SPORTFISH SURVEY OF COASTAL RIVERS IN NORTHEAST NORTH CAROLINA BEFORE AND AFTER HURRICANE IRENE

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Abstract.—On 28 August 2011 Hurricane Irene made landfall in North Carolina causing poor water quality and fish kills in coastal rivers and creeks in the Albemarle Sound drainage. The storm surge and heavy precipitation of a hurricane causes flushing of hypoxic water and organic solids from backwater habitats into creeks and rivers resulting in fish kills. Hypoxia and fish kills were observed in nearly all rivers draining into the Albemarle Sound after Hurricane Irene. Electrofishing surveys were conducted in Pasquotank River, Little River, Perquimans River, Yeopim River, and Scuppernong River during spring 2011 and 2012 to assess sportfish populations before and after Hurricane Irene. Largemouth Bass *Micropterus salmoides*, Bluegill *Lepomis macrochirus*, Pumpkinseed *L. gibbosus*, and Redear Sunfish *L. microlophus* size structure, relative abundance and condition were assessed. Mean length-at-age was calculated for Largemouth Bass collected in 2011 from four of the rivers sampled. Both Largemouth Bass and sunfish abundance and condition varied from 2011 to 2012, but not in a manner indicative of a large-scale fish kill. Despite localized fish kills following Hurricane Irene, both Largemouth Bass and sunfish populations were found to be growing and reproducing in a manner exemplifying a healthy sportfish population. The health of these fish populations can be attributed to relatively stable water conditions in years prior to Hurricane Irene in 2011 and minimal effects from Hurricane Irene associated fish kills in the Albemarle Sound region. While larger systems, such as the Chowan and Roanoke rivers, experienced extensive hypoxia and fish kills immediately after Hurricane Irene, smaller watersheds including the rivers in this study appear to be less susceptible to the introduction of hypoxic water and fish kills following hurricanes.

Introduction

The rivers and creeks that constitute the Albemarle Sound drainage are unique in North Carolina. Large coastal swamps form the head waters of these systems and saltwater intrusions are found near the mouth, making the species composition extremely varied. Some of the most popular rivers to anglers are the Pasquotank River, Little River, Perquimans River, Yeopim River, and Scuppernong River (Figure 1). Anglers on these water bodies primarily target Largemouth Bass *Micropterus salmoides,* Black Crappie *Pomoxis nigromaculatus*, and sunfish *Lepomis* spp*.*

On 28 August 2011, Hurricane Irene made landfall at Cape Lookout, NC, as a Category-1 hurricane and took a northerly path through coastal North Carolina impacting the Pamlico Sound and Albemarle Sound and their associated drainages. Hurricane Irene flooded many of the swamps and back waters with storm surge and heavy precipitation which is typical of such a storm (Bales and Walters 2004). Flushing of hypoxic water and organic solids from backwater habitats into creeks and rivers resulted in a decrease in dissolved oxygen. Low oxygen events typically impact fish communities by causing respiratory distress, displacement, or fish kills. After Hurricane Irene, fish kills and hypoxia were reported in nearly all rivers draining into the Albemarle Sound.

The objective of this survey was to compare population structure collected before and after Hurricane Irene to assess the effects of such a storm on smaller coastal rivers in the Albemarle Sound drainage. Furthermore, periodic sampling of the sportfish populations are needed to determine if current size and creel regulations are adequately protecting the fisheries and to monitor recovery where fish kills have occurred.

Methods

Largemouth Bass and sunfish were collected with boat-mounted electrofishing gear (Smith Root 7.5 GPP; 170−1000 V pulsed DC; 3–22 A) during daylight hours between 20 April and 12 May 2011 and between 29 March and 21 May 2012. The sample sites were located in the upper reaches of the rivers and tributaries and were selected based on relative proportion of available habitat. In 2011, nine sites were selected in the Pasquotank River, five sites were selected in Little River, eight sites were selected in both the Perquimans River and the Yeopim River, and six sites were selected in the Scuppernong River (Figure 1). In 2012, seven sites were selected in the Pasquotank River, five sites were selected in Little River, two sites were selected in both the Perquimans River and the Scuppernong River, and seven sites were selected in the Yeopim River (Figure 1). In 2011, sampling was conducted for 20 minutes per site, whereas sampling was conducted for 15 minutes at each site in 2012. Sites sampled in 2012 were also sampled in 2011, but not all sites sampled in 2011 were sampled in 2012. Largemouth Bass and sunfish species were netted as they were encountered, held in a livewell, measured (TL, mm) and weighed (g) upon transect completion. Sunfish were not collected from the Scuppernong River in 2011 and weights were not recorded for sunfish from the Perquimans River and the Scuppernong River in 2012 due to time constraints.

Relative abundance of Largemouth Bass and sunfish was expressed as the number of fish collected per electrofishing hour and was indexed as catch-per-unit-effort (CPUE; fish/h). Relative abundance was reported for multiple length categories. Length categories are defined for Largemouth Bass as stock-length (200−299 mm), quality length (300−379 mm), preferred-length (380−509 mm), and memorable-length (510−629 mm). For Bluegill *L. macrochirus* and Pumpkinseed *L. gibbosus* length categories are as follows: stock-length (80−149 mm), quality-length (150−199 mm), preferred-length (200−249 mm), and memorable-length (250−300 mm). For Redear Sunfish *L. microlophus* length categories are stock-length (100−179 mm), quality-length (180−299 mm), preferred-length (230−279 mm), and memorable-length (280−329 mm). Size structure of the Largemouth Bass and sunfish populations was evaluated with length frequency histograms as well as examination of proportional stock density (PSD; Anderson and Newman 1996; Guy et al. 2007). Largemouth Bass and sunfish condition was assessed with the relative weight index (W_r; Wege and Anderson 1978).

In 2011, a subsample of up to five Largemouth Bass per 25-mm group was sacrificed for age and growth analysis from the Pasquotank River, Little River, Perquimans River, and Yeopim River. Subsampled fish were identified with uniquely numbered cable ties attached around the lower jaw, placed on ice in the field, and sagittal otoliths were extracted at a later date. Otoliths were prepared and ages were assigned according to methods established in Buckmeier and Howells (2003). Age assigned was the number of annuli counted plus the edge because Largemouth Bass were collected in the spring when annulus formation was incomplete. Two independent readers counted annuli (opaque bands) from sectioned otoliths using a dissecting microscope at 7−45X magnification and reflected light. Discrepancies were rectified during a third read in concert by the same two readers. Mean length-at-age was calculated after applying a length-at-age key to the entire sample using the techniques outlined by Bettoli and Miranda (2001). Weighted catch-curve regression analysis was conducted to assess survival and year class strength (Maceina 1997).

Results

Pasquotank River

In 2011, 146 Largemouth Bass were collected from the Pasquotank River. Relative abundance of Largemouth Bass was highly variable between transects (range 0–109.5 fish/h), and mean CPUE was 46.1 fish/h (SE = 13.1; Figure 2). Largemouth Bass lengths ranged from 112 mm to 550 mm TL and the majority of the sample (55%) was smaller than the minimum length limit (356 mm TL; Figure 3). The most abundant size group was quality-length fish, which constituted 48% of the sample (Figure 4). Mean length for Largemouth Bass was 337 mm (SE = 6.4). PSD for Largemouth Bass was 77%. $PSD_{S\text{-}Q}$ and $PSD_{P\text{-}M}$ were similar at 23% and 26% while $PSD_{Q\text{-}P}$ was twice as large at 50% (Figure 4). Mean relative weight for Largemouth Bass was 87.0 (SE = 0.7) and was similar across all length categories (Stock W_r = 85.7, SE = 2.0; Quality W_r = 88.2, SE = 0.8; Preferred W_r = 88.5, SE = 1.3; and Memorable W_r = 90.9, SE = 8.3; Figure 5). Sixty-four Largemouth Bass were aged, and otolith readers had 100% agreement in assigning ages. Largemouth Bass ages ranged from 1 to10, and the majority of the sample (69%) was age 2–4 (Figure 6). The von Bertalanffy growth model was described as TL = 550 $(1 – e^{-0.196[age+1.044]})$. This model indicated that fish would reach the minimum length limit (356 mm TL) by age 4 (Figure 6). A significant weighted catch-curve regression was observed (F = 5.68; P = 0.05). This model indicated that annual survival approximated 66% and strong year classes were formed in 2004 and 2007 (Figure 7).

In 2012, 107 Largemouth Bass were collected from the Pasquotank River. Relative abundance of Largemouth Bass was highly variable between transects (range 4.0–176.5 fish/h), and mean CPUE was 60.3 fish/h (SE = 23.4; Figure 2). Largemouth Bass lengths ranged from 94 mm to 509 mm TL and 26% of the sample was of harvestable size (356 mm TL; Figure 3). Mean length for Largemouth Bass was 299 mm (SE = 8.1). The most abundant size group was stock-length fish, which constituted 42% of the sample (Figure 4). PSD for Largemouth Bass was 52%. PSD_{S-Q} was 48% while PSD_{Q-P} was 33% and PSD_{P-M} was 19% (Figure 4). Mean relative weight for Largemouth Bass was 89.0 (SE = 1.1) and was similar across all length categories (Stock W_r = 89.5, SE = 1.9; Quality W_r = 86.1, SE = 1.5; Preferred W_r = 90.1, SE = 2.0; Figure 5).

In 2011, 46 Bluegill were collected from the Pasquotank River. Relative abundance of stock-length and longer Bluegill was variable between transects (range 14.7–61.0 fish/h), and mean CPUE was 44.8 fish/h (SE = 15; Figure 8). Bluegill lengths ranged from 96 mm to 227 mm TL and the majority of the sample (76%) was between 130 mm and 200 mm TL (Figure 9). Mean length for Bluegill was 166 mm (SE = 5.1). Bluegill PSD was 61%. PSD_{S-Q}, PSD_{Q-P}, and PSD_{P-M} were similar at 39%, 37% and 34% (Figure 10). Mean relative weight for Bluegill was 94.6 (SE = 2.6), and was similar for stock- and quality-length fish (Stock W_r = 91.5, SE = 4.8; Quality W_r = 90.9, SE = 4.3); however, preferred-length Bluegill displayed a higher condition (W_r = 105.3, SE = 2.2; Figure 11).

In 2012, 98 Bluegill were collected. Relative abundance of stock-length and longer Bluegill was variable between transects (range 7.8–134.4 fish/h), and mean CPUE was 55.6 fish/h (SE = 16.2; Figure 8). Bluegill lengths ranged from 81 mm to 231 mm TL and the majority of the sample (68%) was between 110 mm and 179 mm TL (Figure 9). Mean length for Bluegill was 156 mm (SE = 3.3). Bluegill PSD was 54%. PSD_{S-Q} and PSD_{Q-P}, were similar at 47% and 42%, while PSD_{P-M} was lower at 11% (Figure 10). Mean relative weight for Bluegill was 99.7 (SE = 2.7) and was similar for stock- and quality-length fish (Stock W_r = 102.5, SE = 5.2; Quality W_r = 97.6, SE = 2.8; W_r = 96.4, SE = 4.4; Figure 11).

Twenty-eight Pumpkinseed were collected in 2011 from the Pasquotank River (Figure 11). Relative abundance of stock-length and longer Pumpkinseed was variable between transects (range 9–73 fish/h), and mean CPUE was 40.7 fish/h (SE = 31.9; Figure 12). Pumpkinseed lengths ranged 109–185 mm TL (Figure 13). Mean length for Pumpkinseed was 149 mm (SE = 4.2). Pumpkinseed PSD was 50%. PSD_{S-Q} and PSD_{Q-P} were equal at 50% (Figure 14). Mean relative weight for Pumpkinseed were high at 118.6 (SE = 5.8; Figure 15).

In 2012, 42 Pumpkinseed were collected (Figure 11). Relative abundance of stock-length and longer Pumpkinseed was variable between transects (range 0–52 fish/h), and mean CPUE was 17.0 fish/h (SE = 8.6; Figure 12). Pumpkinseed lengths ranged 62–178 mm TL (Figure 13). Mean length for Pumpkinseed was 102 mm (SE = 5.3). Pumpkinseed PSD was 20%. PSD_{S-Q} and PSD_{Q-P} were 80% and 20% (Figure 14). Mean relative weight for Pumpkinseed was 97.3 (SE = 4.9; Figure 15). In 2011 and 2012, Flier *Centrarchus macropterus*, Redear Sunfish, and Warmouth *L. gulosus* were collected from the Pasquotank River but not in sufficient numbers to warrant analysis.

Little River

In 2011, 159 Largemouth Bass were collected from Little River. Relative abundance of Largemouth Bass varied between transects (range 60.7–120.6 fish/h), and mean CPUE was 90.5 fish/h (SE = 11.3; Figure 2). Largemouth Bass lengths ranged from 97 mm to 549 mm TL and 73% of the sample was of harvestable size (356 mm TL; Figure 3). The most abundant size group was quality-length fish and constituted 39% of the sample (Figure 4). Mean length for Largemouth Bass was 327.0 mm (SE = 7.0). PSD for Largemouth Bass was 73%. $PSD_{S\text{-}Q}$ and $PSD_{P\text{-}M}$ were similar at 27% and 28% while $PSD_{Q\text{-}P}$ was higher at 44% (Figure 4). Mean relative weight for Largemouth Bass was 89.5 (SE = 0.7). Stock-length mean relative weight (W_r = 95, SE = 1.5) was higher than other length categories (Quality W_r = 87.5, SE = 1.1; Preferred W_r = 87.1, SE = 0.8; Memorable W_r = 87.4, SE = 4.9; Figure 5). Seventy-three Largemouth Bass were aged, and otolith readers had 100% agreement in assigning ages. Largemouth Bass ages ranged from 1 to 9 and the majority of the sample (65%) were ages 1 to 3 (Figure 8). The von Bertalanffy growth model was described as $TL = 549(1 - e^{-0.243[age+0.655]})$. This model indicated that Largemouth Bass would reach the minimum length limit (356 mm TL) by age 4 (Figure 6). A significant catch-curve regression was observed (F = 18.6; P = 0.008). This model indicated that annual survival was 57% with a strong cohort in 2004 and with a weak year class in 2003 (Figure 7).

In 2012, 55 Largemouth Bass were collected from Little River. Relative abundance of Largemouth Bass was highly variable between transects (range 11.6–207.6 fish/h), and mean CPUE was 41.5 fish/h (SE = 11.0; Figure 2). Largemouth Bass lengths ranged from 39 mm to 511 mm TL and 38% of the sample was of harvestable size (356 mm TL; Figure 3). Mean length for Largemouth Bass was 321 mm (SE = 13.6). The abundance of quality-length Largemouth Bass was slightly higher than stock- and preferred-length fish (Figure 4). PSD for Largemouth Bass was 72%. $PSD_{Q\text{-}P}$ was 38% while $PSD_{S\text{-}Q}$ was 28% and $PSD_{P\text{-}M}$ was 32% (Figure 4). Mean relative weight for Largemouth Bass was 94.5 (SE = 1.6). Quality- and preferred-length fish were similar while stock-length fish had higher condition (Stock W_r = 99.5, SE = 3.5; Quality W_r = 93.1, SE = 2.1; Preferred W_r = 92.0, SE = 3.1; Figure 5).

In 2011, 57 Bluegill were collected from Little River. Relative abundance of stock-length and longer Bluegill was high (range 119–263 fish/h), and mean CPUE was 231.0 fish/h (SE = 31.7; Figure 8). Bluegill lengths ranged from 64 mm to 242 mm TL (Figure 9). Mean length for Bluegill was 166 mm (SE = 5.1). Bluegill PSD was 38%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 63%, 27% and 11% (Figure 10). Mean relative weight for Bluegill was 91.4 (SE = 2.6). Stock- and quality-length fish condition was similar (Stock W_r = 89.1, SE = 2.9; Quality W_r = 89.7, SE = 5.7); however, preferred-length Bluegill displayed a higher condition (W_r = 108.8, SE = 8.0; Figure 11).

In 2012, 295 Bluegill were collected during the Little River sportfish sample. Relative abundance of stock-length and longer Bluegill was high (range 97.4–226.7 fish/h; mean CPUE 262.0 fish/h; SE = 62.0; Figure 8). Bluegill lengths ranged from 83 mm to 241 mm TL (Figure 9). Mean length for Bluegill was 155 mm (SE = 1.5). Bluegill PSD was 58%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 42%, 53% and 5% (Figure 10). Mean relative weight for Bluegill was 97 (SE = 1.5). Quality- and preferred-length fish were similar in condition (Stock W_r = 101.2, SE = 1.7; Quality W_r = 100.0, SE = 2.2); however, stock-length Bluegill displayed a slightly lower condition (W_r = 91, SE = 2.7; Figure 11).

In 2011, 49 Pumpkinseed were collected from Little River (Figure 11). Relative abundance of stock-length and longer Pumpkinseed was high (mean CPUE was 189.5 fish/h; SE = 3.5; Figure 12). Pumpkinseed lengths ranged from 109 mm to 185 mm TL (Figure 13). Mean length for Pumpkinseed was 126 mm (SE = 4.0). Pumpkinseed PSD was 23%. $PSD_{S\text{-}Q}$ and $PSD_{Q\text{-}P}$ were 77% and 23% (Figure 14). Mean relative weight for Pumpkinseed was 97.3 (SE = 2.2; Figure 15).

In 2012, 159 Pumpkinseed were collected from Little River during the 2012 sample (Figure 11). Relative abundance of stock-length and longer Pumpkinseed was highly variable (range 22.5−259.1 fish/h) and mean CPUE was 113.3 fish/h (SE = 44.5; Figure 12). Pumpkinseed lengths ranged from 54 mm to 180 mm TL (Figure 13). Mean length for Pumpkinseed was 126 mm (SE = 2.3). Pumpkinseed PSD was 25%. $PSD_{S\text{-}Q}$ and $PSD_{Q\text{-}P}$ were 75% and 25% (Figure 14). Mean relative weight for Pumpkinseed was 98.1 (SE = 2.6; Figure 15).

In 2011 and 2012 Black Crappie, Redear Sunfish, and Warmouth were collected but not in sufficient numbers to warrant analysis.

Perquimans River

In 2011, 136 Largemouth Bass were collected from the Perquimans River. Relative abundance of Largemouth Bass was variable between transects (range 20.2–82.2 fish/h), and mean CPUE was 50.4 fish/h (SE = 9.2; Figure 2). Largemouth Bass lengths ranged from 114 mm to 536 mm TL and 39% of the sample was smaller than the minimum length limit (356 mm TL; Figure 3). The most abundant size group was quality-length fish and constituted 34% of the sample (Figure 4). Mean length for Largemouth Bass was 290 mm (SE = 8.5). PSD for Largemouth Bass was 64%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, $PSD_{P\text{-}M}$, and $PSD_{M\text{-}T}$ were 36%, 43%, 18% and 3% (Figure 4). Mean relative weight for Largemouth Bass was 90.8 (SE = 1.43). Stock-length mean relative weight (W_r = 98.9, SE = 3.4) was similar to memorable-length mean relative weight (W_r = 96.6, SE = 3.7), while quality-length mean relative weight (W_r = 85.5, SE = 1.0) was similar to preferred-length mean relative weight (W_r = 85.5, SE = 1.2; Figure 5). Seventy-three Largemouth Bass were aged, and otolith readers had 100% agreement in assigning ages. Largemouth Bass ages ranged from 1 to 10 and the majority of the sample (88%) were ages 1 to 4 (Figure 8). The von Bertalanffy growth model was described as $TL = 536(1 - e^{-0.244[age+0.597]})$. This model indicated that Largemouth bass in Little River would reach the minimum length limit (356 mm TL) by age 4 (Figure 6). A significant catch-curve regression was observed (F = 8.0; P = 0.02). This model indicated that annual survival was 66% and strong year classes occurred in 2004 and 2007 (Figure 7).

In 2012, 45 Largemouth Bass were collected from the Perquimans River. Relative abundance of Largemouth Bass was variable between transects (range 70.1–96.7 fish/h), and mean CPUE was 83.4 fish/h (SE = 13.3; Figure 2). Largemouth Bass lengths ranged from 127 mm to 475 mm TL, and 33% of the sample was of harvestable size (356 mm TL; Figure 3). Mean length for Largemouth Bass was 316 mm (SE = 23.4). Relative abundance was similar across stock-, quality-, and preferred-length fish (Figure 4). PSD for Largemouth Bass was 68%. $PSD_{S\text{-}Q}$ was 33% while $PSD_{Q\text{-}P}$ was

35% and $PSD_{P\text{-}M}$ was 33% (Figure 4). Mean relative weight for Largemouth Bass was 87.3 (SE = 1.6). Stock-, quality- and preferred-length fish had similar condition (Stock W_r = 89.3, SE = 2.9; Quality W_r = 86.2, SE = 2.8; Preferred W_r = 87.3, SE = 2.5; Figure 5).

In 2011, 31 Bluegill were collected from the Perquimans River. Relative abundance of stock-length and longer Bluegill was variable (range 29.9–119 fish/h), and mean CPUE was 74.4 fish/h (SE = 44.6; Figure 8). Bluegill lengths ranged 50–208 mm TL (Figure 9). Mean length for Bluegill was 150 mm (SE = 6.6). Bluegill PSD was 57%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 43%, 50% and 7% (Figure 10). Mean relative weight for all Bluegill was high (Wr = 124.2; SE = 6.1) as were condition for stock-length (Wr = 140.2; SE = 10.9) and quality-length (Wr = 102.2; SE = 3.3) fish (Figure 11).

In 2012, 39 Bluegill were collected from one site in the Perquimans River. Relative abundance of stock-length and longer Bluegill was 163.6 fish/h (Figure 8). Bluegill lengths ranged from 76 mm to 210 mm TL (Figure 9). Mean length for Bluegill was 150 mm (SE = 5.3). Bluegill PSD was 51%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 49%, 41% and 10% (Figure 10). Weights were not recorded in 2012.

Twenty-four Pumpkinseed were collected from the Perquimans River in 2011 (Figure 11). Relative abundance of stock-length and longer Pumpkinseed was variable (range 17.9−107.9 fish/h; mean CPUE was 62.5 fish/h; SE = 44.6; Figure 12). Pumpkinseed lengths ranged 120–159 mm TL (Figure 13). Mean length for Pumpkinseed was 135 mm (SE = 2.7). Pumpkinseed PSD was 21%. $PSD_{S\text{-}Q}$ and $PSD_{Q\text{-}P}$ were 79% and 21% (Figure 14). Mean relative weight for Pumpkinseed was 141.4 (SE = 3.2; Figure 15).

In 2012, 38 Pumpkinseed were collected (Figure 11). Mean relative abundance of stock-length and longer Pumpkinseed was 126.4 fish/h Figure 12). Pumpkinseed lengths ranged from 70 mm to 195 mm TL (Figure 13). Mean length for Pumpkinseed was 128 mm (SE = 5.0). Pumpkinseed PSD was 29%. $PSD_{S\text{-}Q}$ and $PSD_{Q\text{-}P}$ were 71% and 29% (Figure 14). Weights were not recorded in 2012.

In 2011 and 2012 Redear Sunfish and Warmouth were also collected but not in sufficient abundances to warrant analysis.

Yeopim River

In 2011, 162 Largemouth Bass were collected and relative abundance Largemouth Bass was variable between transects (range 35.0–93.8 fish/h), and mean CPUE was 58.5 fish/h (SE = 6.3; Figure 2). Largemouth Bass lengths ranged from 102 mm to 498 mm TL and 67% of the sample was smaller than the minimum length limit (356 mm TL; Figure 3). The most abundant size group was quality-length fish and constituted 40% of the sample (Figure 4). Mean length for Largemouth Bass was 318 mm (SE = 6). PSD for Largemouth Bass was 63%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$, were 37%, 43%, and 19% (Figure 4). Mean relative weight for Largemouth Bass was 89.9 (SE = 0.8). Stock-length mean relative weight (W_r = 92.8, SE = 1.8) was higher than quality-length and preferred-length mean relative weights which were similar (Quality W_r = 84.4, SE = 0.8; Preferred W_r = 89.9, SE = 1.4; Figure 5). Sixty-six Largemouth Bass were aged, and otolith readers had 100% agreement in assigning ages. Largemouth Bass ages ranged from 1 to 9 and the majority of the sample (85%) was ages 2 to 5 (Figure 8). The von

Bertalanffy growth model was described as TL = 498(1 – $e^{-0.262[age+0.8]}$). This model indicated that Largemouth Bass would reach the minimum length limit (356 mm TL) by age 4 (Figure 6). A significant catch-curve regression was observed (F = 23.4; P = 0.005). This model indicated that annual survival was 59% with recruitment variable in 2004 and 2005 (Figure 7).

In 2012, 110 Largemouth Bass were collected from the Perquimans River; relative abundance was variable between transects (range 20–94.9 fish/h) and mean CPUE was 61.5 fish/h (SE = 10.0; Figure 2). Largemouth Bass lengths ranged from 118 mm to 548 mm TL and 25.5% of the sample was of harvestable size (356 mm TL; Figure 3). Mean length for Largemouth Bass was 312 mm (SE = 8.4). The abundance was highest for quality-length Largemouth Bass and stock- and preferred-length abundances were similar (Figure 4). PSD for Largemouth Bass was 67%. $PSD_{S\text{-}Q}$ was 33% while $PSD_{Q\text{-}P}$ was 40%, $PSD_{P\text{-}M}$ was 26%, and $PSD_{M\text{-}T}$ was 1% (Figure 4). Mean relative weight for Largemouth Bass was 87.4 (SE = 0.8). Stock-, quality- and preferred-length fish had similar condition (Stock W_r = 86.5, SE = 1.3; Quality W_r = 88.1, SE = 1.4; Preferred W_r = 87.1, SE = 1.3; Figure 5).

In 2011, 38 Bluegill were collected from the Perquimans River. Relative abundance of stock-length and longer Bluegill was consistent between sites (range 70.2–78.8 fish/h), and mean CPUE was 74.5 fish/h (SE = 4.3; Figure 8). Bluegill lengths ranged from 102 mm to 224 mm TL (Figure 9). Mean length for Bluegill was 175 mm (SE = 4.4). Bluegill PSD was 79%; $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 21%, 68% and 11% (Figure 10). Mean relative weight for all Bluegill was 95.1 (SE = 1.7). Condition was similar for all length categories (Stock W_r = 91.5, SE = 5.8; Quality W_r = 96.8, SE = 1.6; Preferred W_r = 90.9, SE = 3.5; Figure 11).

In 2012, 111 Bluegill were collected during the Yeopim River sportfish survey. Relative abundance of stock-length and longer Bluegill varied between sites (range 80.0–201.6 fish/h), and mean CPUE was 144.1 fish/h (SE = 35.2; Figure 8). Bluegill lengths ranged from 57 mm to 230 mm TL (Figure 9). Mean length for Bluegill was 153.0 mm (SE = 3.3). Bluegill PSD was 50%; $PSDS_{\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 50%, 36% and 14% (Figure 10). Mean relative weight for all Bluegill was 99.1 (SE = 2.6) and condition was similar for all length categories (Stock W_r = 102.8, SE = 5.7; Quality W_r = 96.7, SE = 2.6; Preferred W_r = 95.7, SE = 2.3; Figure 11).

In the 2011 Yeopim River sportfish samples, 27 Pumpkinseed were collected (Figure 11). Mean Relative abundance of stock-length and longer Pumpkinseed was 49 fish/h (SE = 9.6; Figure 12). Pumpkinseed lengths ranged from 96 mm to 202 mm TL (Figure 13). Mean length for Pumpkinseed was 146 mm (SE = 4.9). Pumpkinseed PSD was 56%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 44%, 52%, and 4% (Figure 14). Mean relative weight for Pumpkinseed was at 94.1 (SE = 3.5; Figure 15).

One hundred and fifty-one Pumpkinseed were collected during the 2012 Yeopim River sportfish sample (Figure 11). Relative abundance of stock-length and longer Pumpkinseed varied between sites (range 28–383.4 fish/h), and mean CPUE was 195.0 fish/h (SE = 103.1; Figure 12). Pumpkinseed lengths ranged from 75 mm to 216 mm TL (Figure 13). Mean length for Pumpkinseed was 137 mm (SE = 1.9). Pumpkinseed PSD was 31%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 69%, 30%, and 1% (Figure 14). Mean relative weight for Pumpkinseed was 105.9 (SE = 2.2; Figure 15).

Forty-three Redear Sunfish were collected during the 2011 Yeopim River sportfish survey. Relative abundance of stock-length and longer Redear Sunfish was high (mean CPUE was 94.8 fish/h; SE = 62.7; Figure 16). Redear Sunfish lengths ranged from 83 mm to 265 mm TL (Figure 17). Mean length for Redear Sunfish was 177 mm (SE = 6.2). Redear Sunfish PSD was 56%; $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 44%, 51%, and 5% (Figure 18). Mean relative weight for Redear was at 85.3 (SE = 1.6; Figure 19).

In 2012, 28 Redear Sunfish were collected from Yeopim River. Relative abundance of stock-length and longer Redear Sunfish was 33.0 fish/h (SE = 10.6; Figure 16). Redear Sunfish lengths ranged from 71 mm to 247 mm TL (Figure 17). Mean length for Redear Sunfish was 179 mm (SE = 9.0). Redear Sunfish PSD was 83%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 17%, 71%, and 13% (Figure 18). Mean relative weight for Redear Sunfish was at 87.2 (SE = 4.9; Figure 19).

In 2011 and 2012 Black Crappie, Redbreast Sunfish, and Warmouth were also collected but not in sufficient numbers to warrant analysis.

Scuppernong River

In 2011, 82 Largemouth Bass were collected from the Scuppernong River. Relative abundance of Largemouth Bass was variable between transects (range 23.8–59.5 fish/h), and mean CPUE was 40.2 fish/h (SE = 6.0; Figure 2). Largemouth Bass lengths ranged from 110 mm to 535 mm TL and 55% of the sample was smaller than the minimum length limit (356 mm TL; Figure 3). Preferred- and quality-length fish were the most abundant and constituted 60% of the Largemouth Bass sample (Figure 4). Mean length for Largemouth Bass was 325.0 mm (SE = 11.8). PSD for Largemouth Bass was 74%. $PSD_{S\text{-}Q}$ was 26%, $PSD_{Q\text{-}P}$ and $PSD_{P\text{-}M}$ were similar at 36% and 35%, and $PSD_{M\text{-}T}$ was 3% (Figure 4). Mean relative weight for Largemouth Bass was 91 (SE = 1.2). Condition was lowest for quality-length fish (W_r = 88, SE = 2.5) and similar for all other length groups (Stock W_r = 95, SE = 2.0; Preferred W_r = 91, SE = 1.6; Memorable W_r = 93, SE = 4.4; Figure 5). Largemouth Bass age and sunfish data was not collected from the Scuppernong River in 2011.

In 2012, 16 Largemouth Bass were collected during the Scuppernong River Sample. Relative abundance of Largemouth Bass was variable between transects (range 25.6–33.6 fish/h), and mean CPUE was 29.6 fish/h (SE = 4.0; Figure 2). Largemouth Bass lengths ranged from 298 mm to 498 mm TL and 75.0% of the sample was of harvestable size (356 mm TL; Figure 3). Mean length for Largemouth Bass was 396.0 mm (SE = 14.3). Preferred-length Largemouth Bass were most abundant followed by quality- and stock-length fish (Figure 4). PSD for Largemouth Bass was 94%. $PSD_{S\text{-}Q}$ was 6% while $PSD_{Q\text{-}P}$ was 38% and $PSD_{P\text{-}M}$ was 56% (Figure 4). Mean relative weight for Largemouth Bass was 86.7 (SE = 1.5). Stock-, quality- and preferred-length fish exhibited similar condition (Stock W_r = 86.7; SE = z.z; Quality W_r = 86.1, SE = 2.4; Preferred W_r = 85.9, SE = 2.1; Figure 5).

Sunfish were not collected from the Scuppernong River in 2011; however in 2012, 30 Bluegill were collected during sportfish sampling. Relative abundance of stock-length and longer Bluegill was consistent between the two sunfish sites (range 56.0–58.6 fish/h), and mean CPUE was 57.3 fish/h (SE = 1.3; Figure 8). Bluegill lengths ranged from 127 mm to 226 mm TL (Figure 9). Mean length for Bluegill was 180 mm (SE = 4.3).

Bluegill PSD was 97%. $PSD_{S\text{-}Q}$, $PSD_{Q\text{-}P}$, and $PSD_{P\text{-}M}$ were 3%, 77% and 19% (Figure 10). Weights were not recorded for sunfish in 2012.

The 2012 Scuppernong River sportfish sample yielded 26 Pumpkinseed (Figure 11). Relative abundance of stock-length and longer Pumpkinseed was variable (range 14.7–82.1 fish/h), and mean CPUE was 48.4 fish/h (SE = 33.7; Figure 12). Pumpkinseed lengths ranged from 132 mm to 180 mm TL (Figure 13). Mean length for Pumpkinseed was 164 mm (SE = 2.2). Pumpkinseed PSD was 92%. $PSD_{S\text{-}Q}$ and $PSD_{Q\text{-}P}$ were 8% and 92% (Figure 14).

Discussion

Prior to Hurricane Irene, Largemouth Bass sampled from Albemarle Sound tributaries were growing and reproducing in a manner indicative of healthy populations. Relative abundances for all systems sampled were greater than the coastal North Carolina Largemouth Bass benchmark (25 fish/h) with Little River being the highest at 90.5 fish/h. The size structures of the bass populations were well balanced with quality-length fish being the dominant size group. Growth of Largemouth Bass was similar for all systems with fish reaching harvestable size by age 4. Condition of Largemouth Bass throughout the survey area was at acceptable levels indicating an adequate forage base. Survival of Largemouth Bass varied from 57% to 66%, which is adequate for sustainable Largemouth Bass populations. A strong or above average year class occurred in 2004 for all systems based on available otolith ages.

Results from this study indicate minimal impacts of Hurricane Irene on the Largemouth Bass populations within the study area. Reductions in abundance following Hurricane Irene were apparent in the Pasquotank and Little rivers; however, post-hurricane abundance remained higher than the management target (25 fish/h) for coastal North Carolina rivers. Condition of Largemouth Bass increased in Little River in 2012 in response to a 46% reduction in abundance. Conversely to Little River, the Perquimans River displayed a 60% increase in Largemouth Bass abundance, with all size classes of Largemouth Bass increasing in abundance following Hurricane Irene. Total abundance in Yeopim River remained similar before and after Hurricane Irene, but a 2.8 fold reduction in stock-length Largemouth Bass abundance was observed in 2012. Minor fish kills were reported in the Scuppernong River and may have influenced the 1.5 fold reduction in abundance; however, this decrease was observed only in stock-length fish and smaller. Age structure and growth rates of Largemouth Bass in all systems were considered stable both sample years with recruitment to harvestable size occurring by age 4. Despite localized fish kills and some reductions in abundance after Hurricane Irene, Largemouth Bass populations in northeastern North Carolina coastal rivers remained healthy in 2012.

Before Hurricane Irene, Bluegill relative abundances were adequate for all systems sampled with Little River abundances being extremely high (231 fish/h). Preferred-length Bluegill were relatively abundant and relative weights indicated fish were in good condition. Comparison of Bluegill population metrics indicated that the populations were healthy before and after the hurricane. Similar to the Largemouth Bass populations, Bluegill populations in the Albemarle Sound region showed few signs of hurricane-related fish kills in the 2012 sample. Bluegill abundance increased for all rivers sampled with the exception of Little River, where Bluegill abundance maintained a high but similar abundance from 2011 to 2012. Condition of Bluegill in 2011 and 2012 varied slightly but maintained acceptable levels for a healthy population.

Pumpkinseed and Redear Sunfish angling opportunities will remain secondary to the Bluegill fishery in the Albemarle Sound drainage because of their lower abundances. Population levels are variable among systems; however anglers should expect to see quality-length fish in those fisheries. Pumpkinseed abundances in the Albemarle Sound region appear to be increasing with the exception of Little River which had a slight decrease in abundance. Redear Sunfish abundance decreased by 35% in the Yeopim River. Despite relatively low abundance when compared to Bluegill, Pumpkinseed and Redear Sunfish appear to be doing well in their niche as evidenced by their satisfactory condition. Similar to the Bluegill populations, there seemed to be few negative effects on Pumpkinseed or Redear Sunfish populations due to fish kills cause by Hurricane Irene in 2011.

In general, sportfish populations in the Pasquotank, Perquimans, Little, Yeopim and Scuppernong rivers had benefited from relatively stable environmental conditions for a period of years (2004−2010) prior to Hurricane Irene. Impacts related to Hurricane Irene appeared to be minimal in these smaller rivers within the Albemarle Sound region. Sportfish populations are continuing to grow and reproduce in a manner indicative of healthy populations despite localized fish kills following Hurricane Irene. Fish kills in coastal Albemarle Sound tributaries occurred mainly in the headwaters and upstream areas, but fish appeared to have quickly recolonized these areas from downstream where populations were likely less affected. Minimal hurricane impacts can likely be attributed to the fairly small watershed of these rivers, which limits the amount of hypoxic water draining from backwater swamps after a large rain event and subsequent. Furthermore, the oxygenated waters of the Albemarle Sound assists with dilution of hypoxic waters and often limits fish kills to the upper reaches of these smaller coastal rivers.

Management Recommendations

1. Maintain the current 356 mm minimum length limit and five fish daily creel limit for Largemouth Bass and 30 fish creel limit for sunfish with no more than 12 Redbreast Sunfish.

2. Continue to monitor sportfish abundance and growth rates in Albemarle Sound tributaries by surveying sportfish populations in 2014.

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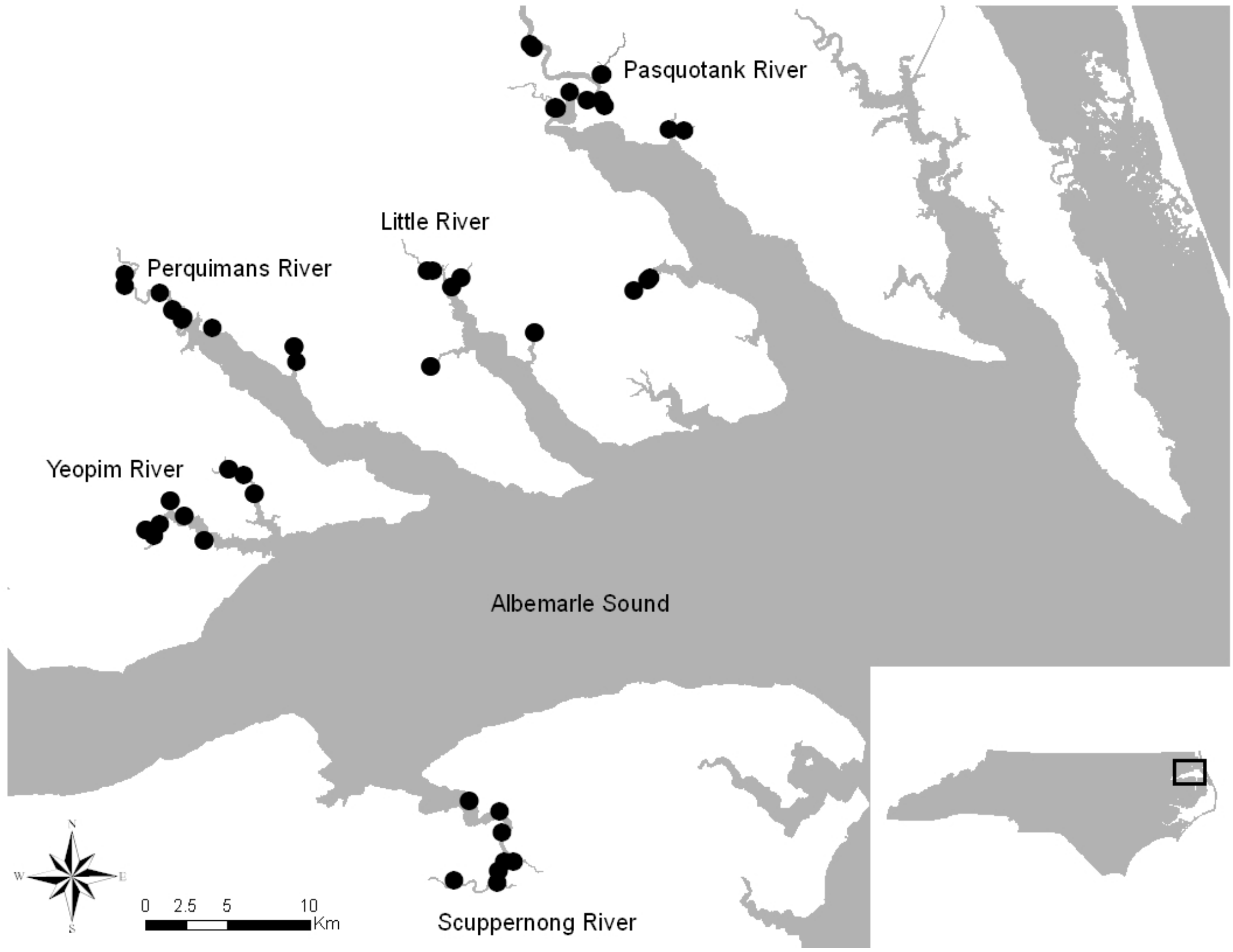

FIGURE 1.—Electrofishing site locations for the 2011−2012 northeast coastal rivers sportfish survey.

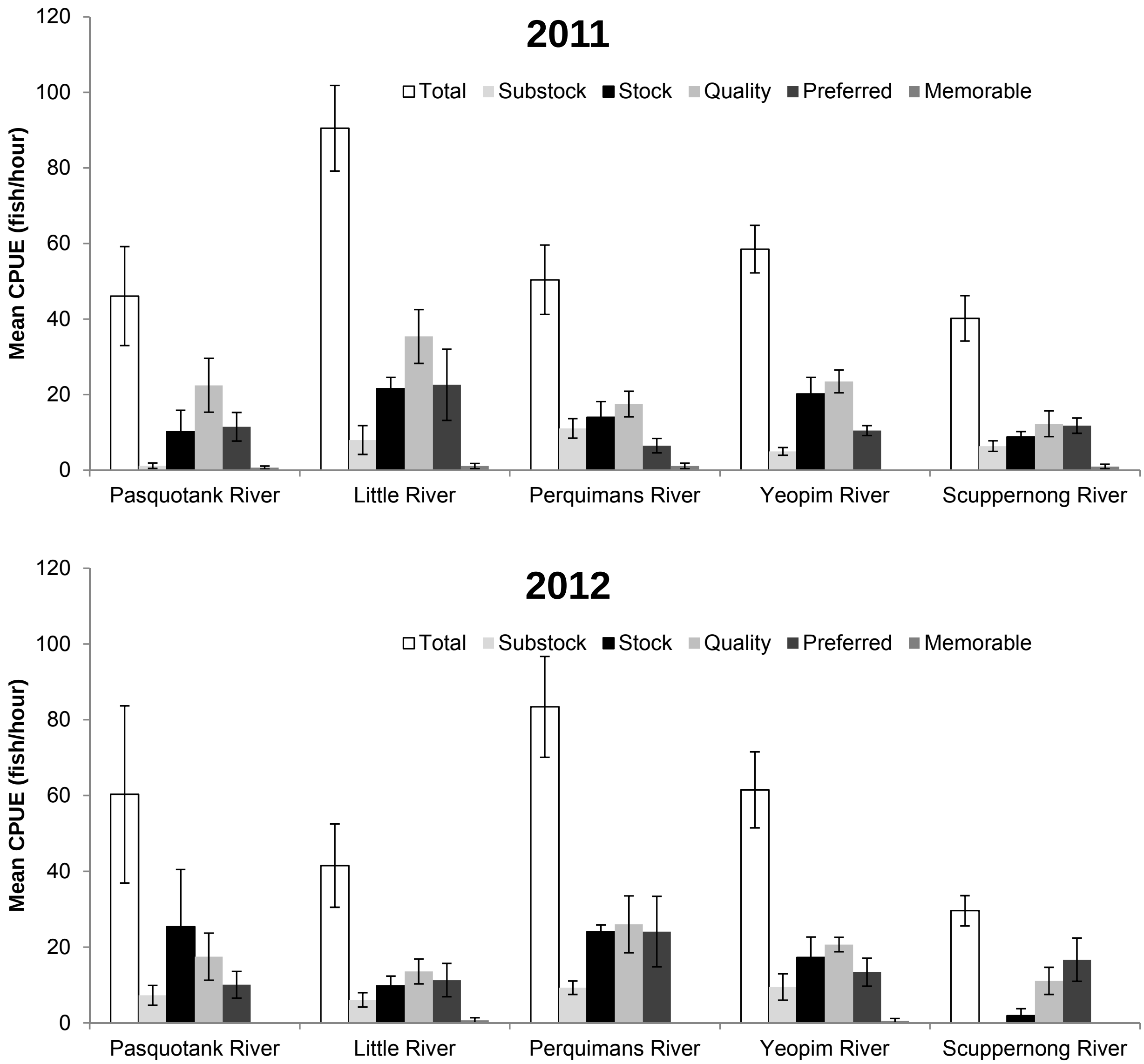

FIGURE 2.—Mean catch per unit effort (CPUE) for Largemouth Bass by river and PSD increments collected during the 2011−2012 northeast coastal rivers sportfish survey. Error bars represent one standard error.

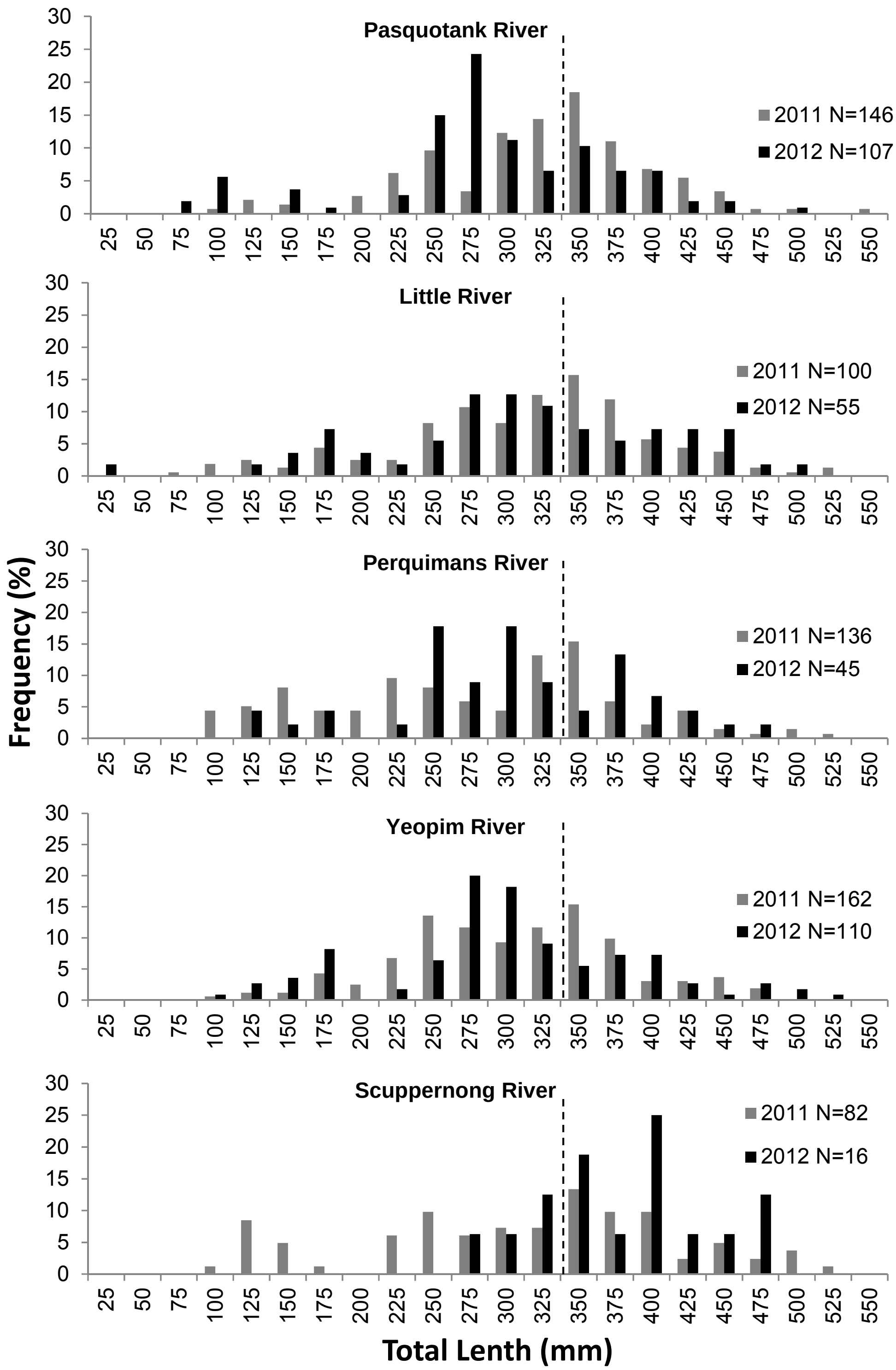

FIGURE 3.—Length distribution by river for Largemouth Bass collected during the 2011−2012 northeast coastal rivers sportfish survey. The dotted line represents the minimum length limit for Largemouth Bass.

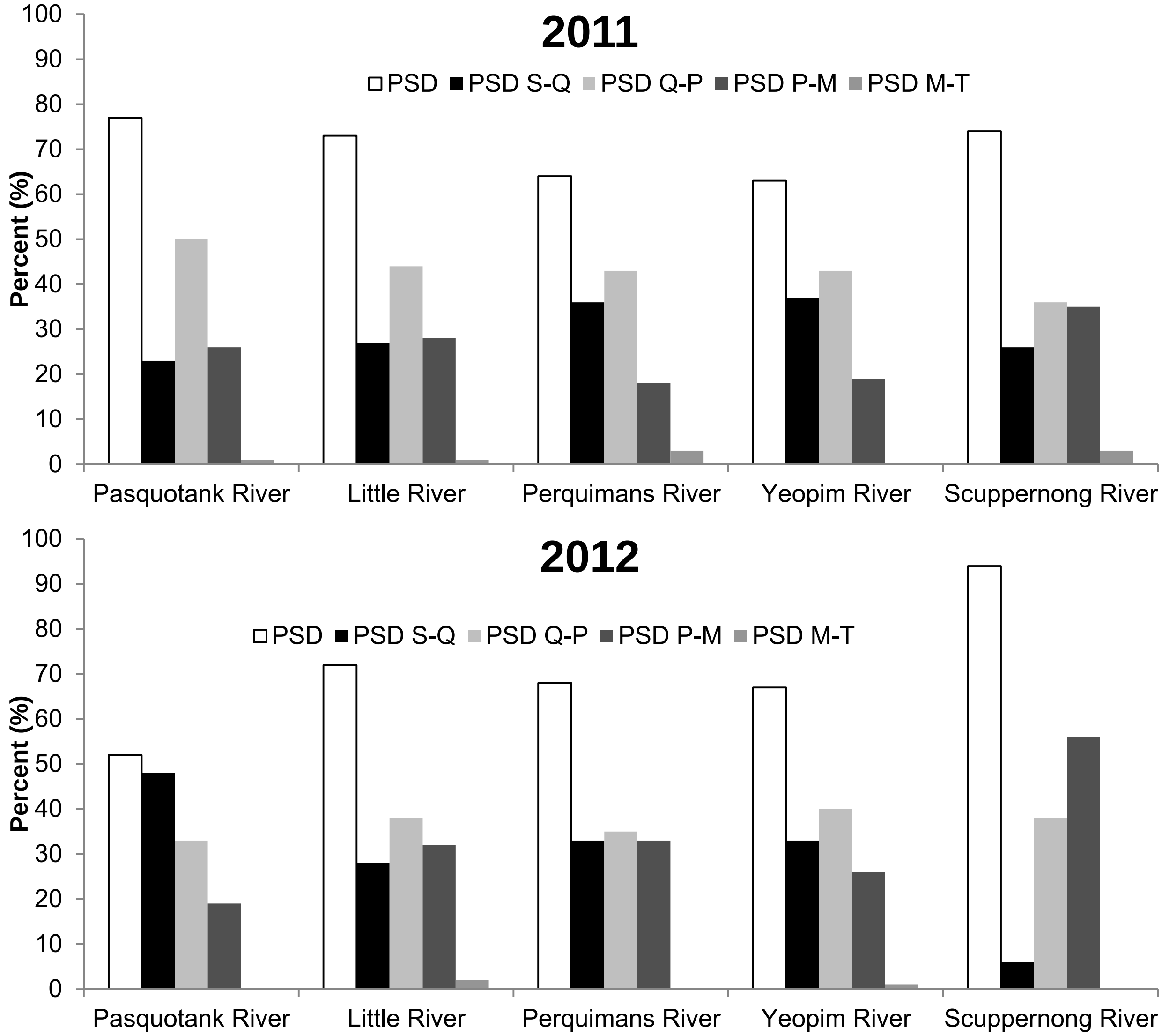

FIGURE 4.—PSD values for Largemouth Bass by river collected during the 2011−2012 northeast coastal rivers sportfish survey.

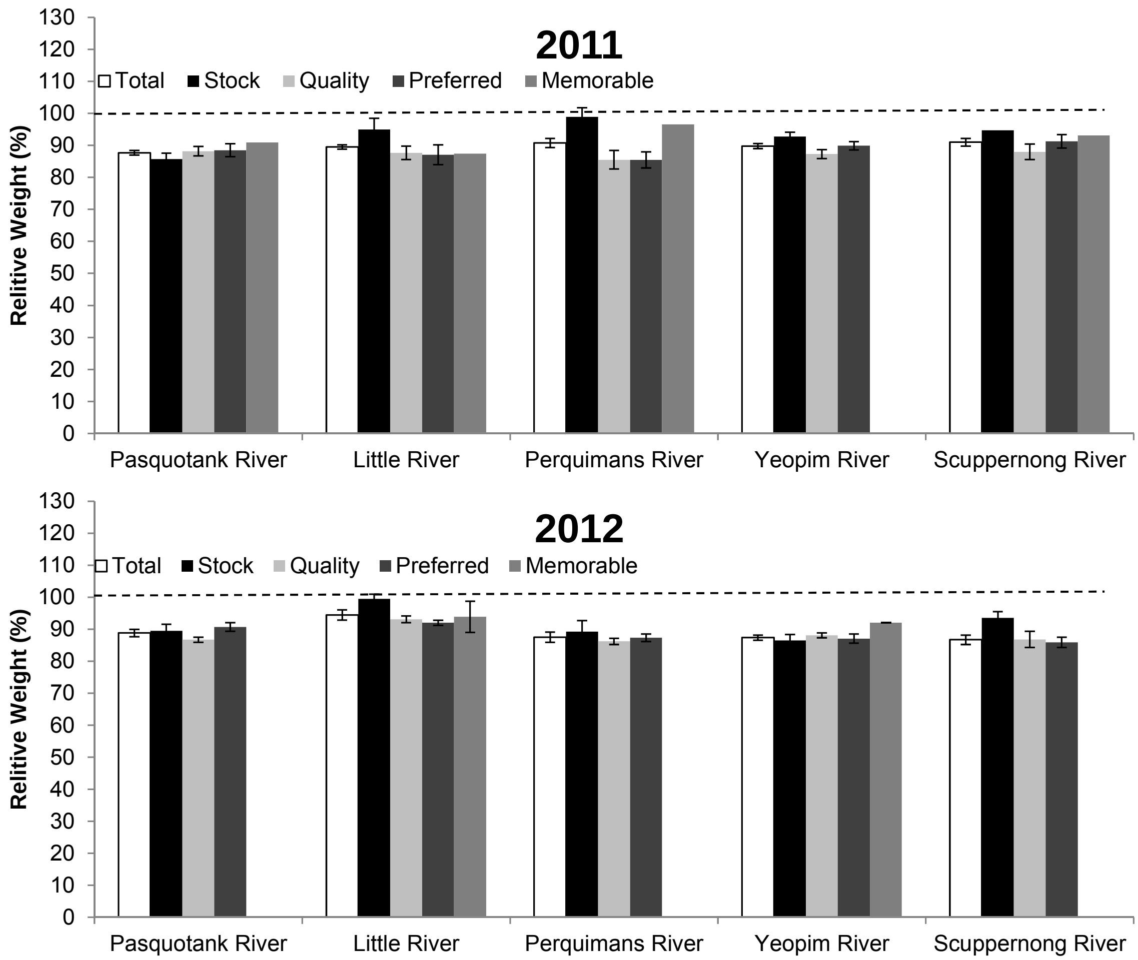

FIGURE 5.—Mean relative weight by PSD length category and river for Largemouth Bass collected during the 2011-2012 northeast coastal rivers sportfish survey. Error bars represent one standard error where more than one fish was collected.

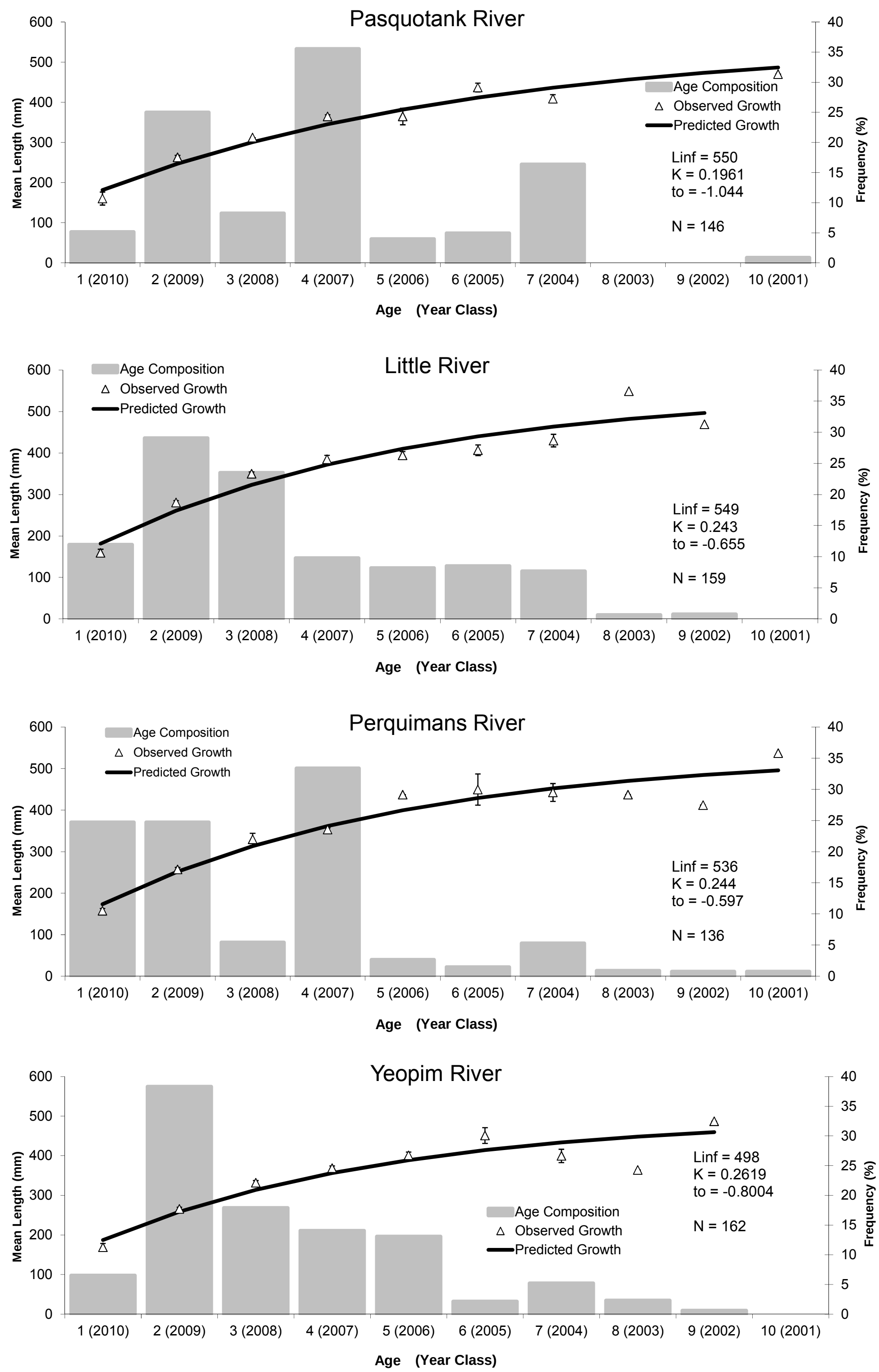

FIGURE 6.—Age distribution by river for Largemouth Bass collected during the 2011 northeast coastal rivers sportfish survey. Error bars represent one standard error. The line displays the von Bertalanffy growth model predicted from Largemouth Bass mean length at age represented by the triangles.

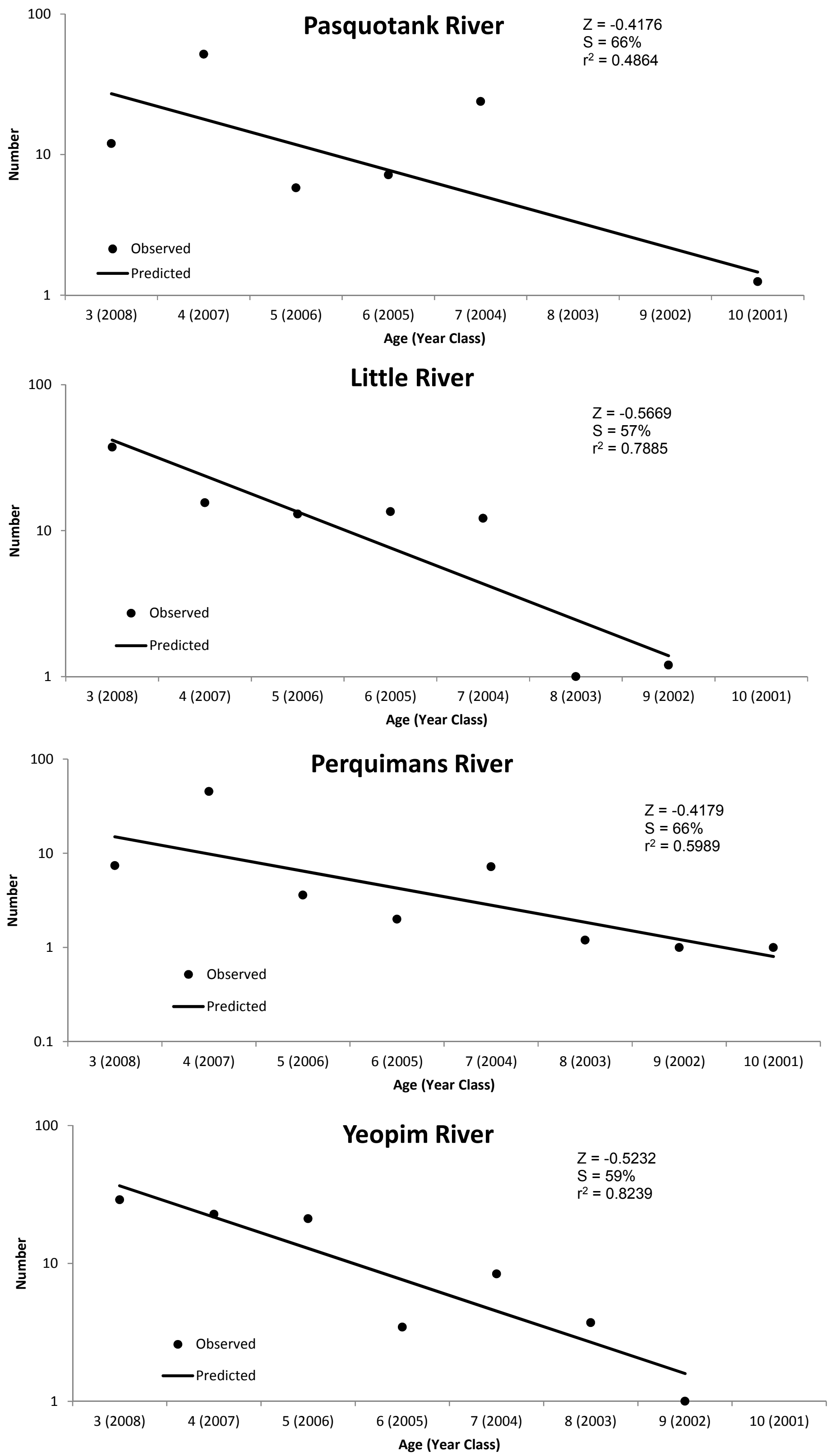

FIGURE 7.—Catch curve regression by river for Largemouth Bass collected during the 2011 northeast coastal rivers sportfish survey.

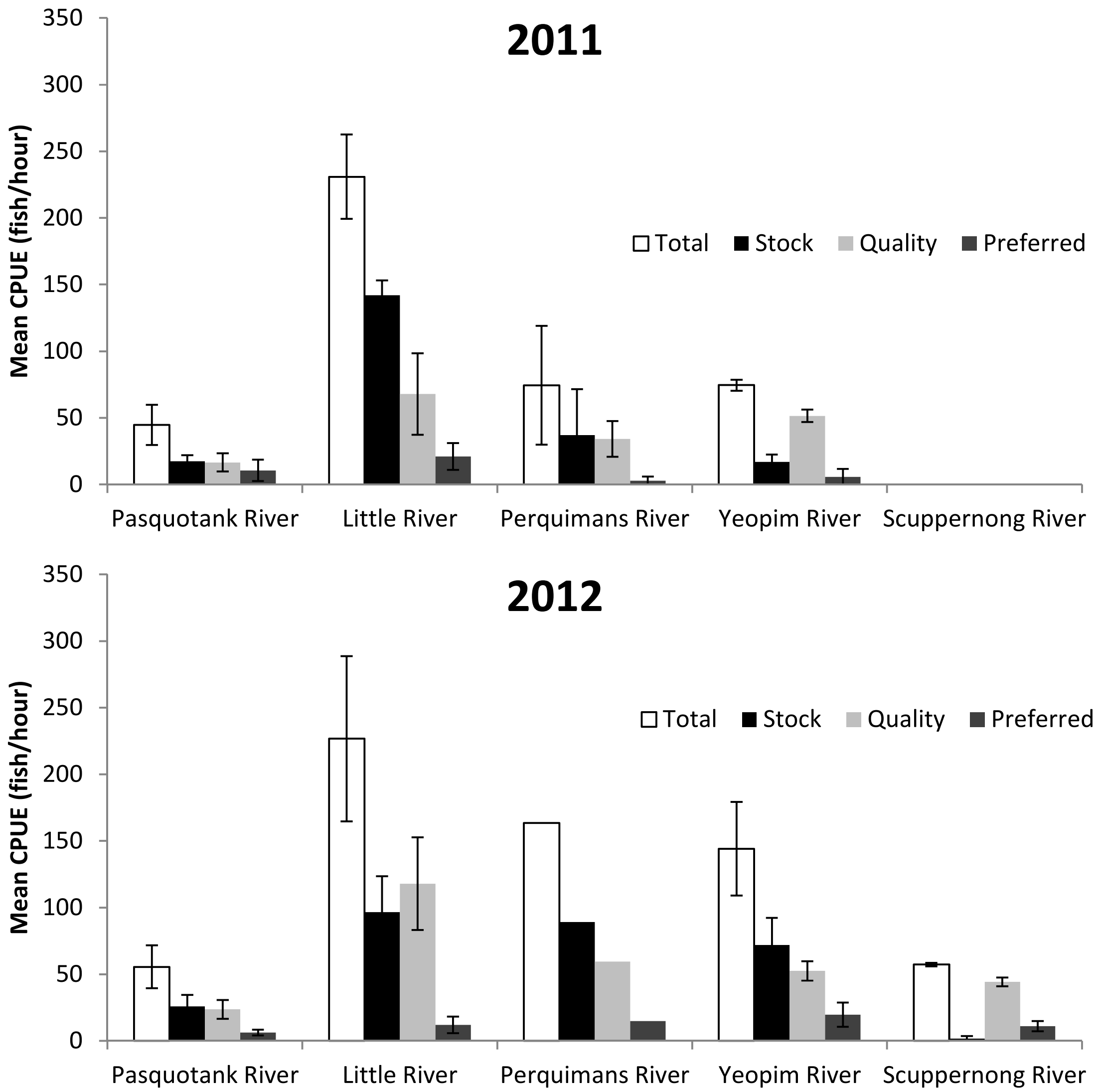

FIGURE 8.—Mean catch per unit effort (CPUE) for Bluegill by river and PSD increments collected during the 2011 and 2012 northeast coastal rivers sportfish survey. Error bars represent one standard error. Scuppernong River was not sampled for sunfish in 2011.

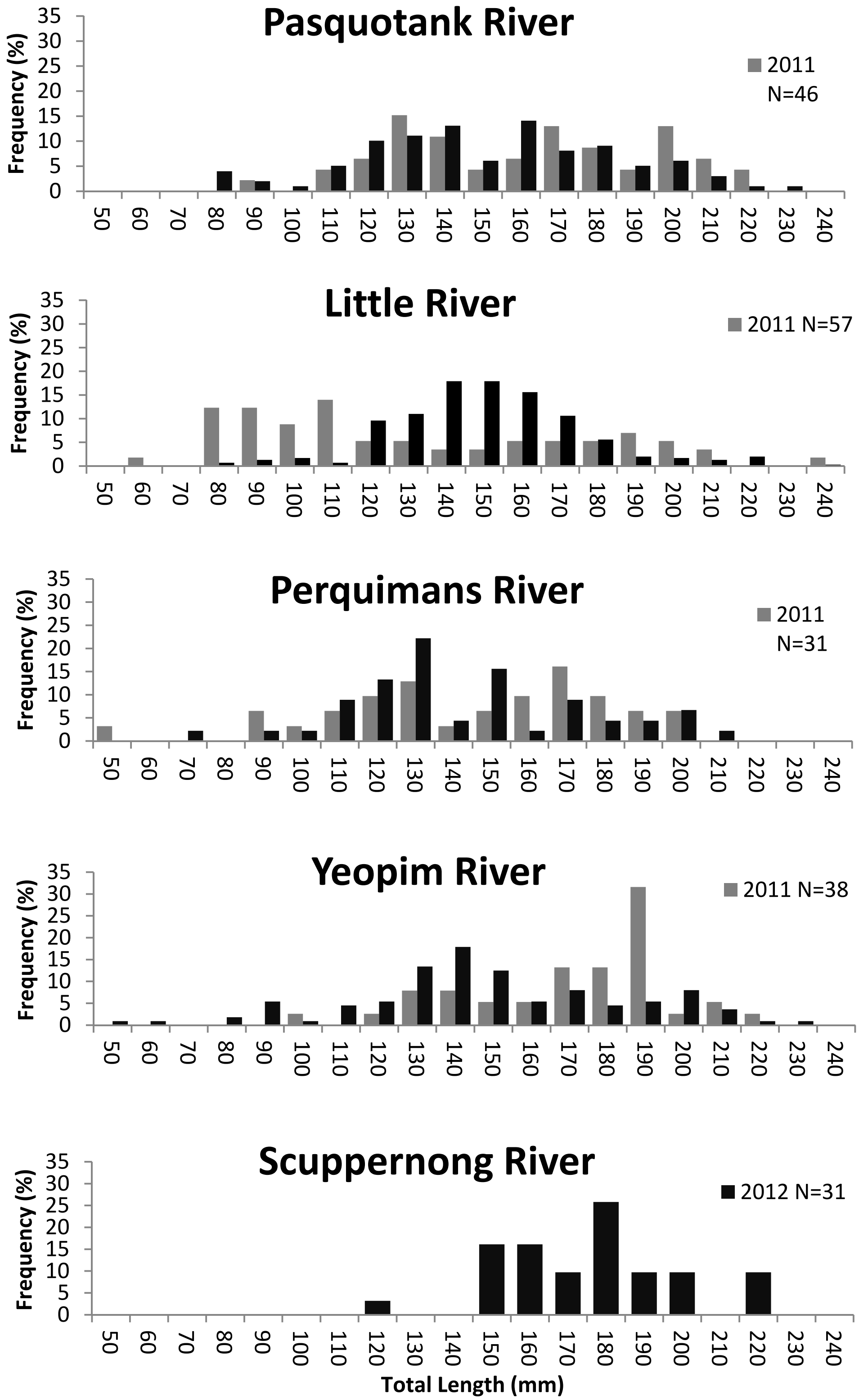

FIGURE 9.—Length distribution by river for Bluegill collected during the 2011 and 2012 northeast coastal rivers sportfish survey. Scuppernong River was not sampled for sunfish in 2011.

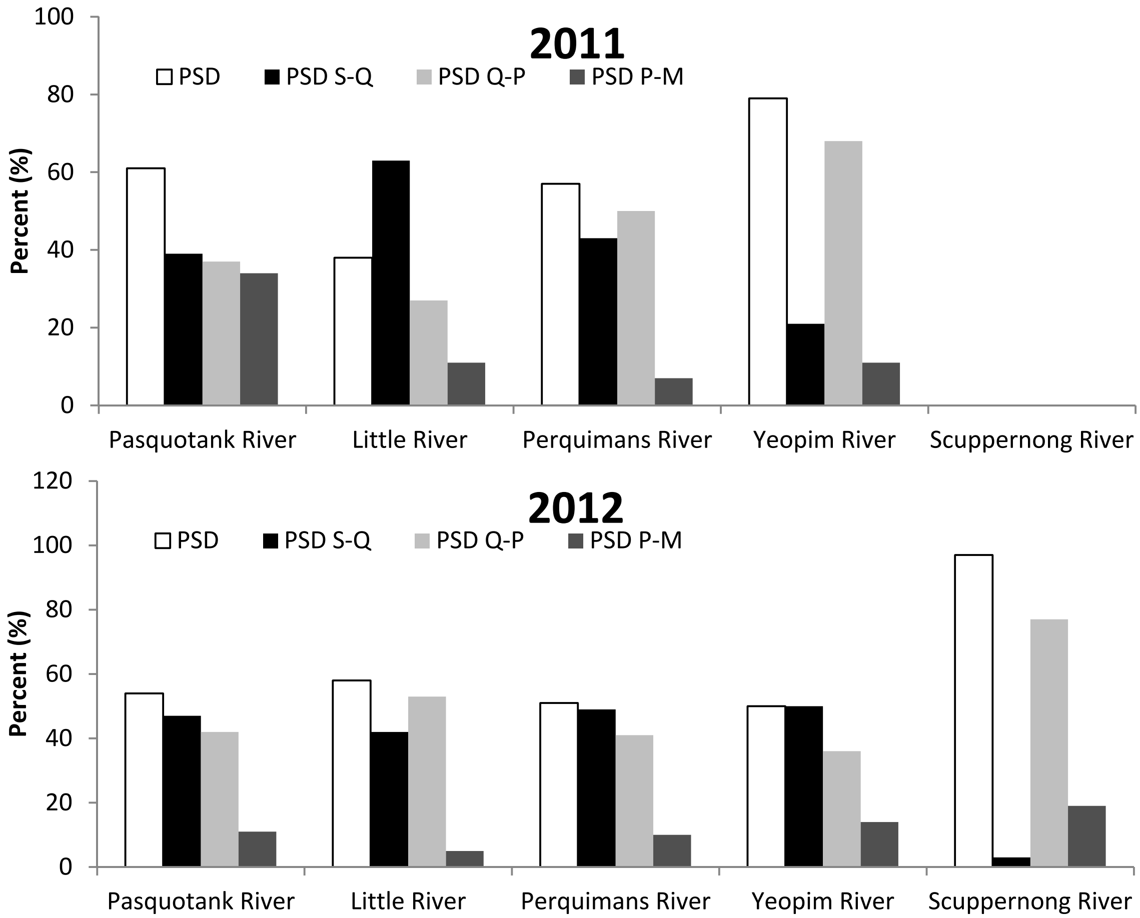

FIGURE 10.—PSD values for Bluegill by river collected during the 2011 and 2012 northeast coastal rivers sportfish survey. Scuppernong River was not sampled for sunfish in 2011.

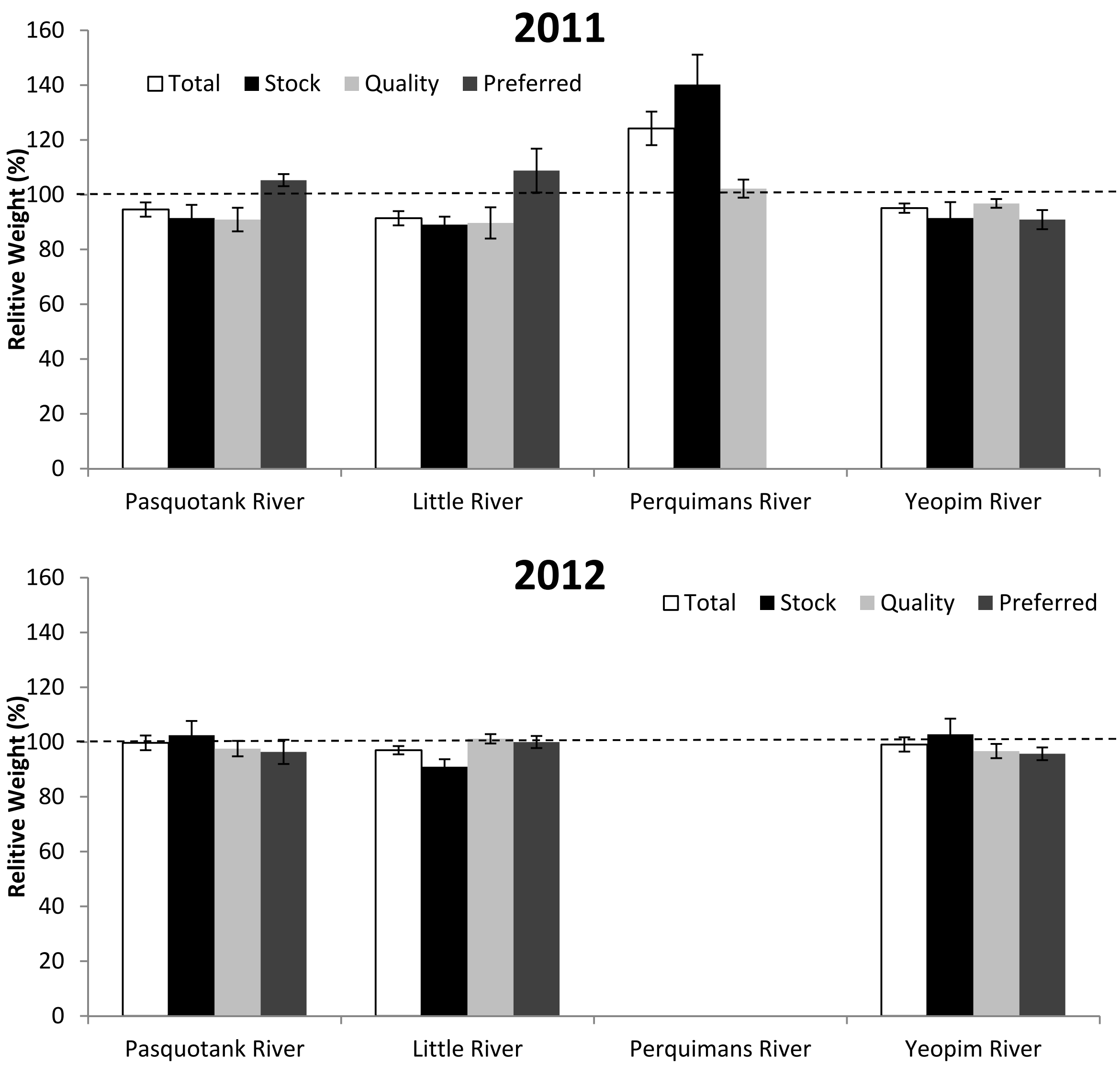

FIGURE 11.—Mean relative weight by PSD length category and river for Bluegill collected during the 2011 and 2012 northeast coastal rivers sportfish survey. The dotted line at Wr = 100 denotes the 75th percentile of weights at given length categories of Bluegill across its entire range. Error bars represent one standard error. Weights were not recorded for sunfish collected from the Perquimans River in 2012.

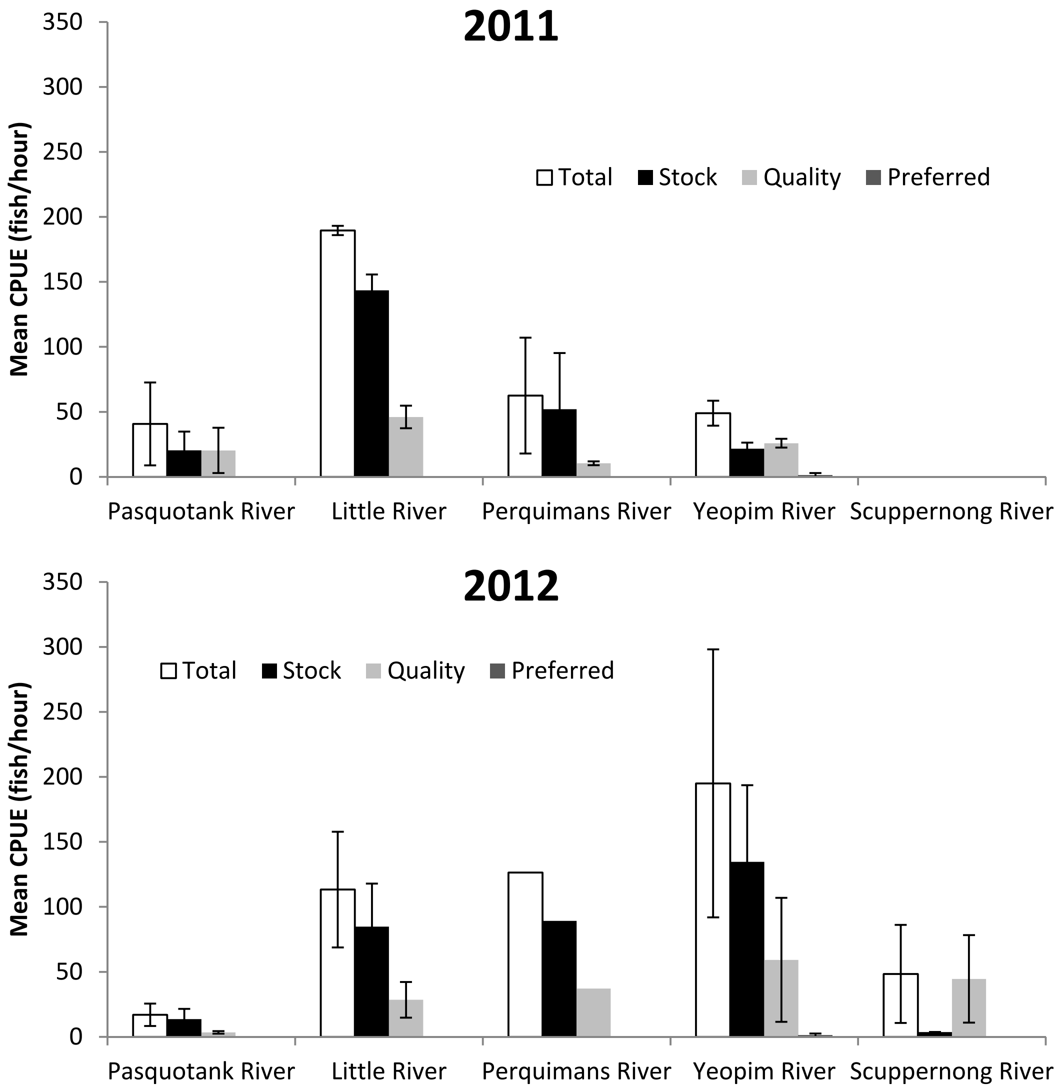

FIGURE 12.—Mean catch per unit effort (CPUE) for Pumpkinseed by river and PSD increments collected during the 2011and 2012 northeast coastal rivers sportfish survey. Error bars represent one standard error. Scuppernong River was not sampled for sunfish in 2011.

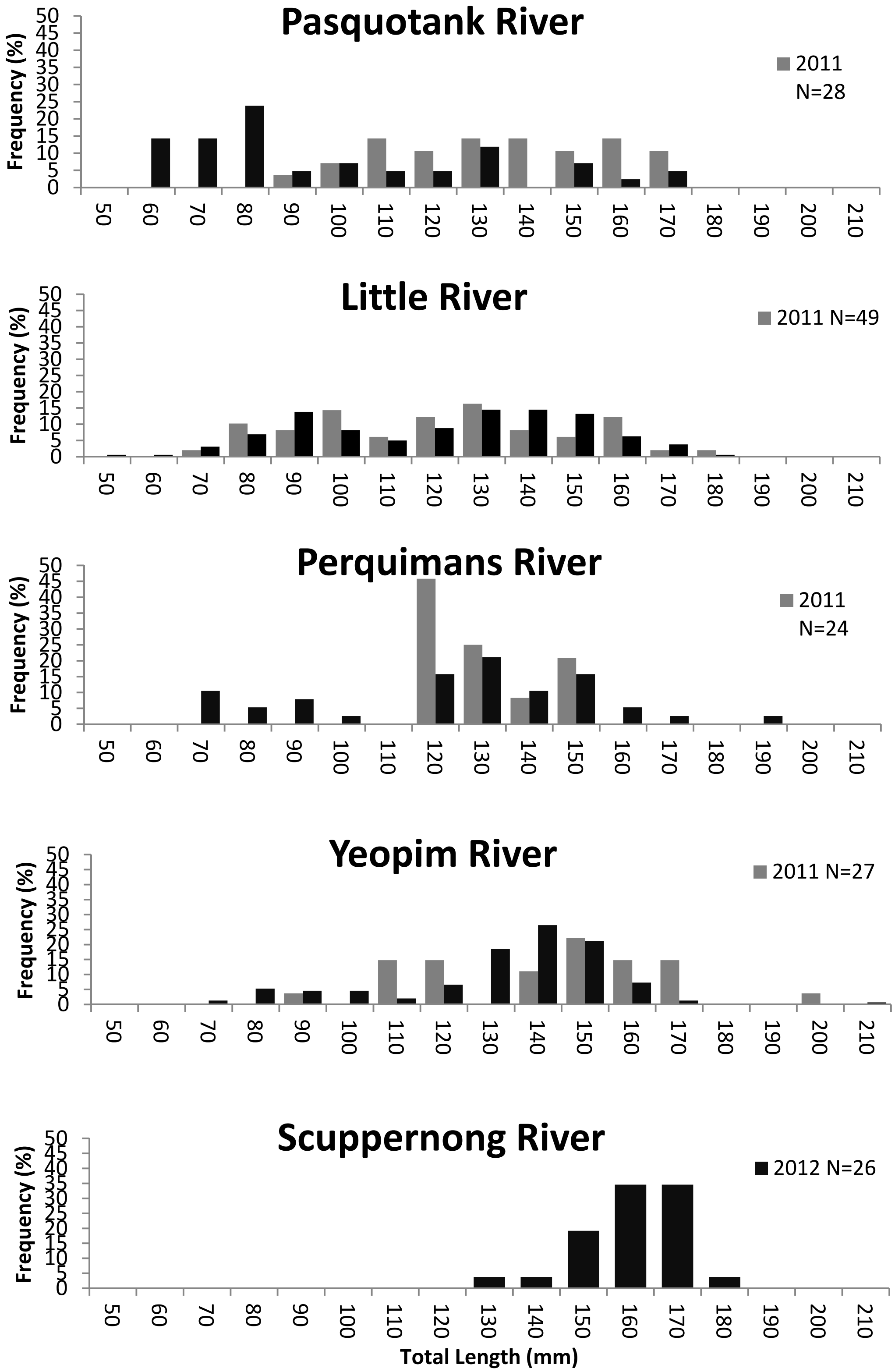

FIGURE 13.—Length distribution by river for Pumpkinseed collected during the 2011and 2012 northeast coastal rivers sportfish survey. Scuppernong River was not sampled for sunfish in 2011.

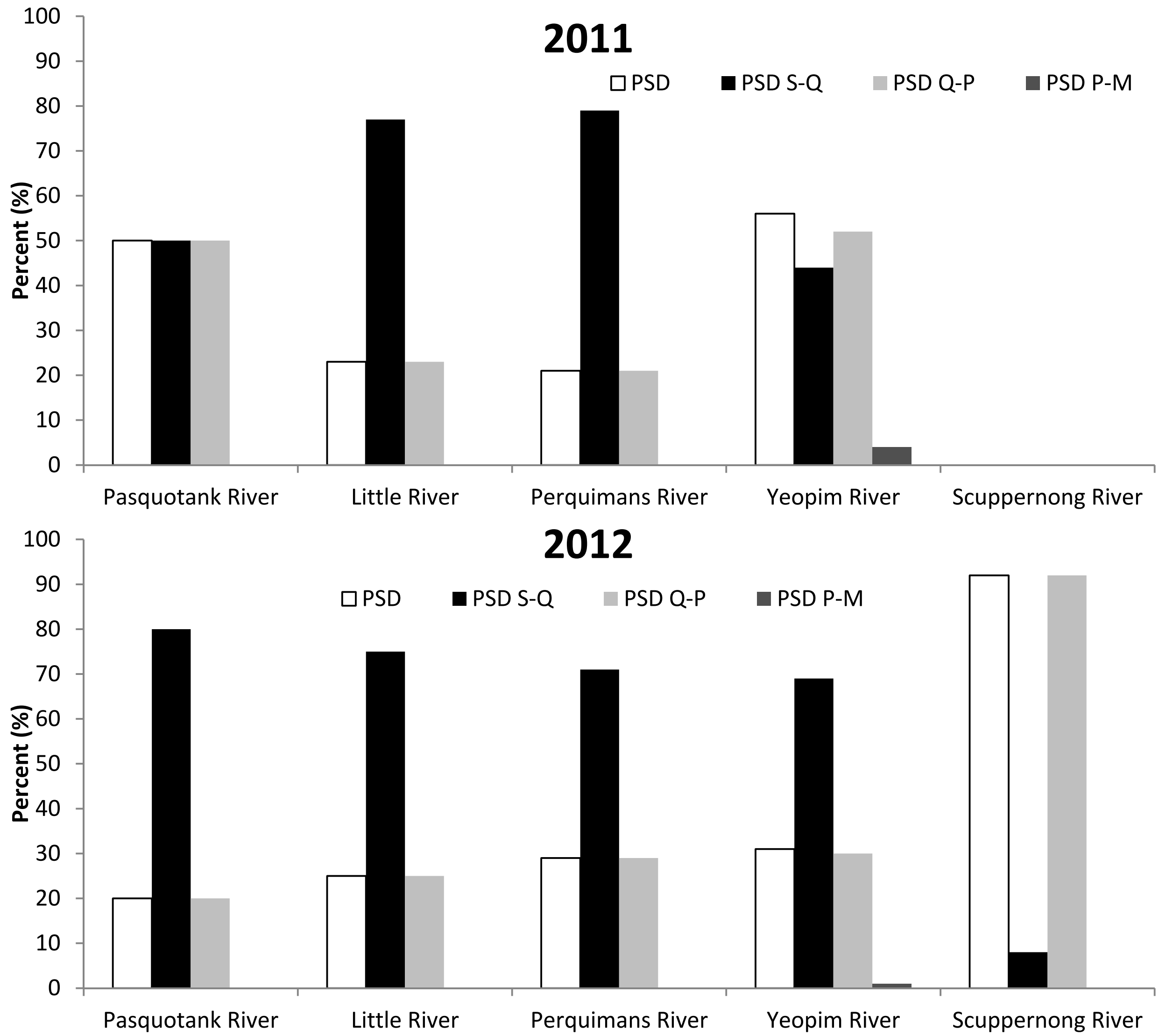

FIGURE 14.—PSD values for Pumpkinseed by river collected during the 2011and 2012 northeast coastal rivers sportfish survey. Scuppernong River was not sampled for sunfish in 2011.

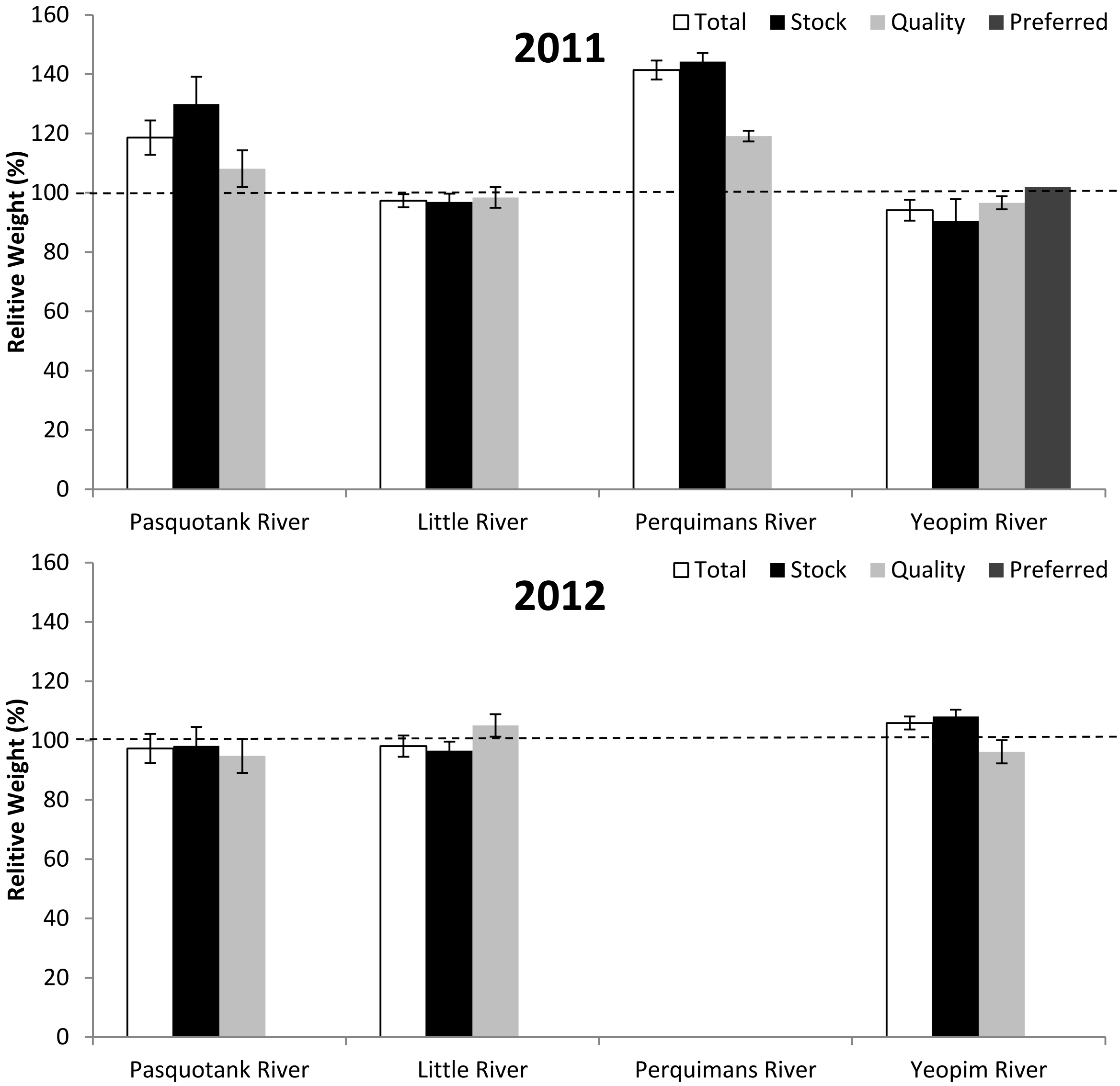

FIGURE 15.—Mean relative weight by PSD length category and river for Pumpkinseed collected during the 2011and 2012 northeast coastal rivers sportfish survey. The dotted line at Wr = 100 denotes the 75th percentile of weights at given length categories of Pumpkinseed across its entire range. Error bars represent one standard error. Weights were not recorded for sunfish collected from the Perquimans River in 2012.

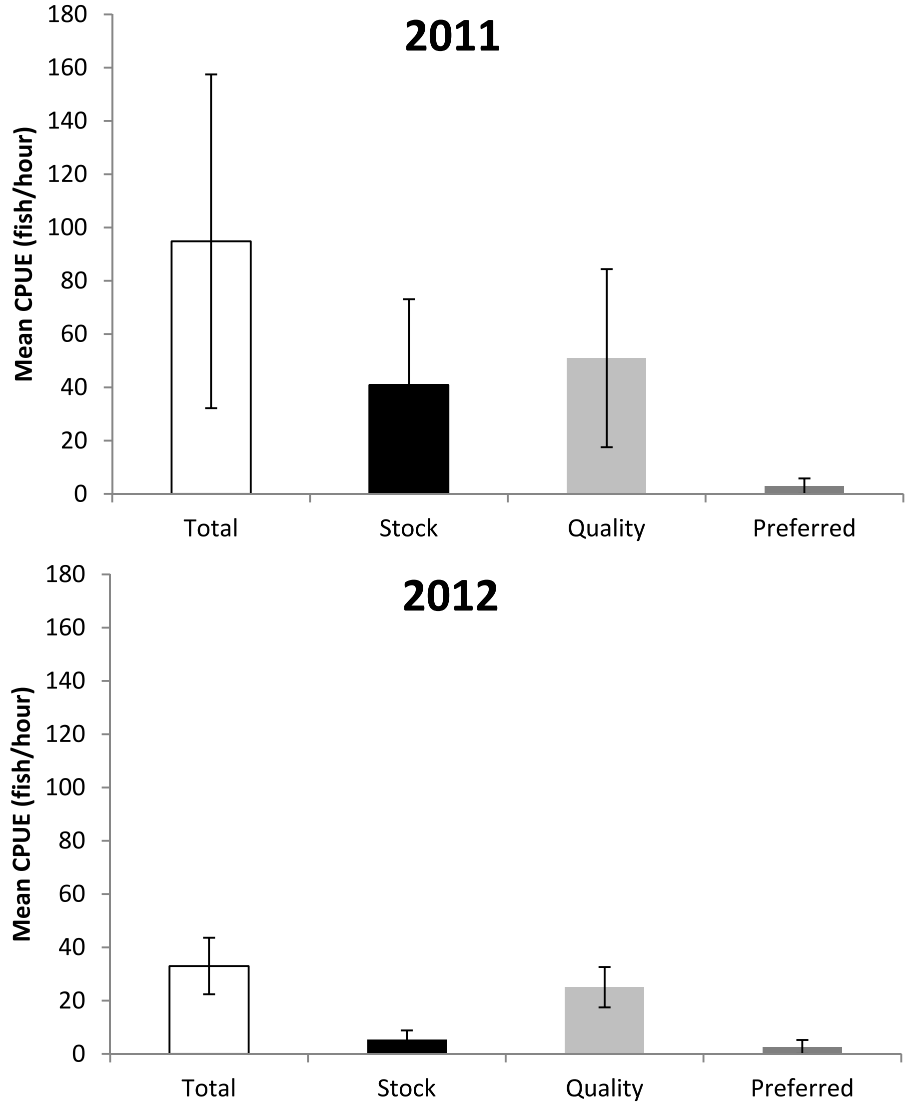

FIGURE 16.—Mean catch per unit effort (CPUE) for Redear Sunfish by PSD increments collected from the Yeopim River during the 2011 and 2012 northeast coastal rivers sportfish survey. Error bars represent one standard error.

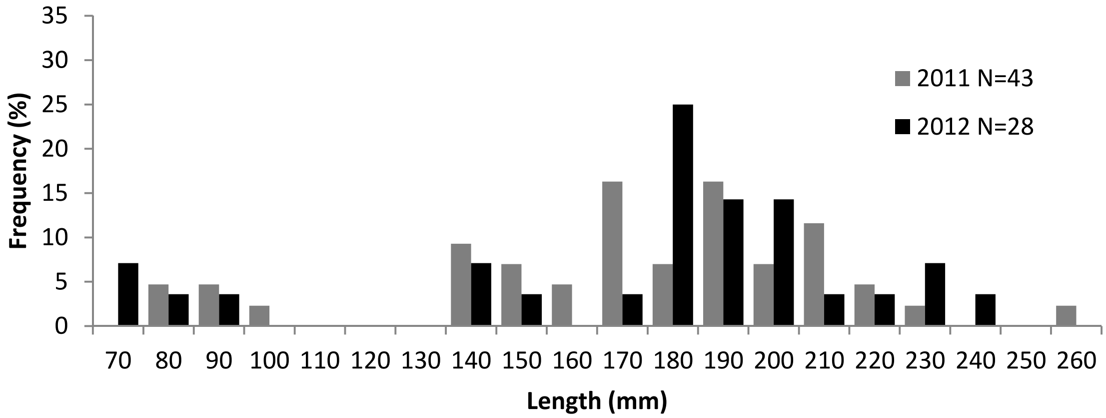

FIGURE 17.—Length distribution for Redear collected from the Yeopim River during the 2011and 2012 northeast coastal rivers sportfish survey.

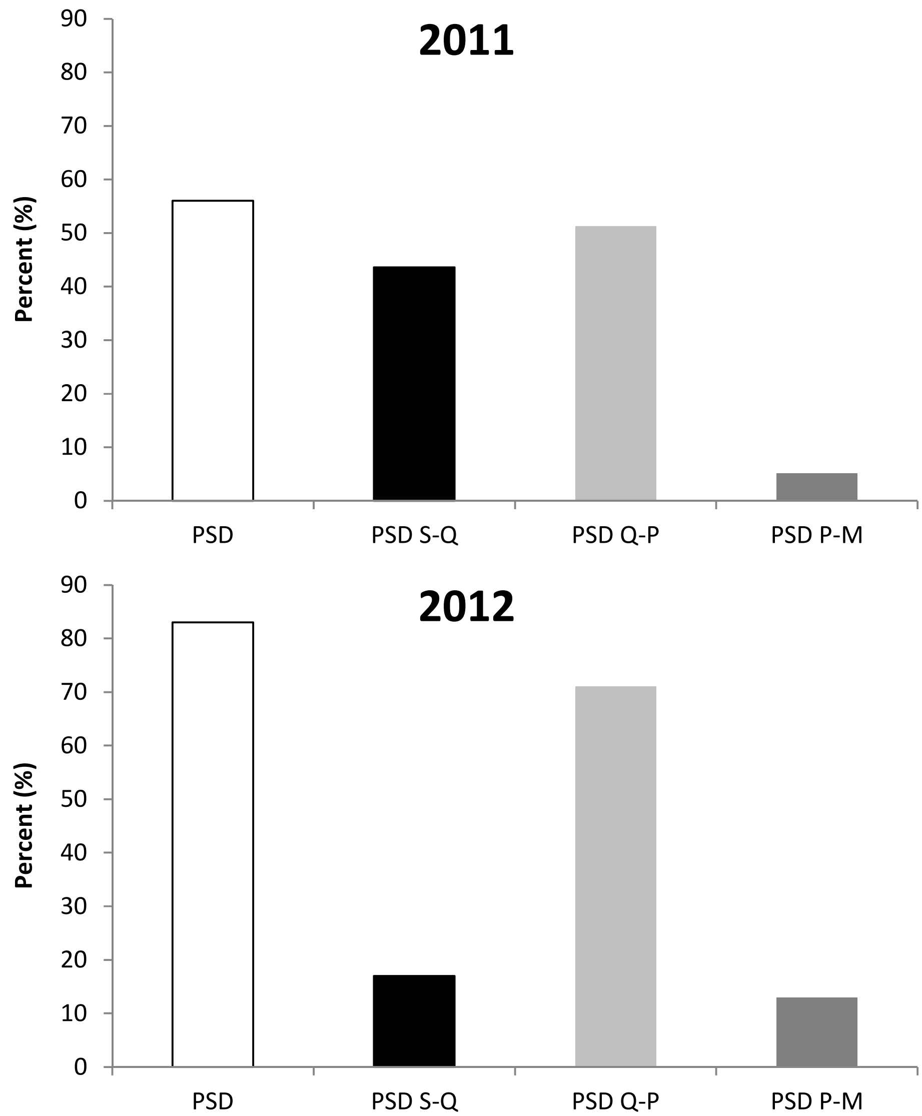

FIGURE 18.—PSD values for Redear Sunfish collected from the Yeopim River during the 2011and 2012 northeast coastal rivers sportfish survey.

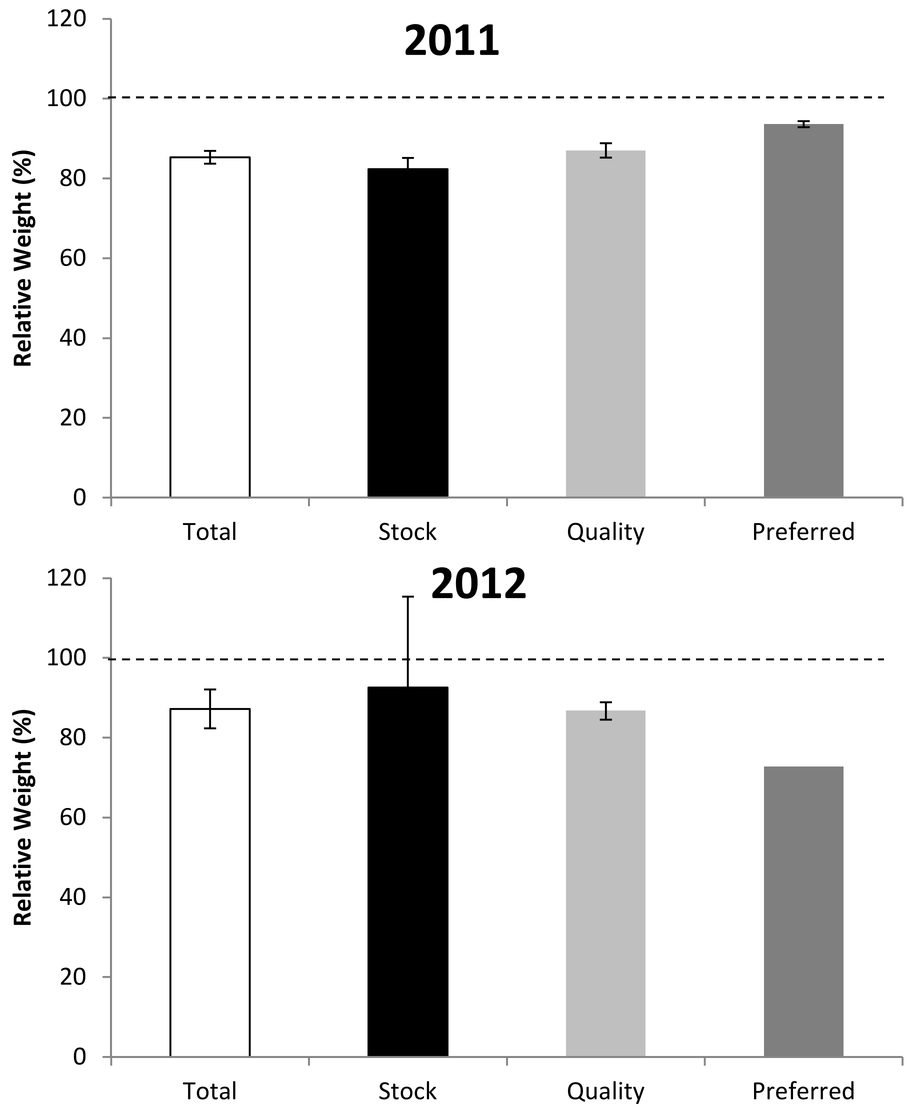

FIGURE 19.—Mean relative weight by PSD length category for Redear Sunfish collected from the Yeopim River during the 2011 and 2012 northeast coastal rivers sportfish survey. The dotted line at Wr = 100 denotes the 75th percentile of weights at given length categories of Redear Sunfish across its entire range. Error bars represent one standard error. Standard error could not be calculated for preferred-length because it was a single observation.