EVALUATION OF ANGLING AS A STOCK ASSESSMENT TOOL FOR RIVERINE SMALLMOUTH BASS POPULATIONS

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Abstract.—Smallmouth Bass (SMB) *Micropterus dolomieu* biological data collected from the mainstem New River, North Fork New River, and South Fork New River by electrofishing and angling in 2013 were compared to determine the utility of angling as a stock assessment tool. Electrofishing data collected by boat-mounted electrofishing gear were compared against angling data collected by angler diarists from all three river segments. Additionally, North Carolina Wildlife Resources Commission (Commission) staff conducted a one-day angling sample on the South Fork New River which was compared against electrofishing and angler diary samples. Similar trends in catch rates among river segments were observed between angling and electrofishing, although the number of angling trips on the North Fork New River was too low to provide conclusive results. The degree of similarity between SMB length-frequency distributions and size structure indices generated by electrofishing and angling was generally positively correlated with angling sample size. While age data were not collected by the angler diarists, they were obtained during the angling survey of the South Fork New River conducted by Commission staff. There was no significant difference in the mean age of SMB collected by electrofishing and Commission angling. The age-frequency distributions of SMB collected using each method were both dominated by the same three age-classes, although electrofishing was more effective at collecting less abundant age-classes. Growth rates of fish collected by angling were significantly higher than for fish collected by electrofishing, although it is not clear if these differences were caused by the collection method itself. While further analyses are needed to determine how well angling data can describe age and growth relative to electrofishing, angling may have the ability to describe fish abundance and population size structure relatively accurately when sufficient sample sizes are collected.

Smallmouth Bass (SMB) *Micropterus dolomieu* populations in rivers and streams comprise a significant portion of the fishery resources in western North Carolina. Interest in fishing for SMB in streams and rivers seems to be on the rise based on the interactions of North Carolina Wildlife Resources Commission (Commission) staff with the angling public, and 34% of anglers statewide and 51% of anglers within the mountain region indicated that they had fished for SMB within the previous year in a 2012 angler opinion survey (Linehan 2013). Given the importance of riverine SMB fisheries to the anglers of North Carolina, the collection of accurate population data describing the relative abundance, size and age structure, and growth and mortality rates of SMB populations is paramount for proper management of these important resources. Rivers inhabited by SMB in North Carolina tend to be relatively shallow and rocky with relatively poor access, making traditional stock assessment work difficult. As a result, only limited attempts have been made to conduct stock assessments of riverine SMB populations within western North Carolina. Because it has historically been one of the more popular SMB rivers in the state and owing to the fact that it is larger than many other western North Carolina SMB streams, the New River in Alleghany and Ashe counties is the only river in the state where significant SMB stock assessment work has been conducted using boat-mounted electrofishing gear, with multiple surveys occurring between 1997 and 2005 (Hodges 1999, 2004, 2006).

Since electrofishing surveys using boat-mounted electrofishing gear are not feasible in most rivers in western North Carolina, attempts have been made to use backpack electrofishing gear for SMB stock assessments. Surveys using backpack electrofishing were conducted in the late-1970s within streams found in the northwestern corner of the state. Few SMB were collected given the low sampling efficiency of the backpack electrofishing gear in use at the time (Mickey 1980). More recently, a major research effort was undertaken to assess riverine SMB populations throughout all of western North Carolina using multiple collection methods, including backpack electrofishing and angling. Overall, a higher proportion of fish ≥ 150 mm in total length (TL) was collected by angling, although these results were not conclusive given that few direct comparisons of the size structure of SMB collected with electrofishing and angling were made within the same stream and year (Goodfred et al. 2009). Regardless of the relative effectiveness of backpack electrofishing gear at collecting larger specimens of SMB, however, it is only an option for smaller streams given that it is not effective at capturing fish in wider and deeper streams. As such, its utility is limited as an assessment tool given that most high-quality SMB fisheries in western North Carolina are found in streams that are too large to allow the use of backpack electrofishing gear.

In situations where traditional stock assessment techniques are not feasible, using stock assessment data gathered by anglers may be a viable option for fishery managers. In lieu of agency staff collecting angling samples themselves, a variety of survey types have been employed to gather catch data from anglers. Creel surveys are costly and may not provide enough usable data to learn about a particular species of interest. Conversely, mail surveys can be targeted at specific angling groups to get data on a particular species, but the data are not always accurate (Roach et al. 1999). Tournament data is another option for getting data from anglers. The size structure of fish caught in tournaments has been found to mimic electrofishing size structure in some studies (Harris et al. 1979; Ebbers 1987), while overrepresenting larger size groups of fish in others (Gabelhouse and Willis 1986). Additionally, tournaments are only an option on waters where tournaments are held, which limits their utility on most SMB rivers where fishing tournaments are not currently popular.

In light of the limitations of the aforementioned methods of gathering biological data from anglers, angler diaries may be the most appropriate method for gathering data on riverine SMB populations when traditional stock assessment techniques are not practical. The quality of the biological data gathered by angler diary programs has been inconsistent, depending largely on the response rate, geographic scale of the study (i.e., all waterbodies within a region vs. one specific waterbody), and the selection process used to recruit volunteers (Ebbers 1987; Prentice et al. 1993; Cooke et al. 2000; Bray and Schramm 2001).

Numerous comparisons of biological data derived from angler diary surveys and traditional biological surveys have been made by examining the relationship between black bass data collected by each method across multiple waterbodies. Positive correlations between angler diary and electrofishing catch rates have been found in some studies (Green et al. 1986), while no relationship was found in others (Prentice et al. 1993; Bray and Schramm 2001). Similarly, significant relationships have been found between electrofishing and angler diary-derived length-frequency distributions (Ebbers 1987; Bray and Schramm 2001) and size-structure indices (Gabelhouse and Willis 1986; Prentice et al. 1993) in some cases but not in others (Bryant and Jones 1989).

While these results suggest that angler diaries may be useful as a stock assessment tool for riverine SMB populations, it should be noted that the previously cited studies all occurred on lakes and reservoirs. Given the biological differences in fish populations between lakes and rivers and the logistical difficulties associated with electrofishing in shallow, rocky rivers, the results of studies comparing biological data collected by angler diaries and electrofishing on lakes and reservoirs may not necessarily be applicable to riverine SMB populations. As such, comparisons of biological data obtained by angler diaries and electrofishing are needed to confirm the validity of angler diaries as a stock assessment tool for riverine SMB populations in North Carolina.

The primary goal of this project was to compare the catch rates and size structure of SMB collected by angler diaries and electrofishing. Additionally, given that low-intensity angling collections of SMB have historically been used as a stock assessment tool by Commission staff, secondary goals included 1) comparing the catch rates and size structure of SMB collected by a one-day angling survey conducted by Commission staff against the data collected by angler diaries and electrofishing surveys, and 2) comparing the age structure and growth rates of SMB collected by a one-day angling survey conducted by Commission staff against the data collected by electrofishing surveys.

Methods

Study site.—The New River is located within Watauga, Ashe, and Alleghany counties in northwest North Carolina (Figure 1). The river originates in Watauga County as the North Fork New River (NFNR) and South Fork New River (SFNR) which both flow northward through Ashe County before converging to form the mainstem New River (MNR) along the border of Ashe and Alleghany counties. The river is generally rocky and shallow (mean depth < 1 m) with frequent shoals and riffles, although the MNR is considerably wider and deeper than either the NFNR or SFNR. Previous electrofishing surveys have demonstrated that densities of SMB vary considerably between the three river segments (Hodges 2004, 2006). This makes the New River an ideal location for this study since the ability of angler diaries to describe trends in fish densities between river segments can be assessed within the same year; otherwise, multiple years of data with each collection method would be needed to determine the ability of angler diaries to describe trends in fish abundance.

Angler diaries.—Project volunteers were recruited through online angling forums, on-air announcements from a local radio station (WKSK, West Jefferson, NC), a direct solicitation to the Ashe County Wildlife Club, and by directly contacting certain anglers familiar to Commission biological and enforcement staff. Diaries were mailed to anglers at the start of the SMB fishing season in the spring. Information requested in the diaries included the date, the section of river fished, the number of anglers in each party, the number of hours fished, the size of each fish caught (measured to the nearest quarter-inch), and whether the fish were harvested or released (Appendix 1). While no training sessions were held with anglers to explain how to fill out the diaries, instructions were printed on the back cover of each diary (Appendix 1). Anglers were notified that they would be sent a postage-paid envelope to return the diaries in once the electrofishing surveys were completed. In return for volunteering, volunteers were promised a report summarizing the findings of the study and the return of the diaries they filled out.

Commission angling.—Commission staff fished a section of the SFNR in Ashe County (Figure 1) on September 18, 2013. Time spent fishing was recorded and all SMB caught were measured for TL. Sagittal otoliths were removed from all SMB collected.

Electrofishing.—Commission staff conducted electrofishing surveys using boat-mounted electrofishing gear on the MNR, NFNR, and SFNR in Ashe and Alleghany counties between May 28 and September 10, 2013, with two sites being surveyed on each segment of the river (Figure

1). Due to mechanical problems encountered during our initial survey of the upstream MNR site in June, a follow-up sample was conducted at the same location in September. Totals of 8.9, 9.6, and 8.8 km of river were sampled on the MNR, NFNR, and SFNR, respectively, using methods described in Hodges (2017). All SMB collected were measured for TL (mm), and sagittal otoliths were removed from all SMB collected from the MNR and from a randomly-selected subset of SMB collected from the SFNR.

Data analysis.—For each collection method and river segment, catch per unit effort (CPUE; fish/hour for electrofishing and fish/angler-hour for angling) was determined, length-frequency distribution histograms were constructed, size-structure indices (Proportional Size Distribution; PSD) were calculated for quality (PSD)-, preferred (PSD-P)-, and memorable (PSD-M)-sized SMB, and an additional length-frequency distribution histogram was constructed to compare sizes of MNR SMB collected by different angler diarists. Catch rates were not determined for the June survey at the upstream MNR site since mechanical problems affected catch rates, or for the upstream site on the NFNR because the timer on the electrofishing unit malfunctioned. Despite requesting that angler diarists measure their fish to the nearest quarter-inch, most fish lengths were reported in whole-inch increments. To maintain consistency, the lengths of all SMB caught by angler diarists were rounded down to whole inches. The lengths for stock-, quality-, preferred-, and memorable-sized SMB used in determining stock index values were those proposed by Gabelhouse (1984) and refined by Guy et al. (2007). Because our dataset contained both continuous (electrofishing) and discrete (angler diary) fish lengths, length-frequency distributions could not be compared using a Kolmogorov–Smirnov test. Instead, a two-sample t-test assuming unequal variances (α = 0.05) was used as a surrogate to test for differences in the mean length of SMB, using the assumption that mean length should be similar if length-frequency distributions were similar. To permit a more direct comparison of the sizes of fish susceptible to being caught by both electrofishing and angling, statistical analyses were only conducted for fish ≥ 200 mm TL.

Otoliths were prepared for reading by breaking them in half perpendicular to their longest axis and polishing the broken end using 320–400 grit sandpaper (Besler 1999). The otolith section was then submerged in a shallow dish of water with the unbroken end embedded in a layer of clay lining the bottom of the dish. The otolith section was illuminated from the side with a fiber optic light and read under a dissecting microscope. Otoliths were read independently by two readers, and discrepancies in annuli counts between readers were rectified at a joint reading. Age-frequency distribution histograms were constructed and mean length at age at time of capture was determined. Mean age and mean length at age at time of capture of fish collected by electrofishing and Commission angling were each compared using a two-sample t-test assuming unequal variances (α = 0.05). Mean length at age was only compared when sufficient numbers of each age-class (n ≥ 5) were collected by each collection method. Similar methods were also used to test for differences in mean length at age of SMB collected from the MNR by electrofishing during surveys conducted in June and September.

The reported age of fish in this survey was not always equal to the number of complete annuli that were present on otoliths. In this survey, the annuli had not yet begun to form in May and June, partially-formed annuli began appearing on some fish in August, and all fish had complete annuli by September. In cases where the new annulus had either not yet begun to form or was only partially complete, fish were assigned an age equal to the number of complete annuli plus one to maintain consistency in age assignment throughout the study period.

Results

The 2013 fishing season in northwest North Carolina was one of the rainiest on record, with daily mean flows for the entire calendar year being the highest since record keeping began in 1925 (USGS 2016). As a result, the river was characterized by high flows and poor water clarities throughout most of the study period, making it difficult to collect fish by both angling and electrofishing. Because of how infrequently the normal flows and good water clarities needed for electrofishing occurred, it took from May through September to complete the electrofishing surveys; consequently, diarists were allowed to collect data from April through October to maximize their fishing opportunities. Despite the protracted length of time anglers were allowed to collect diary data, only 7 of the 22 anglers that received diaries were able to complete a fishing trip during the study period as a result of the poor river conditions.

Abundance.—Anglers fished for a total of 185 hours and caught a total of 417 SMB between April 24 and October 6, 2013. The MNR received most of the fishing effort, with anglers catching 283 SMB in 122 hours of effort (2.3 fish/angler-hour; SE = 0.3). Fishing effort and the number of fish collected were considerably lower on the NFNR and SFNR, with 42 SMB being caught in 11 hours on the NFNR (3.8 fish/angler-hour) and 65 SMB being caught in 38 hours on the SFNR (1.7 fish/angler-hour; SE = 0.35). An additional 27 SMB were caught in 14.5 hours of fishing (1.9 fish/angler-hour; SE = 1.2) during trips for which the location was not noted in the diaries. During the angling trip conducted by Commission staff on the SFNR, 50 SMB were collected in 8 hours of fishing for a CPUE of 6.25 fish/angler-hour. During electrofishing surveys, Commission biologists collected 261 SMB from the MNR (105 fish/hour; SE = 4.5), 185 SMB from the NFNR (139 fish/hour), and 174 SMB from the SFNR (82 fish/hour; SE = 4.7).

Trends in catch rates were similar for data collected by angler diaries and electrofishing, with catch rates for both collection methods being highest in the NFNR, lowest in the SFNR, and catch rates in the MNR being intermediate between the other river segments (Figure 2).

Size structure.—The degree of similarity between the length-frequency distributions of SMB collected by electrofishing and angling varied considerably between river segments.

Within the MNR, there was no significant difference ($P = 0.2$) between the mean length of SMB collected by electrofishing and angler diarists. Trends in the relative abundance of fish ≥ 200 mm TL collected by the two methods were similar, although the proportion of fish ≥ 250 mm TL was higher in the angling sample (Figure 3). While electrofishing surveys captured a lower proportion of larger SMB than angling surveys, the same size-classes were represented with both gears with the exception of a single fish in the 500-mm size-class collected by angling. While the maximum and minimum sizes of SMB collected from the NFNR were comparable between collection methods, mean length of SMB was significantly greater for fish collected by angling ($P = 0.005$). Length-frequency distributions appeared largely dissimilar, with the number of SMB in the 275–325 mm range caught by angler diarists being disproportionately high relative to electrofishing (Figure 4). There were no significant differences in mean length of SFNR SMB collected by electrofishing and angler diarists ($P = 0.3$) or electrofishing and Commission angling ($P = 0.4$), and there was modest agreement between the length-frequency distributions of SMB ≥ 200 mm TL collected by each collection method. The 200- and 250-mm size-classes were the most common size-classes collected by electrofishing and angler diarists, while the size structure of SMB collected during the Commission angling trip was dominated by fish in the 200-, 225-, and 275-mm size-classes (Figure 5).

Size-structure indices generated from angler diary catch data were generally higher than those generated by electrofishing for quality- and preferred-sized fish, while electrofishing generally produced higher size-structure index values for memorable-sized fish (Figure 6). Within the SFNR, size-structure index values generated by Commission angling were generally within the range of values generated by electrofishing and angler diaries (Figure 6).

Age structure and growth.—Ages of SMB collected from the SFNR by electrofishing and Commission angling ranged from 1–9 and 2–7, respectively (Figure 7). There was no significant difference ($P = 0.6$) between the mean age of SMB collected by electrofishing and Commission angling, and the age structures of fish collected by both collection methods were dominated by the same three age-classes, with 3-, 6-, and 2-year-olds, in that order, being most prevalent. While the most abundant age-classes were effectively sampled by both collection methods, electrofishing was more effective at collecting less abundant age-classes. Electrofishing collected members of four age-classes (ages 1, 4, 8, and 9) that were not collected by angling.

While angling by Commission staff on the SFNR produced fewer age-classes of SMB in comparison to electrofishing, length at age of fish collected by angling was generally higher than for fish collected by electrofishing. For all age-classes represented in electrofishing and angling samples by at least five fish (ages 2, 3, and 6), length at age was significantly higher ($P < 0.05$) for fish captured by angling (Figure 8).

Discussion

While the similarity in the trends in electrofishing and angler diary catch rates between river segments suggests that data collected using angler diaries can reflect differences in fish densities, it should be noted that all angling data from the NFNR were collected by one angler during a single trip. As a result, the catch rate obtained during that trip may not be representative of the catch rates that would have been obtained if catch rates were averaged over multiple trips. To demonstrate how much catch rates can vary between a single trip and multiple trips, CPUE for the single Commission angling trip (6.25 fish/angler-hour) on the SFNR was substantially higher than the average obtained during multiple trips by diarists (1.7 fish/angler-hour). There are multiple reasons why catch rates can vary substantially between trips, including weather and river conditions, the skill level of the anglers, the size and type of bait used, and the abundance of fish within the section of river fished. Consequently, abundance estimates based on multiple trips are likely to yield more representative estimates of abundance than would be obtained from single trips.

In general, the degree of similarity between the size distributions of SMB collected by electrofishing and angling was related to the number of fish collected by angling, with the degree of similarity increasing as angling sample size increased. Within the MNR where there was a high degree of similarity between the length-frequency distributions of SMB collected by electrofishing and angling, 283 fish were collected by angling. Within the NFNR, where only 42 fish were collected by angling, there was little resemblance between the size structures of SMB collected by electrofishing and angling. And in the SFNR, sample sizes of fish collected by angler diarists (n = 65) and Commission angling (n = 50), along with the level of agreement between the size distributions of fish collected by electrofishing and each angling method, were intermediate between those of the MNR and NFNR. The size distribution of fish collected by angler diarists (n = 65) appeared more similar to the electrofishing size distribution than the size distribution compiled by Commission angling (n = 50), which contained a higher proportion of fish in the 225- and 275-mm ranges than the electrofishing or angler diary samples. While some of this difference may be related to the smaller sample size collected during the Commission angling trip, it should also be noted that the Commission angling trip took place later (September) than the electrofishing surveys or the trips taken by angler diarists (May–June). Consequently, the larger sizes of fish collected during the Commission angling trip may have simply reflected growth that occurred during the summer. During future comparisons, electrofishing and angling surveys should be conducted during a narrower time frame to eliminate any influences that growth during the study period might have on the size distributions of fish collected during the surveys.

In addition to the effect that sample size may have had on the accuracy of the length-frequency distributions of SMB collected by anglers, the number of trips expended collecting the data should also be considered. In addition to having low samples sizes, the data obtained from the NFNR angler diary and SFNR Commission angling samples that had the poorest correlation with electrofishing size structure were also collected in only one trip per river segment. As such, the size distributions of SMB caught during these trips could potentially have been affected by the aforementioned biases associated with catch rates during single-day collection efforts. In addition to those factors, from an anecdotal standpoint, the sizes of fish caught by anglers are known to vary daily or seasonally, and collecting fish during multiple trips over a more extended time period will likely yield a more representative size distribution than collecting fish in a single outing.

The reason for the apparent selectivity of angling for larger fish in the MNR is unclear. The largest fish in a population are known to sometimes be underrepresented in electrofishing samples for a variety of reasons. It has been postulated that larger individuals may escape capture by detecting the electrical field at a greater distance and being repelled by it or being strong enough to swim away from the field when it is encountered (Bayley and Austin 2002). It has also been speculated that larger fish are less susceptible to capture because they spend more time in deeper water where electrofishing efficiency is decreased (Bayley and Austin 2002). However, even the larger SMB in the New River are relatively small in comparison to larger specimens of black bass that have been shown to avoid capture by electrofishing (DeJesus and Magnelia 2009) and seem unlikely to avoid capture by being more sensitive to the electrical field or being strong enough to escape it. Additionally, owing to its shallow, rocky nature, the New River does not contain many habitats that would seem deep enough to allow fish to avoid capture.

Rather than electrofishing selecting against larger fish, the higher proportion of larger fish captured by angling could be the result of angling selecting for the largest fish in the population. Our electrofishing surveys were conducted by floating downstream with the current and collecting fish from whatever habitat we passed over, theoretically allowing us to sample all habitat types and catch the full size range of fish present in the river. Conversely, anglers are likely to focus their efforts disproportionately on prime habitats that are most likely to be inhabited by the largest fish. This selection for larger fish by anglers would likely be highest with anglers that possessed greater angling skills and had more knowledge of the river and the location of prime habitat types known to be inhabited by the largest fish.

Examination of the MNR data shows that all fish were collected by only three anglers, with one of these anglers being responsible for 80% of the fish that were caught. This angler is known to Commission staff and is considered one of the most avid anglers on the river, having fished it dozens of times per year for many years. As such, it is possible that he was able to capture larger fish not only more effectively than electrofishing, but more effectively than less avid anglers. To assess this possibility, the length-frequency distribution of SMB caught by our most avid angler was compared against the length-frequency distribution of SMB caught by the other two anglers who submitted catch data (Figure 9). Fish sizes were fairly similar for fish <

325 mm TL, but a higher proportion of fish ≥ 325 mm TL was caught by our primary angler, with this angler accounting for all fish ≥ 400 mm TL. While the sample size of fish collected by the other two anglers who submitted catch data was too small to allow for a definitive comparison, this analysis suggests that angler avidity may have played a role in angling selecting for larger SMB on the MNR than electrofishing. Previous comparisons of size structure data collected by electrofishing and angler catch data from bass tournaments and creel surveys in Kansas have shown similar results, with tournament anglers selecting for larger fish than either electrofishing or angling conducted by non-tournament and non-bass anglers (Gabelhouse and Willis 1986).

When examining size-structure indices generated from electrofishing samples, there was little variability across river segments for each size group of fish, suggesting that electrofishing was effective at consistently collecting representative size-structure data. Conversely, the same index values generated by angling varied substantially from one river segment to the next, which suggests that angling data were less reflective of the actual size structure of the SMB population in each river segment than electrofishing data. Analogous to what was observed with length-frequency distributions, the similarity between size-structure indices generated by electrofishing and angling was also related to angling sample size. In the MNR where a high number of fish were caught by angler diarists, PSD and PSD-P values were higher for fish collected by angling than by electrofishing; however, the differences in these indices appear in part to reflect actual differences in population size structure between electrofishing- and angler-generated data. PSD values for the SFNR were generally similar between collection methods, although they were more alike between electrofishing and Commission angling than between electrofishing and angler diaries, despite more fish being collected by angler diarists. PSD-P and PSD-M in the SFNR did not appear to be accurately described by either angler diaries or Commission angling. In the NFNR where fewer fish were collected by anglers than from the other river segments, both PSD and PSD-P for fish collected by angler diarists appeared to be greatly exaggerated as a result of the high proportion of fish in the 275–325 mm range that was collected by anglers, while PSD-M was underestimated. Within both the NFNR and SFNR, PSD-M was likely reduced for fish collected by angling since memorable-sized fish were less likely to be collected given the small sample sizes.

In addition to the accuracy of angler-generated size-structure indices being poor as a result of the low overall number of fish collected by angling in this study, size-structure indices may also have been elevated because stock-sized fish (180 mm) were not fully susceptible to angling. Examination of the length-frequency distributions collected by angling and electrofishing suggests that fish of this size were underrepresented in angling samples, especially in the MNR and NFNR, which would lead to size-structure indices being artificially inflated.

Differences in the age-frequency distributions of SMB collected from the SFNR by electrofishing and Commission angling are likely related to the size selectivity of each gear and the low prevalence of certain age-classes within the population. One-year-old SMB were collected by electrofishing but not by angling as a result of angling selecting against the smallest fish in the population; sizes of 1-year-old SMB collected by electrofishing ranged from 73–105 mm TL, while the smallest fish collected by angling was 165 mm TL. Three-year-old SMB were the primary cohort collected by both gear types, although they made up a much higher proportion of the angling sample (68%) than the electrofishing sample (42%). The high proportion of 3-year-old fish collected by angling is likely explained by the sizes of fish selected for during the angling survey; total lengths of 3-year-old SMB collected by angling ranged from 182–249 mm TL, and most SMB collected by Commission angling were from the 175–249 mm length-classes. The absence of the 4-, 8-, and 9-year-old SMB that were collected by electrofishing but not angling does not seem to be related to the size selectivity of angling since fish of that size should have been fully susceptible to being collected by each gear. The absence of these older age-classes from the angling sample is more likely related to the smaller sample size of the angling sample (n = 50) relative to the electrofishing sample (n = 174), combined with the fact that these three age groups were relatively rare and collectively only comprised < 4% of the entire electrofishing sample. As such, if a more robust sample size had been obtained, these less abundant age-classes might have been collected by angling.

For cohorts of SMB that were fully susceptible to being caught by both electrofishing and angling, it was assumed that growth rates would be comparable among collection methods. As a result, the fact that growth rates of 2-,3-, and 6-year-old SFNR SMB collected by Commission angling were faster than those collected by electrofishing was unexpected. Age-2 SMB appear to have been underrepresented in the Commission angling length-frequency distribution relative to the electrofishing size distribution, presumably because most fish in this cohort (mean TL = 184 mm) were below the size that was targeted most effectively by angling (175–249 mm TL). As such, it seems likely that length at age of 2-year-old SMB collected by angling may have been greater than length at age of the same cohort collected by electrofishing since angling likely selected for the largest, fastest growing members of the cohort while electrofishing likely sampled all members of the cohort more equally. However, 3- and 6-year-old SMB were large enough to be fully recruited to both gears, so size selectivity should not have played a role in the faster growth rates observed for fish of these cohorts collected by angling.

Another possibility for the discrepancy in growth rates observed between the two collection methods could involve the timing of the samples. Electrofishing samples on the SFNR were collected on May 30 and June 17, while the Commission angling sample took place on September 18. Given that SMB collected by angling had an extra 3–3.5 months to grow during the peak of the growing season relative to fish collected by electrofishing, it seems reasonable that they should have been larger than fish collected by electrofishing.

To further explore the possibility that differences in length at age between fish collected by electrofishing and angling may have been related to collection date, growth data from MNR SMB collected by electrofishing during different months were examined. Due to mechanical problems encountered during the initial survey of the MNR on June 25, the same stretch of river was resurveyed on September 10. Length at age data from these two sample dates were compared and found to be much more comparable than the SFNR data collected by electrofishing and Commission angling, with there being no significant differences ($P > 0.1$) in length at age for the three year-classes that were collected in sufficient numbers to allow for statistical comparison (Figure 10). It should be noted, however, that the electrofishing samples on the MNR were conducted only 2.5 months apart while the SFNR electrofishing and angling samples were conducted 3–3.5 months apart, allowing more time for growth between surveys. It is also possible that the results of these comparisons of growth rates between collection methods on the SFNR and sample dates on the MNR are being confounded by the less than ideal sample sizes available for analysis, given that only 50 fish were collected by Commission angling on the SFNR and only 49 fish were collected during the June 25 MNR electrofishing survey. Additional comparisons of the growth rates of SMB are needed to better determine the relationship between growth rates derived from fish collected by electrofishing and angling, with surveys ideally being conducted during a narrower time frame to eliminate the influence growth during the study period might have on length at age.

Management Recommendations

1. Collect a larger sample of SMB with angling in conjunction with the next electrofishing survey of the New River to allow for a more robust comparison of the catch rates, size structures, age structures and growth rates of fish collected by the two collection methods.
2. During future surveys, electrofishing and angling data should be collected as concurrently as possible to eliminate any influences growth during the study period might have on the size structures or length at age of fish collected.

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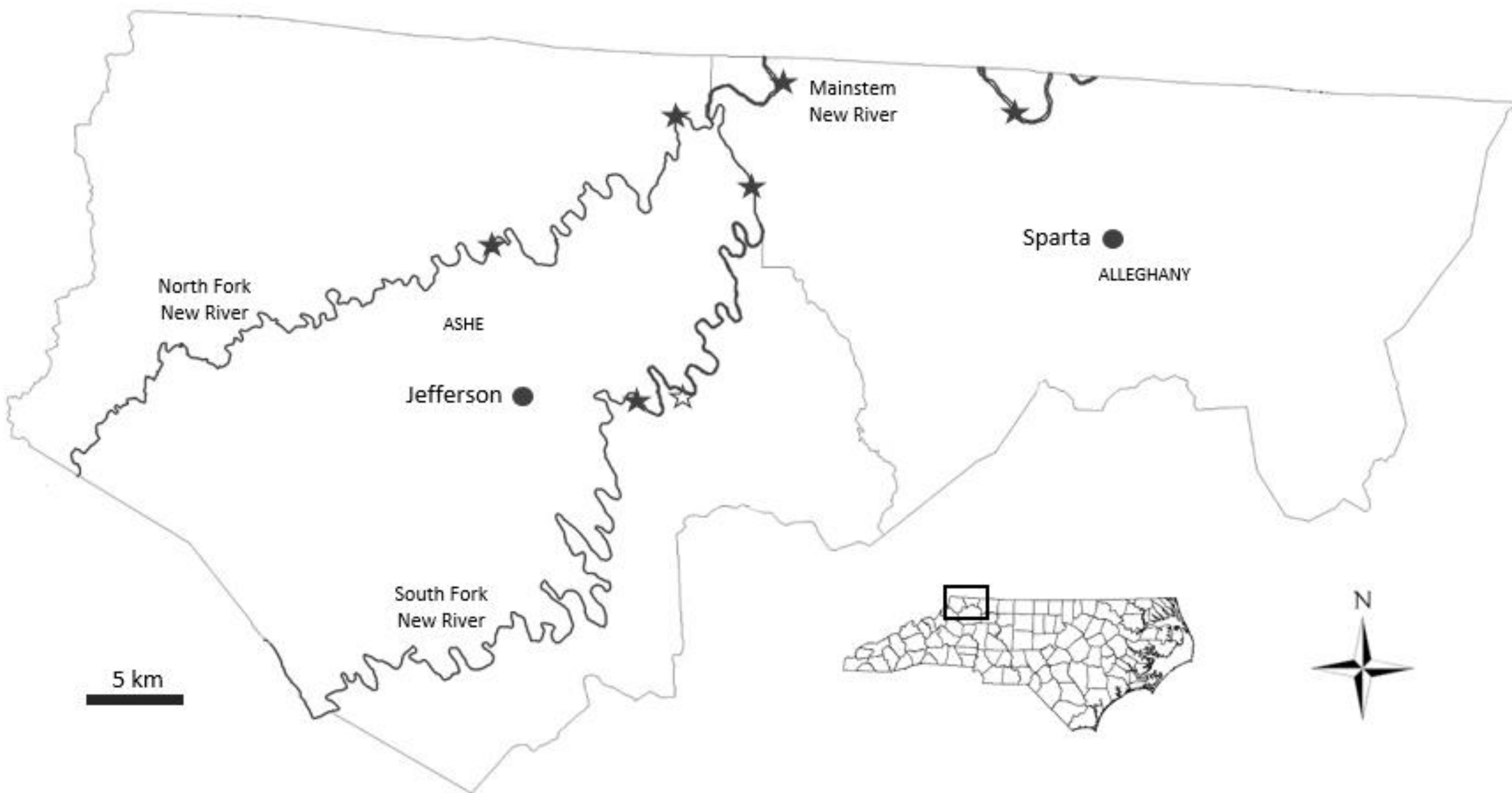

FIGURE 1.—Map of the mainstem New River, North Fork New River, and South Fork New River in Ashe and Alleghany counties showing electrofishing (★) and Commission angling (☆) sites used to collect Smallmouth Bass, 2013.

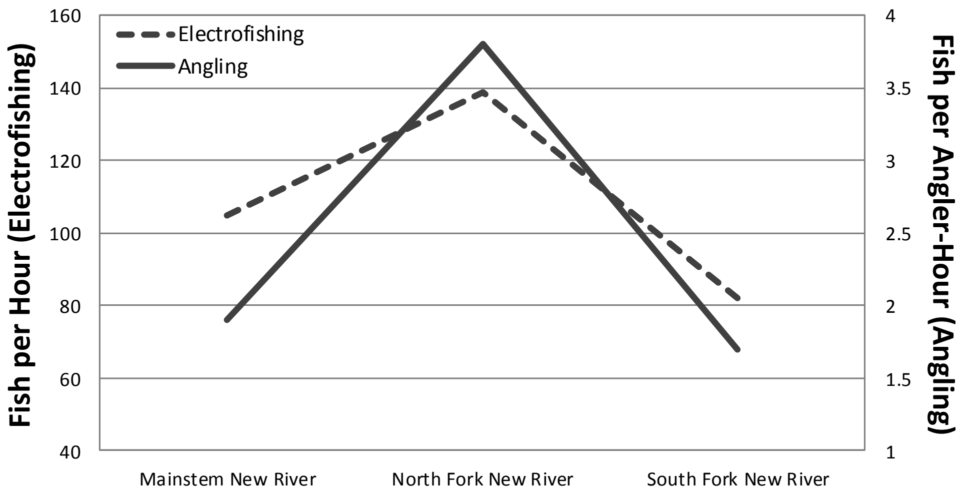

FIGURE 2.—Catch rates of mainstem New River, North Fork New River, and South Fork New River Smallmouth Bass collected by electrofishing and angler diarists, 2013.

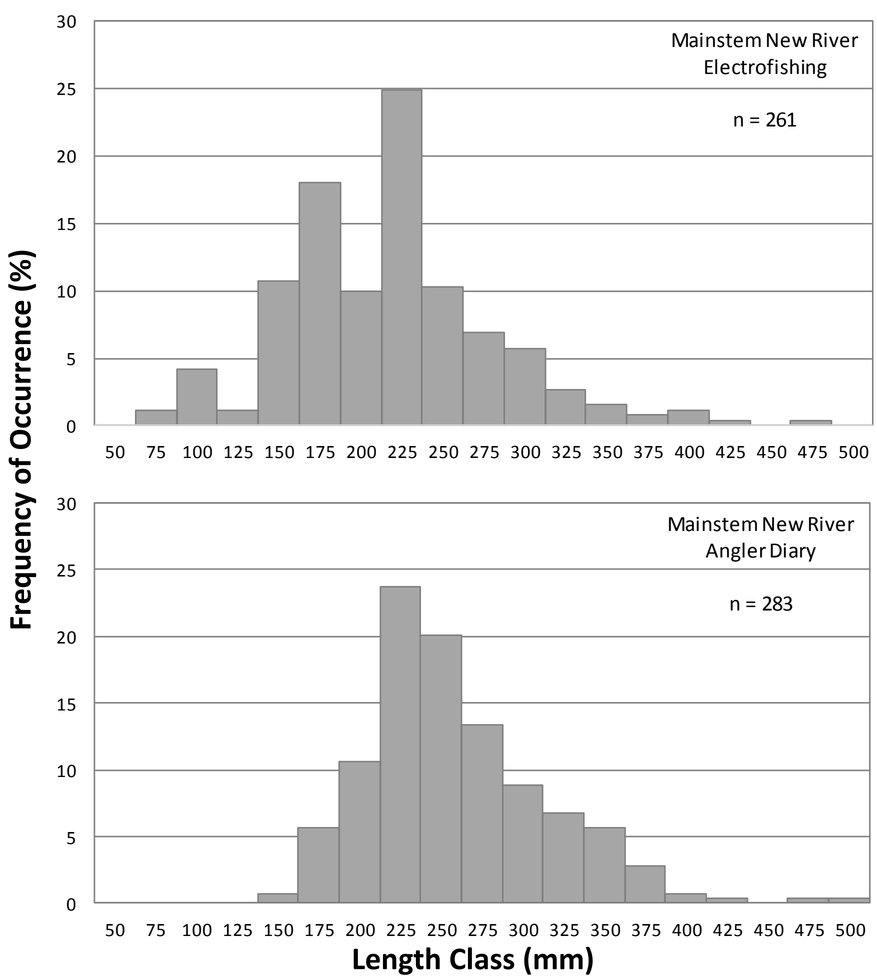

FIGURE 3.—Length-frequency distributions of mainstem New River Smallmouth Bass collected by electrofishing and angler diarists, 2013.

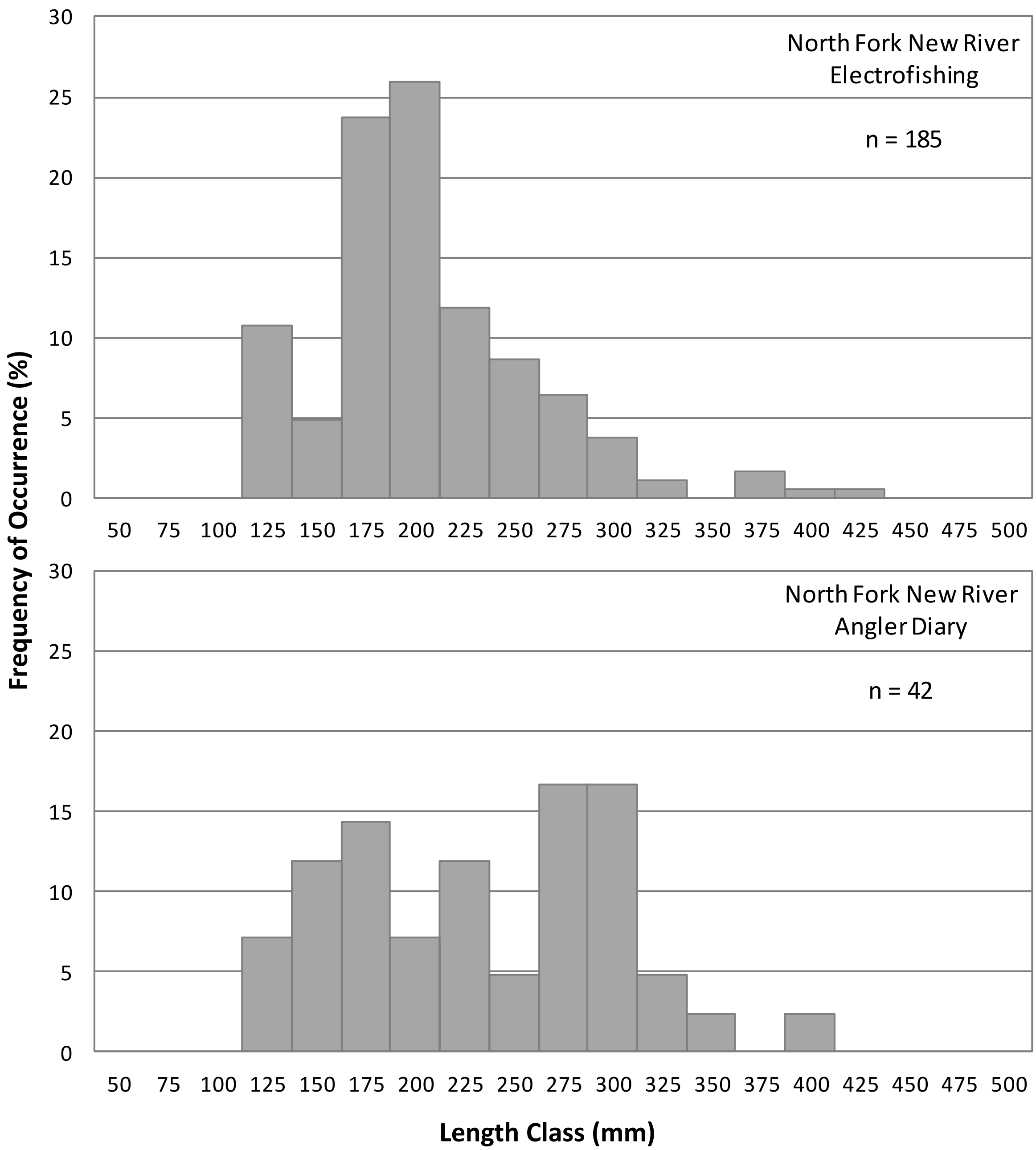

FIGURE 4.—Length-frequency distributions of North Fork New River Smallmouth Bass collected by electrofishing and angler diarists, 2013.

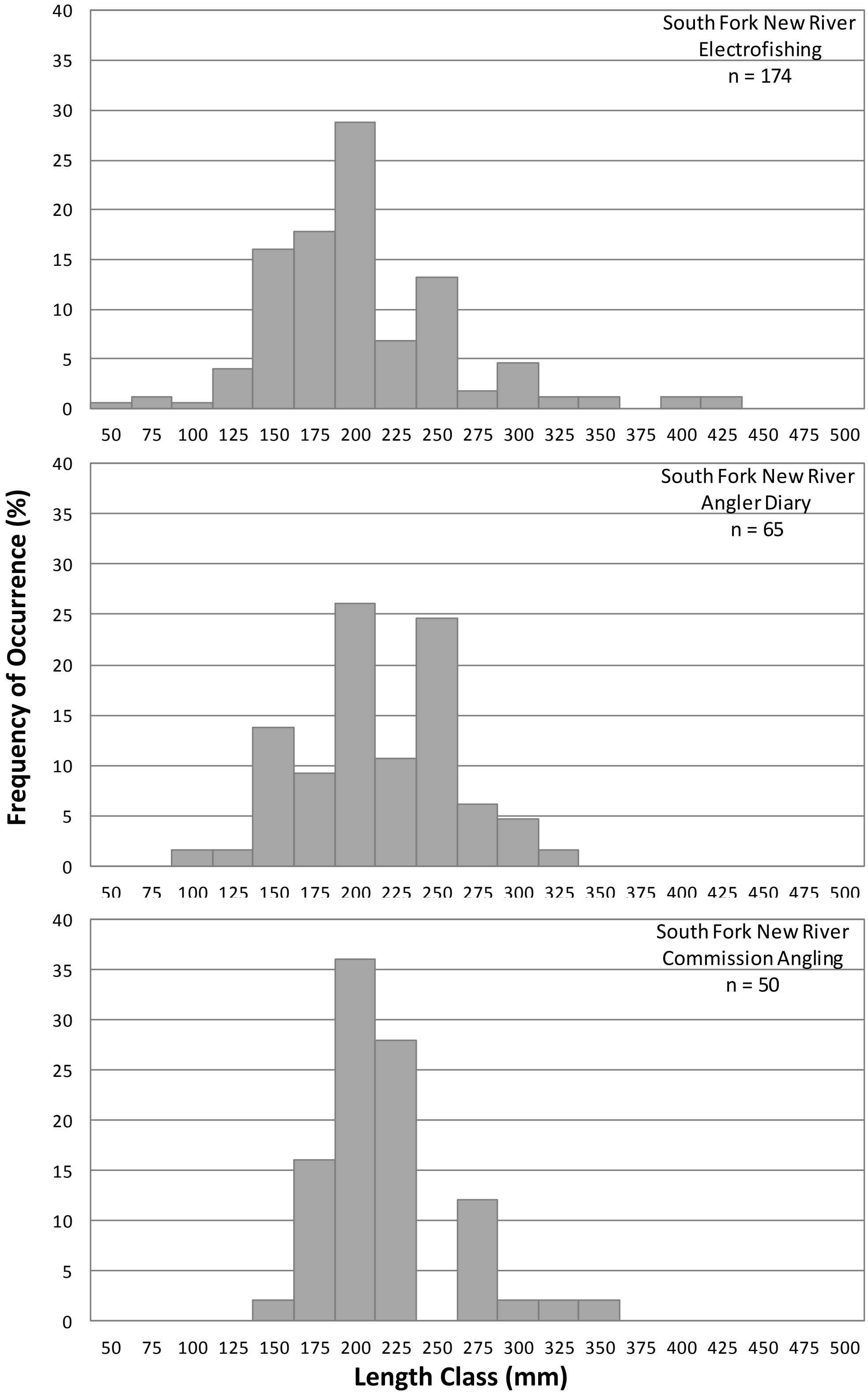

FIGURE 5.—Length-frequency distributions of South Fork New River Smallmouth Bass collected by electrofishing, angler diarists, and angling by Commission staff, 2013.

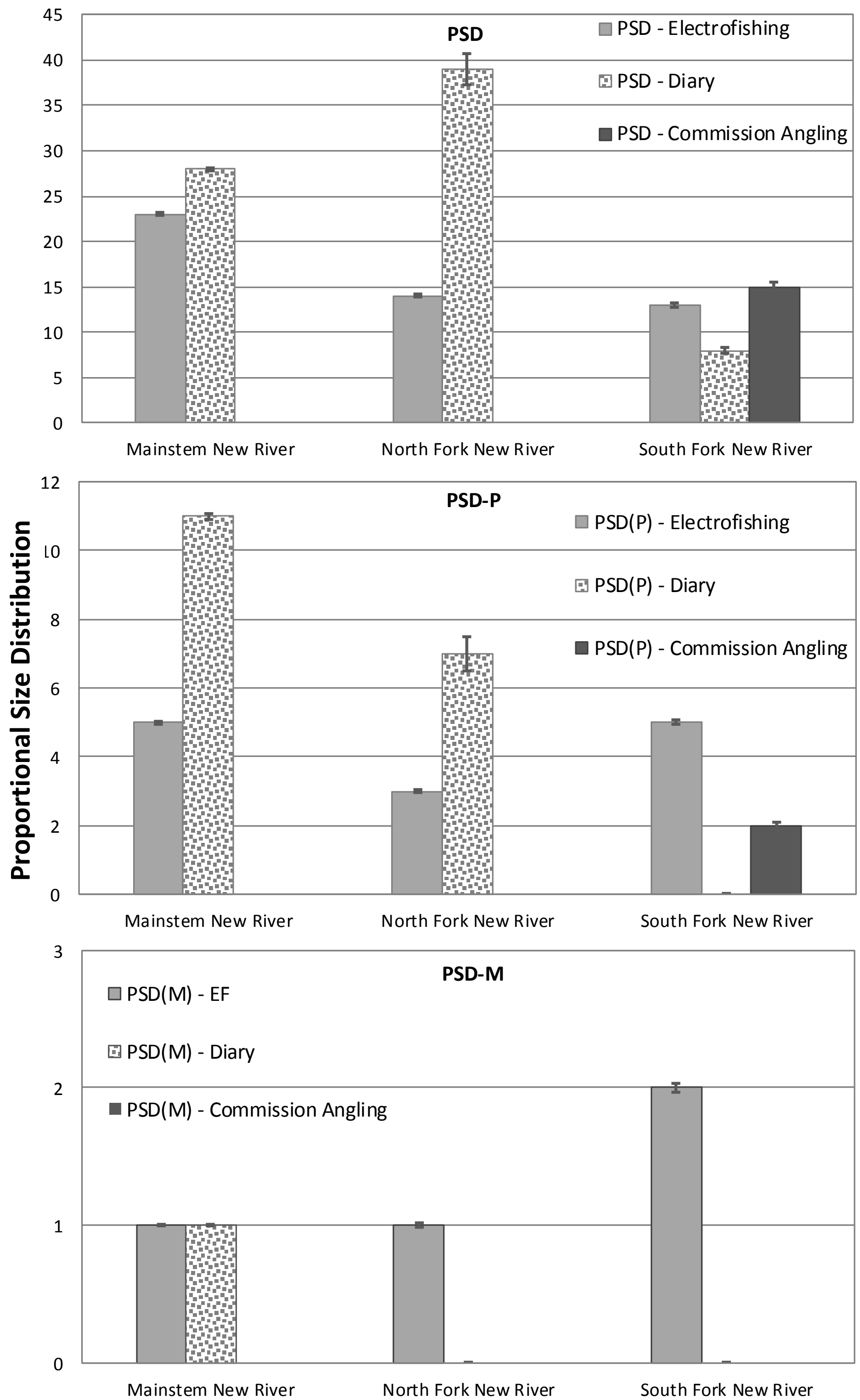

FIGURE 6.—Proportional Size Distributions of quality (PSD)-, preferred (PSD-P)-, and memorable (PSD-M)-sized mainstem New River, North Fork New River, and South Fork New River Smallmouth Bass collected by electrofishing, angler diarists, and angling by Commission staff, 2013. Error bars indicate 95% confidence intervals.

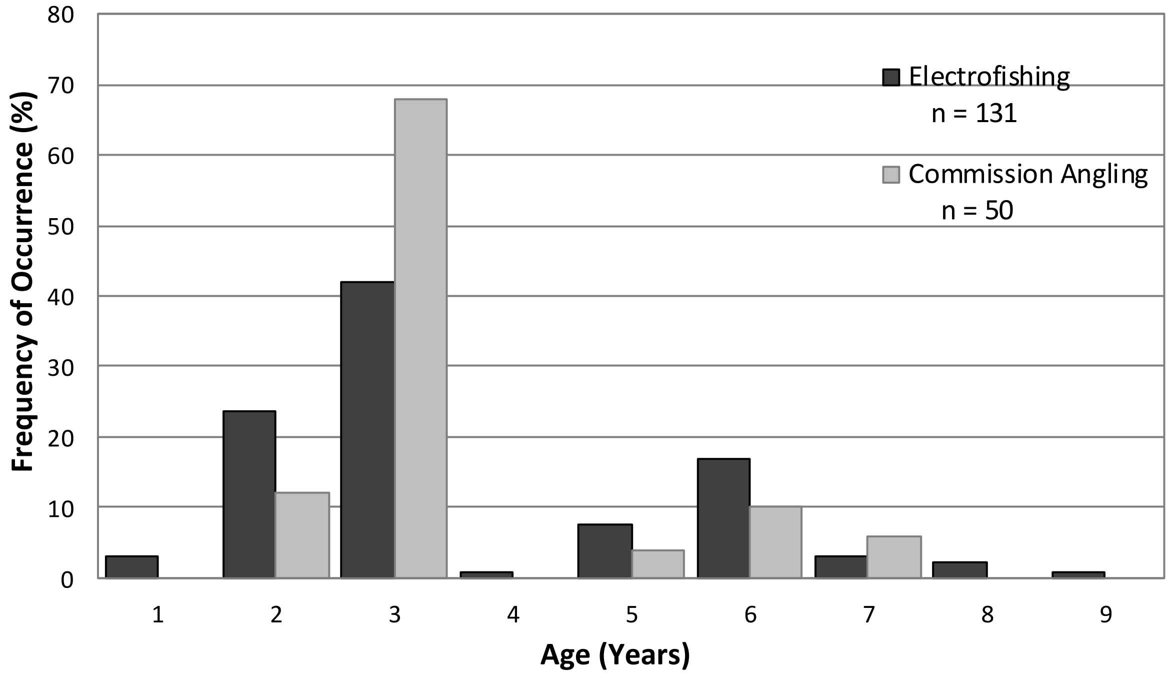

FIGURE 7.—Age-frequency distributions of South Fork New River Smallmouth Bass collected by electrofishing and angling by Commission staff, 2013.

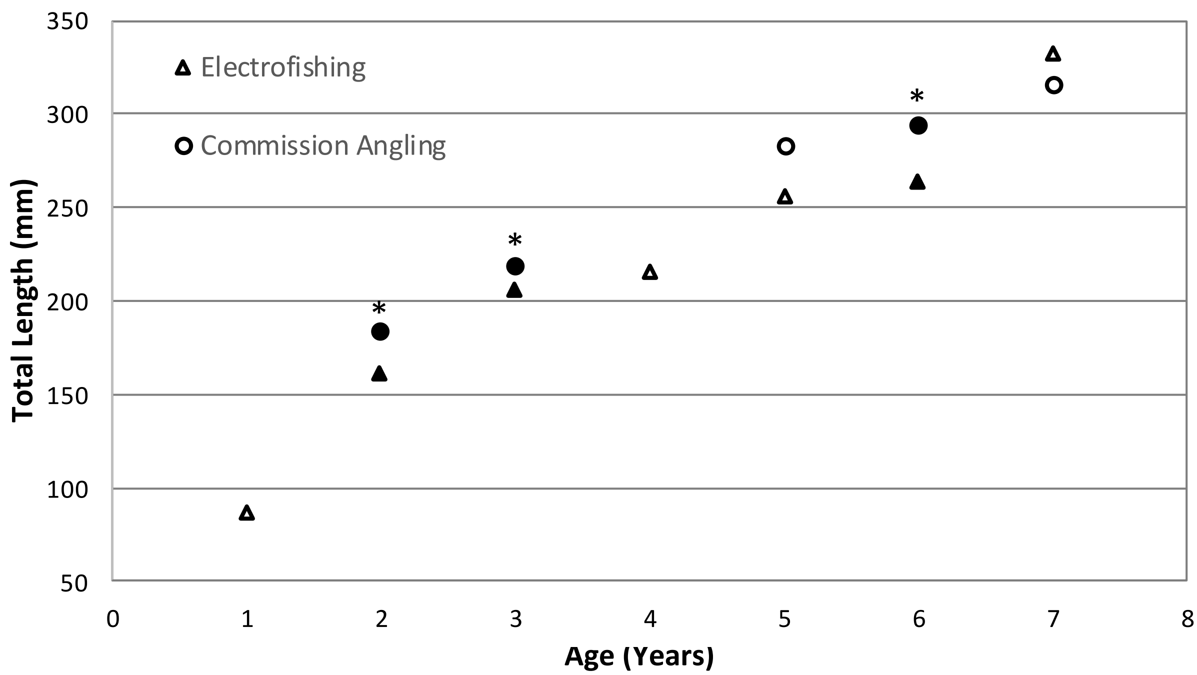

FIGURE 8.— Length at age of South Fork New River Smallmouth Bass collected by electrofishing and angling by Commission staff, 2013. Solid markers indicate that lengths were compared statistically, and * indicate that significant differences were detected (t-test; $P < 0.05$).

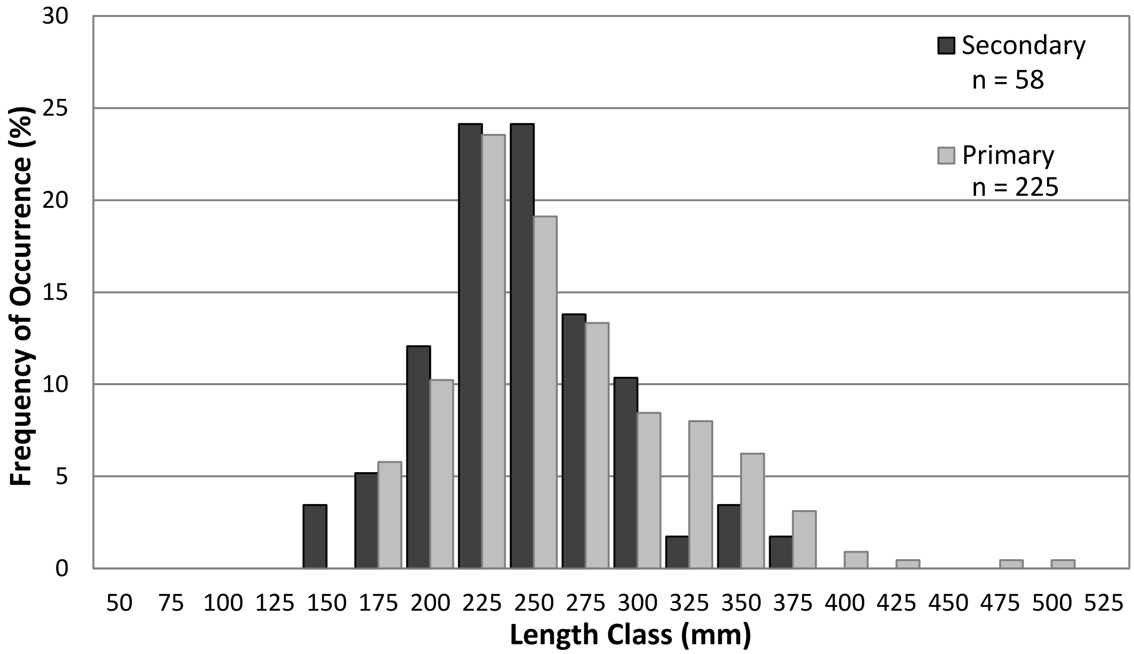

FIGURE 9.—Length-frequency distributions of mainstem New River Smallmouth Bass collected by angling, showing lengths of fish collected by the primary and secondary angler diarists, 2013.

FIGURE 10.—Length at age of mainstem New River Smallmouth Bass collected by electrofishing, June and September, 2013. Solid markers indicate that lengths were compared statistically; no significant differences were detected (t-test; $P > 0.05$).

INSTRUCTIONS

1. Fill out a different sheet each time you go fishing. It is important that you fill out a sheet even on days when **no** fish were caught.
2. Fill in the date of the fishing trip.
3. Circle the section of river where you fished: North Fork (NF), South Fork (SF), or Mainstem (MS) New River (mainstem refers to section of river below confluence of North and South Forks). If your starting point was in the North Fork or South Fork and your takeout point was in the mainstem New River, circle all that apply. For example, if you launched in the South Fork and took out in the mainstem New River, circle " SF" and " MS" . If your launch or takeout point was in Virginia, please note this in the Additional Notes section at the bottom of the page.
4. Record the number of people fishing.
5. Record the total number of hours (to the nearest ¼ hour) that were spent fishing for smallmouth bass.
6. Please fill in the appropriate data within the table for **all** smallmouth bass caught (enter length to the nearest ¼ inch). **If no fish were caught, enter 0 in the table for fish length to indicate that no fish were caught.**
7. Continue recording information for your trip on an additional sheet if you fill all the data boxes on your original form. Write **Continuation of DATE Trip** in the Date section on the next form. For example: Date: Continuation of 6/29/2013 Trip.
8. The Additional Notes section is a place for notes on fish condition, river conditions, other species caught, or any other information that you feel may be of interest to the biologist. In addition, use this section to record the number of fish caught on days when the catch is high and it is not feasible to measure each individual fish.
9. If more than one diary keeper is fishing together, each of you fill out a sheet as if you were fishing alone (enter " 1" for number fishing and record only the fish that you caught). Do not record the same fish in more than one diary.

Contact Kin Hodges at 336.443.9436 or kin.hodges@ncwildlife.org with any questions that arise during the course of the study.

Date ____________________ Body of Water (NF/SF/MS)

Number of People Fishing ______ Hours Fished___________

Fish Length	Check One- Released?	
	Yes	No

Fish Length	Check One- Released?	
	Yes	No

Additional Notes ____________________________________

APPENDIX 1.—Instructions and example of data recording page from angler diary sent to New River angler diarists, 2013.