Addressing an 18-year Largemouth Bass trophy regulation at Lake Phelps utilizing boat electrofishing and angler surveys

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Christopher A. Smith
Kathryn M. Potoka

North Carolina Wildlife Resources Commission
Inland Fisheries Division
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Abstract.—Lake Phelps Largemouth Bass *Micropterus salmoides* populations were sampled with boat-mounted electrofishing in May 2018 and 2019. Largemouth Bass size and age-structure, relative abundance, and body condition (W_r) were assessed. Relative abundance of Largemouth Bass increased in 2018 (68.5 fish/h; SE = 17.0). Relative abundance in 2019 (46.8 fish/h; SE = 12.8) was lower than 2018 but was higher than observed values since 2015. Relative condition of all sizes of Largemouth Bass remained above 85%; however, condition decreased with increasing length. The age distribution in 2019 ranged 1–10 years; most of the catch (81%) was between 1- and 4-years old. The 2010 (age-9) and 2011 (age-8) year classes were absent from the 2019 survey. A von Bertalanffy growth curve indicated high growth rates for fish up to age 4, with growth rapidly slowing thereafter. A Chapman-Robson catch curve analysis estimated total instantaneous mortality (Z) to be 0.52 (SE = 0.12). Average natural mortality (M) was estimated to be 0.48 and total instantaneous fishing mortality (F) was calculated as 0.04. A stratified, non-uniform probability access point creel survey was conducted from 2016 to 2017. This survey interviewed 116 angling parties. Anglers primarily used the Pettigrew boating access area and Cypress Point pier and spent an estimated 10,066 hours (SE = 1,742) fishing on Lake Phelps. The majority of anglers (81%) targeted Largemouth Bass, most of which were catch and release fishing. While catch of Largemouth Bass was high, anglers only harvested an estimated 43 (SE = 25) Largemouth Bass. In the absence of harvest and fishing mortality, trophy regulations on the lake have been ineffective toward the goal of producing individuals larger than 20 inches. A regulation that allows for increased harvest opportunity, while still protecting larger fish should be considered.

Located in Washington and Tyrell counties, Lake Phelps is the second largest naturally-formed lake (6,480 ha) in North Carolina. 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, most of the land is part of the Pocosin Lakes National Wildlife Refuge and Pettigrew State Park. Lake Phelps is oligotrophic (secchi depth of 0.7 – 1.2 m) with the main input being precipitation. For decades, the North Carolina Wildlife Resources Commission (NCWRC) has partnered with Pettigrew State Park to manage recreational fisheries for Largemouth Bass *Micropterus salmoides*, Pumpkinseed *Lepomis gibbosus*, and historically White Perch *Morone americana*. Other species such as Black Crappie *Pomoxis nigromaculatus*, Yellow Perch *Perca flavescens*, White Catfish *Ictalurus catus*, Yellow Bullhead *Ameiurus natalis*, and Chain Pickerel *Esox niger* are also caught by anglers. Species such as Pumpkinseed, Golden Shiner *Notemigonus crysoleucas*, and "Lake Phelps" Killifish *Fundulus cf. diaphanus* serve as forage species for Largemouth Bass (Appendix A).

Since 2002, Largemouth Bass in Lake Phelps have been managed to produce trophy-sized fish. These trophy 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. Previous reports have questioned the effectiveness of the protective slot limit and have recommended changes to the management of Largemouth Bass within the lake (Dockendorf and McCargo 2011; Ricks and McCargo 2011; Ricks and McCargo 2013; Potoka *et al.* 2014). This report will review data from recent electrofishing surveys (2018–2019) and a recent creel survey (2016–2017). These data will be used to evaluate 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 May 10, 24, and 25 of 2018, and May 22, 23, and 29 of 2019. Transects began at each selected starting location and lasted until 1200 seconds (electrofishing time) was reached. 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 and weight (g) was recorded from all 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. The size distribution of Largemouth Bass was 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 as recommended by Gabelhouse (1984). Substock fish are defined as fish less than 200 mm total length. While using these fish in calculations of CPUE or PSD is not recommended (Gablehouse 1984), relative abundance of substock fish in Lake Phelps was used as a recruitment index.

Largemouth Bass 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). Fish less than stock-length were excluded from this analysis.

Age, Growth, and Mortality.—In 2019, three 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 R software (R Core Team 2019). To estimate instantaneous mortality (*Z*) and annual survival (*S*), a Chapman-Robson catch curve analysis was performed using the peak+1 year method as recommended by Smith et al. (2012). The FAMS software (Slipke and Maceina 2014) was also used to calculate natural mortality (*M*) using the average of several models (Cubillos et al. 1999; Djabali et al. 1993; Jensen 1996; Lorenzen 1996). Input parameters for each model can be found in Table 1. Fishing mortality (*F*) was calculated using the estimates of *Z* and average *M*.

Creel Survey.—Anglers at Lake Phelps were surveyed at five locations (Figure 1) using a stratified, non-uniform probability access point survey design (Pollock et al. 1994). The survey began in September of 2016 and continued through August 2017. Due to staffing limitations, anglers were not surveyed in February of 2017. The creel survey was stratified by month, location, time (A.M./P.M.) and day type (weekday/weekend; for the purpose of the survey, Friday was considered a weekend day). Four, six-hour creel sessions were randomly selected each week (two weekday and two weekend sessions). Location probabilities were set and adjusted monthly using weekly trailer and vehicle counts at each location. Time of day probabilities were set for the A.M. (0.33) and P.M. (0.67) for the entire survey. For each interview, the creel clerk recorded the time of day, the number of anglers in the party, the time the party started fishing, species targeted, the number of each species caught, and the number harvested. For harvested fish, the creel clerk measured (total length; mm) and weighed (g) up to 10 individuals of each species. Other questions asked included angler origin, trip expenditures, fish disposition, opinions on regulations, and fishery improvements. Estimates and standard error were calculated for total angler effort, catch of Largemouth Bass, and harvest of Largemouth Bass using equations provided by Jones and Pollock (2012) and Pollock et al. (1994).

Results and Discussion

2018 Largemouth Bass Survey.—During the electrofishing surveys, 270 Largemouth Bass were collected. Relative abundance (of fish ≥ 200 mm) varied among sample sites and ranged from 3.5 to 153.8 fish/h. Mean CPUE was 68.5 fish/h (SE = 16.9; Figure 2). Largemouth Bass lengths ranged from 30 mm to 580 mm. The length distribution was unimodal, peaking at 375 mm (Figure 3). Of the 270 Largemouth Bass collected, 28% were of harvestable size, while 26% fell within the protective slot limit. As in previous years, very few individuals (1%) were above the slot limit (memorable and trophy lengths). The individuals collected consisted mostly of quality- (38%) and preferred-length fish (44%). Substock- (3%) and stock- (13%) fish made up a small percentage of the catch. Proportional size distribution (PSD) was 86% and incremental PSD increased as size increased, except for $PSD_{M\text{-}T}$ (Figure 4). Mean relative weight (*Wr*) observed for Largemouth Bass was 95.4 (SE = 0.9). Mean *Wr* was high for stock-length fish (103.0; SE = 4.9) but decreased as size increased from quality to memorable lengths (Figure 5).

2019 Largemouth Bass Survey.—A total of 219 Largemouth Bass were collected in 2019. Relative abundance (of fish ≥ 200 mm) among sample sites ranged from 0 to 93.9 fish/h with a mean CPUE of 46.8 fish/h (SE = 12.8; Figure 2). Largemouth Bass lengths ranged from 120 mm to 568 mm. The length distribution was bimodal, with the primary peak at 200 mm and a secondary peak at 400 mm (Figure 3). Of Largemouth Bass collected, 19% were of harvestable size, while 18% fell within the protective slot limit. Few individuals (2%) were above the slot limit (memorable and trophy lengths). The individuals consisted mostly of quality- (24%) and preferred-length fish (27%). Substock-(24%) and stock-length (23%) fish also made up a large contribution of the catch. Proportional size distribution (PSD) was 69%. Incremental PSD remained relatively constant for stock- (30%), quality- (31%) and preferred-lengths (35%), while PSD for memorable-length fish was much lower (2%; Figure 4). Mean relative weight (*Wr*) observed for Largemouth Bass was 97.0 (SE = 0.9). Mean *Wr* decreased as size increased from stock- to preferred-lengths; however, an increase in relative weight was seen for memorable-length fish (Figure 5).

Age, Growth, and Mortality.—In 2019, 86 Largemouth Bass otoliths were aged by two independent readers. The two readers agreed on 92% of the ages; however, reader agreement ± 1 year was 96%. 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 10 years; however, no age-8 (2010 year class) or age-9 (2011 year class) fish were present in the sample. The majority of the population (91%) was between age 1 and age 4, with age-1 (2018 year class) fish making up 44% the total catch (Figure 6). Growth of Largemouth Bass increased steadily until age 4, after which growth was minimal (Figure 7). The catch curve analysis estimated total instantaneous mortality (*Z*) to be 0.52 (SE = 0.1). Estimated instantaneous natural mortality rates (*M*) ranged from 0.31 to 0.61, with an average *M* of 0.48 (Table 1). Using the average *M*, instantaneous fishing mortality rate (*F*) was 0.04.

Creel Survey.—From September 2016 through August 2017, the creel clerk conducted 115 interviews comprised of 253 anglers. The majority of these interviews occurred at the Pettigrew boating access area (BAA; 54%) and Cypress Point pier (30%; Figure 8). No interviews were conducted at the southwest piers during the survey due to weather restricting access to the lake. Anglers spent an estimated 10,066 hours (SE = 1,742) fishing on Lake Phelps. Angling

effort peaked in late spring (April and May) and declined until early fall (Figure 9). Anglers at Lake Phelps spent a similar amount of time fishing during weekdays (5,192 hours; SE = 1,702) and weekends (4,873 hours; SE = 1,025). Most anglers (62%) targeted Largemouth Bass, while 30% targeted anything, and 8% targeted Pumpkinseed. The majority (91%) of the anglers that targeted Largemouth Bass were practicing catch and release fishing. Over the creel period, anglers caught an estimated 3,884 (SE = 535) Largemouth Bass. Catch of Largemouth Bass peaked in late spring with a second, but smaller peak in early fall (Figure 10a). Harvest of Largemouth Bass was low during the creel survey with only five Largemouth Bass weighed and measured. Anglers harvested an estimated 43 (SE = 25) Largemouth Bass during the survey (Figure 10b). Anglers were also asked their opinion on regulations and the overall fishery at Lake Phelps. Regarding the protective slot limit on Largemouth Bass, 81% of anglers either supported or strongly-supported this regulation (Table 2). When asked about improvements to the fisheries at the lake, the top responses included more access areas to the lake (43%), more habitat in the lake (10%), and regulation changes (6%; Table 3).

Management Implications

Relative abundance of Largemouth Bass in Lake Phelps has been stable since 2010, varying about the 50 fish/h mark. While, relative abundance in 2018 was the highest since 2011, relative abundance in 2019 was near average catch rates. The 2019 population consists of mostly 1–4 year-old fish with very few fish older than age 7 collected. Lake Phelps is unique in that the relatively clear water likely allows for improved observation and netting of substock individuals compared to less clear water in other waterbodies. This scenario creates an opportunity for a relative assessment of Largemouth Bass recruitment index at Lake Phelps. Successful spawning and recruitment of the 2018 year-class was evident by the large number of substock, age-1 fish collected in 2019. The 2019 age distribution is truncated compared to the 2015 age analysis (Smith and Potoka 2016). However, it is similar to the pre-slot distribution in 2001 (Hand and Thomas 2001). Poor spawns and recruitment of the 2007, 2008, and 2009 year-classes likely limited the number of older fish observed in 2019. Largemouth Bass exhibited excellent growth until they reached the slot limit, at about age 4, after which growth slowed dramatically, with rare occurrences of growth out beyond the protective slot limit. This trend was documented in previous reports (Hand and Thomas 2001; Ricks and McCargo 2011; Smith and Potoka 2016). Mark recapture data from Lake Phelps (NCWRC unpublished data) also shows minimal growth in individuals above 400 mm in length (roughly age 4). The reduced growth rates in the older fish may be related to the abundance of suitable prey. Pumpkinseed growth rates are extremely high, reaching 200 mm by age 3 (NCWRC unpublished data). The growth rates of Pumpkinseed force older Largemouth Bass to compete with smaller Largemouth Bass for smaller-sized prey (Olson 1996). Relative condition of Largemouth Bass was at acceptable levels in 2018 and 2019, however, the decreasing trend in relative weight as length increases is concerning. Although relative weights have increased, this trend has occurred since 2001. When Hand and Thomas (2001) recommended a protective slot, they stated that harvest of fish under the slot limit must increase for regulations to be effective. Estimates of mortality in 2019 indicated that the natural mortality was the main driver of total mortality. Fishing mortality was extremely low, and strongly indicative of a catch and release

fishery. The protective slot limit has failed to produce more memorable- and trophy-length fish. This regulation should be modified with a regulation that increases harvest opportunities, including exemptions of smaller fish, while protecting the most mature, and older individuals.

The last creel survey at Lake Phelps was conducted in 1979 (Kornegay and Dineen 1983). Since then, some notable changes in fishing practices have occurred. Total effort was approximately 5,000 hours lower in the current creel survey than in the previous survey (15,468 angler hours). In 1979, more angling effort occurred on weekends than weekdays, while anglers spent about an equal amount of effort on weekdays and weekends during the current survey. While Largemouth Bass was the most targeted species in both surveys, a shift in the Largemouth Bass fishery was noted. In the previous study, anglers harvested more Largemouth Bass than they released; however, anglers in the current study almost exclusively practiced catch and release. In 1979, it was estimated that anglers harvested 1,773 Largemouth Bass, rates that were magnitudes higher than the estimated harvest in the current survey and indicate a paradigm shift in angling practices at Lake Phelps. The current estimates of effort, harvest, and catch do not include data from private piers that are located on the lake. While the likelihood of encountering anglers on these piers was low (personal communication with Pettigrew State Park rangers and NCWRC wildlife officers), weather limited access to the lake on the few days that the piers were selected to be surveyed. Future creel surveys should be designed to obtain a representative sample from the private piers.

Currently, Lake Phelps provides anglers with quality fishing and ample opportunities to catch Largemouth Bass from 14 to 20 inches (356 mm to 508 mm), with rare opportunity to catch Largemouth Bass over 20 inches. Since being implemented nearly 18 years ago, the trophy regulations have been ineffective at increasing the number of Largemouth Bass over 20 inches. Slot limits are most effective at altering size structures when fishing mortality is high (Novinger 1984). Results from this report show that harvest and fishing mortality are extremely low. Removing the protective slot limit may promote more harvest from anglers who previously avoided the lake due to the protective slot limit. With the high relative abundance of young (1-4 years old) fish between 200 mm (8 inches) and 400 mm (16 inches) the Largemouth Bass population at Lake Phelps would be able to support a minimum length limit of 14 inches and a creel limit of five fish per day.

Management Recommendations

1. Propose a regulation that would remove the protective slot limit and implement a minimum length limit of 14 inches and a creel limit of five (5) fish per day.
2. Gather public input and comments on the proposed regulation and a suite of potential alternate regulations to optimize management strategies.
3. Monitor and survey Largemouth Bass and sportfish populations every spring, collecting otoliths as needed to assess age distribution.
4. Increase forage fish in Lake Phelps by stocking Threadfin Shad *Dorosoma petenense*. Another smaller prey species should improve Largemouth Bass growth rates without significant impacts to the lake's ecosystem.
5. Design a study to determine the contribution of catch and release mortality to the total mortality of Largemouth Bass in Lake Phelps.

6. Continue to maintain and monitor artificial habitat currently deployed in Lake Phelps. Consider adding more habitat at the current locations, or new locations if suitable depths can be found.
7. Conduct a creel survey in 2023 to assess potential changes in angling practices. Design the survey to intercept more anglers at private piers.
8. Partner with other agencies to construct a second boating access area on the southern side of the lake.

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Literature Cited

Bettoli, P. W., and L. E. Miranda. 2001. Cautionary note about estimating mean length at age with subsampled data. North American Journal of Fisheries Management 21:425–428.

Buckmeier, D. L., and R. G. Howells. 2003. Validation of otoliths for estimating ages of Largemouth Bass to 16 years. North American Journal of Fisheries Management 23:590–593.

Cubillos, L. A., R. Alarcon, and A. Brante. 1999. Empirical estimates of natural mortality for the Chilean Hake (*Merluccius gayi*): evaluation of precision. Fisheries Research 42:147–153.

Djabali, F., A. Mehailia, M. Koudil, and B. Brahmi. 1993. Empirical equations for the estimation of natural mortality in Mediterranean teleosts. Naga, the ICLARM Quarterly 16:35–37.

Dockendorf, K. J., and J. W. McCargo. 2011. Largemouth Bass electrofishing surveys at Lake Phelps, North Carolina. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-22, Final Report, Raleigh.

Gabelhouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273–285.

Guy, C. S., R. M. Neumann, D. W. Willis, and R. O. Anderson. 2007. Proportional Size Distribution (PSD): A Further Refinement of Population Size Structure Index Terminology. Fisheries 32(7):348.

Hand, G. R., and C. D. Thomas. 2001. Assessment of Largemouth Bass and sunfish populations in Lake Phelps, North Carolina. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-22, Final Report, Raleigh.

Jensen, A. L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences 53:820–822.

Jones, C. M., and K. H. Pollock. 2012. Recreational survey methods: estimation of effort, harvest, and released catch. Pages 883–919 *in* A. V. Zale, D. L. Parrish, and T. M. Sutton, editors. Fisheries Techniques, 3rd edition. American Fisheries Society, Bethesda, Maryland.

Kornegay, J. W., and K. W. Dineen. 1983. Determination of Sport Fishing Pressure and Harvest on Lake Phelps. North Carolina Wildlife Resources Commission, Federal Aid in Fish Restoration, Project F-22, Final Report, Raleigh.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Journal of Fish Biology 49:627–647.

Murphy, B. R., D. W. Willis, and T. A. Springer. 1991. The relative weight index in fisheries management: status and needs. Fisheries 16(2):30–38.

Novinger, G. D. 1984. Observations on the use of size limits for black basses in large impoundments. Fisheries 9(4):2-6.

Olsen, M. H. 1996. Predator-prey interaction in size-structured fish communities: implications of prey growth. Oecoloigia 108:757–763.

Pollock, K. H., C. M. Jones, and L. T. Brown. 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society, Special Publication 25, Bethesda, Maryland.

Potoka, K. M., J. W. McCargo, and B. R. Ricks. 2014. Characteristics of Largemouth Bass and Pumpkinseed populations at Lake Phelps, 2013-2014. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-108, Final Report, Raleigh.

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ricks, B. R., and J. W. McCargo. 2011. Characteristics of Largemouth Bass and Pumpkinseed populations at Lake Phelps, 2010. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-22, Final Report, Raleigh.

Ricks, B. R., and J. W. McCargo. 2013. Characteristics of Largemouth Bass and Pumpkinseed populations at Lake Phelps, 2011–2012. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-22, Final Report, Raleigh.

Slipke, J. W., and M. J. Maceina. 2014. Fishery Analysis and Modeling Simulator (FAMS). Version 1.64. American Fisheries Society, Bethesda, Maryland.

Smith, M. W., A. Y. Then, C. Wor, G. Ralph, K. H. Pollock, and J. M. Hoenig. 2012. Recommendations for catch-curve analysis. North American Journal of Fisheries Management 32:956–967.

Smith, C. A., and K. M. Potoka. 2016. Population Characteristics of Largemouth Bass and Pumpkinseed in Lake Phelps, NC; 2015–2016. North Carolina Wildlife Resources Commission, Federal Aid in Sport Fish Restoration, Project F-108, Final Report, Raleigh.

Wege, G. J., and R. O. Anderson. 1978. Relative weight (Wr): a new index of condition for Largemouth Bass. Pages 79–91 *in* G. Novinger and J. Dillard, editors. New approaches to the management of small impoundments. American Fishery Society, North Central Division, Special Publication 5, Bethesda, Maryland.

TABLE 1. Models, parameters and natural mortality estimates of Lake Phelps Largemouth Bass in 2019.

Model	Model Parameters				Natural Mortality
	K	t_0	W_{inf}		M
Cubillos et al. (1999)	0.41	0.00			0.57
Djabali et al. (1993)	0.41		2551.46		0.42
Jensen (1996)	0.41				0.61
Lorenzen (1996)	0.41		2551.46		0.31
				Average	0.48

TABLE 2. Angler opinions collected during the 2016–2017 creel survey regarding the 16–20 inch protective slot limit on Largemouth Bass in Lake Phelps, NC.

Protective Slot Opinions	**Number of Angling Parties**	**%**
Strongly Support	67	58
Support	26	23
Neutral	8	7
Oppose	0	0
Majorly Oppose	3	3
Not Sure	2	2
Didn't Know	7	6
Declined Response	2	2
Total	115	

TABLE 3. Angler opinions collected during the 2016–2017 creel survey regarding the improvement of the fisheries at Lake Phelps. Multiple responses were accepted for this question; therefore, the number of angling party responses did not sum to total number of interviews conducted (N = 115).

Fishery Improvements	Number of Angling Parties	%
Access	52	43
Forage fish	4	3
Habitat	12	10
None	46	38
Other	1	1
Regulations	7	6
Total	122	

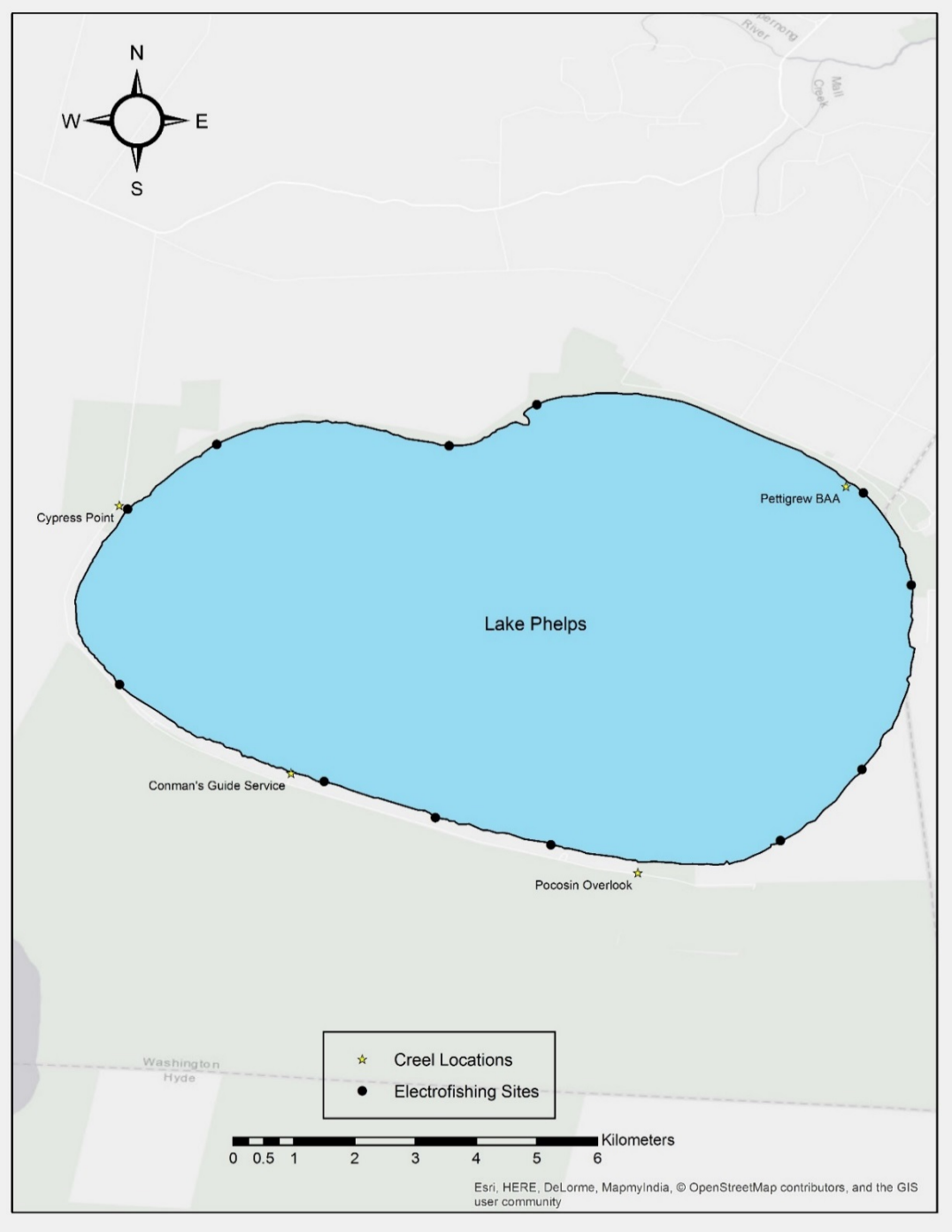

FIGURE 1. Electrofishing sites at Lake Phelps in 2018 and 2019, and 2016–2017 creel locations.

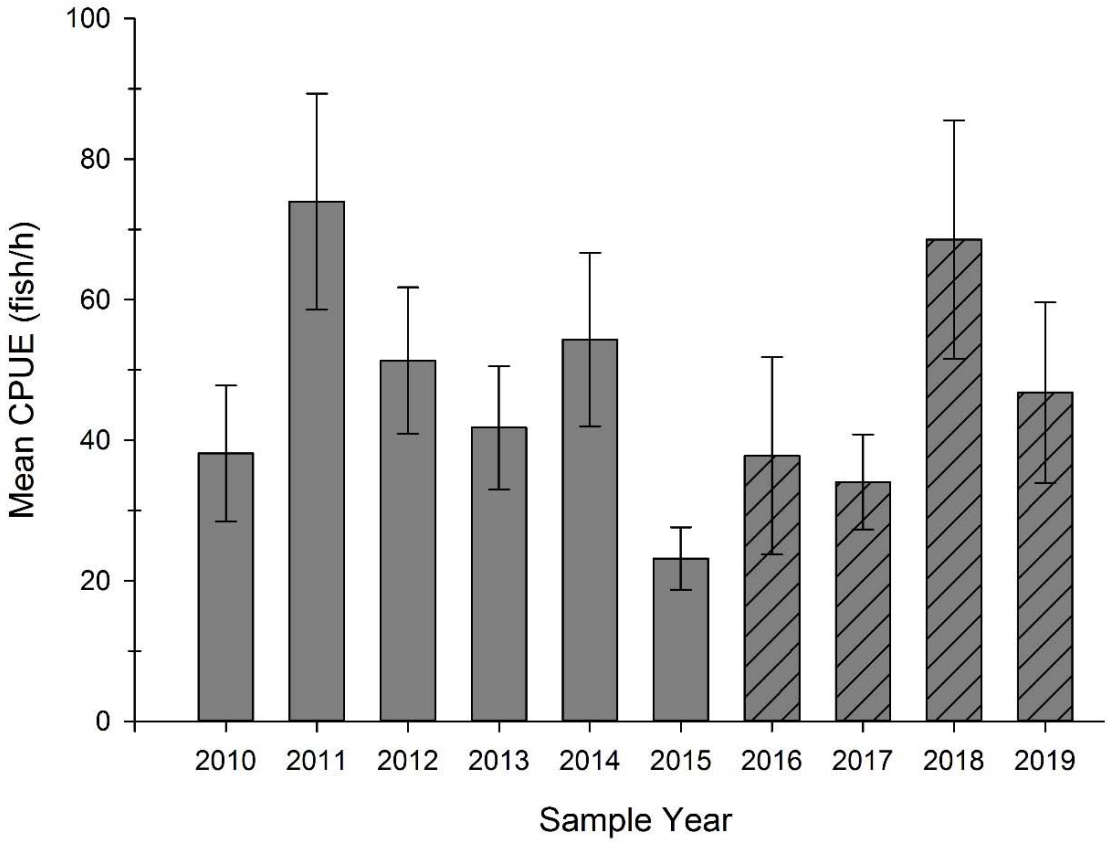

FIGURE 2. Mean catch per unit effort (CPUE) of Largemouth Bass ≥ 200 mm collected at Lake Phelps with boat electrofishing from 2010–2019. Data from 2010–2012 (Ricks and McCargo 2011 and 2013), 2014–2017 (Potoka et al. 2014; Smith and Potoka 2016; unpublished data). Error bars indicate one standard error. The dashed bars indicate for 2016–2019 new sample site selection (Smith and Potoka 2016).

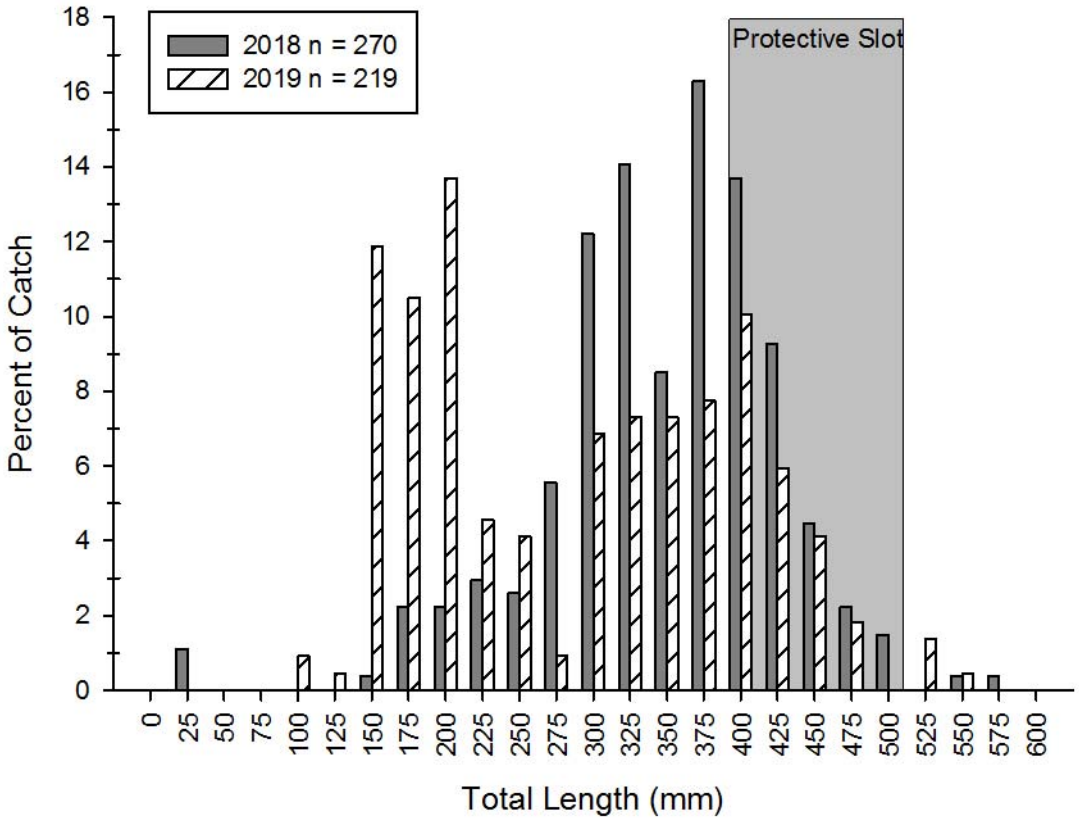

FIGURE 3. Length distribution of Largemouth Bass collected from Lake Phelps in 2018 and 2019. The protective slot limit (gray box) for Largemouth Bass is from 406 mm to 508 mm.

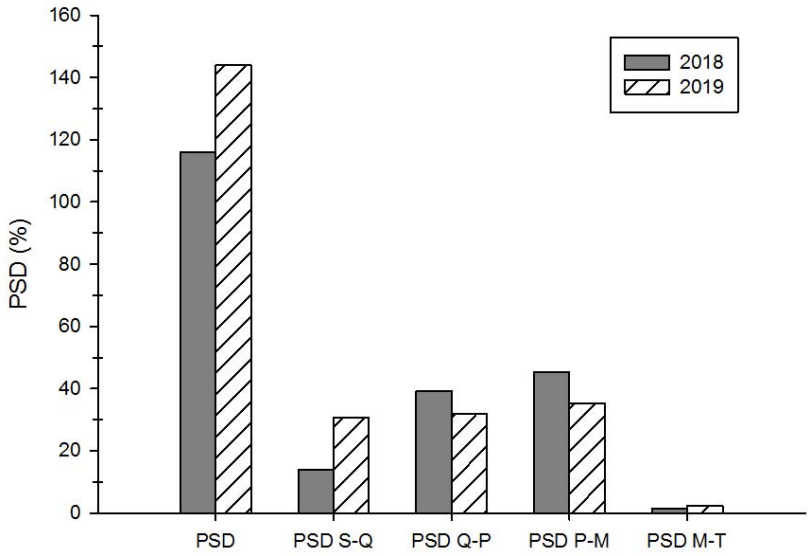

FIGURE 4. PSD values for Largemouth Bass collected during the 2018 and 2019 Lake Phelps sport fish surveys.

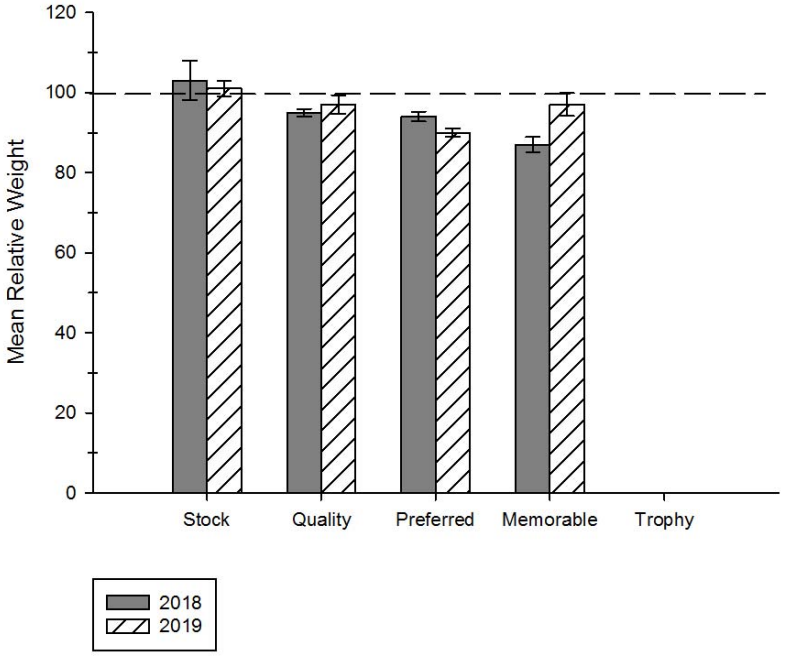

FIGURE 5. Mean relative weights of Lake Phelps Largemouth Bass by proportional stock density category for 2018 and 2019. The dotted line at $W_r = 100$ denotes the 75th percentile of weights at given length categories of Largemouth Bass across its entire range. Error bars indicate standard error.

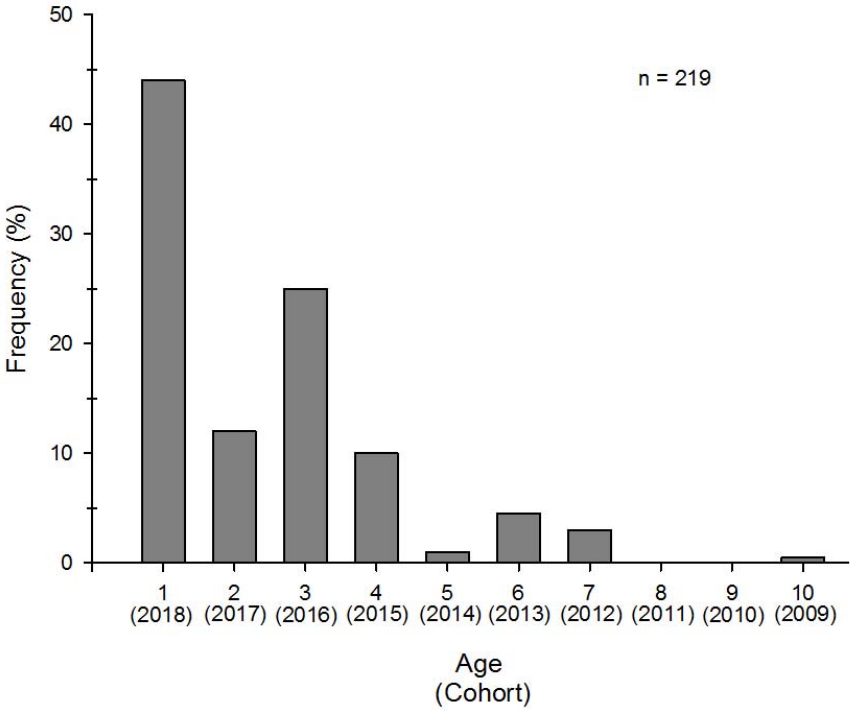

FIGURE 6. Age distribution of Largemouth Bass collected during the 2019 Lake Phelps sportfish survey.

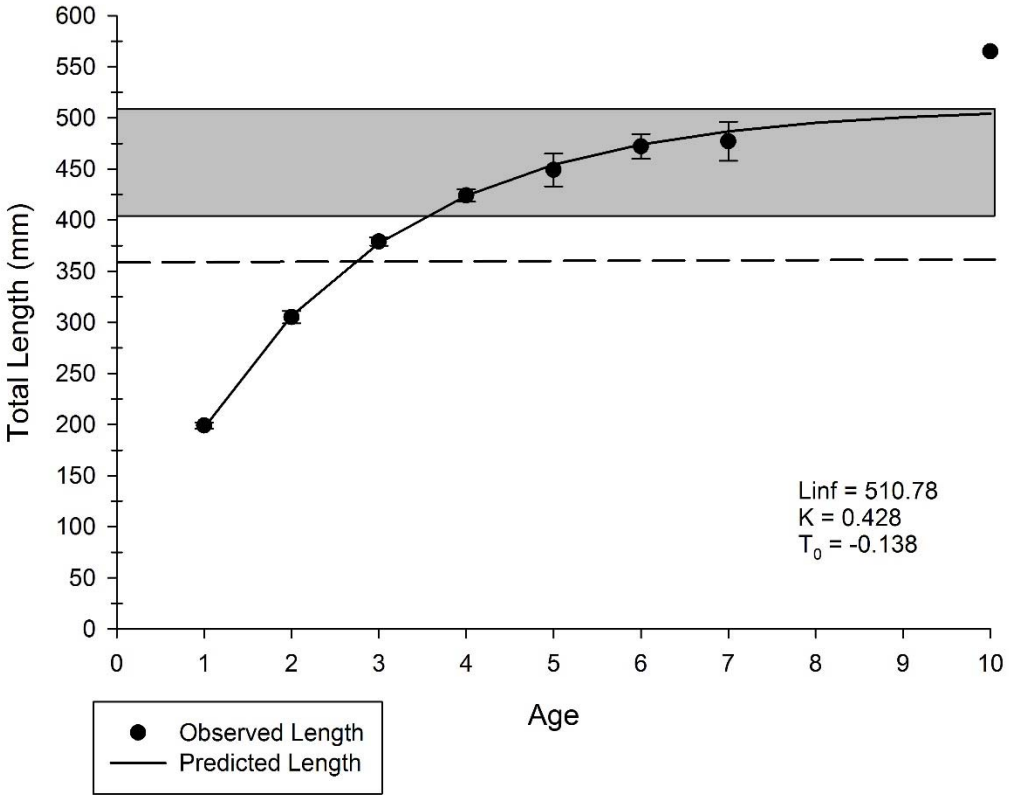

FIGURE 7. Mean length at age for Largemouth Bass collected in 2019 from Lake Phelps. Error bars indicate one standard error. The dashed line represents the minimum length limit, while the shaded box represents the protected slot limit. The solid line (curve) is the von Bertalanffy growth curve predicted from mean length at age.

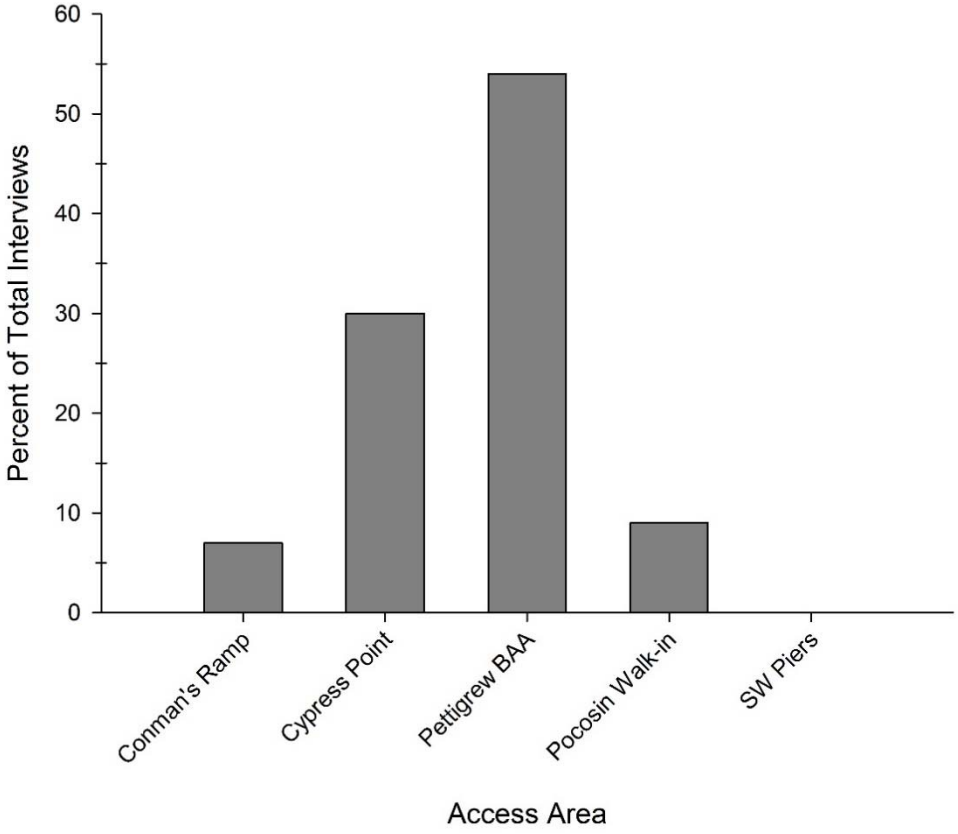

FIGURE 8. Percent of interviews by location from the 2016–2017 creel survey.

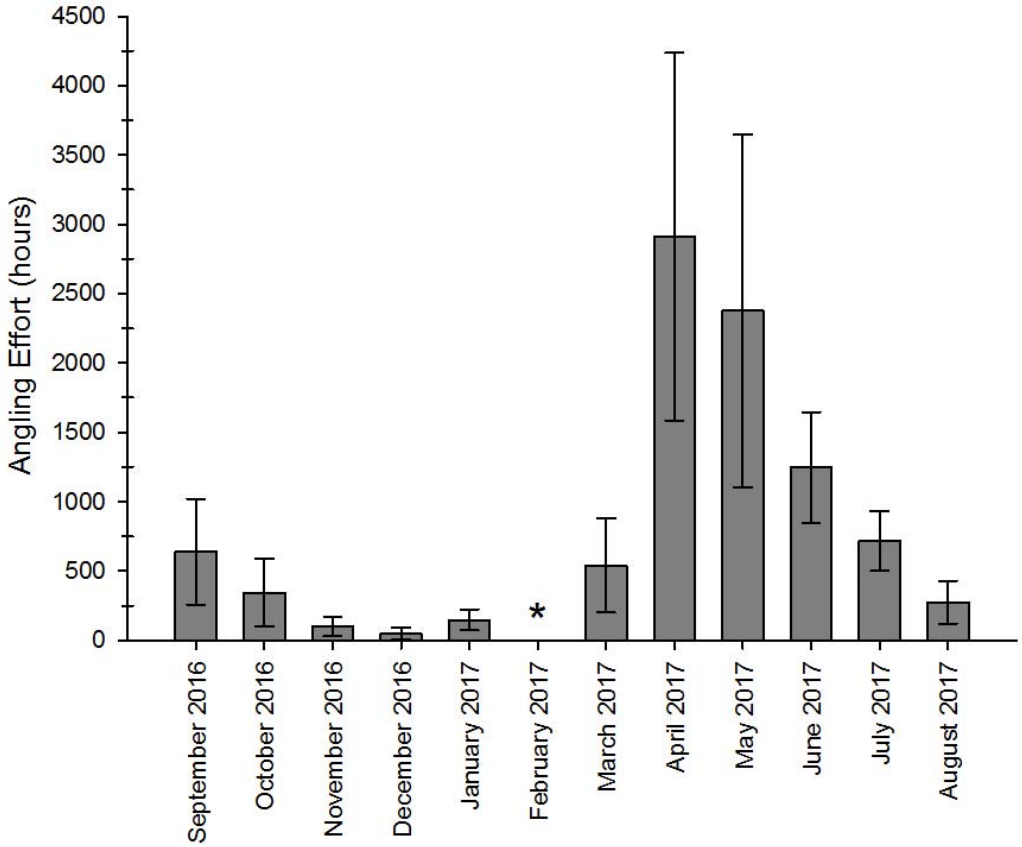

FIGURE 9. Estimated monthly angling effort during the 2016–2017 creel survey. Error bars indicate one standard error. The creel survey was not conducted during February 2017 due to staffing limitations.

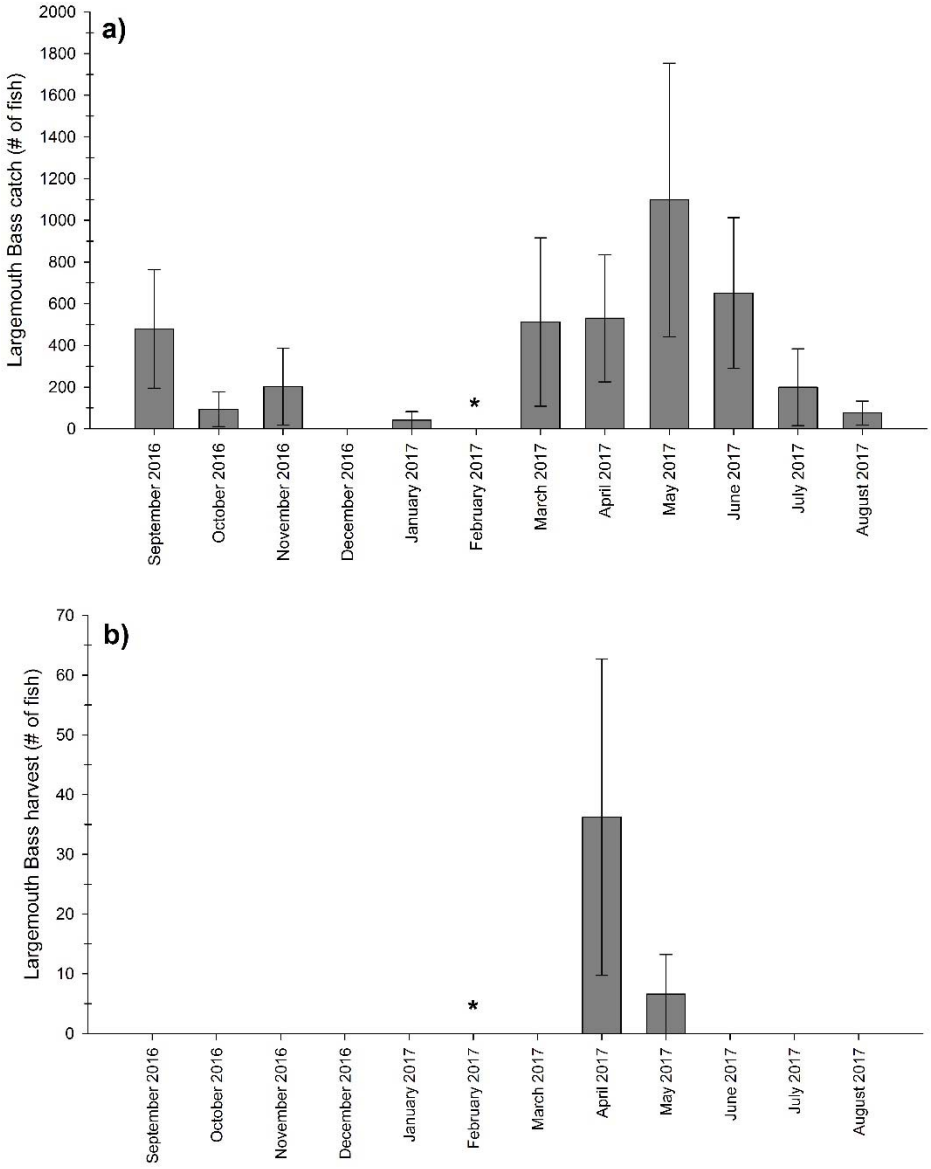

FIGURE 10. Estimated monthly catch (a) and harvest (b) of Largemouth Bass (number of fish) during the 2016–2017 creel survey. Error bars indicate one standard error. The creel survey was not conducted during February 2017 due to staffing limitations.

APPENDIX A: Fish species collected from Lake Phelps

Common Name	Scientific Name	Year of Last Capture
Alewife	*Alosa pseudoharengus*	2019
American Eel	*Anguilla rostrata*	2019
Banded Killifish	*Fundulus diaphanus*	2019
Bowfin	*Amia calva*	2019
Bluegill	*Lepomis macrochirus*	2019
Black Crappie	*Pomoxis nigromaculatus*	2019
Chain Pickerel	*Esox niger*	2019
Gizzard Shad	*Dorosoma cepedianum*	2019
Golden Shiner	*Notemigonus crysoleucas*	2019
Largemouth Bass	*Micropterus salmoides*	2019
Longnose Gar	*Lepisosteus osseus*	2017
Eastern Mosquitofish	*Gambusia holbrooki*	2019
Pumpkinseed	*Lepomis gibbosus*	2019
Redfin Pickerel	*Esox americanus*	2014
Tadpole Madtom	*Noturus gyrinus*	2017
Spottail Shiner	*Notropis hudsonius*	2018
White Catfish	*Ameiurus catus*	2019
White Perch	*Morone americana*	2019
Yellow Bullhead	*Ameiurus natalis*	2019
Yellow Perch	*Perca flavescens*	2019
Blueback Herring	*Alosa aestivalis*	1996
Satinfin Shiner	*Cyprinella analostana*	1996
Channel Catfish	*Ictalurus punctatus*	1996
Banded Sunfish	*Enneacanthus obesus*	1984
Swamp Darter	*Etheostoma fusiforme*	1984
Warmouth	*Lepomis gulosus*	1972
Bluespotted Sunfish	*Enneacanthus gloriosus*	1972
Brown Bullhead	*Ameiurus nebulosus*	1972
Inland Silverside	*Menidia beryllina*	1972