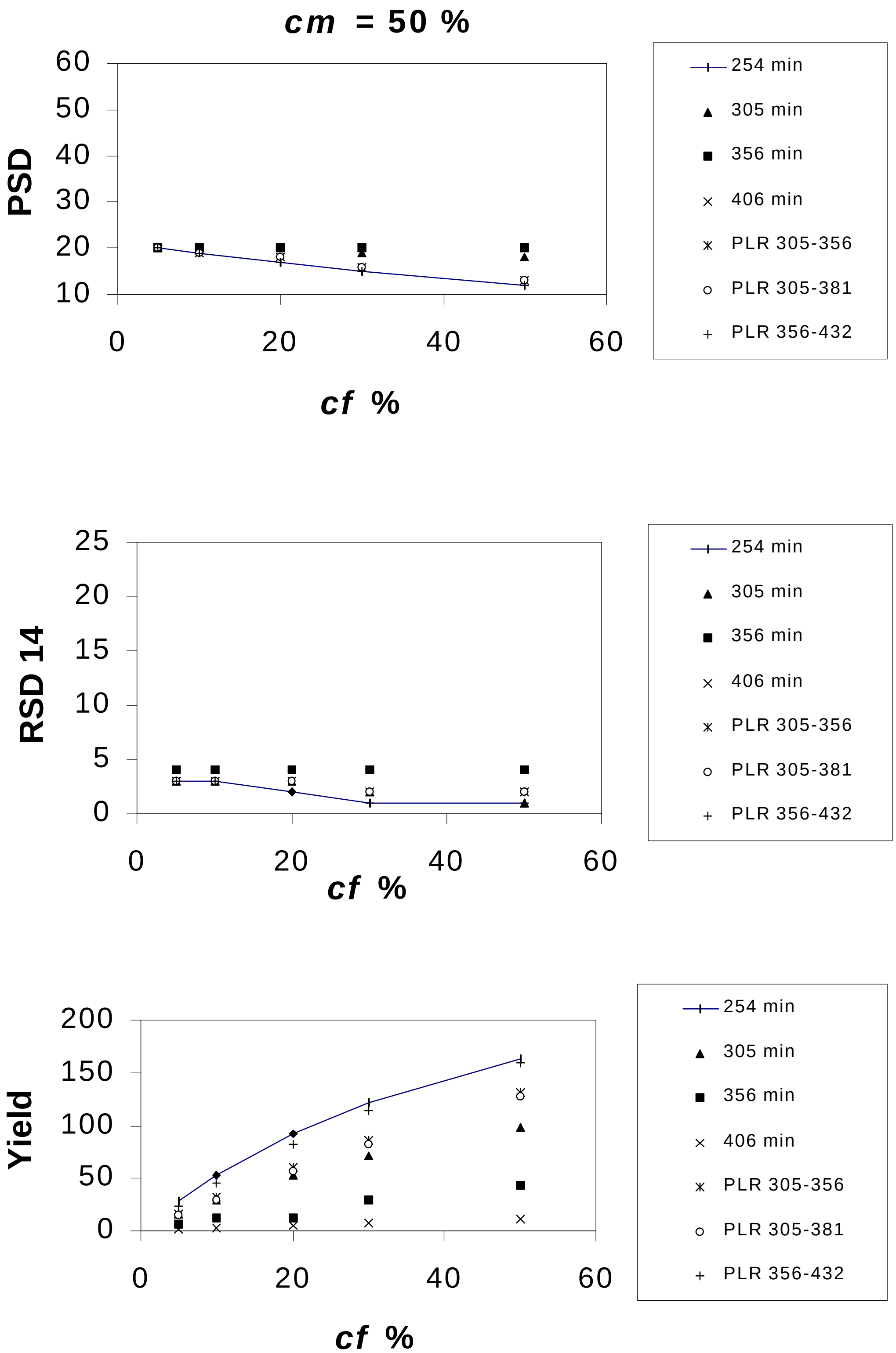


Figure 12. Predicted PSD, RSD14, and yield given a conditional mortality rate (*cm*) of 50 % over a range of conditional fishing mortality rates (*cf*), and a variety of length restrictions for the statewide smallmouth bass population. The 254-mm regulation (solid line) is an approximation of a “no minimum length limit” as few bass less than 254 mm are harvested by anglers.

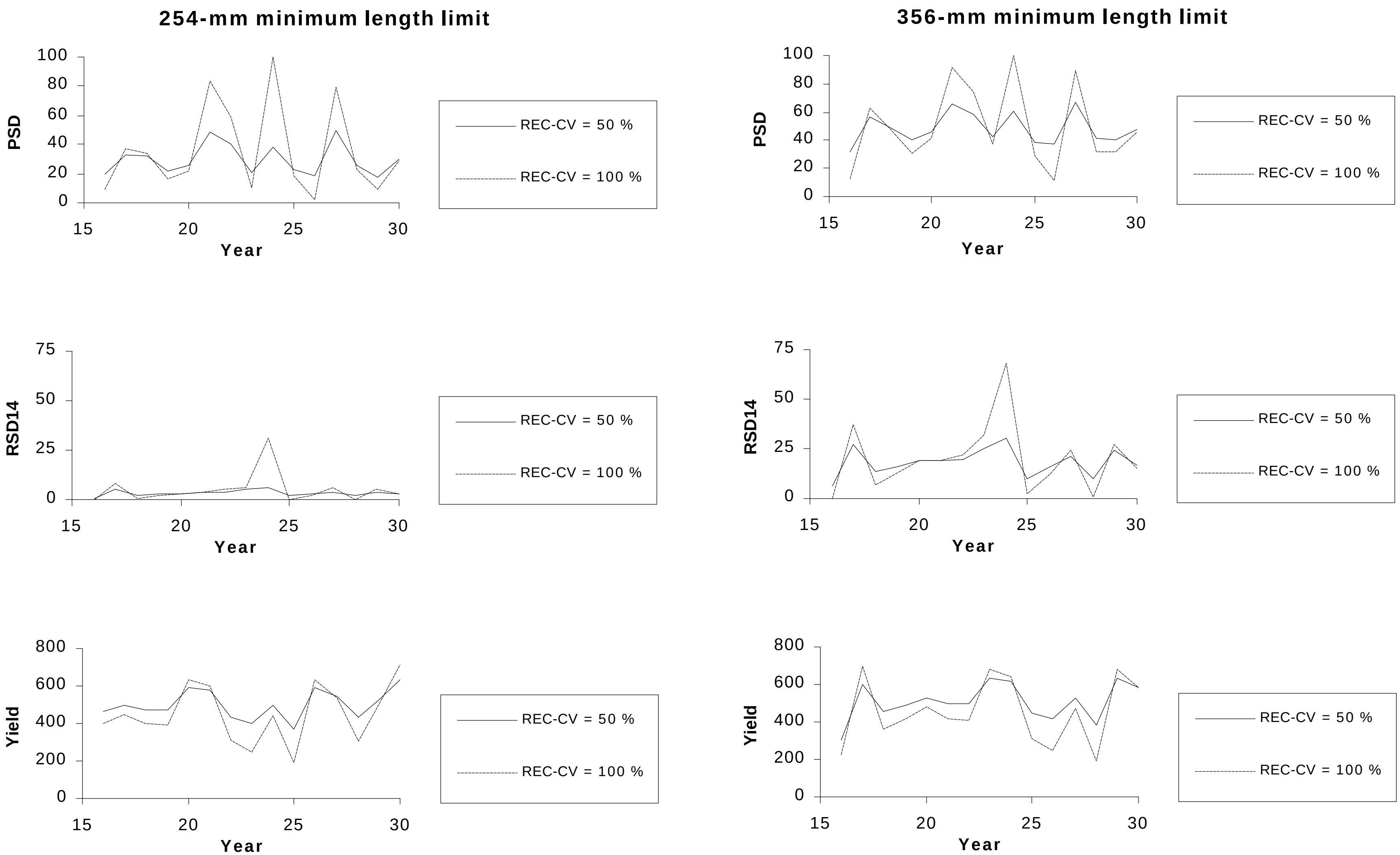


Figure 13. Predicted PSD, RSD14, and yield for the statewide smallmouth bass population over a 15-year period based on the Dynamic Pool model with a 254-mm length limit (an approximation of no length limit) and a 356-mm minimum length limit. In each case *cm* was 20 % , *cf* was 50%, and recruitment variability (REC-CV) was based on the same set of normally-distributed, random numbers with coefficients of variability at either 50 or 100 %.

Appendix A. Mean (MTL), standard error (SETL), minimum (MINTL), and maximum total length (MAXTL) for each age of smallmouth bass at time of collection (age-x+) at each location. Bass collected by angling are not included in this appendix so that mortality calculations may be made using these data.

OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
1	1	BIG_RICHLAND_CK	1996	FAST	STREAM	1	1	126.000	.	126	126
2	1	HORSE_CK	1998	UNK	STREAM	5	1	362.000	.	362	362
3	1	LICK_CK	1998	MED	STREAM	2	1	170.000	.	170	170
4	1	LICK_CK	1998	MED	STREAM	3	4	249.250	6.7376	230	261
5	1	STANDING_ROCK_CK	1998	MED	STREAM	0	5	66.800	4.0423	59	81
6	1	STANDING_ROCK_CK	1998	MED	STREAM	1	5	147.600	8.7898	120	168
7	1	STANDING_ROCK_CK	1998	MED	STREAM	2	11	244.727	11.1511	191	320
8	1	STANDING_ROCK_CK	1998	MED	STREAM	3	1	232.000	.	232	232
9	1	STANDING_ROCK_CK	1998	MED	STREAM	4	2	272.500	6.5000	266	279
10	1	WHITE_OAK_CK	1996	FAST	STREAM	0	6	76.667	8.8982	48	102
11	1	WHITE_OAK_CK	1996	FAST	STREAM	1	4	156.750	5.3910	145	169
12	1	WHITE_OAK_CK	1996	FAST	STREAM	2	5	218.400	6.1449	207	239
13	1	WHITE_OAK_CK	1996	FAST	STREAM	3	3	261.000	5.2915	251	269
14	1	WHITE_OAK_CK	1996	FAST	STREAM	5	2	346.000	11.0000	335	357
15	2	BEANS_CK	1998	UNK	STREAM	2	3	170.000	17.9258	140	202
16	2	BEAVERDAM_CK	1999	MED	STREAM	2	1	289.000	.	289	289
17	2	BEAVERDAM_CK	1999	MED	STREAM	3	1	253.000	.	253	253
18	2	BEAVERDAM_CK	1999	MED	STREAM	5	1	332.000	.	332	332
19	2	BIG_BIGBY_CK	1999	FAST	STREAM	2	1	158.000	.	158	158
20	2	BIG_BIGBY_CK	1999	FAST	STREAM	3	3	279.000	5.5076	270	289
21	2	BIG_BIGBY_CK	1999	FAST	STREAM	4	2	364.000	22.0000	342	386
22	2	BIG_BIGBY_CK	1999	FAST	STREAM	5	4	369.500	4.8734	363	384
23	2	BIG_BIGBY_CK	1999	FAST	STREAM	7	1	405.000	.	405	405
24	2	BIG_BIGBY_CK	1999	FAST	STREAM	8	1	386.000	.	386	386
25	2	BIG_BIGBY_CK	1999	FAST	STREAM	10	1	423.000	.	423	423
26	2	BIG_SWAN_CK	1997	FAST	STREAM	1	2	134.500	7.5000	127	142
27	2	BIG_SWAN_CK	1997	FAST	STREAM	3	5	240.200	13.2755	203	274
28	2	BIG_SWAN_CK	1997	FAST	STREAM	4	1	332.000	.	332	332
29	2	BIG_SWAN_CK	1997	FAST	STREAM	6	2	305.500	31.5000	274	337
30	2	BUFFALO_R	1995	MED	RIVER	1	1	81.000	.	81	81
31	2	BUFFALO_R	1996	MED	RIVER	0	21	80.190	3.1256	53	110
32	2	BUFFALO_R	1996	MED	RIVER	1	61	151.148	2.3619	116	205
33	2	BUFFALO_R	1996	MED	RIVER	2	23	208.652	3.0610	183	235
34	2	BUFFALO_R	1996	MED	RIVER	3	14	250.071	4.9895	215	285
35	2	BUFFALO_R	1996	MED	RIVER	4	5	261.600	6.3293	243	275
36	2	BUFFALO_R	1996	MED	RIVER	5	8	351.250	13.3761	285	405

Appendix A. Mean (MTL), standard error (SETL), minimum (MINTL), and maximum total length (MAXTL) for each age of smallmouth bass at time of collection (age-x+) at each location. Bass collected by angling are not included in this appendix so that mortality calculations may be made using these data.

OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
37	2	BUFFALO_R	1996	MED	RIVER	6	1	440.000	.	440	440
38	2	BUFFALO_R	1996	MED	RIVER	7	1	405.000	.	405	405
39	2	BUFFALO_R	1998	MED	RIVER	0	21	91.238	3.0023	65	112
40	2	BUFFALO_R	1998	MED	RIVER	1	30	141.667	2.5687	106	173
41	2	BUFFALO_R	1998	MED	RIVER	2	48	199.563	2.8669	151	266
42	2	BUFFALO_R	1998	MED	RIVER	3	22	239.909	4.1456	206	293
43	2	BUFFALO_R	1998	MED	RIVER	4	4	273.500	25.5816	243	350
44	2	BUFFALO_R	1998	MED	RIVER	5	2	342.000	58.0000	284	400
45	2	BUFFALO_R	1998	MED	RIVER	7	1	447.000	.	447	447
46	2	DUCK_R	1995	FAST	RIVER	.	1	195.000	.	195	195
47	2	DUCK_R	1995	FAST	RIVER	1	6	136.167	5.6711	117	147
48	2	DUCK_R	1995	FAST	RIVER	2	5	247.800	4.2000	234	258
49	2	DUCK_R	1995	FAST	RIVER	3	2	272.000	4.0000	268	276
50	2	DUCK_R	1995	FAST	RIVER	4	2	334.000	6.0000	328	340
51	2	DUCK_R	1995	FAST	RIVER	7	1	376.000	.	376	376
52	2	DUCK_R	1996	FAST	RIVER	0	5	82.400	13.5374	58	130
53	2	DUCK_R	1996	FAST	RIVER	1	16	146.188	6.5665	120	225
54	2	DUCK_R	1996	FAST	RIVER	2	50	215.500	3.6441	175	285
55	2	DUCK_R	1996	FAST	RIVER	3	23	278.913	5.9264	215	340
56	2	DUCK_R	1996	FAST	RIVER	4	5	339.600	21.8050	286	395
57	2	DUCK_R	1996	FAST	RIVER	5	1	345.000	.	345	345
58	2	DUCK_R	1996	FAST	RIVER	7	1	430.000	.	430	430
59	2	DUCK_R	1996	FAST	RIVER	8	1	395.000	.	395	395
60	2	DUCK_R	1998	FAST	RIVER	.	0	.	.	.	.
61	2	DUCK_R	1998	FAST	RIVER	0	5	72.800	6.1188	60	96
62	2	DUCK_R	1998	FAST	RIVER	1	14	152.357	5.0889	130	206
63	2	DUCK_R	1998	FAST	RIVER	2	56	222.589	3.8498	144	276
64	2	DUCK_R	1998	FAST	RIVER	3	16	280.625	7.2468	235	356
65	2	DUCK_R	1998	FAST	RIVER	4	15	298.733	9.1290	243	356
66	2	DUCK_R	1998	FAST	RIVER	5	5	323.800	29.2582	232	390
67	2	DUCK_R	1998	FAST	RIVER	6	2	316.000	4.0000	312	320
68	2	DUCK_R	1998	FAST	RIVER	9	2	405.000	40.0000	365	445
69	2	ELK_R	1997	SLOW	RIVER	1	5	133.400	4.1304	122	144
70	2	ELK_R	1997	SLOW	RIVER	2	1	163.000	.	163	163
71	2	ELK_R	1997	SLOW	RIVER	3	4	234.000	19.5917	205	290
72	2	ELK_R	1997	SLOW	RIVER	4	2	320.000	90.0000	230	410

Appendix A. Mean (MTL), standard error (SETL), minimum (MINTL), and maximum total length (MAXTL) for each age of smallmouth bass at time of collection (age-x+) at each location. Bass collected by angling are not included in this appendix so that mortality calculations may be made using these data.

OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL	
73	2	ELK_R	1997	SLOW	RIVER	5	7	271.286	6.9718	242	295	
74	2	ELK_R	1997	SLOW	RIVER	6	3	307.667	21.4191	275	348	
75	2	ELK_R	1997	SLOW	RIVER	7	1	340.000	.	340	340	
76	2	ELK_R	1997	SLOW	RIVER	8	1	362.000	.	362	362	
77	2	ELK_R	1997	SLOW	RIVER	9	1	392.000	.	392	392	
78	2	ELK_R	1997	SLOW	RIVER	15	1	435.000	.	435	435	
79	2	ELK_R	1999	SLOW	RIVER	0	2	68.500	3.5000	65	72	
80	2	ELK_R	1999	SLOW	RIVER	1	16	147.250	6.1890	123	227	
81	2	ELK_R	1999	SLOW	RIVER	2	40	148.275	2.8438	119	203	
82	2	ELK_R	1999	SLOW	RIVER	3	9	226.222	13.5644	163	282	
83	2	ELK_R	1999	SLOW	RIVER	4	4	263.250	11.5857	236	291	
84	2	ELK_R	1999	SLOW	RIVER	5	1	268.000	.	268	268	
85	2	ELK_R	1999	SLOW	RIVER	7	1	346.000	.	346	346	
86	2	ELK_R	1999	SLOW	RIVER	9	1	400.000	.	400	400	
87	2	E_FORK_STONES_R	1997	MED	RIVER	0	8	52.000	3.3004	42	69	
88	2	E_FORK_STONES_R	1997	MED	RIVER	1	3	139.333	15.1914	111	163	
89	2	E_FORK_STONES_R	1997	MED	RIVER	2	31	198.065	3.6629	155	234	
90	2	E_FORK_STONES_R	1997	MED	RIVER	3	26	242.423	5.4000	194	305	
91	2	E_FORK_STONES_R	1997	MED	RIVER	4	15	273.400	11.5683	219	359	
92	2	E_FORK_STONES_R	1997	MED	RIVER	5	4	309.500	24.8680	274	380	
93	2	E_FORK_STONES_R	1997	MED	RIVER	6	4	333.500	26.9367	300	414	
94	2	E_FORK_STONES_R	1997	MED	RIVER	7	2	386.500	55.5000	331	442	
95	2	E_FORK_STONES_R	1999	MED	RIVER	0	6	83.333	8.1432	51	109	
96	2	E_FORK_STONES_R	1999	MED	RIVER	1	18	166.167	1.5323	158	178	
97	2	E_FORK_STONES_R	1999	MED	RIVER	2	11	216.273	3.4380	200	232	
98	2	E_FORK_STONES_R	1999	MED	RIVER	3	4	253.750	3.4490	248	263	
99	2	E_FORK_STONES_R	1999	MED	RIVER	4	1	266.000	.	266	266	
100	2	E_FORK_STONES_R	1999	MED	RIVER	5	3	293.667	10.6823	282	315	
101	2	E_FORK_STONES_R	1999	MED	RIVER	6	1	411.000	.	411	411	
102	2	E_FORK_STONES_R	1999	MED	RIVER	7	1	364.000	.	364	364	
103	2	FACTORY_CK	1997	MED	STREAM	1	1	115.000	.	115	115	
104	2	FACTORY_CK	1997	MED	STREAM	3	1	228.000	.	228	228	
105	2	FACTORY_CK	1997	MED	STREAM	5	1	342.000	.	342	342	
106	2	FACTORY_CK	1997	MED	STREAM	6	3	329.667	18.2239	297	360	
107	2	FACTORY_CK	1997	MED	STREAM	362	9	1	412.000	.	412	412
108	2	FORTYEIGHT_CK	1998	FAST	STREAM	362	2	2	226.500	16.5000	210	243

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OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
109	2	FORTYEIGHT_CK	1998	FAST	STREAM	3	2	270.000	20.0000	250	290
110	2	FORTYEIGHT_CK	1998	FAST	STREAM	4	1	312.000	.	312	312
111	2	FORTYEIGHT_CK	1998	FAST	STREAM	9	1	435.000	.	435	435
112	2	FOUNTAIN_CK	1999	FAST	STREAM	0	2	45.500	5.5000	40	51
113	2	FOUNTAIN_CK	1999	FAST	STREAM	1	1	147.000	.	147	147
114	2	FOUNTAIN_CK	1999	FAST	STREAM	2	1	164.000	.	164	164
115	2	FOUNTAIN_CK	1999	FAST	STREAM	3	9	244.000	7.8316	205	284
116	2	FOUNTAIN_CK	1999	FAST	STREAM	4	1	342.000	.	342	342
117	2	FOUNTAIN_CK	1999	FAST	STREAM	5	2	339.000	24.0000	315	363
118	2	GARRISON_FORK_CK	1998	MED	STREAM	1	9	113.222	3.7851	102	141
119	2	GARRISON_FORK_CK	1998	MED	STREAM	2	27	166.593	8.0688	92	230
120	2	GARRISON_FORK_CK	1998	MED	STREAM	3	10	257.300	7.2312	230	293
121	2	GARRISON_FORK_CK	1998	MED	STREAM	4	1	263.000	.	263	263
122	2	GARRISON_FORK_CK	1998	MED	STREAM	5	3	307.000	12.7671	282	324
123	2	GARRISON_FORK_CK	1998	MED	STREAM	6	2	314.000	4.0000	310	318
124	2	GARRISON_FORK_CK	1998	MED	STREAM	7	1	379.000	.	379	379
125	2	GARRISON_FORK_CK	1998	MED	STREAM	8	2	389.000	11.0000	378	400
126	2	GARRISON_FORK_CK	1998	MED	STREAM	9	1	360.000	.	360	360
127	2	GARRISON_FORK_CK	1998	MED	STREAM	10	3	412.333	16.7962	382	440
128	2	GREEN_R	1995	FAST	STREAM	0	8	92.750	4.2751	78	110
129	2	GREEN_R	1995	FAST	STREAM	1	6	180.667	9.0542	152	218
130	2	GREEN_R	1995	FAST	STREAM	2	1	217.000	.	217	217
131	2	GREEN_R	1995	FAST	STREAM	4	4	337.500	12.0727	307	361
132	2	HARPETH_R	1997	MED	RIVER	0	2	66.500	7.5000	59	74
133	2	HARPETH_R	1997	MED	RIVER	1	6	170.667	4.2714	151	179
134	2	HARPETH_R	1997	MED	RIVER	2	6	222.333	4.8212	209	242
135	2	HARPETH_R	1997	MED	RIVER	3	6	238.000	5.2026	227	262
136	2	HARPETH_R	1997	MED	RIVER	4	6	278.000	5.6095	264	296
137	2	HARPETH_R	1997	MED	RIVER	6	2	375.500	54.5000	321	430
138	2	HARPETH_R	1999	MED	RIVER	0	18	99.778	5.4152	55	126
139	2	HARPETH_R	1999	MED	RIVER	1	17	187.706	4.8255	152	220
140	2	HARPETH_R	1999	MED	RIVER	2	2	242.500	6.5000	236	249
141	2	HARPETH_R	1999	MED	RIVER	4	4	283.250	11.4991	259	312
142	2	HARPETH_R	1999	MED	RIVER	5	2	340.500	36.5000	304	377
143	2	HARPETH_R	1999	MED	RIVER	6	1	375.000	.	375	375
144	2	JONES_CK	1999	MED	STREAM	0	1	67.000	.	67	67

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OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
145	2	JONES_CK	1999	MED	STREAM	1	2	150.500	5.5000	145	156
146	2	JONES_CK	1999	MED	STREAM	4	1	294.000	.	294	294
147	2	JONES_CK	1999	MED	STREAM	5	1	398.000	.	398	398
148	2	JONES_CK	1999	MED	STREAM	6	1	396.000	.	396	396
149	2	KNOB_CK	1995	FAST	STREAM	1	1	167.000	.	167	167
150	2	KNOB_CK	1995	FAST	STREAM	2	2	253.000	15.0000	238	268
151	2	KNOB_CK	1995	FAST	STREAM	4	4	331.000	25.5767	275	399
152	2	KNOB_CK	1995	FAST	STREAM	5	1	280.000	.	280	280
153	2	KNOB_CK	1995	FAST	STREAM	6	1	373.000	.	373	373
154	2	KNOB_CK	1995	FAST	STREAM	11	1	415.000	.	415	415
155	2	LEIPERS_CK	1998	FAST	STREAM	4	4	345.250	15.9707	300	375
156	2	LICK_CK	1995	FAST	STREAM	0	1	63.000	.	63	63
157	2	LICK_CK	1995	FAST	STREAM	1	2	173.500	16.5000	157	190
158	2	LICK_CK	1998	FAST	STREAM	1	1	129.000	.	129	129
159	2	LICK_CK	1998	FAST	STREAM	2	2	185.500	5.5000	180	191
160	2	LICK_CK	1998	FAST	STREAM	3	1	295.000	.	295	295
161	2	LICK_CK	1998	FAST	STREAM	8	1	391.000	.	391	391
162	2	LITTLE_BIGBY_CK	1999	SLOW	STREAM	1	1	113.000	.	113	113
163	2	LITTLE_BIGBY_CK	1999	SLOW	STREAM	2	3	207.333	23.6667	160	231
164	2	LITTLE_BIGBY_CK	1999	SLOW	STREAM	3	2	220.500	14.5000	206	235
165	2	LITTLE_BIGBY_CK	1999	SLOW	STREAM	4	5	267.800	5.9363	250	282
166	2	LITTLE_BIGBY_CK	1999	SLOW	STREAM	5	2	300.000	4.0000	296	304
167	2	LITTLE_BIGBY_CK	1999	SLOW	STREAM	7	2	371.500	12.5000	359	384
168	2	LITTLE_BIGBY_CK	1999	SLOW	STREAM	8	2	352.500	4.5000	348	357
169	2	LITTLE_BIGBY_CK	1999	SLOW	STREAM	9	1	381.000	.	381	381
170	2	LITTLE_HARPETH_R	1999	FAST	STREAM	0	2	119.000	68.0000	51	187
171	2	LITTLE_HARPETH_R	1999	FAST	STREAM	1	9	146.556	13.5463	82	194
172	2	LITTLE_HARPETH_R	1999	FAST	STREAM	2	2	205.000	40.0000	165	245
173	2	LITTLE_HARPETH_R	1999	FAST	STREAM	3	2	265.500	1.5000	264	267
174	2	LITTLE_HARPETH_R	1999	FAST	STREAM	4	2	281.000	16.0000	265	297
175	2	LITTLE_HARPETH_R	1999	FAST	STREAM	5	8	297.000	12.3158	221	334
176	2	LITTLE_HARPETH_R	1999	FAST	STREAM	6	3	303.667	24.8484	254	330
177	2	LITTLE_HARPETH_R	1999	FAST	STREAM	7	2	355.000	1.0000	354	356
178	2	LITTLE_HARPETH_R	1999	FAST	STREAM	8	2	356.500	3.5000	353	360
179	2	LONG_FORK_CK	1997	MED	STREAM	1	13	122.769	8.8195	65	168
180	2	LONG_FORK_CK	1997	MED	STREAM	2	8	211.375	6.2420	176	230

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OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
181	2	LONG_FORK_CK	1997	MED	STREAM	3	4	259.750	13.2626	222	281
182	2	MILL_CK	1997	MED	STREAM	1	2	175.500	9.5000	166	185
183	2	MILL_CK	1997	MED	STREAM	2	8	209.000	7.4690	167	235
184	2	MILL_CK	1997	MED	STREAM	3	10	259.500	6.5629	236	296
185	2	MILL_CK	1997	MED	STREAM	4	4	313.500	8.9861	295	336
186	2	MILL_CK	1997	MED	STREAM	5	1	307.000	.	307	307
187	2	MILL_CK	1997	MED	STREAM	6	1	372.000	.	372	372
188	2	MILL_CK	1997	MED	STREAM	7	2	342.000	14.0000	328	356
189	2	MILL_CK	1997	MED	STREAM	8	1	362.000	.	362	362
190	2	MILL_CK	1997	MED	STREAM	9	1	442.000	.	442	442
191	2	E_F_MULBERRY_CK	1997	MED	STREAM	1	9	157.111	5.0565	128	175
192	2	E_F_MULBERRY_CK	1997	MED	STREAM	2	10	191.500	5.7101	165	224
193	2	E_F_MULBERRY_CK	1997	MED	STREAM	3	7	260.571	9.6260	234	297
194	2	E_F_MULBERRY_CK	1997	MED	STREAM	4	2	304.500	32.5000	272	337
195	2	E_F_MULBERRY_CK	1997	MED	STREAM	5	6	339.833	14.6365	294	392
196	2	E_F_MULBERRY_CK	1997	MED	STREAM	8	2	419.500	10.5000	409	430
197	2	E_F_MULBERRY_CK	1997	MED	STREAM	9	1	450.000	.	450	450
198	2	E_F_MULBERRY_CK	1997	MED	STREAM	11	1	410.000	.	410	410
199	2	RED_R	1999	MED	RIVER	0	12	87.833	3.2772	65	106
200	2	RED_R	1999	MED	RIVER	1	7	173.000	1.5119	168	180
201	2	RED_R	1999	MED	RIVER	2	3	206.667	5.1747	201	217
202	2	RED_R	1999	MED	RIVER	3	2	259.000	16.0000	243	275
203	2	RED_R	1999	MED	RIVER	4	8	267.750	10.6465	242	332
204	2	RED_R	1999	MED	RIVER	5	1	242.000	.	242	242
205	2	RICHLAND_CK	1998	FAST	STREAM	2	3	241.667	8.8192	225	255
206	2	RICHLAND_CK	1998	FAST	STREAM	3	1	282.000	.	282	282
207	2	RUTHERFORD_CK	1999	MED	STREAM	2	2	215.000	19.0000	196	234
208	2	RUTHERFORD_CK	1999	MED	STREAM	3	3	236.000	10.5040	215	247
209	2	RUTHERFORD_CK	1999	MED	STREAM	5	1	380.000	.	380	380
210	2	SHOAL_CK	1999	FAST	STREAM	1	15	149.400	5.3191	129	198
211	2	SHOAL_CK	1999	FAST	STREAM	2	1	224.000	.	224	224
212	2	SHOAL_CK	1999	FAST	STREAM	3	9	288.000	7.3182	244	317
213	2	SHOAL_CK	1999	FAST	STREAM	4	2	328.500	43.5000	285	372
214	2	SHOAL_CK	1999	FAST	STREAM	5	2	380.000	19.0000	361	399
215	2	SHOAL_CK	1999	FAST	STREAM	7	1	467.000	.	467	467
216	2	SHOAL_CK	1999	FAST	STREAM	10	1	522.000	.	522	522

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OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
217	2	STONES_R	1997	UNK	RIVER	1	3	143.000	4.3589	136	151
218	2	STONES_R	1997	UNK	RIVER	2	2	166.000	3.0000	163	169
219	2	SYCAMORE_CK	1997	MED	STREAM	2	2	182.500	22.5000	160	205
220	2	SYCAMORE_CK	1997	MED	STREAM	3	1	254.000	.	254	254
221	2	SYCAMORE_CK	1997	MED	STREAM	5	1	354.000	.	354	354
222	2	SYCAMORE_CK	1997	MED	STREAM	6	1	323.000	.	323	323
223	2	S_HARPETH_R	1996	FAST	STREAM	1	13	156.615	3.6489	129	178
224	2	S_HARPETH_R	1996	FAST	STREAM	2	5	201.400	9.2607	176	228
225	2	S_HARPETH_R	1996	FAST	STREAM	3	2	251.500	3.5000	248	255
226	2	S_HARPETH_R	1998	FAST	STREAM	2	1	145.000	.	145	145
227	2	S_HARPETH_R	1998	FAST	STREAM	3	3	275.667	26.1683	249	328
228	2	S_HARPETH_R	1998	FAST	STREAM	4	1	272.000	.	272	272
229	2	TURNBULL_CK	1997	FAST	STREAM	1	10	170.300	6.3597	145	205
230	2	TURNBULL_CK	1997	FAST	STREAM	2	7	261.286	9.0125	228	288
231	2	TURNBULL_CK	1997	FAST	STREAM	3	1	286.000	.	286	286
232	2	TURNBULL_CK	1997	FAST	STREAM	4	3	330.667	11.9210	307	345
233	2	YELLOW_CK	1999	UNK	STREAM	1	2	147.500	20.5000	127	168
234	3	ISHAM_SPRING	1995	UNK	STREAM	2	1	151.000	.	151	151
235	3	BLACKBURN_FK	1995	UNK	STREAM	2	1	211.000	.	211	211
236	3	CANEY_FORK_R	1998	SLOW	RIVER	.	12	132.917	22.9721	54	258
237	3	CANEY_FORK_R	1998	SLOW	RIVER	3	1	206.000	.	206	206
238	3	CHARLES_CK	1997	SLOW	STREAM	4	2	251.000	6.0000	245	257
239	3	CHARLES_CK	1997	SLOW	STREAM	6	2	310.000	26.0000	284	336
240	3	CHARLES_CK	1997	SLOW	STREAM	7	1	300.000	.	300	300
241	3	COLLINS_R	1998	SLOW	RIVER	1	10	105.400	6.3878	90	161
242	3	COLLINS_R	1998	SLOW	RIVER	2	18	169.500	4.1706	142	200
243	3	COLLINS_R	1998	SLOW	RIVER	3	51	188.627	5.0099	132	279
244	3	COLLINS_R	1998	SLOW	RIVER	4	21	212.762	8.2262	155	292
245	3	COLLINS_R	1998	SLOW	RIVER	5	59	248.085	5.4210	158	329
246	3	COLLINS_R	1998	SLOW	RIVER	6	6	235.167	26.7412	171	317
247	3	COLLINS_R	1998	SLOW	RIVER	7	25	297.480	10.2869	185	382
248	3	COLLINS_R	1998	SLOW	RIVER	8	6	338.500	20.3187	277	420
249	3	COLLINS_R	1998	SLOW	RIVER	10	1	400.000	.	400	400
250	3	COLLINS_R	1998	SLOW	RIVER	11	2	432.500	17.5000	415	450
251	3	COLLINS_R	1998	SLOW	RIVER	12	1	481.000	.	481	481
252	3	DADDYS_CK	1998	UNK	STREAM	0	6	82.667	2.1858	72	86

Appendix A. Mean (MTL), standard error (SETL), minimum (MINTL), and maximum total length (MAXTL) for each age of smallmouth bass at time of collection (age-x+) at each location. Bass collected by angling are not included in this appendix so that mortality calculations may be made using these data.

OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
253	3	DADDYS_CK	1998	UNK	STREAM	1	2	130.500	9.5000	121	140
254	3	DRY_CK	1996	UNK	STREAM	5	1	309.000	.	309	309
255	3	FLAT_CK	1996	SLOW	STREAM	1	1	104.000	.	104	104
256	3	FLAT_CK	1996	SLOW	STREAM	3	1	212.000	.	212	212
257	3	FLAT_CK	1996	SLOW	STREAM	4	1	192.000	.	192	192
258	3	FLAT_CK	1996	SLOW	STREAM	6	1	239.000	.	239	239
259	3	HICKORY_CK	1997	MED	STREAM	4	1	267.000	.	267	267
260	3	HILLS_CK	1996	UNK	STREAM	1	1	128.000	.	128	128
261	3	ROARING_R	2000	MED	STREAM	.	1	145.000	.	145	145
262	3	ROARING_R	2000	MED	STREAM	1	6	145.000	3.4157	135	155
263	3	ROARING_R	2000	MED	STREAM	3	1	235.000	.	235	235
264	3	ROARING_R	2000	MED	STREAM	4	2	270.000	10.0000	260	280
265	3	ROARING_R	2000	MED	STREAM	5	1	330.000	.	330	330
266	3	SMITH_FORK_CK	1998	FAST	STREAM	1	2	121.500	0.5000	121	122
267	3	SMITH_FORK_CK	1998	FAST	STREAM	2	3	204.333	2.3333	200	208
268	3	SMITH_FORK_CK	1998	FAST	STREAM	3	2	277.500	9.5000	268	287
269	3	SMITH_FORK_CK	1998	FAST	STREAM	4	2	287.500	2.5000	285	290
270	3	SMITH_FORK_CK	1998	FAST	STREAM	5	1	375.000	.	375	375
271	3	SMITH_FORK_CK	1998	FAST	STREAM	11	1	422.000	.	422	422
272	3	SMITH_FORK_CK	2000	FAST	STREAM	.	16	119.125	14.8307	73	312
273	3	SMITH_FORK_CK	2000	FAST	STREAM	0	2	114.500	0.5000	114	115
274	3	SMITH_FORK_CK	2000	FAST	STREAM	1	9	184.778	8.7493	156	245
275	3	SMITH_FORK_CK	2000	FAST	STREAM	2	9	209.889	11.9646	168	266
276	3	SMITH_FORK_CK	2000	FAST	STREAM	3	7	287.429	8.5631	265	330
277	3	SMITH_FORK_CK	2000	FAST	STREAM	4	2	340.500	1.5000	339	342
278	3	SMITH_FORK_CK	2000	FAST	STREAM	6	1	371.000	.	371	371
279	3	WHITE_OAK_CK	1996	UNK	STREAM	5	1	249.000	.	249	249
280	4	BEECH_CK	1995	SLOW	STREAM	2	5	171.600	9.0144	154	196
281	4	BEECH_CK	1995	SLOW	STREAM	3	3	194.667	16.8556	161	213
282	4	BIG_CK	1995	SLOW	STREAM	0	2	41.000	2.0000	39	43
283	4	BIG_CK	1995	SLOW	STREAM	1	2	128.500	15.5000	113	144
284	4	BIG_CK	1995	SLOW	STREAM	2	2	180.000	2.0000	178	182
285	4	BIG_CK	1997	SLOW	STREAM	1	1	77.000	.	77	77
286	4	BIG_CK	1997	SLOW	STREAM	2	6	142.500	8.0447	120	168
287	4	BIG_CK	1997	SLOW	STREAM	3	3	190.667	2.0276	187	194
288	4	BIG_CK	1997	SLOW	STREAM	4	4	214.750	5.6476	204	230

Appendix A. Mean (MTL), standard error (SETL), minimum (MINTL), and maximum total length (MAXTL) for each age of smallmouth bass at time of collection (age-x+) at each location. Bass collected by angling are not included in this appendix so that mortality calculations may be made using these data.

OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
289	4	BIG_CK	1997	SLOW	STREAM	5	1	258.000	.	258	258
290	4	BIG_WAR_CK	1995	SLOW	STREAM	0	4	49.250	3.2243	43	57
291	4	BIG_WAR_CK	1995	SLOW	STREAM	2	3	173.667	7.0553	163	187
292	4	BIG_WAR_CK	1995	SLOW	STREAM	3	4	248.000	3.1091	239	253
293	4	BIG_WAR_CK	1995	SLOW	STREAM	4	1	213.000	.	213	213
294	4	BIG_WAR_CK	1995	SLOW	STREAM	5	1	326.000	.	326	326
295	4	CITICO_CK	1997	UNK	STREAM	1	7	136.000	5.8105	121	166
296	4	CITICO_CK	1997	UNK	STREAM	2	1	233.000	.	233	233
297	4	CITICO_CK	1997	UNK	STREAM	5	1	324.000	.	324	324
298	4	CLINCH_R	1999	MED	RIVER	0	17	58.353	3.0425	37	80
299	4	CLINCH_R	1999	MED	RIVER	1	85	155.082	1.4505	123	182
300	4	CLINCH_R	1999	MED	RIVER	2	49	203.143	2.5048	135	243
301	4	CLINCH_R	1999	MED	RIVER	3	23	245.826	2.8477	216	272
302	4	CLINCH_R	1999	MED	RIVER	4	13	278.923	4.2914	242	306
303	4	CLINCH_R	1999	MED	RIVER	5	7	315.571	8.5603	272	345
304	4	CLINCH_R	1999	MED	RIVER	6	6	349.833	9.7140	310	372
305	4	CLINCH_R	1999	MED	RIVER	9	1	379.000	.	379	379
306	4	CLINCH_R	1999	MED	RIVER	11	1	520.000	.	520	520
307	4	DOE_R	1996	SLOW	RIVER	0	1	48.000	.	48	48
308	4	DOE_R	1996	SLOW	RIVER	1	3	119.000	5.2915	109	127
309	4	DOE_R	1996	SLOW	RIVER	3	8	198.875	11.8283	123	233
310	4	DOE_R	1996	SLOW	RIVER	4	9	216.556	5.0003	191	238
311	4	DOE_R	1996	SLOW	RIVER	9	1	345.000	.	345	345
312	4	DUNN_CK	1996	UNK	STREAM	.	1	90.000	.	90	90
313	4	DUNN_CK	1996	UNK	STREAM	6	1	332.000	.	332	332
314	4	FRENCH_BROAD_R	2000	FAST	RIVER	0	12	73.250	2.6859	54	90
315	4	FRENCH_BROAD_R	2000	FAST	RIVER	1	44	147.614	2.6253	117	183
316	4	FRENCH_BROAD_R	2000	FAST	RIVER	2	29	224.000	3.6685	192	252
317	4	FRENCH_BROAD_R	2000	FAST	RIVER	3	1	360.000	.	360	360
318	4	FRENCH_BROAD_R	2000	FAST	RIVER	4	1	319.000	.	319	319
319	4	FRENCH_BROAD_R	2000	FAST	RIVER	5	2	421.000	11.0000	410	432
320	4	FRENCH_BROAD_R	2000	FAST	RIVER	7	2	417.500	43.5000	374	461
321	4	FT_PAT_TW	2000	FAST	RIVER	0	12	65.333	3.1342	45	82
322	4	FT_PAT_TW	2000	FAST	RIVER	1	69	141.246	1.6598	112	185
323	4	FT_PAT_TW	2000	FAST	RIVER	2	17	217.647	6.6791	138	246
324	4	FT_PAT_TW	2000	FAST	RIVER	3	4	267.000	6.8069	250	278

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OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
325	4	FT_PAT_TW	2000	FAST	RIVER	4	5	327.200	9.1837	300	356
326	4	FT_PAT_TW	2000	FAST	RIVER	5	1	370.000	.	370	370
327	4	FT_PAT_TW	2000	FAST	RIVER	6	2	390.000	10.0000	380	400
328	4	FT_PAT_TW	2000	FAST	RIVER	7	5	390.600	12.3556	355	425
329	4	FT_PAT_TW	2000	FAST	RIVER	8	1	402.000	.	402	402
330	4	FT_PAT_TW	2000	FAST	RIVER	9	3	425.667	5.3645	415	432
331	4	FT_PAT_TW	2000	FAST	RIVER	13	1	440.000	.	440	440
332	4	FT_PAT_TW	2000	FAST	RIVER	14	2	445.000	20.0000	425	465
333	4	HINDS_CK	1996	UNK	STREAM	2	1	203.000	.	203	203
334	4	INDIAN_CK	1995	SLOW	STREAM	1	1	87.000	.	87	87
335	4	INDIAN_CK	1995	SLOW	STREAM	2	9	155.889	5.9709	125	179
336	4	INDIAN_CK	1995	SLOW	STREAM	3	4	162.750	11.3165	141	193
337	4	INDIAN_CK	1995	SLOW	STREAM	4	1	260.000	.	260	260
338	4	INDIAN_CK	1995	SLOW	STREAM	8	1	347.000	.	347	347
339	4	INDIAN_CK	1995	SLOW	STREAM	12	1	391.000	.	391	391
340	4	LITTLE_PIGEON_R	2000	UNK	RIVER	0	1	35.000	.	35	35
341	4	LITTLE_PIGEON_R	2000	UNK	RIVER	1	7	124.429	4.4124	106	139
342	4	LITTLE_PIGEON_R	2000	UNK	RIVER	2	5	207.800	19.6454	180	285
343	4	LITTLE_PIGEON_R	2000	UNK	RIVER	6	1	330.000	.	330	330
344	4	LITTLE_R	1996	SLOW	RIVER	1	6	107.333	2.6289	96	114
345	4	LITTLE_R	1996	SLOW	RIVER	2	1	157.000	.	157	157
346	4	LITTLE_R	1996	SLOW	RIVER	4	1	272.000	.	272	272
347	4	LITTLE_R	1996	SLOW	RIVER	5	1	314.000	.	314	314
348	4	LITTLE_R	1996	SLOW	RIVER	6	1	382.000	.	382	382
349	4	LITTLE_R	1997	SLOW	RIVER	1	3	88.333	3.4801	82	94
350	4	LITTLE_R	1997	SLOW	RIVER	2	5	166.400	6.9181	148	184
351	4	LITTLE_R	1997	SLOW	RIVER	4	1	252.000	.	252	252
352	4	LITTLE_R	1997	SLOW	RIVER	5	1	326.000	.	326	326
353	4	LITTLE_R	1997	SLOW	RIVER	10	1	457.000	.	457	457
354	4	NOLICHUCKY_R	1996	MED	RIVER	4	3	246.000	27.0555	192	276
355	4	NOLICHUCKY_R	1996	MED	RIVER	5	2	309.500	9.5000	300	319
356	4	NOLICHUCKY_R	1996	MED	RIVER	6	2	314.500	7.5000	307	322
357	4	NOLICHUCKY_R	1998	MED	RIVER	0	30	69.567	2.8222	42	107
358	4	NOLICHUCKY_R	1998	MED	RIVER	1	50	153.180	3.1286	109	196
359	4	NOLICHUCKY_R	1998	MED	RIVER	2	26	218.923	6.7900	147	268
360	4	NOLICHUCKY_R	1998	MED	RIVER	3	26	254.923	5.9049	201	313

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OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
361	4	NOLICHUCKY_R	1998	MED	RIVER	4	3	328.000	11.5902	305	342
362	4	NOLICHUCKY_R	1998	MED	RIVER	5	10	329.400	11.3345	271	383
363	4	NOLICHUCKY_R	1998	MED	RIVER	6	5	380.200	21.7380	325	434
364	4	NOLICHUCKY_R	1998	MED	RIVER	8	3	401.667	11.5662	381	421
365	4	N_FK_CLINCH	1995	UNK	STREAM	0	2	45.500	1.5000	44	47
366	4	N_FK_CLINCH	1995	UNK	STREAM	2	3	155.000	7.5056	140	163
367	4	N_FK_HOLSTON_R	1997	SLOW	RIVER	0	2	103.500	8.5000	95	112
368	4	N_FK_HOLSTON_R	1997	SLOW	RIVER	1	11	152.727	3.3766	142	182
369	4	N_FK_HOLSTON_R	1997	SLOW	RIVER	2	1	193.000	.	193	193
370	4	N_FK_HOLSTON_R	1997	SLOW	RIVER	3	1	221.000	.	221	221
371	4	N_FK_HOLSTON_R	1997	SLOW	RIVER	4	2	301.500	5.5000	296	307
372	4	N_FK_HOLSTON_R	1997	SLOW	RIVER	6	1	439.000	.	439	439
373	4	N_FK_HOLSTON_R	1997	SLOW	RIVER	7	1	459.000	.	459	459
374	4	N_FK_HOLSTON_R	1997	SLOW	RIVER	12	1	472.000	.	472	472
375	4	N_FK_HOLSTON_R	1998	SLOW	RIVER	1	13	109.923	4.9153	75	135
376	4	N_FK_HOLSTON_R	1998	SLOW	RIVER	2	38	172.395	2.0553	150	204
377	4	N_FK_HOLSTON_R	1998	SLOW	RIVER	3	11	222.909	8.5975	178	278
378	4	N_FK_HOLSTON_R	1998	SLOW	RIVER	4	19	249.632	4.7042	197	278
379	4	N_FK_HOLSTON_R	1998	SLOW	RIVER	5	23	296.304	5.5484	237	342
380	4	N_FK_HOLSTON_R	1998	SLOW	RIVER	6	6	345.667	9.9588	310	375
381	4	N_FK_HOLSTON_R	1998	SLOW	RIVER	7	3	371.333	26.5351	335	423
382	4	N_FK_HOLSTON_R	1998	SLOW	RIVER	8	2	438.000	37.0000	401	475
383	4	PIGEON_R	1995	MED	RIVER	2	4	171.500	4.8391	157	177
384	4	PIGEON_R	1995	MED	RIVER	3	1	160.000	.	160	160
385	4	PIGEON_R	1995	MED	RIVER	5	4	323.750	14.9464	295	360
386	4	PIGEON_R	1995	MED	RIVER	8	1	470.000	.	470	470
387	4	PIGEON_R	1995	MED	RIVER	9	1	450.000	.	450	450
388	4	PIGEON_R	1996	MED	RIVER	.	6	117.167	5.1731	100	127
389	4	PIGEON_R	1996	MED	RIVER	0	5	38.400	2.6192	32	43
390	4	PIGEON_R	1996	MED	RIVER	1	21	123.905	2.7411	102	155
391	4	PIGEON_R	1996	MED	RIVER	2	5	186.200	9.9920	160	212
392	4	PIGEON_R	1996	MED	RIVER	3	23	240.217	5.8248	185	320
393	4	PIGEON_R	1996	MED	RIVER	4	2	305.500	6.5000	299	312
394	4	PIGEON_R	1996	MED	RIVER	5	1	254.000	.	254	254
395	4	PIGEON_R	1996	MED	RIVER	6	4	344.500	12.0451	323	378
396	4	PIGEON_R	1996	MED	RIVER	10	1	455.000	.	455	455

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OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
397	4	PIGEON_R	1997	MED	RIVER	1	62	96.194	1.6260	72	132
398	4	PIGEON_R	1997	MED	RIVER	2	25	173.360	5.4975	123	247
399	4	PIGEON_R	1997	MED	RIVER	3	8	241.375	14.3402	146	270
400	4	PIGEON_R	1997	MED	RIVER	4	9	262.667	14.7827	219	333
401	4	PIGEON_R	1997	MED	RIVER	5	4	260.500	9.4736	242	281
402	4	PIGEON_R	1997	MED	RIVER	6	1	333.000	.	333	333
403	4	PIGEON_R	1997	MED	RIVER	7	8	394.375	13.1583	349	440
404	4	PIGEON_R	1997	MED	RIVER	8	1	352.000	.	352	352
405	4	PIGEON_R	1997	MED	RIVER	11	2	469.500	12.5000	457	482
406	4	PIGEON_R	1997	MED	RIVER	15	1	470.000	.	470	470
407	4	PIGEON_R	1998	MED	RIVER	.	0	.	.	.	.
408	4	PIGEON_R	1998	MED	RIVER	0	2	42.500	2.5000	40	45
409	4	PIGEON_R	1998	MED	RIVER	1	11	100.636	2.5308	85	115
410	4	PIGEON_R	1998	MED	RIVER	2	26	144.308	4.4614	115	202
411	4	PIGEON_R	1998	MED	RIVER	3	7	217.714	7.1204	185	238
412	4	PIGEON_R	1998	MED	RIVER	4	3	292.000	4.3589	285	300
413	4	PIGEON_R	1998	MED	RIVER	5	11	287.455	7.7698	235	325
414	4	PIGEON_R	1998	MED	RIVER	6	1	282.000	.	282	282
415	4	PIGEON_R	1998	MED	RIVER	8	6	388.833	10.2385	353	420
416	4	PIGEON_R	2000	MED	RIVER	.	137	176.036	6.1202	40	460
417	4	POWELL_R	1999	MED	RIVER	0	13	71.846	3.3567	55	97
418	4	POWELL_R	1999	MED	RIVER	1	104	140.904	2.1533	93	187
419	4	POWELL_R	1999	MED	RIVER	2	73	199.753	2.4026	155	250
420	4	POWELL_R	1999	MED	RIVER	3	16	233.875	4.1108	206	262
421	4	POWELL_R	1999	MED	RIVER	4	27	275.185	4.1981	230	318
422	4	POWELL_R	1999	MED	RIVER	5	4	311.750	33.9347	267	411
423	4	POWELL_R	1999	MED	RIVER	6	16	342.125	8.0890	294	394
424	4	POWELL_R	1999	MED	RIVER	7	4	428.250	35.6917	323	475
425	4	STONY_FORK	1996	SLOW	STREAM	1	3	82.000	3.0000	76	85
426	4	STONY_FORK	1996	SLOW	STREAM	2	1	152.000	.	152	152
427	4	STONY_FORK	1996	SLOW	STREAM	3	6	185.000	7.0427	167	205
428	4	STONY_FORK	1996	SLOW	STREAM	4	2	194.000	23.0000	171	217
429	4	S_FK_HOLSTON_R	2000	UNK	RIVER	0	5	59.000	6.2290	48	82
430	4	S_FK_HOLSTON_R	2000	UNK	RIVER	1	8	137.000	4.3793	120	158
431	4	S_FK_HOLSTON_R	2000	UNK	RIVER	8	1	453.000	.	453	453
432	4	WATUAGA_R	1996	SLOW	STREAM	1	8	104.875	3.8519	90	117

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OBS	REGION	LOCATION	YEAR	GROWTH	SIZE	AGE	N	MTL	SETL	MINTL	MAXTL
433	4	WATUAGA_R	1996	SLOW	STREAM	2	2	124.000	9.0000	115	133
434	4	WATUAGA_R	1996	SLOW	STREAM	3	6	181.333	17.6175	141	254
435	4	WATUAGA_R	1996	SLOW	STREAM	4	1	287.000	.	287	287
436	4	WILHITE_CK	1996	MED	STREAM	3	1	245.000	.	245	245
437	4	W_P_L_PIGEON_R	1997	SLOW	RIVER	1	1	108.000	.	108	108
438	4	W_P_L_PIGEON_R	1997	SLOW	RIVER	3	3	218.667	9.6839	208	238
439	4	W_P_L_PIGEON_R	1997	SLOW	RIVER	4	2	259.000	12.0000	247	271
440	4	W_P_L_PIGEON_R	1997	SLOW	RIVER	7	1	391.000	.	391	391