CHOWAN AND MEHERRIN RIVER LARGEMOUTH BASS POPULATION RESPONSE FOLLOWING HURRICANE IRENE

Federal Aid in Sport Fish Restoration
Project F-108
Final Report

Kathryn M. Potoka
Jeremy W. McCargo
Benjamin R. Ricks

North Carolina Wildlife Resources Commission
Division of Inland Fisheries
Raleigh

2014

Keywords: Largemouth Bass, Chowan River, electrofishing, hurricane response

This project was funded under the Federal Aid in Sport Fish Restoration Program utilizing state fishing license money and federal grant funds derived from federal excise taxes on fishing tackle and other fishing related expenditures. Funds from the Sport Fish Restoration Program are used for fisheries management and research, aquatic education, and boating access facilities. The program is administered cooperatively by the N.C. Wildlife Resources Commission and the U.S. Fish and Wildlife Service.

Abstract.—After landfall of Hurricane Irene on 27 August 2011, portions of the Chowan River upstream of Holiday Island experienced significant declines in dissolved oxygen resulting in a widespread fish kill. To monitor initial impacts and population recovery following Hurricane Irene, the Largemouth Bass *Micropterus salmoides* population was surveyed with boat mounted electrofishing gear in fall 2011, spring and fall 2012, and spring 2013. Anoxic and hypoxic conditions were documented from Wiccacon River upstream to Virginia tributaries, spanning roughly 50 river km. The lower Chowan River was largely unaffected by Hurricane Irene and by spring 2013 relative abundance of Largemouth Bass greater than 200 mm surpassed the benchmark for coastal North Carolina rivers (25 fish/h) with a mean CPUE of 28 fish/h (SE=2). The middle Chowan River Largemouth Bass population experienced significant declines in relative abundance following Hurricane Irene. However, Largemouth Bass in the middle Chowan River nearly recovered to the relative abundance coastal benchmark; mean CPUE in spring 2013 was 18 fish/h (SE=5.4). Following Hurricane Irene, hypoxic waters were documented throughout the entire upper Chowan River and widespread fish kills were reported. Relative abundance of Largemouth Bass did not reach pre-hurricane levels by spring 2013, with a mean CPUE of 5 fish/h (SE=3.3). Future survey efforts should focus on the Upper Chowan River to assess the need for management actions to supplement natural recovery of Largemouth Bass. The Meherrin River, a major tributary to the Chowan River, Largemouth Bass population was also impacted by hypoxic waters; however, relative abundance increased during the study period and reached 14 fish/h (SE=2.8) by spring 2013. In general, Largemouth Bass in the Chowan River have the capacity to naturally recover to pre-hurricane levels. Successful reproduction in spring 2012 was apparent throughout the Chowan River and was evident by the large numbers of sub stock-length Largemouth Bass collected in fall 2012. The Largemouth Bass population was also found to be shifting toward larger individuals. Spatial patterns in Largemouth Bass population recovery following hurricanes will help determine if augmentation to the population is warranted.

Largemouth Bass *Micropterus salmoides* are popular sport fish throughout North Carolina and are the most sought after fish in the Chowan River (Dockendorf et al. 2004). Many Largemouth Bass tournaments are held on the Chowan River due to the abundance of quality fish available for capture. While Largemouth Bass are an economically important sport fish, they are also ecologically important top predators within the aquatic community. Therefore, it is important to maintain a healthy population of Largemouth Bass to support recreational fishing and maintain ecological balance. Still, Largemouth Bass population dynamics in the Chowan River tend to fluctuate as a result of both natural and anthropogenic disturbances.

In coastal areas, hurricanes are unique disturbances that can severely impact freshwater river systems. Hurricanes can produce strong storm surges, and in turn, can cause saltwater intrusion and the flooding of swamps and backwaters. The flushing of these swamps and backwaters often result in high inputs of organic material and sediment loading, increasing in-stream biological oxygen demand. When oxygen demands cannot be met, hypoxic and anoxic conditions can cause fish kills and have been well documented in coastal river systems (Burkholder et al. 1999; Mallin 2002; Alford et al. 2009; Thomas and Dockendorf 2009; McCargo and Dockendorf 2010). In North Carolina, 4.0 mg/l is the minimum acceptable instantaneous dissolved oxygen concentration (NCDENR 2007; Homan and Dycus 2013). Consequences of low dissolved oxygen exposure in fish include: respiratory distress, reduced metabolic rates, reduced growth, displacement, and mortality of larvae, eggs, and adults. A reduction in resting metabolic rates in Largemouth Bass was found to occur at dissolved oxygen concentrations less than 2.6 mg/l in 25°C (Cech et al. 1979). Largemouth Bass eggs and larvae exposed to dissolved oxygen concentrations of 2.5 mg/l had high rates of mortality (Spoor 1977). Whitmore et al. (1960) found that Largemouth Bass began avoiding dissolved oxygen concentrations of 3.0 mg/l. A recent study conducted in the Chowan River documented Largemouth Bass avoidance of episodic hypoxic and anoxic conditions when refugia were available (Brown et al. 2014). Depressions in dissolved oxygen concentrations are regularly documented following hurricanes in coastal rivers in North Carolina.

On 27 August 2011, Hurricane Irene made landfall at Cape Lookout, North Carolina and continued on a northerly path, impacting the Albemarle Sound and its associated drainages. Swamps and backwaters of the Chowan River system were inundated by heavy rainfall and storm surges; between 5 and 10 inches of rain were documented in the Albemarle Sound area (Avila and Cangialosi 2011). Hypoxic and anoxic conditions were documented as far upstream as the Virginia tributaries of the Chowan River, approximately 50 km from its mouth, and as a result, widespread fish kills were observed (NCDENR 2011). Post-hurricane management activities conducted by the North Carolina Wildlife Resources Commission (Commission) includes identifying areas of hypoxia and anoxia, surveying fish populations following hurricane landfall and for multiple consecutive years to monitor recovery, and to supplement localized populations with stockings when necessary. In a previous study completed in 2009, The Chowan River Largemouth Bass population was documented to be fully recovered from similar fish kills following Hurricane Isabel in 2003 (McCargo and Dockendorf 2010). The objectives of this study were to evaluate the status and document recovery of the Largemouth Bass population in the Chowan River following Hurricane Irene, assess the need for changes to current size and creel limits, and determine if management actions were required to aid with natural recovery.

Methods

Study Area.—The Chowan River is formed by the confluence of the Blackwater and Nottoway rivers along the Virginia/North Carolina border and flows approximately 75 km southeast before emptying into the Albemarle Sound near Edenton, North Carolina. Most of the watershed lies within Virginia, and approximately 2,116 km2 (25%) of the basin is located within all or portions of the North Carolina counties of Northampton, Hertford, Gates, Bertie, and Chowan. The majority of the river basin is rural with over 57% of the land cover consisting of forest or agriculture (NCDWQ 2002).

Field Collections.—Largemouth Bass were collected with boat-mounted electrofishing gear (Smith-Root 7.5 GPP; 170–1000 V pulsed DC; 2–4 A) in 2011, 2012, and 2013. In 2011, sampling was conducted from 24 to 26 October at 12 total sites; nine tributary and three mainstem sites (Figure 1). In 2012, a total of 16 sites, 14 tributary and two mainstem sites, were sampled from 12 April to 18 May; an additional 31 sites, 25 tributary and eight mainstem sites, were sampled from 1 to 23 October (Figure 1). In 2013, sampling was conducted from 17 April to 15 May at a total of 33 sites; 25 tributary and 8 mainstem sites (Figure 1). Each site was sampled for 20 minutes with boat electrofishing. Largemouth Bass were netted when encountered, held in a live well, measured (TL mm), and weighed (g) upon completion of each site. At each site, electrofishing time (seconds) and water quality parameters were recorded including: water temperature (Celsius), dissolved oxygen saturation (%), dissolved oxygen concentration (mg/L), specific conductivity (µS/cm), salinity (ppt), pH, and secchi depth (m).

Data Analysis.—The Chowan River was divided into four sections to ensure samples were representative of the entire basin and were defined as: Upper (NC/VA state line to US Hwy 158 bridge), Middle (US Hwy 158 bridge to Wiccacon River), Lower (Wiccacon River to Chowan River mouth), and Meherrin River (McCargo and Dockendorf 2010). Several parameters were used to evaluate the status of the Chowan River Largemouth Bass population. Relative abundance of Largemouth Bass was expressed as the number of fish greater than 200 mm collected per electrofishing hour and was indexed as catch-per-unit-effort (CPUE; fish/h). To assess recovery of the Chowan River Largemouth Bass population, CPUE estimates for all survey seasons were compared to the CPUE coastal rivers benchmark of 25 fish/h (≥ 200 mm). Additionally, relative abundance of Largemouth Bass was reported for multiple length categories for each section of the Chowan River. Length categories for Largemouth Bass were defined as sub stock-length (<200 mm), stock-length (200–299 mm), quality-length (300–379 mm), preferred-length (380–509 mm), and memorable-length (510–629 mm) (Anderson and Neumann 1996). A length frequency histogram was constructed using 25-mm length groupings to categorize the size structure of Largemouth Bass in each section of the Chowan River.

Results

Lower Chowan.—In fall 2011, 39 Largemouth Bass were collected from five sites in the lower Chowan River. Relative abundance was highly variable between sites (range 0–73 fish/h), and mean CPUE was 22 fish/h (SE=12.9; Figure 2). Largemouth Bass lengths ranged 85–491 mm and the majority of the sample (69%) was quality length or greater. However, no fish of memorable-length were collected, and very few fish of stock-length and smaller were captured

(Figure 3). In spring 2012, 56 Largemouth Bass were collected in seven lower Chowan River sites. Relative abundance was the same in spring 2012; mean CPUE was 22 fish/h (SE=3.5). Largemouth Bass lengths ranged 31–581 mm, and the majority of the sample (64%) was quality-length or greater with fish of memorable-length collected. The relative abundance of sub stock-length fish increased from 0.6 fish/h in 2011 to 7 fish/h in spring 2012. In fall 2012, 135 Largemouth Bass were collected from 11 sites. Relative abundance decreased slightly, and mean CPUE was 21 fish/h (SE=2.5). Largemouth Bass lengths ranged 71–555 mm. Catch-per-unit-effort and length frequencies revealed sub-stock length Largemouth Bass represented roughly 50% of the sample in fall 2012, indicating a successful spawn one year following Hurricane Irene. In spring of 2013, 112 Largemouth Bass were collected from 12 survey sites in the lower Chowan River. Mean CPUE was 28 fish/h (SE=1.9). A wide range of sizes were present and total lengths ranged 76–534 mm, similar to fall 2012.

Middle Chowan.—In fall 2011, 16 Largemouth Bass were collected from five sites in the Middle Chowan River. Relative abundance was low; mean CPUE was 7 fish/h (SE=1.1; Figure 4). Largemouth Bass lengths ranged 72–376 mm, and no fish greater than quality-length were collected (Figure 5). The majority of the sample (65%) was less than quality length. In spring 2012, 12 Largemouth Bass were collected in four sites. Relative abundance increased; mean CPUE was 10 fish/h (SE=4.6). The majority of individuals (67%) collected were quality-length or greater, indicating a shift toward larger individuals. In fall 2012, 66 Largemouth Bass were collected in 10 sites. Relative abundance continued to increase, and mean CPUE was 12 fish/h (SE=2.4). A wide range of size classes were present (63–455 mm), the majority of the sample was sub-stock length but individuals greater than quality-length represented a larger proportion of the sample. In spring 2013, 57 Largemouth Bass were collected in 10 sites. Relative abundance increased, mean CPUE was 18 fish/h (SE=5.4). A wide range of size classes were present and lengths ranged 63–455 mm.

Upper Chowan.—In fall 2011, one Largemouth Bass (62 mm) was collected from one site in the upper Chowan River. No Largemouth Bass greater than 200 mm were collected (Figure 6). In spring 2012, four Largemouth Bass were collected from two sites. Relative abundance was low, mean CPUE was 6 fish/h (SE=5.8). Largemouth Bass lengths ranged 94–317 mm, with the majority of individuals (75%) collected stock-length or below. Only one individual collected was quality length (Figure 7). In fall 2012, 15 Largemouth Bass were collected from three sites. Relative abundance decreased slightly, as mean CPUE was 4 fish/h (SE=0.1). Lengths ranged 48–454 mm; the majority of individuals were sub-stock length, only two individuals were greater than quality-length. In spring 2013, eight Largemouth Bass were collected from 3 sites. Relative abundance increased; mean CPUE was 5 fish/h (SE=3.3). Lengths ranged 172–404 mm, and 50% of fish collected were quality-length or greater.

Meherrin River.—In fall 2011, seven Largemouth Bass were collected from one site in the Meherrin River. Relative abundance was extremely low; CPUE was 3 fish/h (Figure 8). Only two size classes were present with the majority of individuals (86%) in the sub-stock length category and only one individual in the quality length category (Figure 9). In spring 2012, nine Largemouth Bass were collected from three sites. Relative abundance increased; mean CPUE was 9 fish/h (SE=6.9). A wide range of size classes was present and total lengths ranged 76–397 mm. In fall 2012, 42 Largemouth Bass were collected from eight sites. Relative abundance decreased, mean CPUE was 3 fish/h (SE=1.4). Lengths ranged 60–466 mm; the majority of

individuals (76%) were sub-stock length, with very few fish quality length or greater. In spring 2013, 49 Largemouth Bass were collected from eight sites. Relative abundance increased, and mean CPUE was 14 fish/h (SE=2.8). A wide range of size classes was present and total lengths ranged 74–453 mm. Stock-length individuals represented the highest proportion (41%).

Discussion

Prior to Hurricane Irene, Largemouth Bass sampled from the Chowan River drainage were growing and reproducing in a manner indicative of a healthy population (McCargo and Dockendorf 2010). In 2009, relative abundance of Largemouth Bass ≥ 200 mm was greater than the North Carolina coastal benchmark in the lower Chowan (53 fish/h; SE=10.9), middle Chowan (31 fish/h; SE=3.6), and Meherrin River (26 fish/h; SE=3.4). Overall CPUE for the Chowan River at the end of the current study period in spring 2013 was 19.6 fish/h (SE=2.3) and was below the overall CPUE in 2009 (32 fish/h; SE=3.2). The size structures of Largemouth Bass were well balanced with quality and greater fish available for capture and the number of large individuals and growth of Largemouth Bass was at or above acceptable levels. Results from the current study indicate impacts of Hurricane Irene on the Largemouth Bass population varied with regard to location within the Chowan River drainage. Reductions in relative abundance were apparent in all sections of the Chowan River drainage immediately following Hurricane Irene; however, the upper Chowan River and Meherrin River had more significant reductions in relative abundance than the middle and lower sections.

The lower Chowan River was the least impacted by Hurricane Irene. While relative abundance by the end of the study period in 2013 (34 fish/h) did not recover to pre-hurricane levels (53 fish/h; SE=10.9); it did surpass the North Carolina coastal benchmark for Largemouth Bass. In fall 2011, following Hurricane Irene, surveys in the lower Chowan River showed relative abundance was only slightly below the coastal North Carolina Largemouth Bass benchmark. There were very few sub stock-length fish in the fall 2011 collection, likely because the young-of-year fish had already reached stock-length. In spring 2012, relative abundance remained slightly below the coastal benchmark, yet was representative of a healthy population with a wide range of size classes and numerous fish of quality length and greater available for capture. In fall 2012, a spike in numbers of sub stock-length Largemouth Bass indicated a successful spawn, with numerous young-of-year fish present. By spring 2013, relative abundance was above the North Carolina coastal benchmark. The quick recovery of Largemouth Bass can be attributed to stable water quality conditions during Hurricane Irene as the larger size of the Chowan River in the lower section likely mediated the effects of increased oxygen demand following Hurricane Irene.

The middle Chowan River was moderately impacted by Hurricane Irene and relative abundance was slightly below the coastal North Carolina Largemouth Bass benchmark in spring 2013. In fall 2011, CPUE (7 fish/h) was significantly lower than in 2009 surveys (31 fish/h), and only 2 fish greater than quality length were intercepted. The presence of smaller individuals indicated that young-of-year fish were able to survive the storm surge and low dissolved oxygen conditions. In spring 2012, the Largemouth Bass population shifted toward larger individuals and by fall 2012, a wide range of sizes was present. The increase in sub stock-length Largemouth Bass was indicative of a successful spring spawn one year following the hurricane.

Although the relative abundance coastal benchmark and pre-hurricane level was not reached by spring 2013, Largemouth Bass population parameters were representative of a healthy balanced population and should naturally recover given multiple years of good and relatively stable water quality conditions.

The upper Chowan River was heavily impacted by Hurricane Irene; anoxic and hypoxic conditions were documented in the entire upper Chowan River section for an extended period of time (i.e., multiple consecutive days; NCDMF, unpublished data). The upper Chowan River was the only section in 2009 surveys that did not meet the North Carolina Largemouth Bass coastal benchmark, mean CPUE was 20 fish/h (SE=2.4). In fall 2011, only 1 Largemouth Bass was collected in 20 minutes of survey time; however, inferences regarding population parameters are limited due to insufficient sampling. Although few Largemouth Bass were collected and the majority of those collected from fall 2011 and spring 2012 were below quality length, the large number of sub stock-length Largemouth Bass in fall 2012 indicated spawning had occurred in the Upper Chowan River one year following Hurricane Irene. Largemouth Bass in the upper Chowan River likely had a high level of mortality or were displaced as a result of hypoxic and anoxic water conditions following the hurricane. Although relative abundance was well below the coastal benchmark at the end of the study period, it is likely that individuals from other sections of the Chowan River will recolonize these areas and eventually repopulate the upper Chowan River. In 2013, however, no stock-length fish were collected which indicated poor survival or recruitment of age-1 fish. Poor survival and low density of adult fish warrant stocking of juvenile Largemouth Bass or moving pre-spawn Largemouth Bass adults to the upper Chowan River to aid in recovery (Thomas and Dockendorf 2009). Future monitoring efforts should aim to survey more sites in the upper Chowan River to monitor the recovery of the Largemouth Bass population and assess the need for moving pre-spawn adults in future years.

The Meherrin River was also negatively impacted by Hurricane Irene. Immediately following Hurricane Irene, the relative abundance of Largemouth Bass in fall 2011 (3 fish/h) was significantly below the coastal North Carolina benchmark and 2009 survey results (26 fish/h; SE=3.4). In subsequent years relative abundance fluctuated. In spring 2012, length frequencies indicated a shift toward larger individuals, and the large proportion of sub stock-length fish in fall 2012 indicated a successful spawn. By spring 2013, a wide range of sizes were present and the population began looking like a healthy balanced population. Given time and good water quality conditions, it is likely the Meherrin River Largemouth Bass population will recover without the need for stockings or changes in existing regulations.

It is important to continue to monitor the Largemouth Bass population in the Chowan River watershed annually to unveil spatial trends in population recovery. Monitoring the Largemouth Bass population will lend insight into necessary management efforts needed to improve relative abundance and numbers of quality fish to reach pre-hurricane levels. Future monitoring efforts should focus on surveys in the upper Chowan River to determine the current status of Largemouth Bass population recovery. The lower and middle Chowan River still possess good numbers of quality fish that are available for capture; these fish will support recreational fishing and tournaments and likely be the foundation for the ecological enhancement of the river. Future management efforts following major hurricane events that influence fish populations should be similar to management activities following Hurricane Irene.

Management Recommendations

1. Continue to annually monitor the Largemouth Bass population in the Chowan River, particularly in the Upper Chowan, and conduct a Largemouth Bass survey in fall 2014 at fixed sites identified in the 2009 survey.

2. Following results of the fall 2014 survey, consider the need for transplanting pre-spawn adults to the Upper Chowan in spring 2015 to support natural recovery of Largemouth Bass.

3. Continue to respond to hurricane events that impact fish populations with similar management activities as conducted following Hurricane Irene.

4. Maintain current length limit (356 mm) and daily creel limit (5 Largemouth Bass per angler) for Largemouth Bass on the Chowan River.

Literature Cited

Alford, J. B., D. M. O'Keefe, and D. C. Jackson. 2009. Effects of stocking adult Largemouth Bass to enhance fisheries recovery in Pascagoula River floodplain lakes impacted by Hurricane Katrina. Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies 63:104–110.

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447–481 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques. 2nd Edition. American Fisheries Society, Bethesda, Maryland.

Avila, L. A. and J. Cangialosi. 2011. Tropical cyclone report, Hurricane Irene, 21–28 August 2011. National Oceanic and Atmospheric Administration, National Hurricane Center, Miami.

Brown, D. T., J. A. Rice, and D. D. Aday. 2014. Response of coastal Largemouth Bass to episodic hypoxia. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-100-R, Final Report, Raleigh.

Burkholder, J. M., M. A. Mallin, and H. B. Glasgow, Jr. 1999. Fish Kills, bottom-water hypoxia, and the toxic *Pfiesteria* complex in the Neuse River and estuary. Marine Ecology Progress Series 179:301–310.

Cech, J. J., C. G. Campagna, and S. J. Mitchell. 1979. Respiratory responses of Largemouth Bass (*Micropterus salmoides*) to environmental changes in temperature and dissolved oxygen. Transactions of the American Fisheries Society 108(2):166–171.

Dockendorf, K. J., C. D. Thomas, and J. W. Kornegay. 2004. Chowan River recreational angling survey, 2001–2002. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-22, Final Report, Raleigh.

Homan, J. M. and J. C. Dycus. 2013. Neuse and Trent River sport fish community recovery following Hurricane Irene. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-108, Final Report, Raleigh.

Mallin, M. A., M. H. Posey, M. R. McIver, D. C. Parsons, S. H Ensign, and T. D. Alphin. 2002. Impacts and recovery from multiple hurricanes in a piedmont-coastal plain river system. BioScience 52(11):999–1010.

McCargo, J. W., and K. J. Dockendorf. 2010. Chowan River Largemouth Bass survey 2007–2009. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-22, Final Report, Raleigh.

NCDENR (North Carolina Department of Environment and Natural Resources). 2011. North Carolina division of water quality annual report of fish kill events 2011. Division of Water Quality. Final Report, Raleigh.

NCDENR (North Carolina Department of Environment and Natural Resources). 2007. Classifications of water quality standards applicable to surface water and wetlands of North Carolina. Subchapter 2B Surface Water and Wetland Standards 15A NCAC 02B.0101.

NCDWQ (North Carolina Division of Water Quality). 2002. Basinwide assessment report: Chowan River and Pasquotank River Basins. North Carolina Division of Water Quality, Final Report, Raleigh.

Spoor, W. A. 1977. Oxygen requirements of embryos and larvae of the Largemouth Bass, *Micropterus salmoides* (Lacepede). Journal of Fish Biology 11(2):77–86.

Thomas, C. D., and K. J. Dockendorf. 2009. Contribution of stocked Largemouth Bass following hurricane-induced fish kills in two North Carolina coastal rivers. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-22, Final Report, Raleigh.

Whitmore, C. M., C. E., Warren, and P. Doudoroff. 1960. Avoidance reactions of Salmonid and Centrarchid fishes to low oxygen concentrations. Transactions of the American Fisheries Society 89(1):17–26.

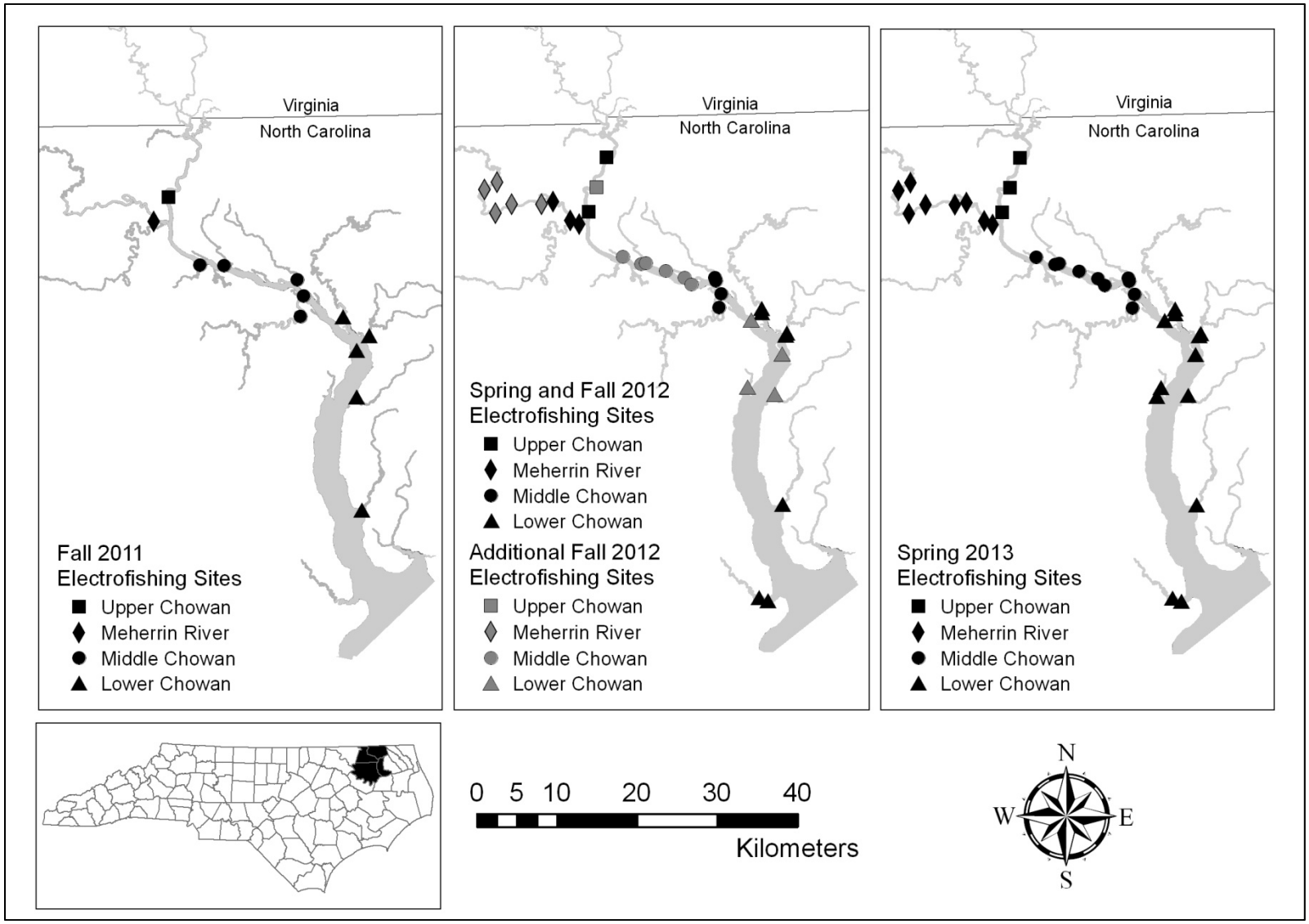

FIGURE 1.—Chowan River boat electrofishing sites in October 2011, April–May and October 2012, and April–May 2013.

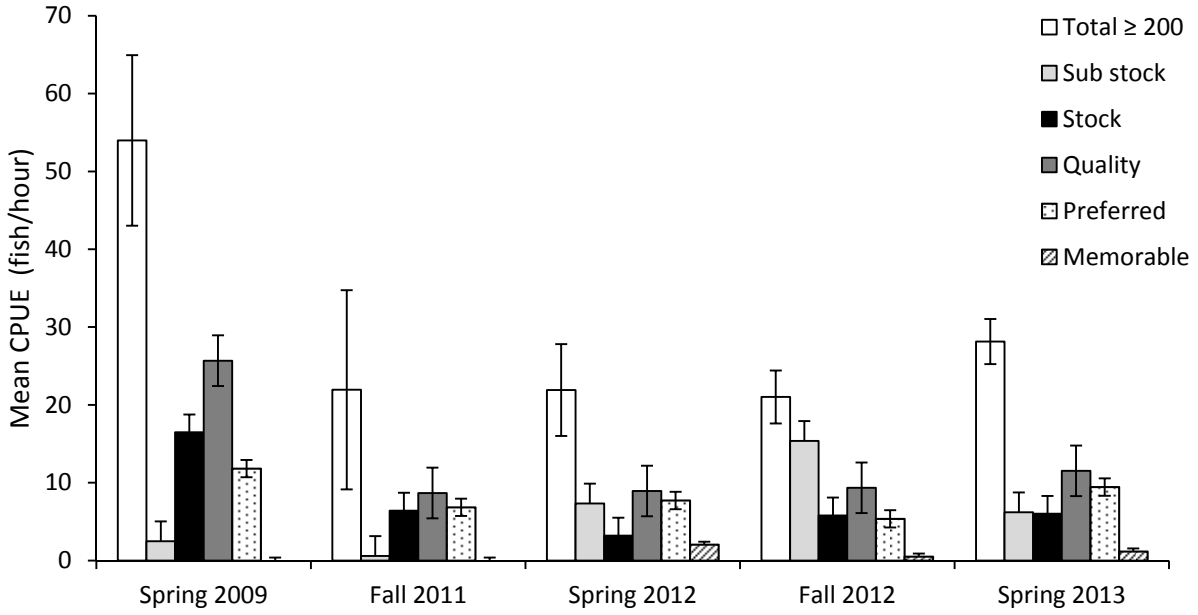

FIGURE 2.—Mean Electrofishing CPUE (fish/hour) of Largemouth Bass from selected size groups from the Lower Chowan River, 2011–2013; 2009 data obtained from McCargo and Dockendorf (2010). The North Carolina coastal river benchmark for Largemouth Bass ≥200 mm is 25 fish/h.

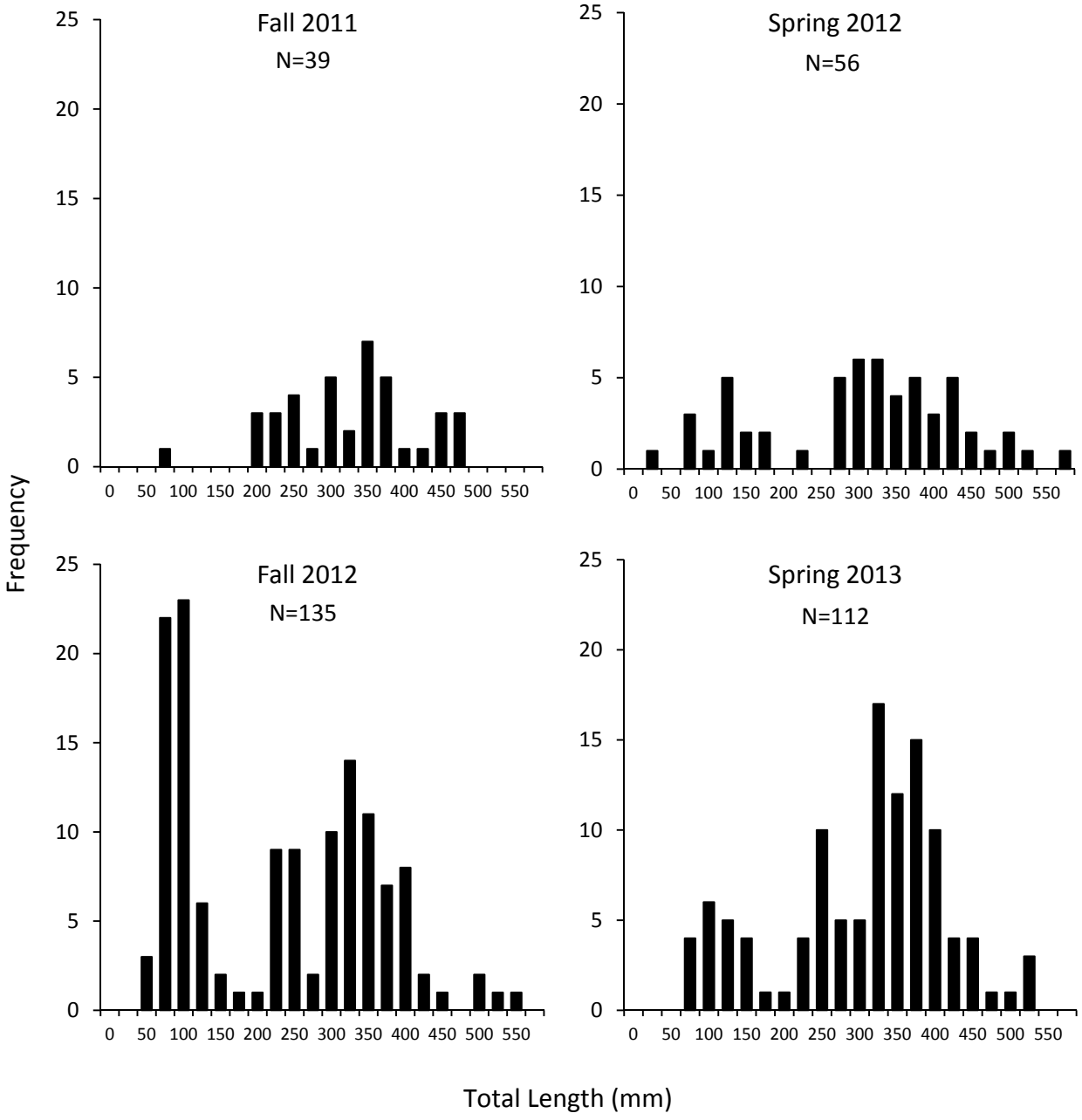

FIGURE 3.—Length frequency distribution of Largemouth Bass recorded in 25 mm length groups collected by electrofishing in the Lower Chowan River, 2011–2013.

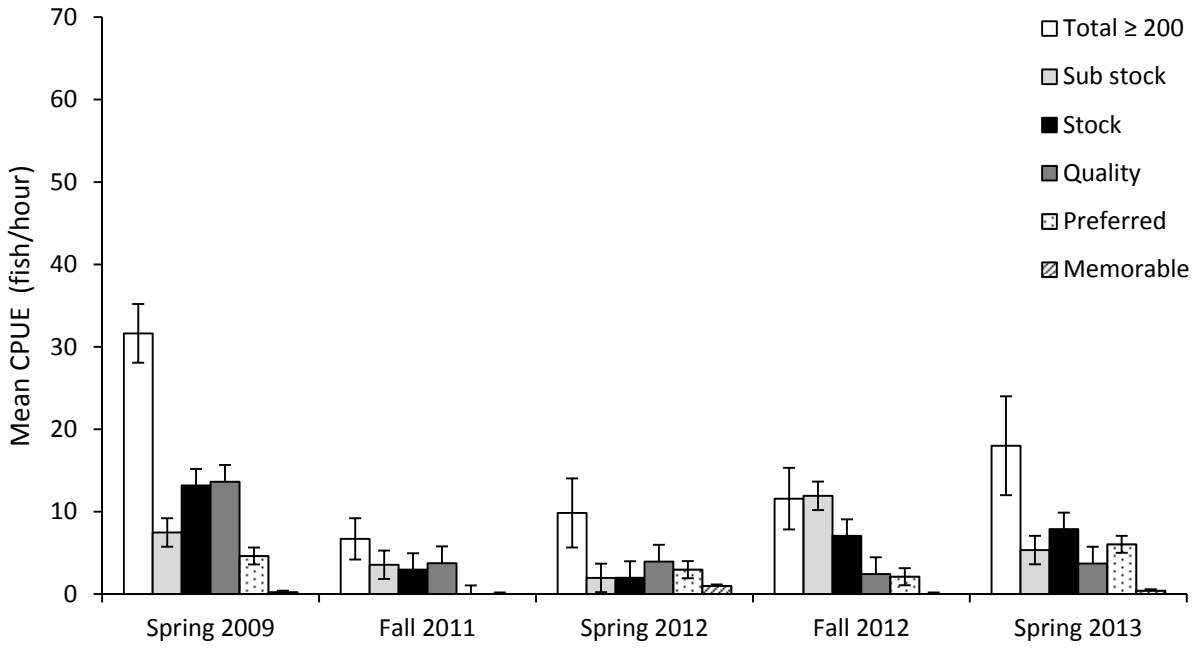

FIGURE 4.—Mean Electrofishing CPUE (fish/hour) of Largemouth Bass from selected size groups from the Middle Chowan River, 2011–2013; 2009 data obtained from McCargo and Dockendorf (2010). The North Carolina coastal river benchmark for Largemouth Bass ≥200 mm is 25 fish/h.

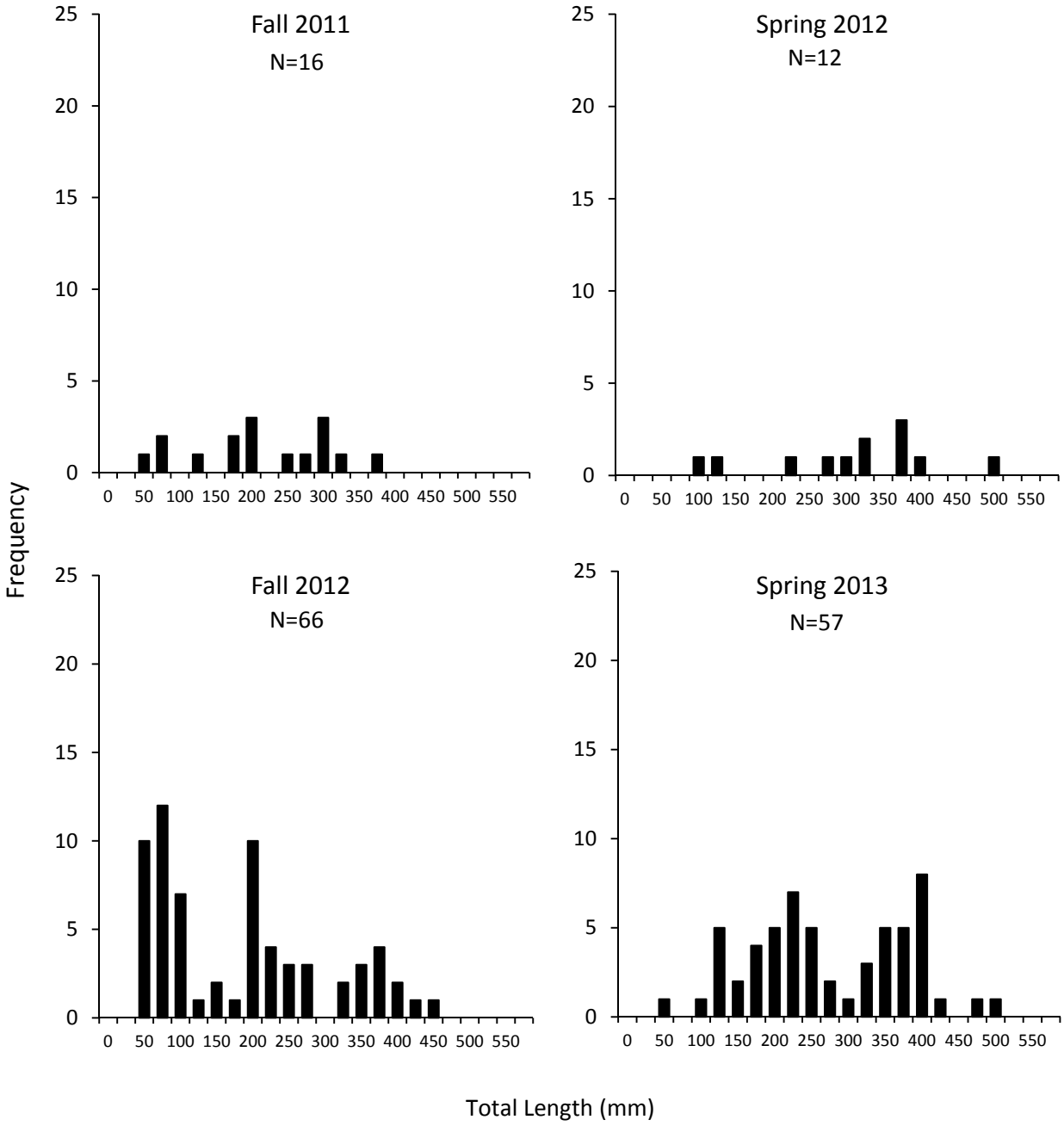

FIGURE 5.—Length frequency distribution of Largemouth Bass recorded in 25 mm length groups collected by electrofishing in the Middle Chowan River, 2011–2013.

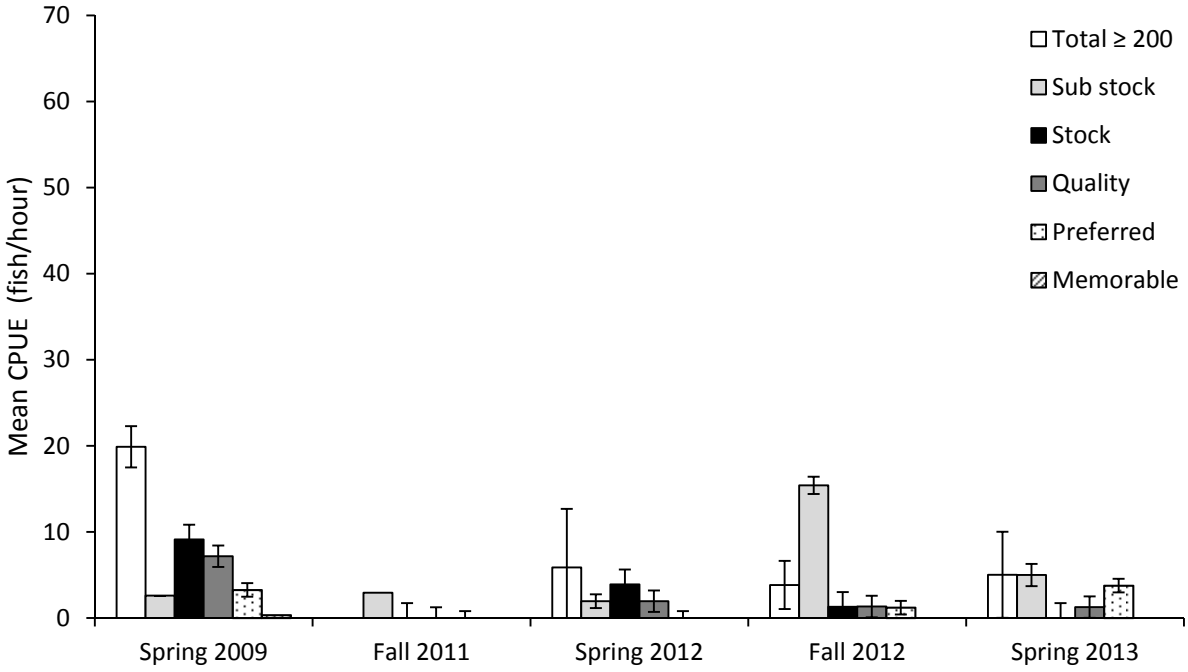

FIGURE 6.—Mean electrofishing CPUE (fish/hour) of Largemouth Bass from selected size groups from the Upper Chowan River, 2011–2013; 2009 data obtained from McCargo and Dockendorf (2010). The North Carolina coastal river benchmark for Largemouth Bass ≥200 mm is 25 fish/h.

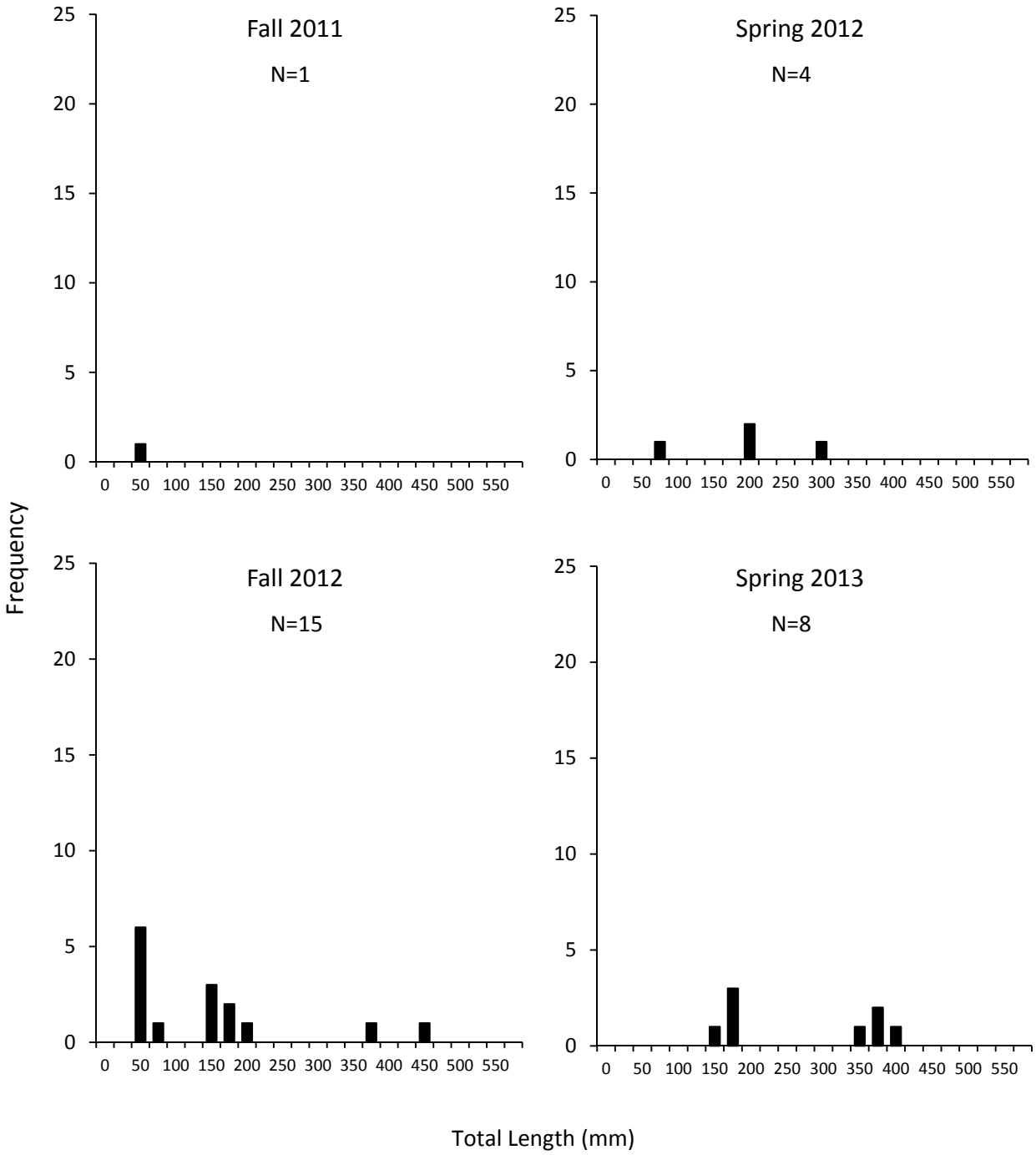

FIGURE 7.—Length frequency distribution of Largemouth Bass recorded in 25 mm length groups collected by electrofishing in the Upper Chowan River, 2011–2013.

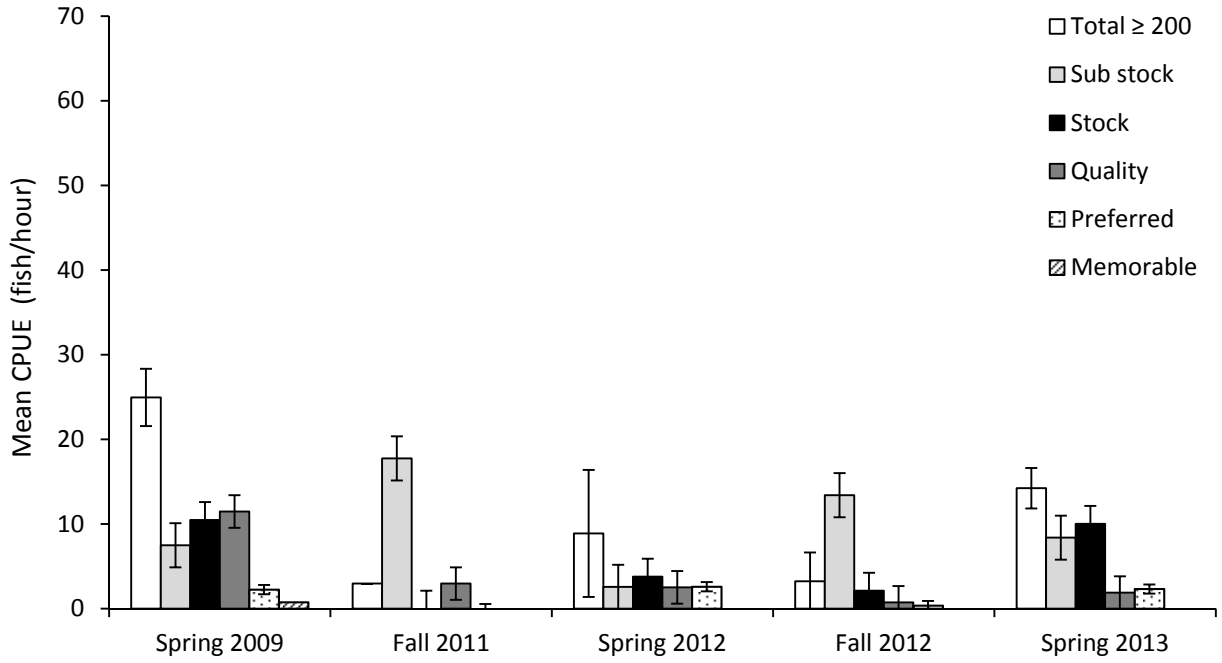

FIGURE 8.—Mean electrofishing CPUE (fish/hour) of Largemouth Bass from selected size groups from the Meherrin River, 2011–2013; 2009 data obtained from McCargo and Dockendorf (2010). The North Carolina coastal river benchmark for Largemouth Bass ≥200 mm is 25 fish/h.

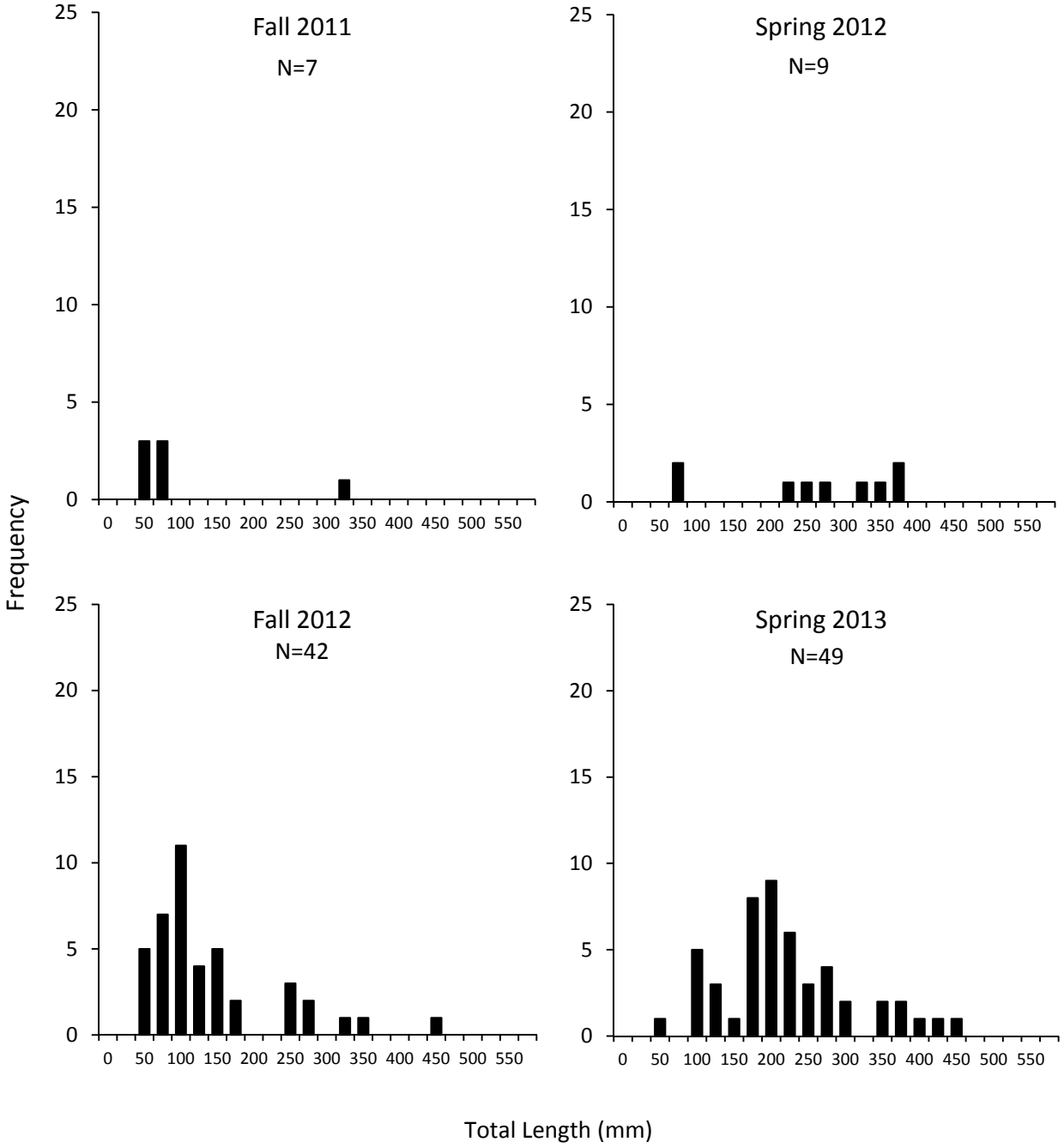

FIGURE 9.—Length frequency distribution of Largemouth Bass recorded in 25 mm length groups collected by electrofishing in the Meherrin River, 2011–2013.