Population Characteristics of Largemouth Bass and Pumpkinseed in Lake Phelps, 2015–2016

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Abstract. —Lake Phelps Largemouth Bass *Micropterus salmoides* and Pumpkinseed *Lepomis gibbosus* populations were sampled with boat-mounted electrofishing in June 2015 and May 2016. Largemouth Bass and Pumpkinseed size structure, relative abundance, and body condition (W_r) were assessed. Largemouth Bass overall mean catch-per-unit effort in 2015 (23.3 fish/h; SE=4.5) was lower than previous years which was a continuation of a long-term decrease in relative abundance since 2003. The mean CPUE in 2016 (34.7 fish/h; SE = 13.8) was slightly higher than in 2015 yet still lower than in 2013 and 2014. Relative condition of stock-length Largemouth Bass remained high; however, factors that lowered the condition of larger fish were not definitive. The relative abundance of memorable-length fish was low and similar to that of previous samples. A von Bertalanffy growth curve indicated high growth rates for fish up to age 4, with growth slowing thereafter. Growth rates also indicated density dependent growth within the slot limit. The Lake Phelps sunfish population was comprised mainly of Pumpkinseed. The relatively low numbers of Pumpkinseed greater than 200 mm may indicate high levels of harvest or stunting of the Pumpkinseed population in Lake Phelps. The mean CPUE of Pumpkinseed was 148 fish/h (SE= 36.0) in 2015 and 155.1 fish/h (SE = 60.3) in 2016, both of which continued a stable trend in relative abundance. Low condition for preferred and quality-length fish may indicate that intraspecific competition is limiting growth. The large number of quality-length Pumpkinseed will continue to support recreational fishing and serve as a prey base for memorable-length Largemouth Bass. Future research activities should focus on examining the effects of water level fluctuations on recruitment and year class strength of Largemouth Bass. The results of the ongoing creel survey should be used, along with these data, to examine necessary changes to the Largemouth Bass protective slot limit.

Located in Washington and Tyrell counties, Lake Phelps is the second largest natural lake in North Carolina (6,480 ha). Lake Phelps is a shallow (mean depth = 1.4 m) open water lake, with benthic habitats composed of sand and mud. A small portion of the land surrounding the lake is privately owned; however, the majority of the land is part of the Pocosin Lakes National Wildlife Refuge and Pettigrew State Park. Unlike the surrounding bodies of water, Lake Phelps is oligotrophic (secchi depth of approximately 0.7 – 1.2 m) with the main source of water being precipitation. For decades, the North Carolina Wildlife Resources Commission has partnered with Pettigrew State Park to manage recreational fisheries for Largemouth Bass *Micropterus salmoides*, Pumpkinseed *Lepomis gibbosus*, and historically White Perch *Morone americana* in Lake Phelps. Other species such as Yellow Perch *Perca flavescens*, White Catfish *Ictalurus catus*, Yellow Bullhead *Ameiurus natalis*, and Chain Pickerel *Esox niger* are also targeted by anglers. Species such as Pumpkinseed, Golden Shiner *Notemigonus crysoleucas*, and "Lake Phelps" Killifish *Fundulus cf. diaphanus* serve as forage species for Largemouth Bass.

Since 2002, Largemouth Bass in Lake Phelps have been managed to produce trophy-sized fish. These management measures include a minimum size of 356 mm, a protective slot limit from 406 to 508 mm, and a five-fish daily creel limit. While no length limit exists for sunfish species, the creel limit is 30 fish per day. Results of recent Largemouth Bass surveys have questioned the effectiveness of the protective slot limit, and the corresponding reports (Dockendorf and McCargo 2010; Ricks and McCargo 2011; Ricks and McCargo 2013, and Potoka *et al.* 2014) have also recommended changes to the management of Largemouth Bass within the lake. Current surveys documented in this report were conducted to assess the Largemouth Bass and Pumpkinseed populations and to obtain age data for Largemouth Bass. These data will be used to further evaluate the effectiveness of current management regulations on Lake Phelps.

Methods

Fish sampling.—Electrofishing surveys in Lake Phelps were conducted along 12 shoreline transects (Figure 1) during daylight hours of June 2, 5, and 9 of 2015, and May 10, 11, and 27 of 2016. Transects began at each selected location or km and lasted until 1200 s (electrofishing time) was reached. Sampling sites in 2015 were based on long-term, fixed stations, while sampling sites in 2016 were randomly selected based on shoreline km. Electrofishing gear consisted of a boat-mounted Smith Root 7.5 GPP electrofishing unit with boom electrodes that delivered approximately 1000 V of pulsed direct current (60 Hz) at 3–5 A. All fish were netted (1 netter) during the first 300 seconds of each transect, then only Largemouth Bass were collected for the remaining portion of the transect (approximately 900 s). Total length (TL; mm) was measured for all sport fish, and weight (g) was recorded for sunfish and Largemouth Bass.

Data analysis.—Relative abundance of Largemouth Bass was indexed as catch-per-unit-effort (CPUE; number of fish ≥ 200 mm collected per hour of electrofishing), and mean CPUE was calculated by averaging the CPUE at each site. Mean CPUE of Largemouth Bass was $\log_{10}$ transformed for comparison with previous study years. Mean CPUE was also calculated for Pumpkinseed. Size structures of Largemouth Bass and Pumpkinseed were evaluated with length-frequency histograms as well as calculations of proportional size distribution (PSD) and incremental PSD metrics (Guy et al. 2007). Stock-, quality-, preferred- and memorable-length

categories were used for Largemouth Bass and Pumpkinseed as recommended by Gabelhouse (1984) and Anderson and Neumann (1996).

Largemouth Bass and Pumpkinseed condition was assessed using a relative weight index (Wr) described by Wege and Anderson (1978). Relative weight was calculated as:

$$Wr = \frac{W}{Ws} * 100$$

where W is the measured weight (g) of each fish, and W_s is a length specific standard weight. The W_s equation for Largemouth Bass was $\log_{10}(W_s)$ = -5.316 + 3.191 $\log_{10}$(TL) (Murphy et al. 1991), and the W_s equation for Pumpkinseed was $\log_{10}(W_s)$ = -5.197 + 3.237 $\log_{10}$(TL) (Liao et al. 1995). Fish less than stock-length of each species were excluded from this analysis.

Age and growth analysis.—In 2015, five Largemouth Bass per 10-mm size bin were collected for otolith ageing purposes. Otoliths were removed, sectioned, and prepared following methods describe by Buckmeier and Howells (2003). Once prepared, otoliths were aged under a dissecting microscope. All otoliths were read by a primary reader and then verified by a second reader. The proportion of each age class within each 10-mm size bin was calculated and expanded to the total number of Largemouth Bass within each size bin. Mean length at age was calculated for the whole sample using the conservative approach described by Bettoli and Miranda (2001). To estimate growth rates, a von Bertalanffy growth curve was constructed using mean length at age values and FAMS software (Slipke and Maceina 2014). The 2015 length-age key could not be applied to the fish collected in 2016 due to the missing age-6 cohort in 2015.

Results

Largemouth Bass.—We collected 100 and 161 Largemouth Bass in 2015 and 2016, respectively. Relative abundance among sample sites in 2015 ranged from 2.8 to 50.3 fish/h and from 0 to 55.3 fish/h in 2016. In 2015 mean CPUE was 23.3 fish/h (SE = 4.5). The 2015 relative abundance, after a log transformation, was the lowest since 2001 (Figure 2). Mean CPUE in 2016 was 34.7 fish/h (SE = 13.8). In 2015, Largemouth Bass length ranged from 200 mm to 540 mm. The length distribution was unimodal, peaking between 340–359 mm. A secondary peak was also visible at 470 mm (Figure 3). Of the 100 Largemouth Bass collected, 26% were of harvestable size, while 29% fell within the protective slot limit. Few individuals (5%) were above the slot limit (memorable and trophy lengths). The individuals collected in the 2015 survey consisted mostly of quality- (n = 40) and preferred-length fish (n = 41). Sub-stock fish were absent from the 2015 survey, and the catch of stock-length fish (n = 14) was much lower than in previous years. Largemouth Bass collected in 2016 ranged in length from 153 mm to 564 mm. In 2016, 22% of the catch was harvestable, and 35% of the fish were slot-length fish. Fish above the slot limit accounted for 4% of the 2016 catch. The individuals collected in 2016 consisted mostly of stock- (n = 46) and preferred-length (n = 70) Largemouth Bass. Since the implementation of the protective slot limit, a decline in the CPUE of memorable and larger fish has been seen (Figure 4). A total of 18 sub-stock fish was also collected in 2016. Proportional size distribution (PSD) was higher in 2015 (86%) than in 2016 (68%; Figure 5). Incremental PSD

for quality-length (PSD_{Q-P}) was higher in 2015 (40%) than in 2016 (14%), while PSD for stock- and preferred-length Largemouth Bass were all much lower in 2015 (PSD_{S-Q} = 14, PSD_{P-M} = 40,) than in 2016 (PSD_{S-Q} = 32, PSD_{P-M} = 49; Table 1). In both 2015 and 2016, PSD for memorable-length fish was 5%.

Mean relative weight (*Wr*) observed for Largemouth Bass in 2015 was 94.7 (SE = 1.2). Mean *Wr* for stock-length fish was high (109; SE = 3.2) but sharply decreased as size increased from quality to preferred lengths. There was a slight increase in mean relative weight from preferred to memorable-length fish (Figure 6). In 2016, mean *Wr* for Largemouth Bass was 102 (SE = 0.9). An increase in *Wr* was seen from stock- to quality-length fish; however, a decreasing trend in *Wr* was seen in fish larger than quality-length.

Largemouth Bass age and growth analysis.—A total of 85 Largemouth Bass otoliths was aged by two independent readers. The two readers agreed on 86% of the ages; however, reader agreement ± 1 year was 99%. Discrepancies between the primary and secondary ages were reconciled in concert by the two readers to achieve a reader agreement of 100%. Largemouth Bass ranged in age from 1 to 12 years; however, no age-6 (2009 year class) fish were present in the sample. The majority of the population was age 2–5, with age-2 (2013 year class) fish making up over half the total catch (Figure 7). Growth of Largemouth Bass increased steadily until age 4, after which growth was minimal (Figure 8). The von Bertalanffy growth model for Largemouth Bass at Lake Phelps was

$$TL = 467.386 * (1 - e^{-0.564(age-0.343)})$$

Pumpkinseed.—We collected a total of 188 Pumpkinseed in 2015, while 161 Pumpkinseed were collected in 2016. Mean CPUE values in 2015 (132.0 fish/h; SE=36.7) and 2016 (149.1 fish/h; SE = 60.5) were lower than in 2014 (208 fish/h; Figure 9) although they remained within the range of standard errors. The 2015 length distribution ranged 70–205 mm, with peak frequency (35%) occurring at the 190–199 mm length range (Figure 10). The majority of the fish captured (79%) were quality-length fish. Few fish were of stock- and preferred-length, and no sub-stock or memorable-length fish were present in the survey. Pumpkinseed lengths in 2016 ranged from 43 mm to 260 mm. Peak frequency (34%) occurred at the 200–209 mm range. Contrary to 2015, preferred-length fish made up the majority (51%) of the 2016 catch. The Pumpkinseed PSD value for 2015 was 93% while the 2016 PSD was 92% (Figure 11), both of which were much higher than recommended PSD values for sunfish species in a balanced population (50–80%; Gabelhouse 1984 or 20–60%; Anderson and Neumann 1996).

Discussion

A long-term decline in Largemouth Bass relative abundance has been evident in Lake Phelps since 2000. Beginning in 2010, relative abundance had trended slightly upward; however, this increasing trend was not observed in 2015 or 2016 (Ricks and McCargo 2011, Ricks and McCargo 2013 and Potoka *et al*. 2014). Relative abundance in 2015 was the lowest since surveys began in the late 1990s, although the 2015 value remained within the range of standard errors observed since 2010 with the exception of 2014. Reasons for this decline may be associated with sampling biases related to sampling later in the year than usual (June 2015).

A marginal increase in relative abundance over the 2015 values was seen in 2016, although a change in site selection methods hindered direct comparison to previous years. The continued growth of the strong 2013 year class should produce opportunities for harvest before these fish shift into the protective slot within the next year. As in previous years, the relative abundance of memorable-length fish was low, partially due to missing (2009) or poor (2008) year classes. These poor year classes were spawned during years when low lake levels (< 10.5 ft.) likely limited recruitment and spawning success (Figure 12). Additional information that quantifies the relationship between water level in Lake Phelps and recruitment and spawning success of Largemouth Bass is essential to effective management of this population, especially during and after significant drought years.

Past reports have questioned the effectiveness and need for a protective slot limit in Lake Phelps, citing overcrowding and limited growth of fish within the current slot limit as a major concern (Ricks and McCargo 2011, Ricks and McCargo 2013, and Potoka *et al*. 2014). Growth curves produced using age data from 2015 showed excellent growth of Largemouth Bass from age 1 (mean length of 260 mm) to age 4 (mean length of 441 mm). Growth into the protective slot usually occurred between ages 3 and 4, after which growth slowed. These growth patterns mimic patterns calculated in the 2010 survey (Ricks and McCargo 2011). Slot limits are used to alter the structure and condition of individuals within the set limits and are typically most effective when fishing mortality is high (Novinger 1984). There is no current estimate of recreational effort or harvest of Largemouth Bass from Lake Phelps. The last creel survey was conducted over 30 years ago (Kornegay and Dineen 1983) and predates the implementation of the slot limit. Creel survey results will be essential for evaluating necessary changes to length limits and the protective slot limit.

The sunfish fishery in Lake Phelps is unique because it is dominated by Pumpkinseed. Relative abundance has remained stable since 2011. The Lake Phelps Pumpkinseed fishery was dominated by larger fish (170 –260 mm) that fall within the quality, preferred, and memorable categories. While these larger fish are excellent for anglers, they are not readily fed upon by Largemouth Bass. Even though relative condition for stock length Pumpkinseed was high, the condition of preferred and quality length fish fell below the 75% percentile, possibly indicating density dependent growth within the population. The effects of the Largemouth Bass population on the Pumpkinseed population should be taken into consideration if future changes in Largemouth Bass management are warranted.

Historically, Bluegill *L. macrochirus* were abundant in Lake Phelps (Kornegay and Dineen 1979). Despite stocking efforts from 2002 to 2012, the relative abundance of Bluegill in 2015 (n = 12) and 2016 (n = 3) was extremely low. The low relative abundance of Bluegill has been documented since the late 1990s (Hodges 1997, Hand and Thomas 2001, Ricks and McCargo 2011, Ricks and McCargo 2013 and Potoka *et al*. 2014); factors associated with the paucity of Bluegill at Lake Phelps are not fully understood.

In 2015, several small Gizzard Shad *Dorosoma cepedianum* were collected in electrofishing surveys. This was the first time this species had been documented in the lake. While no Gizzard Shad were captured in the 2016 electrofishing surveys, large schools of Gizzard Shard have been reported by boaters and anglers. The presence of Gizzard Shad in the lake may provide more forage opportunities for Largemouth Bass, although the impacts of this introduction will need to be evaluated.

Management Recommendations

1. Maintain current harvest regulations for Largemouth Bass and Pumpkinseed. Pending the results of the creel survey, evaluate and consider changes to the current protective slot limit to promote the growth of more Largemouth Bass to memorable and trophy lengths.
2. Continue to annually monitor Largemouth Bass population characteristics at Lake Phelps at all 12 of the 2016 sampling sites. Conduct age and growth analysis in 2018 by collecting up to five fish per 10-mm length group to monitor effects of regulations. Congruent with the 2018 age and growth analysis, estimate mortality rates in order to relate year class strength to environmental factors.
3. Assess age structure of Pumpkinseed in Lake Phelps by collecting up to five fish per 10-mm length group every three years starting in 2017.
4. Increase angler success and catch rates by installing Mossback© artificial habitat around access areas. Morning and Nicholson (1994) found that artificial habitat concentrated more fishes than natural weed habitat or open water habitat. Artificial habitat should be placed near access areas that are surrounded by little or no submerged habitat.
5. Collect forage species during yearly sampling to determine relative abundance. Complement relative abundance estimates with gut content analysis of Largemouth Bass. The last dietary analysis conducted in Lake Phelps was 1981 (Kornegay 1981) and changes in Largemouth Bass diet may have occurred.
6. Continue to obtain water level data from Pettigrew State Park and install water level gages at the Pocosin Overlook and Cypress Point access areas.
7. Promote the Largemouth Bass and Pumpkinseed fisheries of Lake Phelps through distribution of sampling information on the agency website and social media opportunities. Present recent information to angling groups interested in fisheries management at Lake Phelps.

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TABLE 1.—Incremental PSD values for Lake Phelps Largemouth Bass from 2010 to 2016.

	2010	2011	2012	2013	2014	2015	2016
PSD_{S-Q}	1.79	15.76	30.90	8.77	38.72	14.00	32.17
PSD_{Q-P}	7.14	4.24	8.15	31.58	17.02	40.00	13.99
PSD_{P-M}	88.39	78.18	57.08	53.80	40.85	41.00	48.95
PSD_{M-T}	2.68	1.82	3.86	5.85	3.40	5.00	4.90

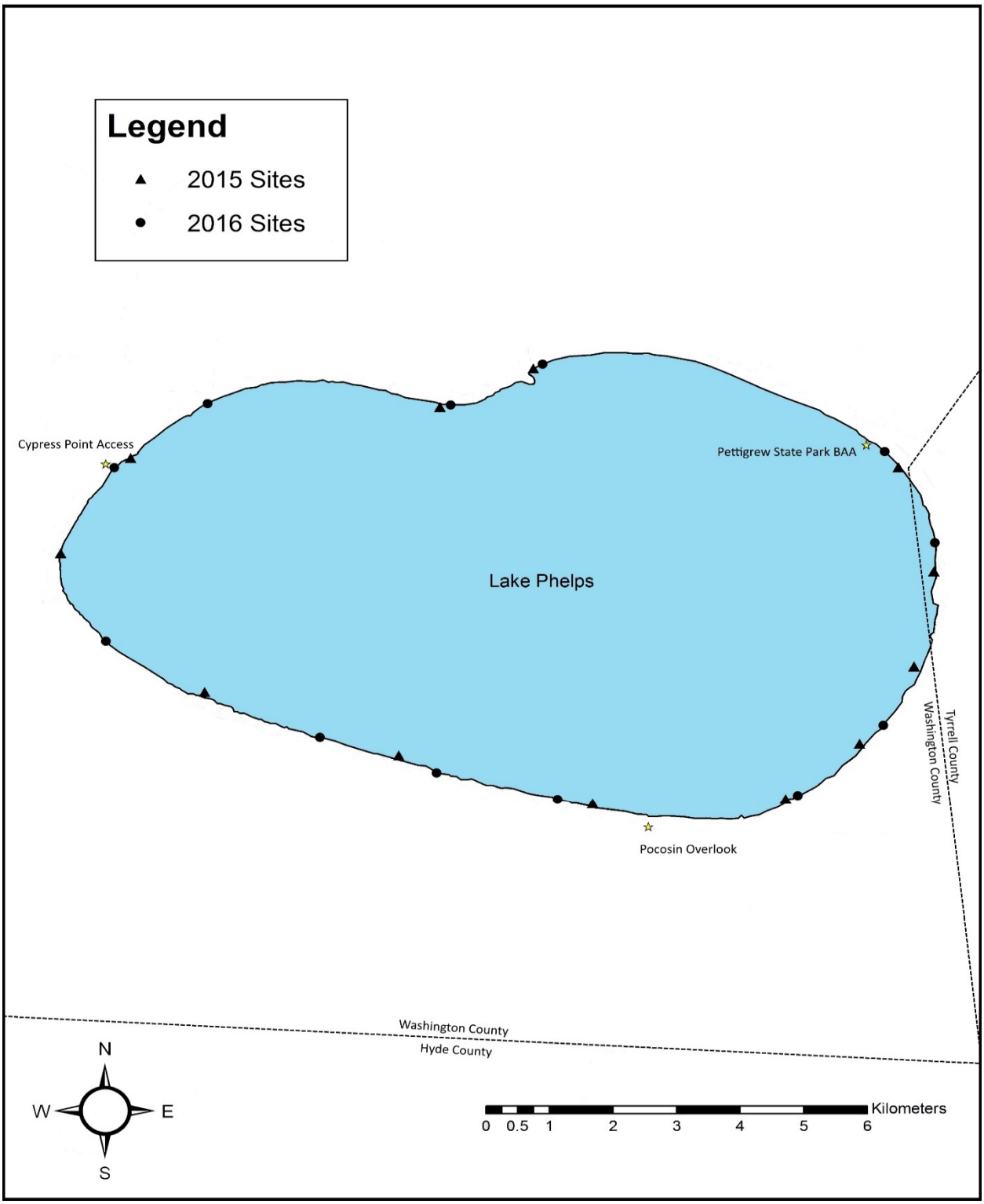

FIGURE 1.—Electrofishing sites at Lake Phelps in 2015 and 2016. Stars indicate public lake access areas. Sampling sites in 2015 were based on long-term, fixed stations, while sampling sites in 2016 were randomly selected based on shoreline km. The Pettigrew boating access area (BAA) is the only public boat ramp on Lake Phelps.

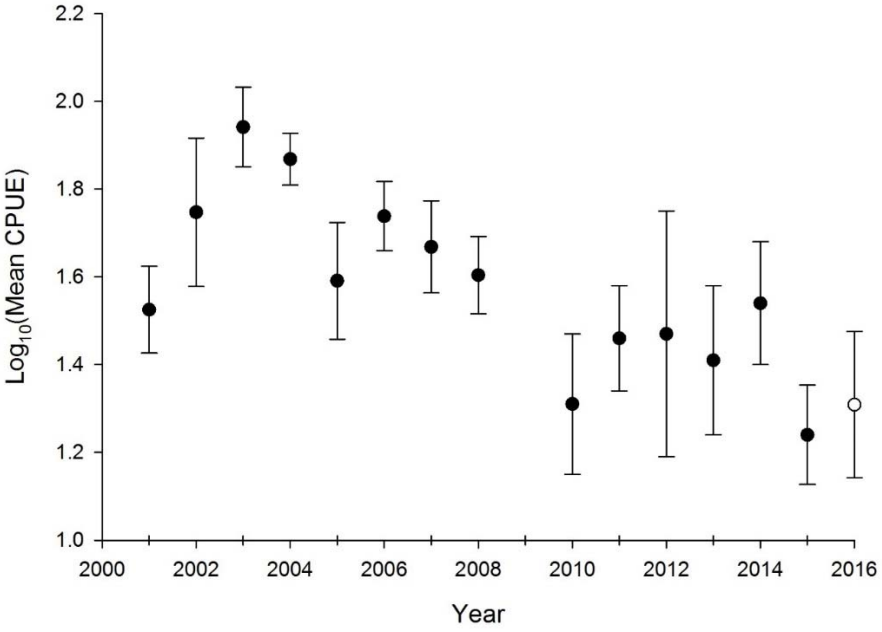

FIGURE 2.—Log_{10} mean catch per unit effort (CPUE) of Largemouth Bass ≥ 200 mm collected at Lake Phelps with boat electrofishing from 2001–2015. Data from 2001 (Hand and Thomas 2001), 2002 (NCWRC, unpublished data), 2003–2008 (Dockendorf and McCargo 2010), 2010–2012 (Ricks and McCargo 2011 and 2013), and 2014 (Potoka et al. 2014) were included for comparison. Error bars represent one standard error. Surveys were not conducted from 1997–2000 or in 2009. The open circle for 2016 indicates year of new sampling site selection.

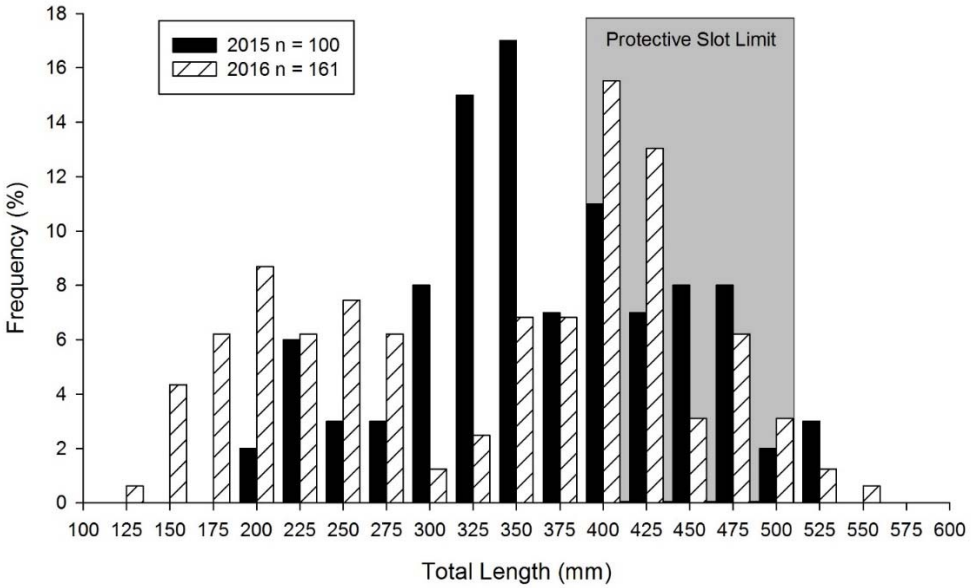

FIGURE 3.—Length distribution of Largemouth Bass collected from Lake Phelps in 2015 and 2016. The protective slot limit (gray box) for Largemouth Bass is from 406 mm to 508 mm.

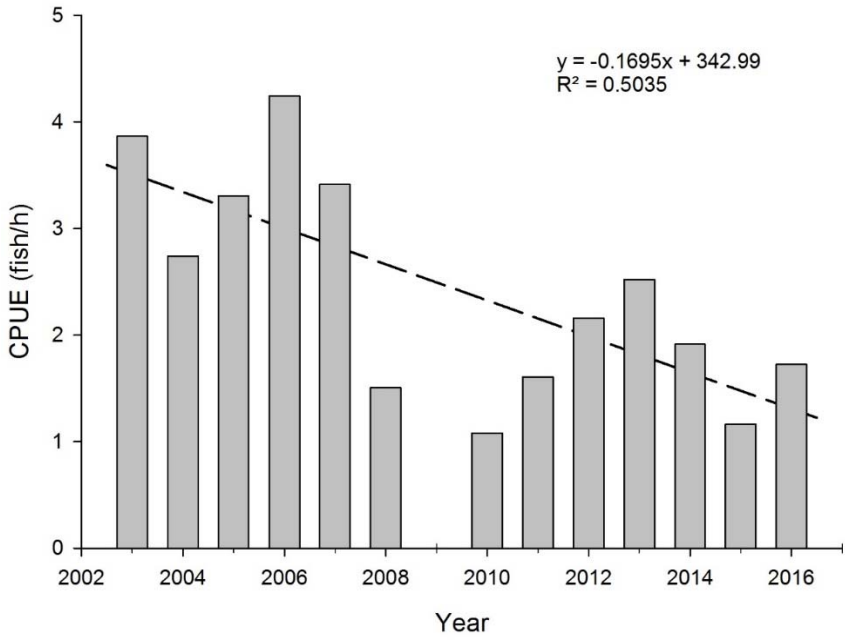

FIGURE 4.—Long-term CPUE for Largemouth Bass greater than or equal to memorable length. Regression (dashed line) indicates a decreasing trend in CPUE. Data were not collected in 2009.

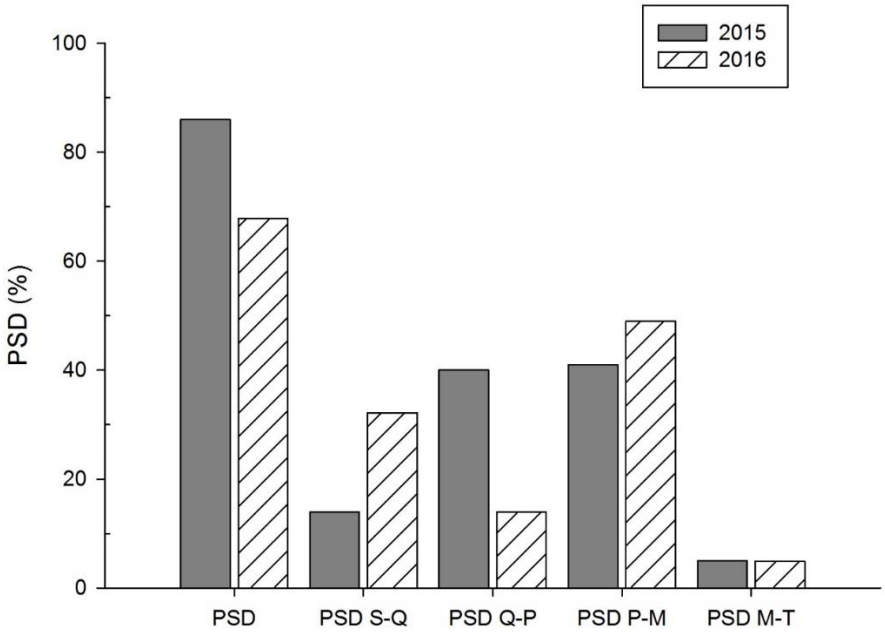

FIGURE 5.—PSD values for Largemouth Bass collected during the 2015 and 2016 Lake Phelps sport fish surveys.

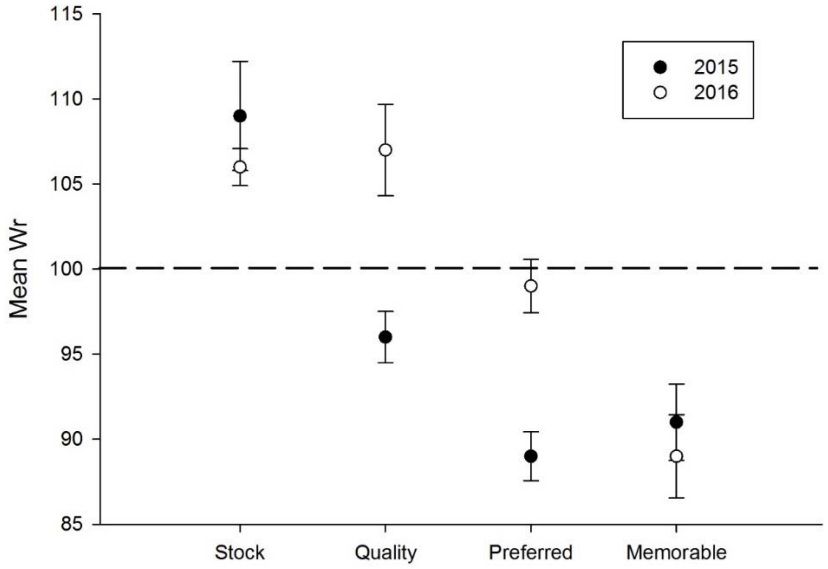

FIGURE 6.—Mean relative weights of Lake Phelps Largemouth Bass by proportional stock density category for 2015 and 2016. The dotted line at W_r=100 denotes the 75th percentile of weights at given length categories of Largemouth Bass across its entire range. Target *Wr* for Largemouth Bass should be above 85 (Gablehouse 1987). Error bars represent one standard error.

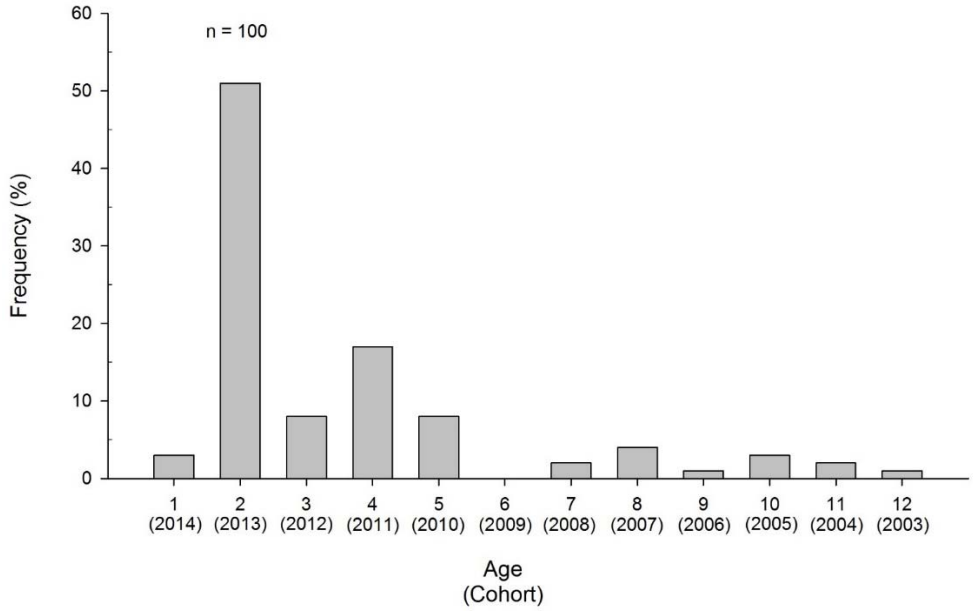

FIGURE 7.—Age distribution of Largemouth Bass collected during the 2015 Lake Phelps sportfish survey.

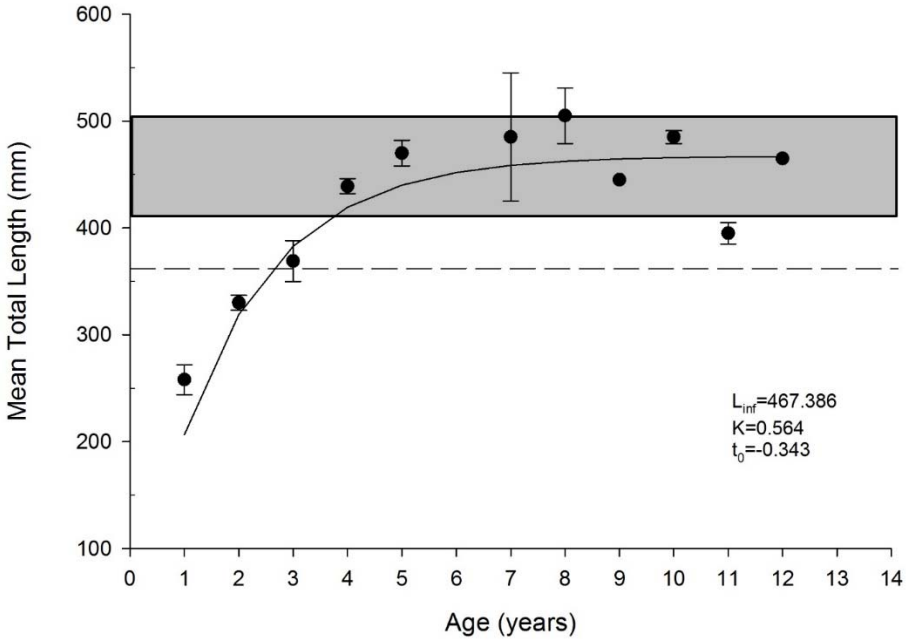

FIGURE 8.—Mean length at age for Largemouth Bass collected in 2015 from Lake Phelps. The dashed line represents the minimum length limit, while the solid box represents the protected slot limit. The solid line (curve) is the von Bertalanffy growth curve predicted from mean length at age.

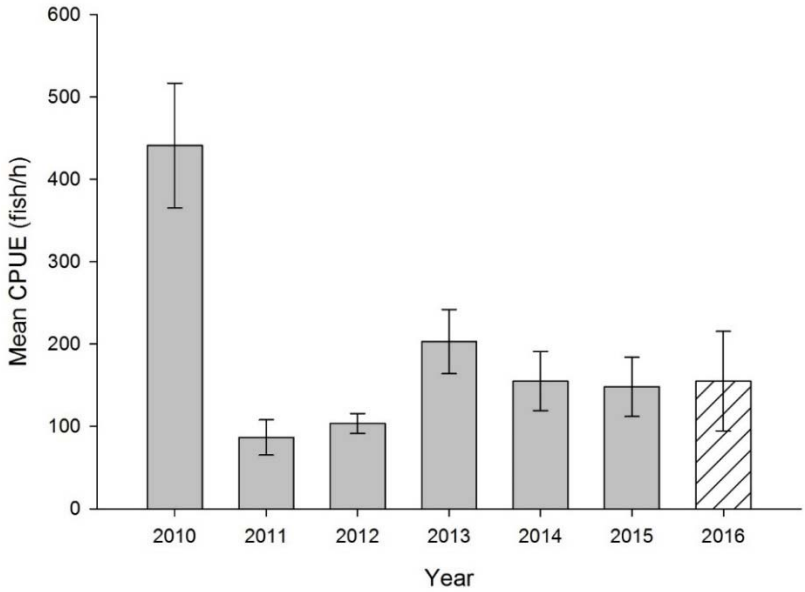

FIGURE 9.—Mean catch per unit effort (CPUE) of Pumpkinseed collected from Lake Phelps with electrofishing in 2015 and 2016. Data from 2010–2012 (Ricks and McCargo 2013) and 2014 (Patoka *et al.* 2014) are included for comparison. Error bars represent one standard error. White bar for 2016 indicates year of new sampling site selection.

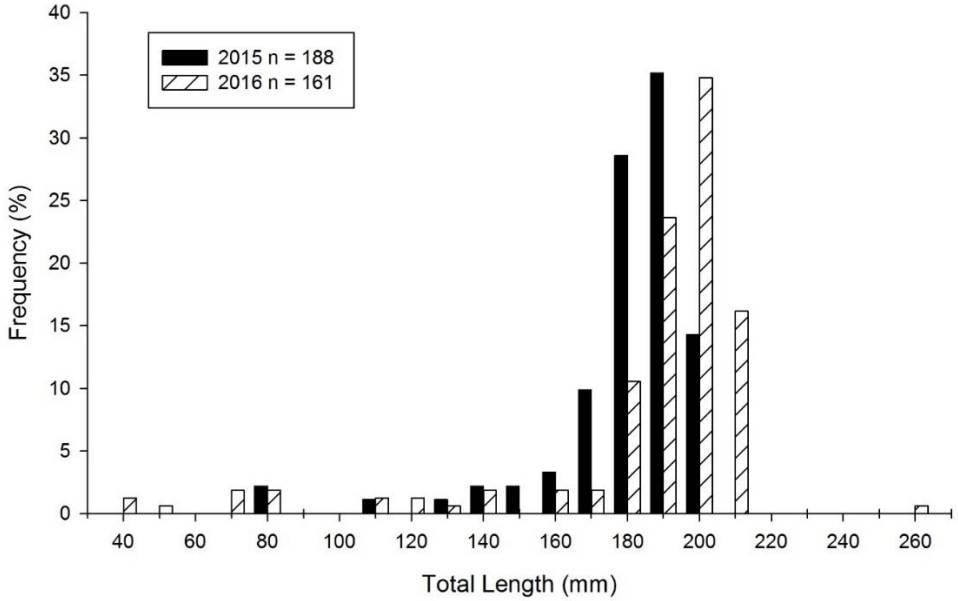

FIGURE 10.—Length distribution of Pumpkinseed collected from Lake Phelps in 2015 and 2016.

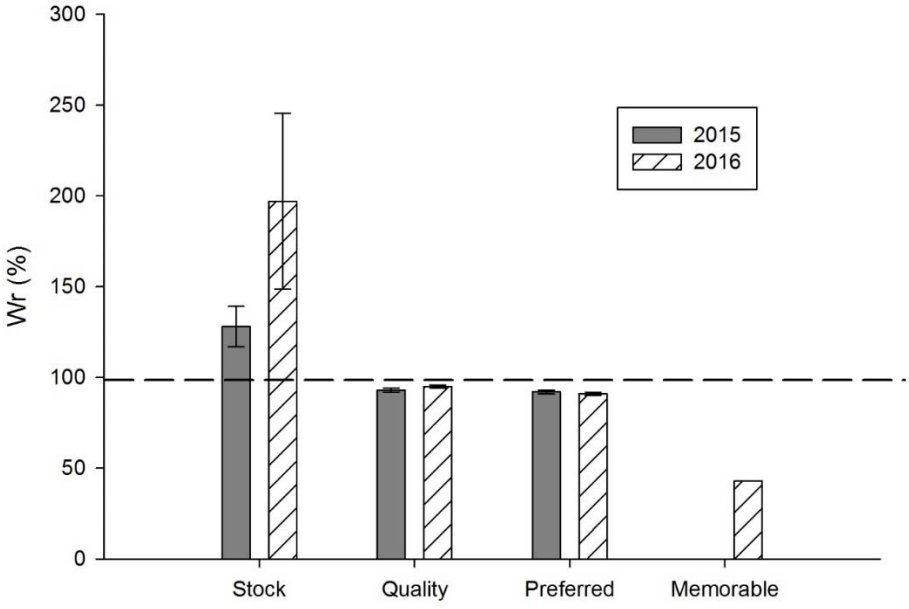

FIGURE 11.—Mean relative weights of Pumpkinseed by proportional stock density category for the 2015 and 2016 Lake Phelps sportfish surveys. The dotted line at W_r=100 denotes the 75th percentile of weights at give length categories of Pumpkinseed across its entire range. Error bars represent one standard error.

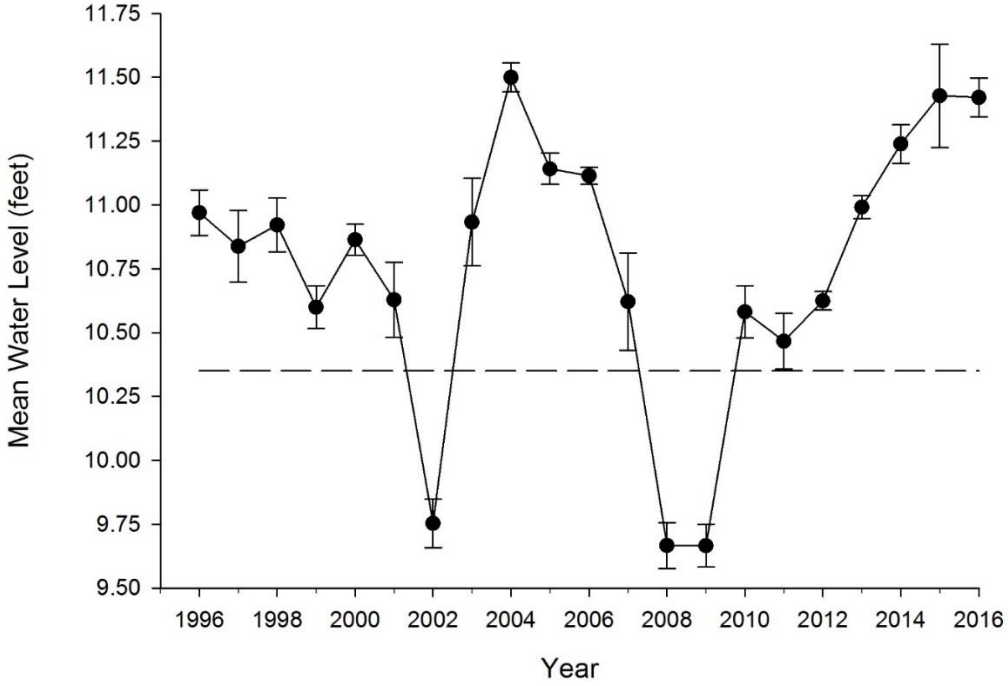

FIGURE 12.—Mean daily water level from Pettigrew State Park records (1996–2016). Dotted line represents water level below which Largemouth Bass recruitment is likely limited. Error bars represent one standard error.