McKinney Lake Feeding Program: Bluegill and Largemouth Bass Stock Assessment

Federal Aid in Sport Fish Restoration
Project F-108

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Abstract. In 2016, an adaptive fisheries management program was initiated to improve the fishery at McKinney Lake, a small (26 ha), relatively unproductive Sandhills impoundment. The primary objective was to increase the average size and abundance of sportfish, particularly Bluegills *Lepomis macrochirus*, using established fisheries management techniques. Primary management activities included feeding, supplemental Bluegill stocking to offset poor recruitment and harvest, and removal of undesirable species that could consume feed (chubsuckers *Erimyzon spp*.). From 2016–2021, 10 automatic fish feeders dispensed commercial fish feed at a rate of 5 kg per feeder per day during March–October, when fish are actively feeding. Approximately 11,400 60–155 mm Bluegills were stocked and approximately 400 kgs of chubsuckers (average length 300–350 mm) were removed from 2016–2021. Largemouth Bass *Micropterus salmoides* and Bluegill populations were surveyed by boat electrofishing (April 2016–2019, March 2021) and trap-net sampling (October–November 2017–2021) to obtain stock assessment data. Anecdotal evidence suggests the feeding program has been successful with an increase in angler use and multiple Bluegills larger than 454 g observed. The Largemouth Bass population appears to be relatively unchanged. However, drawing meaningful data-based conclusions has been difficult because of low and variable catch. It is recommended to continue the feeding program at McKinney Lake as funding allows but more productive sites should be

considered for future feeding programs in order to utilize labor and fiscal resources more efficiently.

Anglers commonly fish the impoundments of the Sandhills Game Lands but because the underlying soil structure is composed almost entirely of well-leached silicate sands (Humphries 1964), these waters are relatively unproductive. Fish species that are undesirable to anglers often predominate while catch rates of sportfish are often low. Although management efforts to increase primary productivity could yield significant improvements in fish abundance and average size, traditional liming and fertilization regimes are not practical because of high flow-through rates, tannic water, and extensive aquatic vegetation. These issues can be bypassed by directly feeding the fish. Because of this, we hypothesized that feeding is likely the most practical way to significantly improve a Sandhills fishery. However, to be successful, potential negative factors such as poor recruitment, excessive predation, overharvest, and competition from undesirable species should be addressed as part of a comprehensive management program.

In 2016, an adaptive fisheries management program was initiated at McKinney Lake, a Sandhills impoundment. The primary objective was to increase the average size and abundance of sportfish, particularly Bluegills *Lepomis macrochirus*, available to anglers. Established fisheries management techniques were utilized to reach this objective. Although the initial strategy was to establish a feeding program, preliminary sampling indicated that additional management action, including sportfish stocking and fish removal, was necessary to ensure the likelihood of success. Management success was evaluated by comparing Bluegill and Largemouth Bass *Micropterus salmoides* stock assessment data over time. Although Largemouth Bass were not expected to consume feed, feeding could have created an indirect benefit by increasing forage biomass.

The objective of this survey was to obtain stock assessment data on the Bluegill and Largemouth Bass populations to evaluate the management of the fishery at McKinney Lake. Other sportfish species in McKinney Lake that might benefit from feeding, such as Redear Sunfish *L. microlophus*, were not assessed due to low overall catch.

Methods

Study site. McKinney Lake is a small reservoir of approximately 26.3 ha located in the Sandhills Game Lands near Hoffman, NC (Figure 1). It was impounded in January 1936 (King 1943) as a water supply for what is now McKinney Lake State Fish Hatchery. The average depth is approximately 2 m and the upper third of the lake contains stumps that make boating access difficult. The shoreline is mostly forested and habitat consists primarily of woody debris and emergent vegetation. Primary game fish include Largemouth Bass, Chain Pickerel *Esox niger*, and Bluegill, but Black Crappies *Pomoxis nigromaculatus,* Redear Sunfish, Yellow Perch *Perca flavescens,* and Fliers *Centrarchus macropterus* are also present. General statewide size and creel limits apply for these species. It is open to the public during daylight hours for fishing.

Feeding program. In 2016, 10 automatic, floating fish feeders were installed in 1.5–3 m of water and evenly spaced along the shoreline approximately 20 m from shore (Figure 1). Each feeder has a 150 kg capacity and is powered by a solar-charged 12 VDC battery that is programmed to dispense feed hourly during daytime hours. From 2016–2021, each feeder dispensed approximately 5 kg of commercial fish feed per day during the warmer months when fish are actively feeding (March–October).

Adaptive management. The initial electrofishing survey in 2016 indicated poor Bluegill recruitment with only a few adults larger than 120 mm. Additionally, the forage base was composed primarily of chubsuckers (*Erimyzon* spp.), which have a diet similar to Bluegills and are known to consume fish feed (Shireman et al 1978). In order to help ensure success and maximize the efficiency of the feeding program, Bluegill stocking and chubsucker removal were initiated in Summer 2016.

Bluegill stocking. Bluegills collected as part of normal catfish harvesting operations at McKinney Lake State Fish Hatchery were stocked into McKinney Lake in the summers of 2016-2021 (Table 1). These fish are typically considered bycatch and would have otherwise passed into downstream areas.

Chubsucker removal. Chubsuckers were removed from McKinney Lake as collected during sportfish sampling efforts, beginning with the initial electrofishing sample in 2016. Subsequent chubsucker removal efforts were conducted during fall trap-net sampling (2017-2021, Table 2).

Field collections. Largemouth Bass and Bluegills were collected from the entire accessible shoreline April 2016–2019, and March 2021, during daylight hours using a Smith-Root 7.5 GPP boat electrofisher (1000 VDC, 3–4 A). Bluegills were collected October–November 2017–2018 using 25.4-mm-bar-mesh trap nets set perpendicular to the shoreline. Total length (mm) and weight (g) were measured and the left pelvic fin was clipped as a marker so that data from recaptured fish would not be used. After processing, the fish were released back into the lake.

Data assessment. The status of the Largemouth Bass and Bluegill populations was determined by evaluating several variables: 1) Relative Abundance; 2) Size Structure; 3) Body Condition. Data were compared with surveys from previous years to monitor population trends and develop management recommendations to maintain and improve the fishery.

Relative abundance. Relative abundance was quantified by using catch-per-unit-effort (CPUE). CPUE was measured as the number of Largemouth Bass and Bluegills collected per hour of electrofishing time and as the number of Bluegills collected per trap net night. High catch rates may indicate overcrowding, which can lead to poor growth rates and stunted populations. Low catch rates may indicate high annual mortality (natural and fishing) and poor survival of young fish (recruitment). However, variable catch rates can also be due to sample bias. Because trap nets are stationary, catch rates can vary depending on fish movement and the density of fish within the area of the net set.

Size distribution. Size distributions were evaluated using length and weight distribution indices, length frequency histograms, and stock density indices. Size distribution indices used for Largemouth Bass were mean length and proportions of fish greater than 356 mm and 457 mm. Size distribution indices used for Bluegills were the proportions of fish greater than 227 g, 340 g, and 454 g. Proportional Size Distribution (PSD) and Proportional Size Distribution-Preferred (PSD-P) were calculated for Bluegills and Largemouth Bass using equations developed by Gabelhouse (1984). Low PSD and PSD-P values indicate that few large fish were collected, which may be due to insufficient forage or an overcrowded population. High values suggest poor recruitment or sampling bias, such as small fish escaping through the net mesh.

Body condition. Relative weight (Wege and Anderson 1978) provides an indication of body condition by representing a fish's weight as a percentage of a standard weight for that length and species of fish. Relative weights were calculated using the standard weight equations developed for Bluegills (Hillman 1982) and Largemouth Bass (Henson 1991). A relative weight of 100 is considered ideal and represents fish in above average condition. This is because the standard weight was developed using the 75th percentile of weights from a national database. Low relative weight values mean fish are skinnier than average and high values indicate that fish are heavier than average.

Results

Bluegill

Relative Abundance. Catch rates were low overall, with a total of 510 Bluegills collected over 6 years. This represents 26.5 total hours of electrofishing and 100 net nights of trap-netting data. Electrofishing yielded an average catch rate of 14.2 fish per hour (n = 351) over the course of the project while trap netting averaged 1.9 fish per net night (n = 159). Overall, electrofishing tended to yield more, but smaller, fish. Relative abundance has fluctuated dramatically between gears and over time (Table 3). No clear trends were evident. The highest electrofishing CPUE of 22.1 fish per hour was recorded in 2018 while the lowest, 5.7 fish per hour, was recorded in 2019. The highest trap-netting CPUE of 4.7 fish per net night was recorded in 2018 while the lowest, 0.7 fish per net night, was recorded in 2020.

Size Distribution. Although size distribution values documented the presence of larger fish and indicated high proportions of larger fish, it is difficult to assess clear trends because of sampling variability. The mean length of Bluegills collected over the course of the project was 163 mm and peaked at 207 mm in 2020 (Table 4, Figures 2–7). The proportion of Bluegills that were greater than 227, 340, and 454 g seemed to increase over time and peaked at 35.7, 35.7, and 7.1%, respectively in 2020, before appearing to drop to pre-feeding levels in 2021. Similarly, values for PSD and PSD-P increased to highs of 86 and 50, respectively in 2020, before dropping in 2021. However, higher values were contingent on the proportion of trap-netted fish collected, which were generally larger than those collected by electrofishing. The 2020 values were probably abnormally high since no electrofishing sample was collected due to the Covid-19 pandemic. Also the sample size was low with only 14 individuals collected so it can’t be assumed that these fish were representative of the entire population. In 2021, the trap-net catch was even lower at 10, while the electrofishing sample was 65, which increased the proportion of smaller fish. Overall, 27 Bluegills over 340 g were collected, 9 over 454 g were collected, and the largest weighed 799 g.

Body Condition. Relative weights generally increased with length, particularly for fish greater than 200 mm (Figures 8–13). This indicates that larger fish may have benefitted more from feeding. Relative weight values varied over the course of the project with lows of 78 in 2016 and 2021 and a high of 90 in 2018 (Table 4). As with size structure values, relative weight means mostly reflected the proportion of trap-netted fish in the sample. The 2016 and 2021 samples with the lowest relative weights also had the lowest proportion of trap-netted fish. Because trap-netting was conducted at the end of the growing (feeding) season and typically collected larger fish, the relative weights were normally higher than those from the spring electrofishing surveys held at the start of the feeding period. Overall, relative weights were low. This reflects the low productivity of the lake in April and to a lesser extent the slower adaptation of smaller fish to feeding.

Largemouth Bass

Relative Abundance. Relative abundance has fluctuated since the feeding program was initiated in 2016, but no clear trend was evident (Table 5). The highest mean CPUE of 39.2 was recorded in 2018 while the lowest (24.9) was recorded in 2021. These values are on the low end of the average range for Piedmont reservoirs (30–60 fish per hour; Oakley and Dorsey 2013).

Size Distribution. Overall, size structure values have fluctuated somewhat over time but no clear trends are evident (Table 5, Figures 14–18). The mean length of Largemouth Bass collected over the course of the project was only 232 mm. In comparison, the typical mean for most Piedmont reservoirs is well over 300 mm. The highest mean length of 268 mm was recorded in 2021 while the lowest (200 mm) was recorded in 2019. The percentages of fish greater than 356 mm, and 457 mm, respectively have been consistent over time with the exception of 2019. Only six Largemouth Bass greater than 356 mm were collected in this sample which skewed the percentage lower. Values for PSD have trended lower over time with a high of 68 in 2016 and a low of 44 in 2021. However, this is mostly explained by the nearly three-fold increase in the number of 200–300 mm fish collected in 2021 versus 2016; the 2017–2019 values are similar. With the exception of 2019, PSD values have been in the average range for a Piedmont reservoir (50–70; Oakley and Dorsey 2013). PSD-P values have fluctuated over time with a high of 21 in 2016 and a low of 4 in 2019 (only 2 fish preferred size and larger were collected in 2019). These values have been consistently below the average PSD-P range for a Piedmont reservoir (30–40; Oakley and Dorsey 2013).

Body Condition. Relative weights for Largemouth Bass averaged 80 throughout the study and ranged from a low 78 in 2021 to a high of 81 in 2017 and 2018 (Table 5). This is below average for Piedmont reservoirs, where relative weights typically average over 90 (Oakley and Dorsey 2013). Relative weights generally increased with length for fish greater than 300 mm (Figures 19–23).

Discussion

Anecdotal evidence suggests the feeding program at McKinney Lake has been successful since its implementation in 2016. Fisheries staff have noted an increase in angler use and multiple Bluegills over 454g have been observed since feeding began. However, it is difficult to draw biologically meaningful conclusions based on survey data. Although no clear trends in body condition, size, and relative abundance were evident for Bluegills or Largemouth Bass, it has been difficult to collect a representative sample in order to quantify population improvements. This was a concern from the outset. Electrofishing can be difficult in Sandhills impoundments due to tannic water, which often has low conductivity and poor visibility. At McKinney Lake, electrofishing did not appear to adequately sample larger fish. After poor catch in the initial sample, fall trap netting was implemented to help bolster the Bluegill sample. As a passive gear, trap nets are dependent upon fish movement for success, and this wasn’t reliably the case at McKinney Lake. Catch rates from both trap netting and electrofishing were relatively low but highly variable, both in terms of size distribution and numbers collected. Trap-net data was beneficial in that it tended to collect larger, better conditioned fish compared to electrofishing. This is likely due in part to the timing of the sample at the end of the growing (feeding) season. However, most metrics skewed lower in years when trap-net data was limited. This, coupled with variable electrofishing catch, made it difficult to draw meaningful conclusions or track trends.

Data analysis indicated the presence of larger Bluegills from 2017 through 2020, with several fish larger than 454 g collected. In 2021 all of the size structure and condition metrics were reduced, primarily because of the very low trap-net catch relative to the electrofishing catch. In fact, the 2021 data looks very similar to the 2016 data, which preceded significant feeding. However, this is most likely due to sampling variability rather than a complete failure of the program. Harvest may play a role, however, as the fishery has become more popular since the feeding program began. Staff at McKinney Lake have observed anglers targeting and harvesting larger Bluegills (NCWRC staff observation).

Although Largemouth Bass do not readily take feed and are not the primary focus of the feeding program, they could potentially receive a secondary benefit from increased forage. However, the Largemouth Bass population appears to be relatively unchanged since the feeding program began in 2016. This could indicate that the forage base has not changed appreciably in size. Feeding and stocking additions may have been offset by chubsucker removals.

McKinney Lake is logistically ideal for a feeding program, with staff as well as feed delivery and storage on-site. Since the feeding program has been well received by anglers and appears to have increased angler use, it is recommended to continue it at McKinney Lake as resources allow. The feeding rate was reduced to a less intensive rate of 2.5 kg/feeder/day for 2022. This was done to reduce demands on hatchery staff and because there was evidence at times that not all of the feed was being consumed at the higher feeding rate.

Management objectives, available resources, labor and funding should all be considered before initiating a feeding program for small impoundments. When compared with more productive small impoundments, Sandhills reservoirs likely require additional management input and strategies to achieve similar results. For example, Bluegill recruitment appeared to be poor at McKinney Lake so stocking was initiated in an attempt to increase the population. In more productive waters, Bluegill recruitment is not typically an issue so stocking would likely not be needed. In general, it would be a more efficient use of labor and fiscal resources to start with a productive system that doesn’t require as much input. Additionally, consistent stock assessments would likely be easier to achieve in waters with higher conductivity and productivity.

Lastly, it is recommended that sufficient baseline data be collected before commencing a new project. Depending on funding availability, creel or angler surveys can also be useful to help document changes in angler catch and perceptions after a project is implemented.

Management Recommendations

1. Continue the feeding program at McKinney Lake during the active feeding months of March to October at a rate of 2.5 kg/feeder/day.
2. Continue to stock Bluegills (> 60 mm) into McKinney Lake as available.
3. Sample McKinney Lake every three years in spring with electrofishing and fall with trap nets to evaluate the management of the Bluegill and Largemouth Bass fisheries.

4. Continue to remove chubsuckers as encountered during fall trap net sampling at McKinney Lake.

Acknowledgments

This project would not have been possible without the efforts of Rick Bradford, Doug Hinshaw, and Carson Pope of the McKinney Lake State Fish Hatchery. Furthermore, their ongoing contributions, including filling and maintaining the feeders as well as stocking surplus Bluegills, are instrumental to the continuance of the feeding program.

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TABLE 1. Approximate number of 60–100mm and 100–155 Bluegills stocked into McKinney Lake, April–October 2016–2021.

Year	N (60–100 mm)	N (100–155 mm)
2016	3000	0
2017	3000	0
2018	2000	0
2019	1000	400
2020	1000	0
2021	1000	0

TABLE 2. Net nights, total number, and total weight (kg) of chubsuckers removed from McKinney Lake by electrofishing (April 2016) and trap netting (October–November 2017–2021).

Year	Net nights	N	Total weight (kg)
2016	-----	-----	68.2
2017	20	234	102.5
2018	16	129	43.7
2019	16	159	81.8
2020	32	165	78.5
2021	16	85	24.0

TABLE 3. Total number collected (electrofishing), mean number of fish collected per hour (with standard error), total number collected (trap netting), mean number of fish collected per net night, for Bluegills collected from McKinney Lake by electrofishing (April 2016–2019, March 2021), and trap netting (October–November 2017–2021).

Year	N (EF)	Fish per hour (SE)	N (TN)	Fish per net night
2016	60	12.4 (2.9)	-----	-----
2017	119	17.3 (5.0)	20	1
2018	77	22.1 (4.4)	75	4.7
2019	30	5.7 (1.4)	40	2.6
2020	-----	-----	14	0.4
2021	65	13.5 (1.8)	10	0.6

TABLE 4. Mean length (mm), percent of fish larger than 227 g, percent of fish larger than 340 g, percent of fish larger than 454 g, Proportional Size Distribution, Proportional Size Distribution-Preferred, and mean relative weight (with standard error) of Bluegills collected from McKinney Lake by electrofishing (April 2016–2019, March 2021), and trap netting (October–November 2017–2021).

Year	Mean length (mm)	% > 227 g	% > 340 g	% > 454 g	PSD	PSD-P	Mean relative weight (SE)
2016	139	1.8	1.8	0.0	38	7	78.4 (1.3)
2017	132	5.0	1.4	0.7	26	9	82.1 (1.1)
2018	180	21.1	9.2	3.3	76	32	90.6 (1.1)
2019	171	22.1	7.4	2.9	60	36	83.8 (1.7)
2020	207	35.7	35.7	7.1	86	50	85.7 (4.4)
2021	146	1.3	0.0	0.0	45	7	78.3 (1.3)

TABLE 5. Mean number of fish collected per hour (with standard error), mean length (mm), percent of fish larger than 356 mm, percent of fish larger than 457 mm, Proportional Size Distribution, Proportional Size Distribution-Preferred, and mean relative weight (with standard error) of Largemouth Bass collected from McKinney Lake by electrofishing, April 2016–2019, 2021.

Year	Fish per hour (SE)	Mean length (mm)	% > 356 mm	% > 457 mm	PSD	PSD-P	Mean relative weight (SE)
2016	31.3 (4.5)	222	12.1	2.8	68	21	80 (1.0)
2017	26.3 (3.4)	231	11.9	3.1	57	13	81 (0.7)
2018	39.2 (5.1)	240	12.5	3.7	52	16	81 (0.8)
2019	30.7 (2.1)	200	4.1	0.7	54	4	79 (0.6)
2021	24.9 (0.9)	268	12.3	2.9	44	11	78 (0.5)

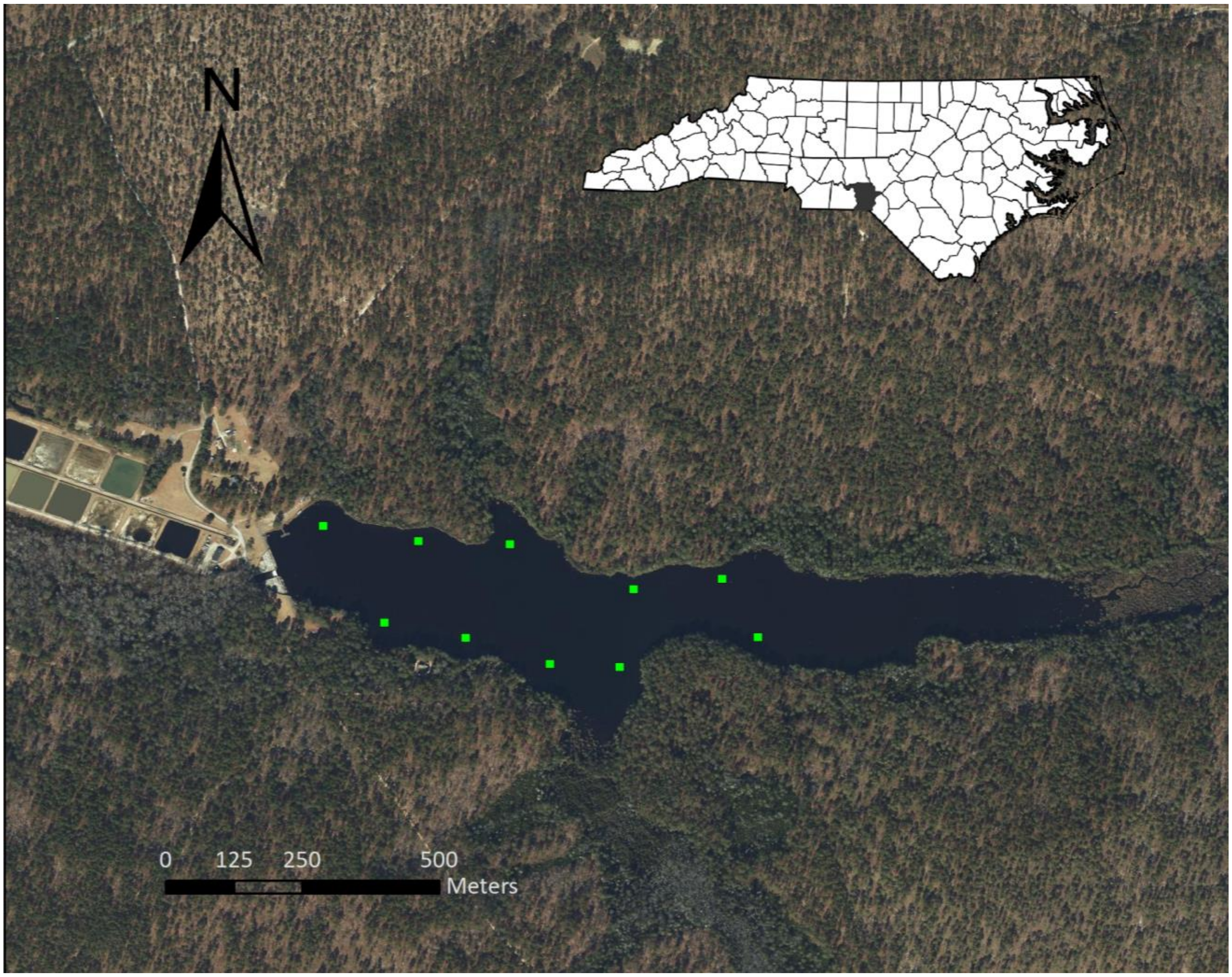

FIGURE 1. Fish feeder sites at McKinney Lake, Hoffman, North Carolina.

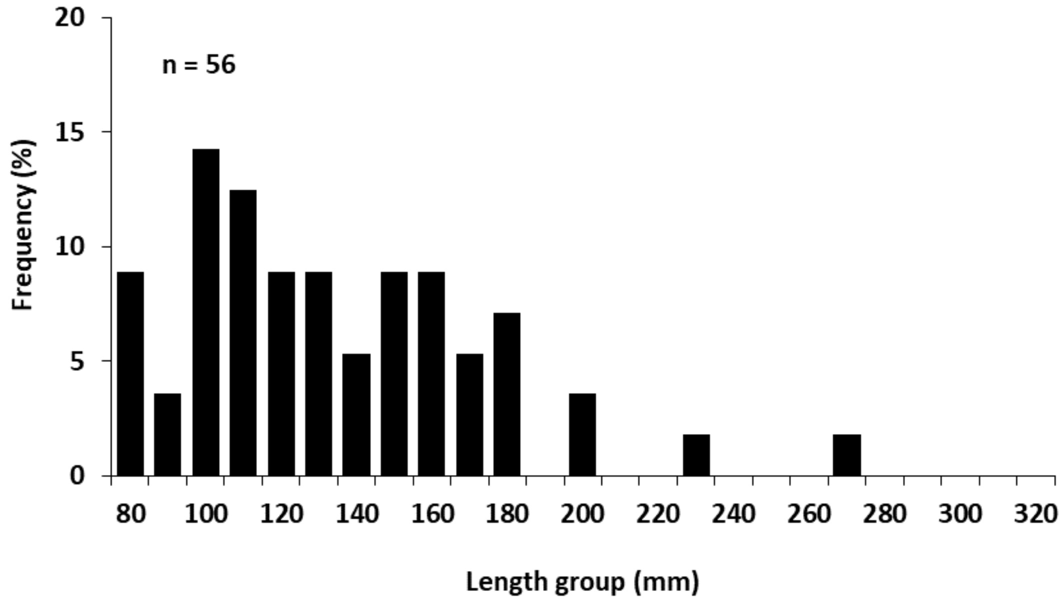

FIGURE 2. Length frequency distribution of Bluegills collected from McKinney Lake by electrofishing, April 2016.

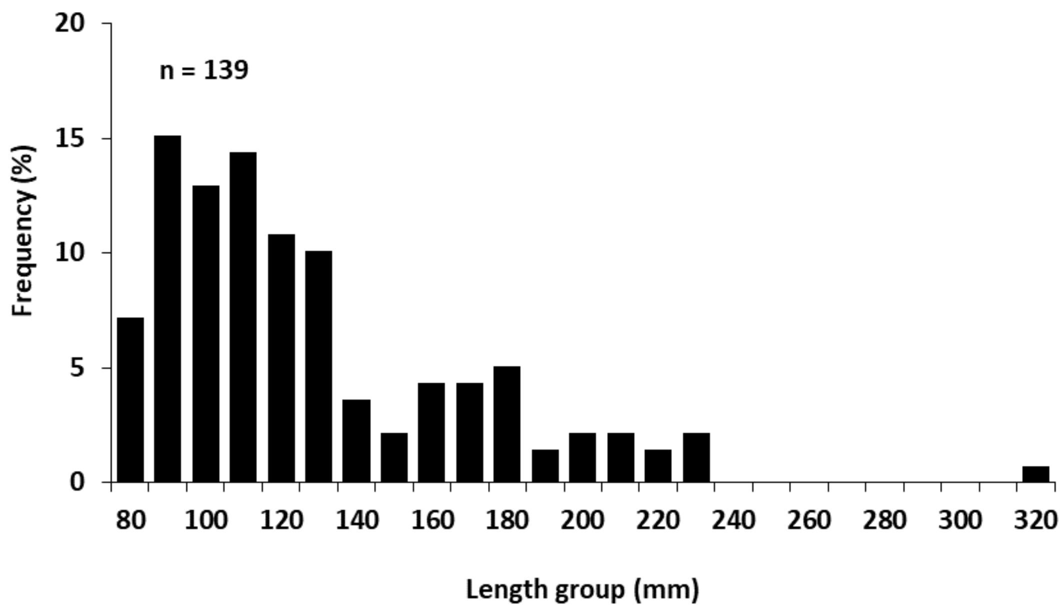

FIGURE 3. Length frequency distribution of Bluegills collected from McKinney Lake by electrofishing (April 2017) and trap netting (November 2017).

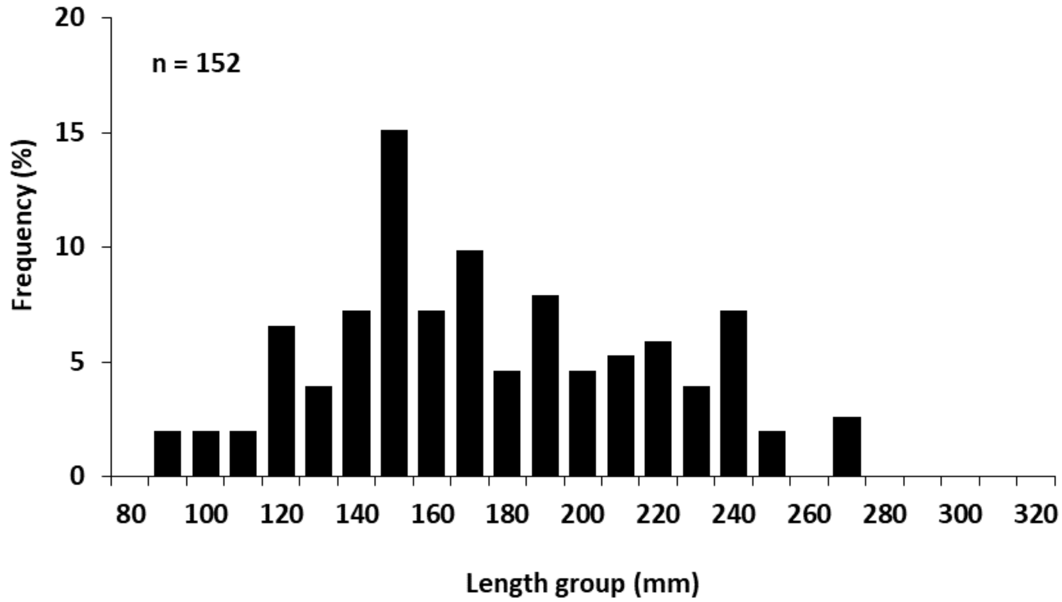

FIGURE 4. Length frequency distribution of Bluegills collected from McKinney Lake by electrofishing (April 2018) and trap netting (October 2018).

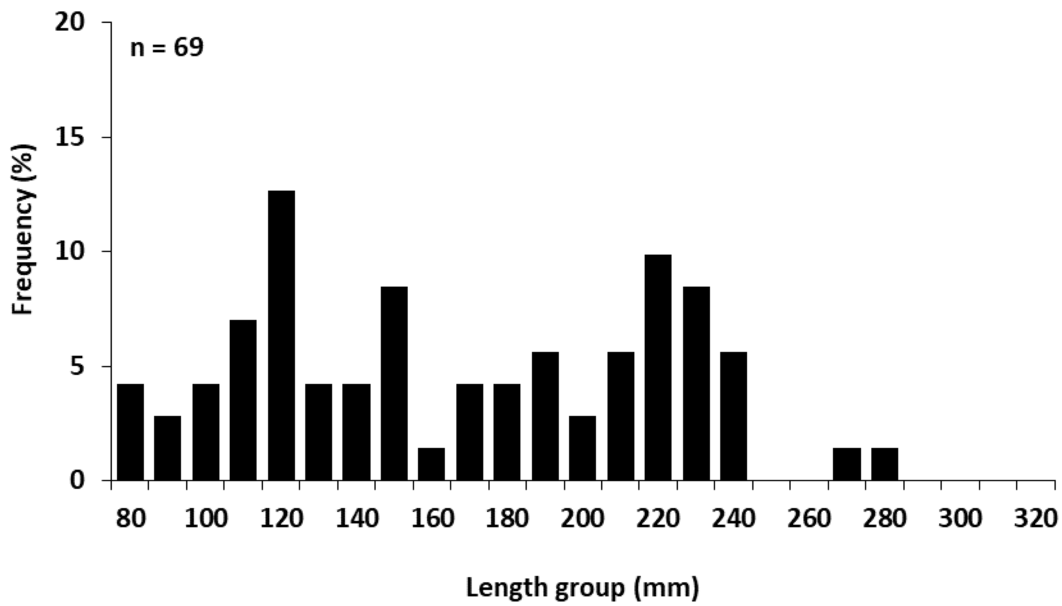

FIGURE 5. Length frequency distribution of Bluegills collected from McKinney Lake by electrofishing (April 2019) and trap netting (November 2019).

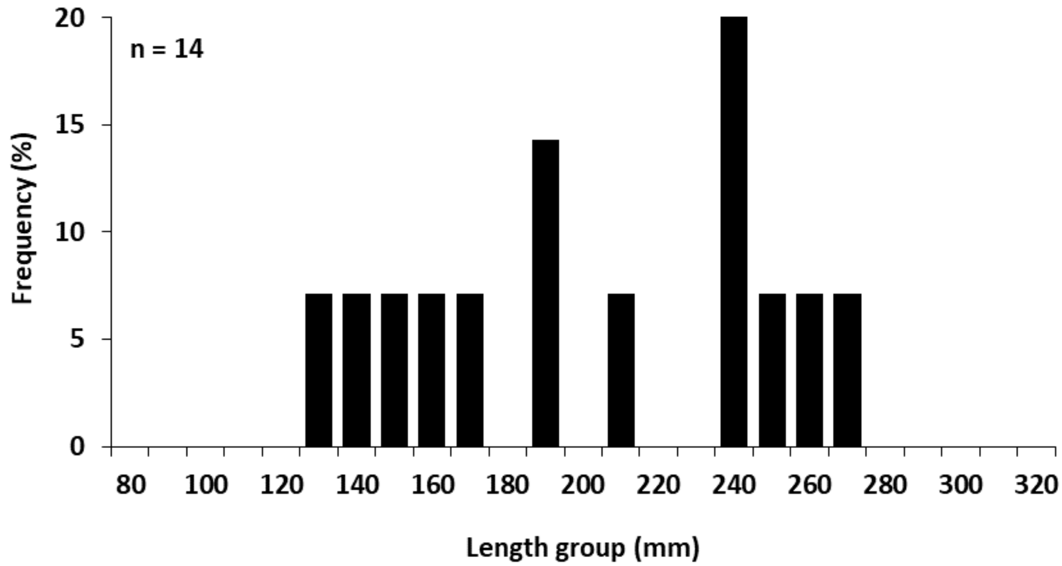

FIGURE 6. Length frequency distribution of Bluegills collected from McKinney Lake by trap netting (October–November 2020).

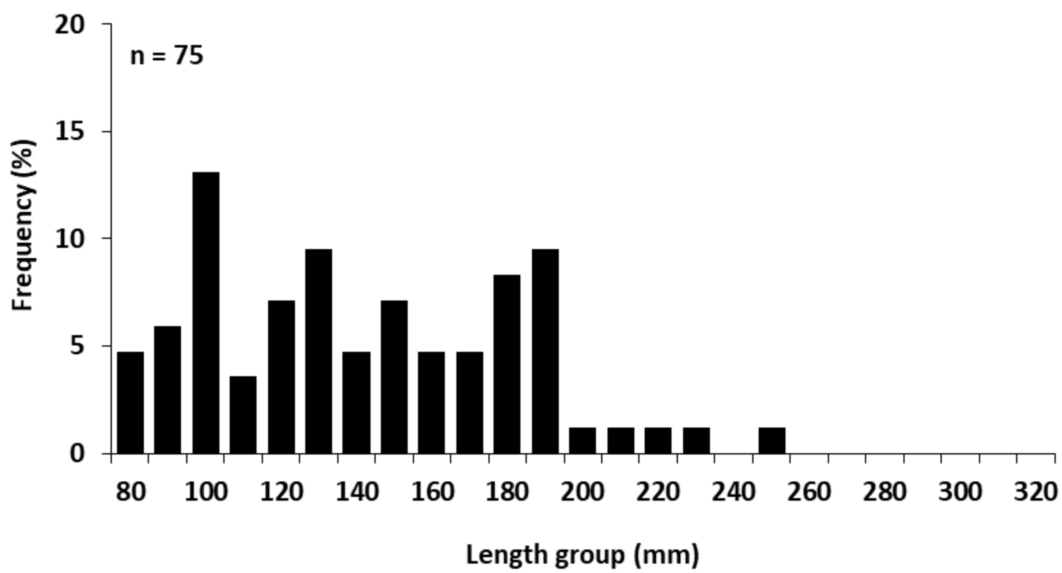

FIGURE 7. Length frequency distribution of Bluegills collected from McKinney Lake by electrofishing (March–April 2021) and trap netting (October 2021).

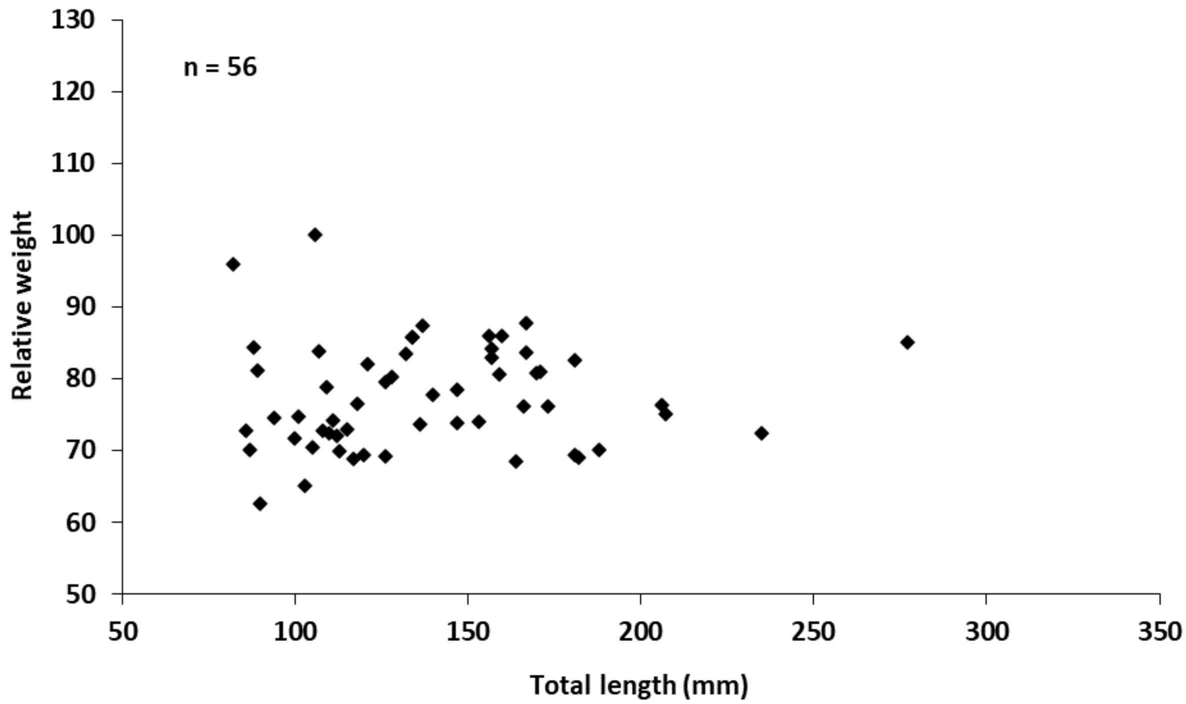

FIGURE 8. Relationship between length and relative weight of Bluegills collected from McKinney Lake by electrofishing (April 2016).

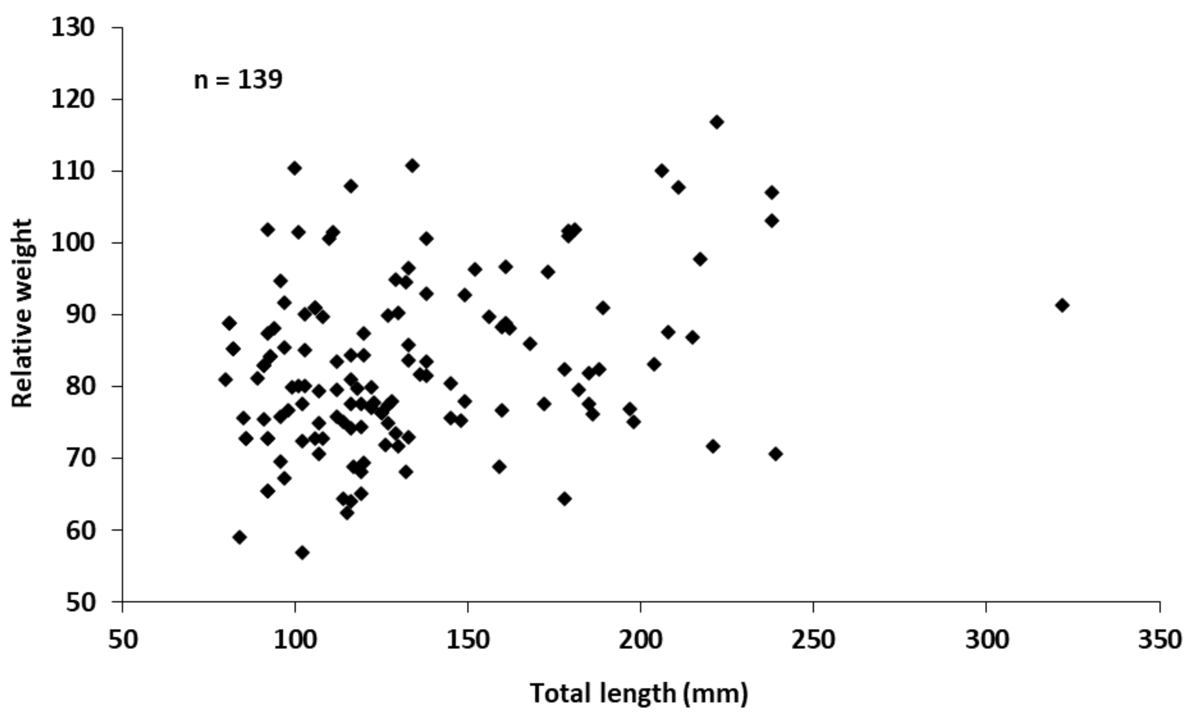

FIGURE 9. Relationship between length and relative weight of Bluegills collected from McKinney Lake by electrofishing (April 2017) and trap netting (November 2017).

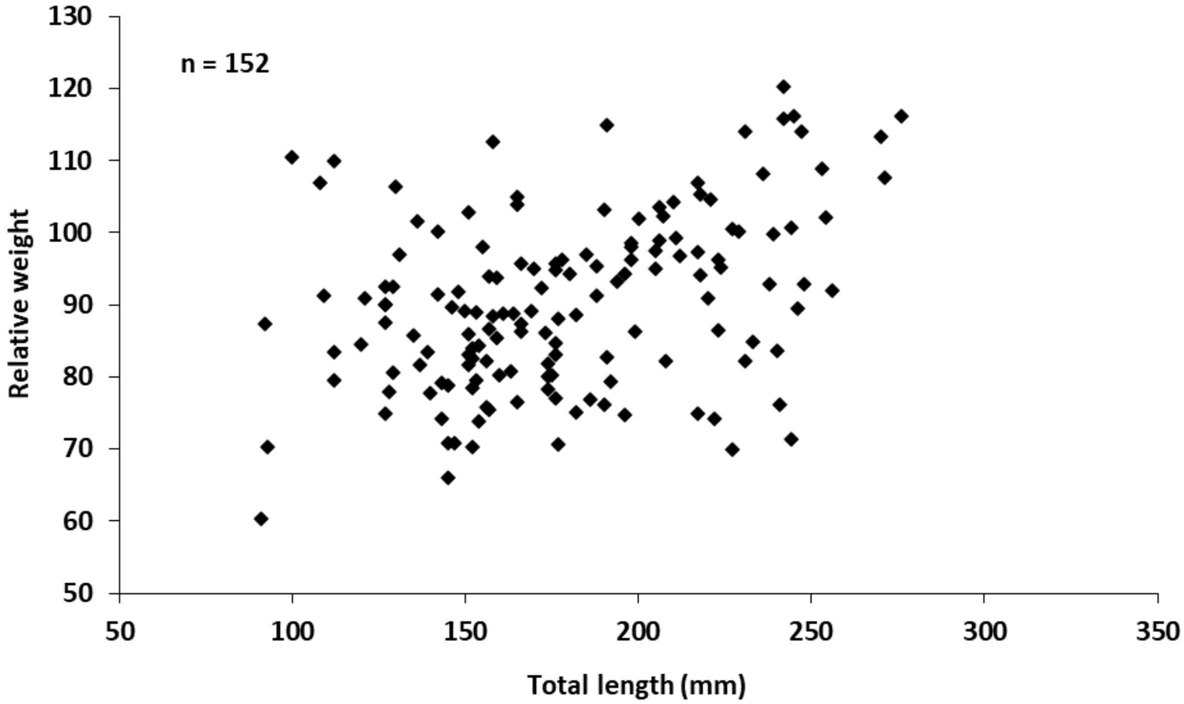

FIGURE 10. Relationship between length and relative weight of Bluegills collected from McKinney Lake by electrofishing (April 2018) and trap netting (October 2018).

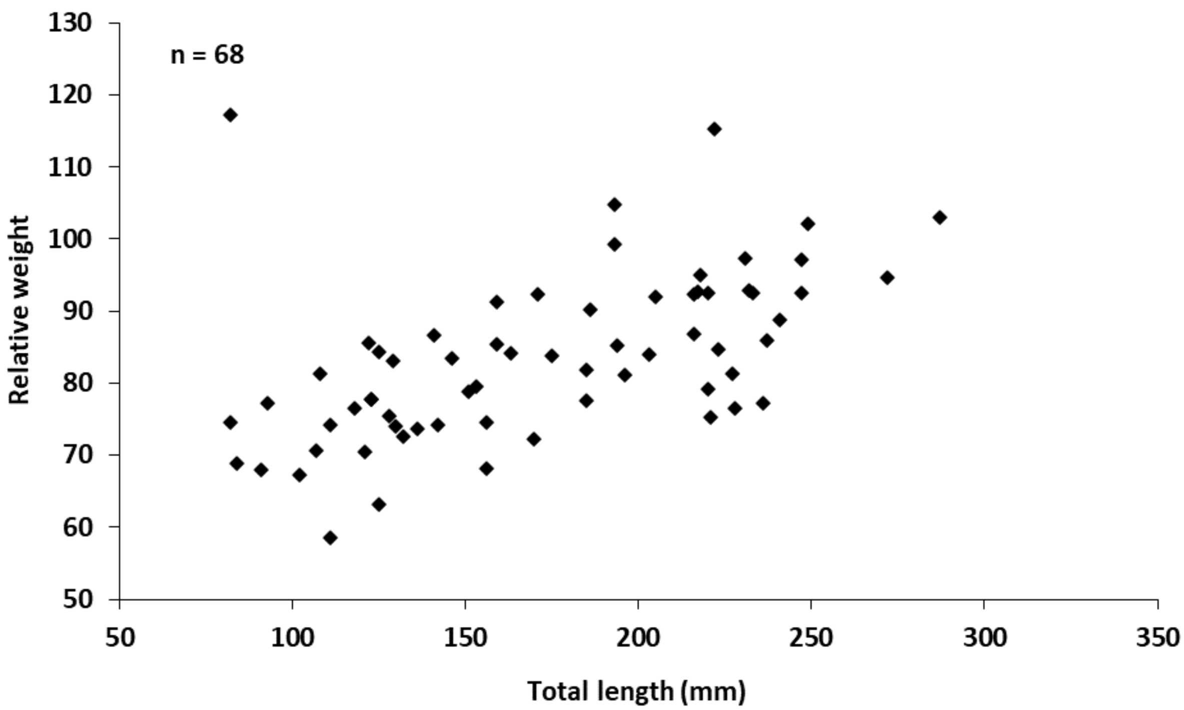

FIGURE 11. Relationship between length and relative weight of Bluegills collected from McKinney Lake by electrofishing (April 2019) and trap netting (November 2019).

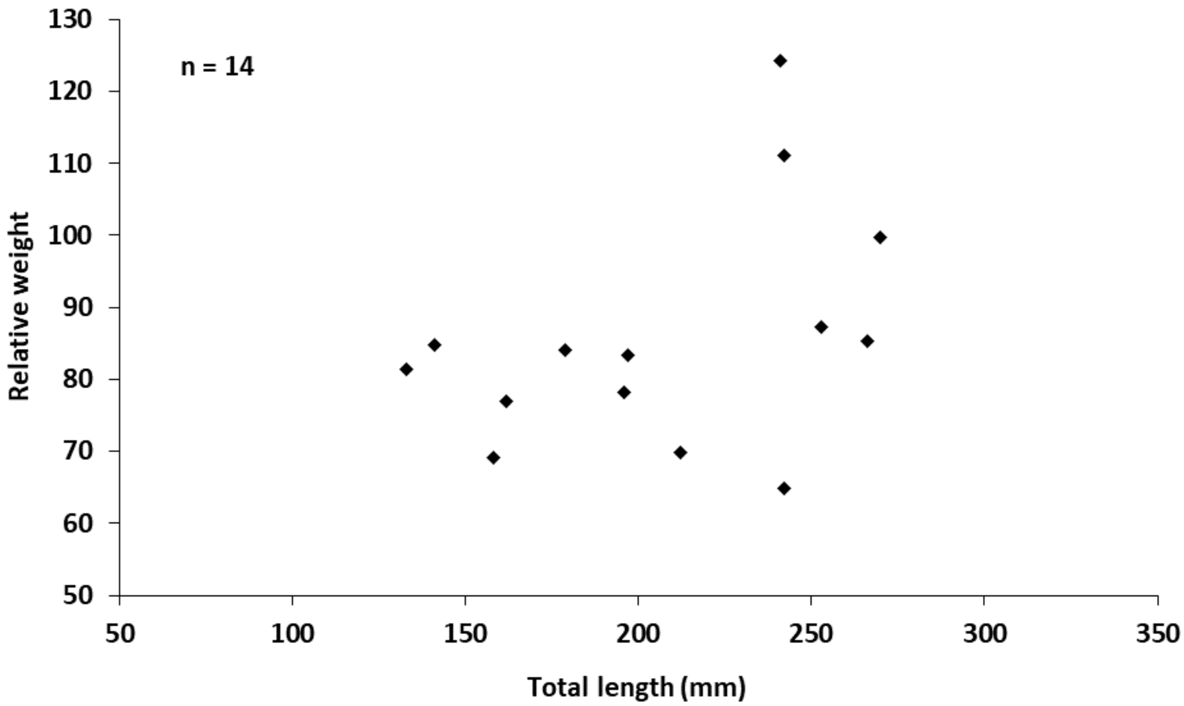

FIGURE 12. Relationship between length and relative weight of Bluegills collected from McKinney Lake by trap netting (October–November 2020).

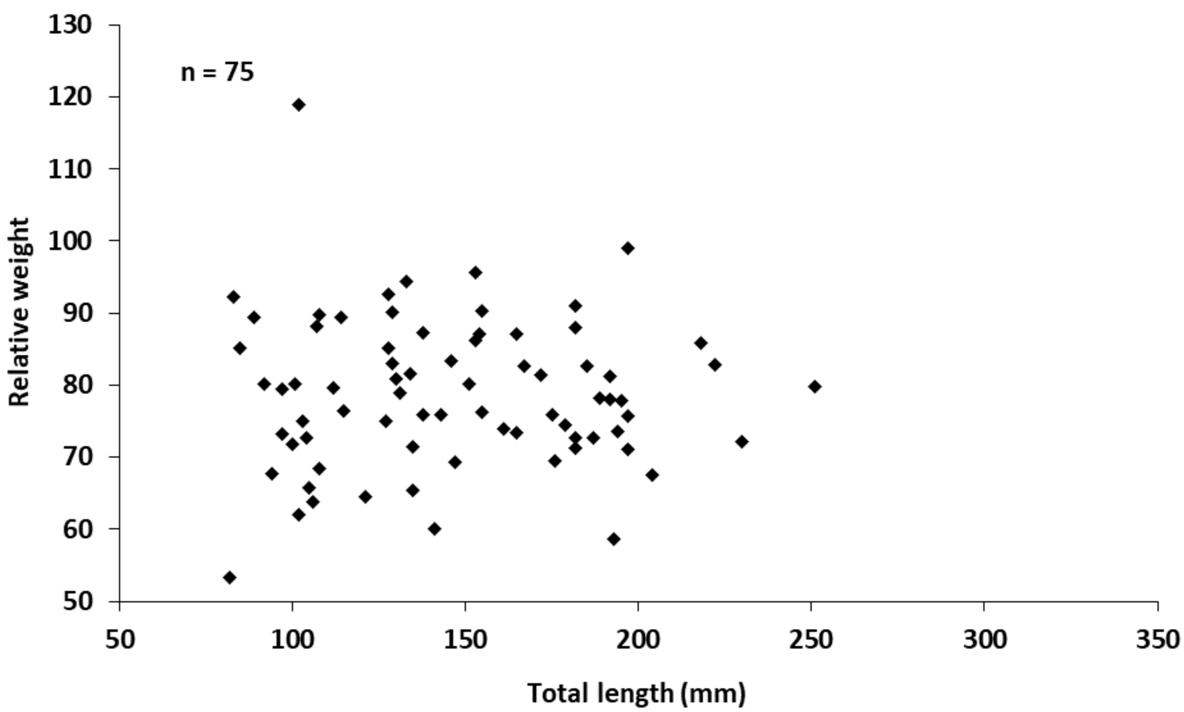

FIGURE 13. Relationship between length and relative weight of Bluegills collected from McKinney Lake by electrofishing (March–April 2021) and trap netting (October 2021).

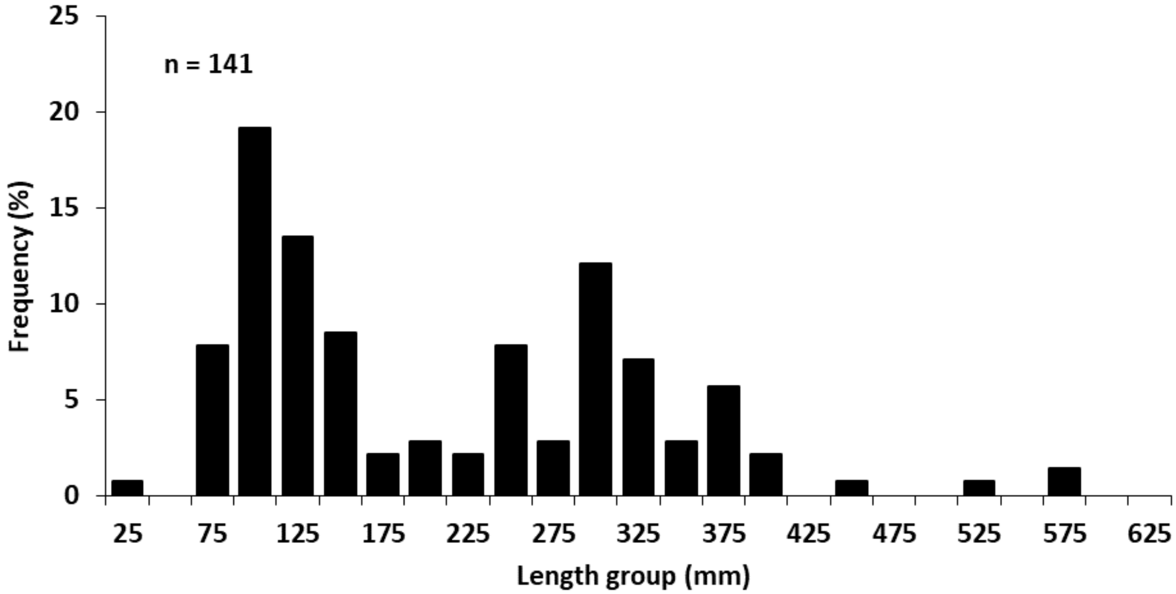

FIGURE 14. Length frequency distribution of Largemouth Bass collected from McKinney Lake by electrofishing, April 2016.

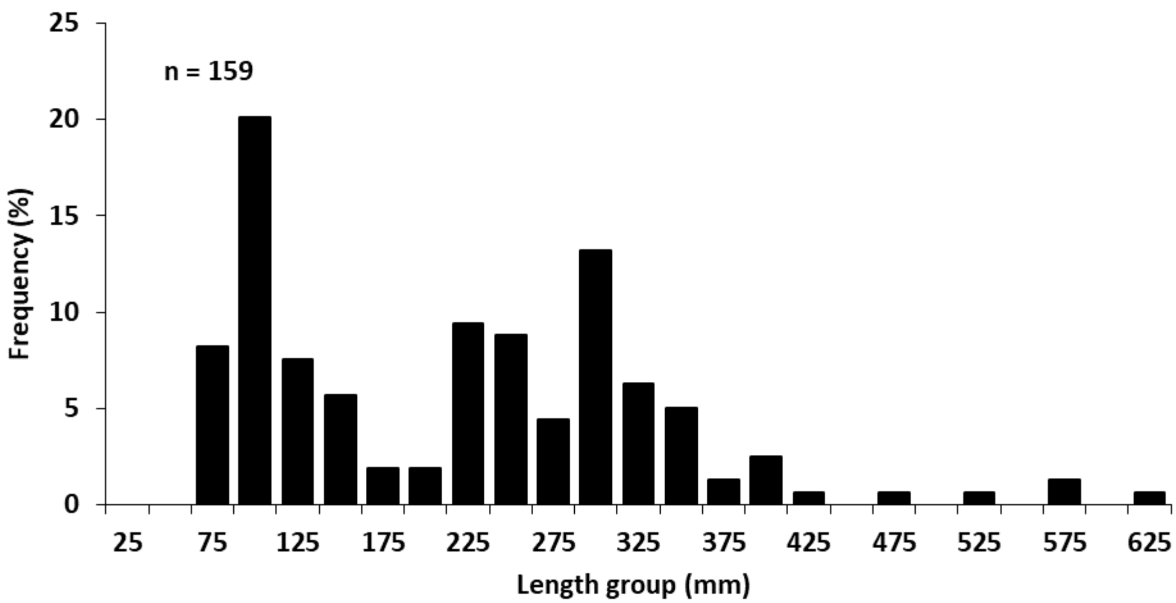

FIGURE 15. Length frequency distribution of Largemouth Bass collected from McKinney Lake by electrofishing, April 2017.

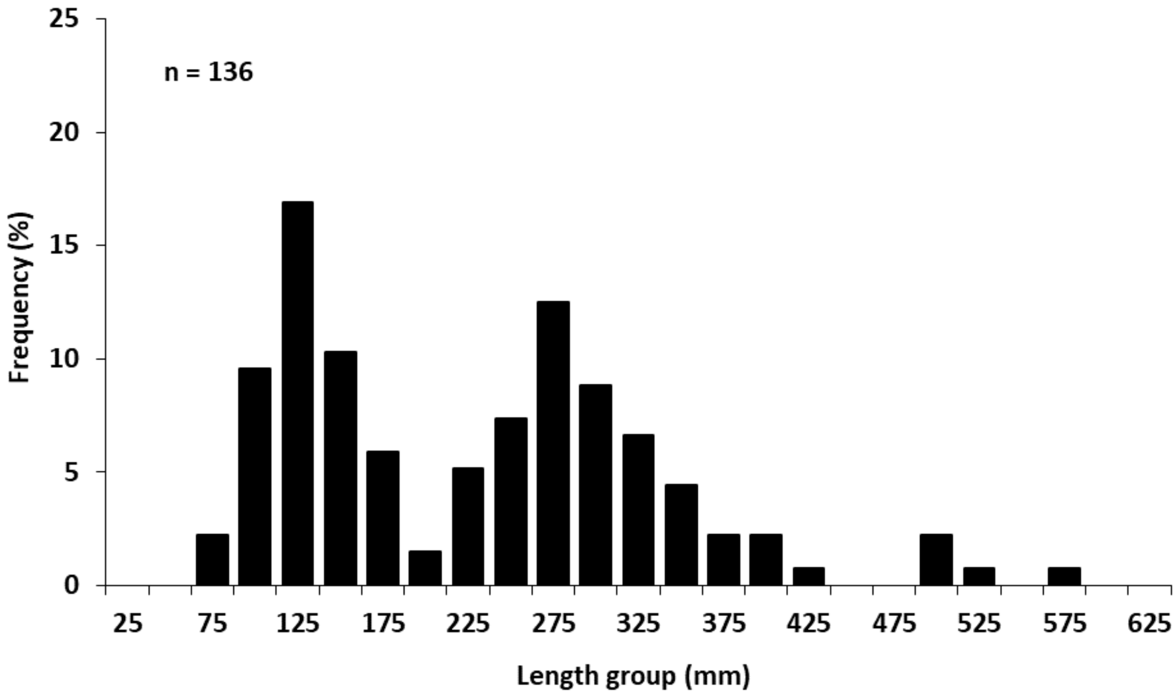

FIGURE 16. Length frequency distribution of Largemouth Bass collected from McKinney Lake by electrofishing, April 2018.

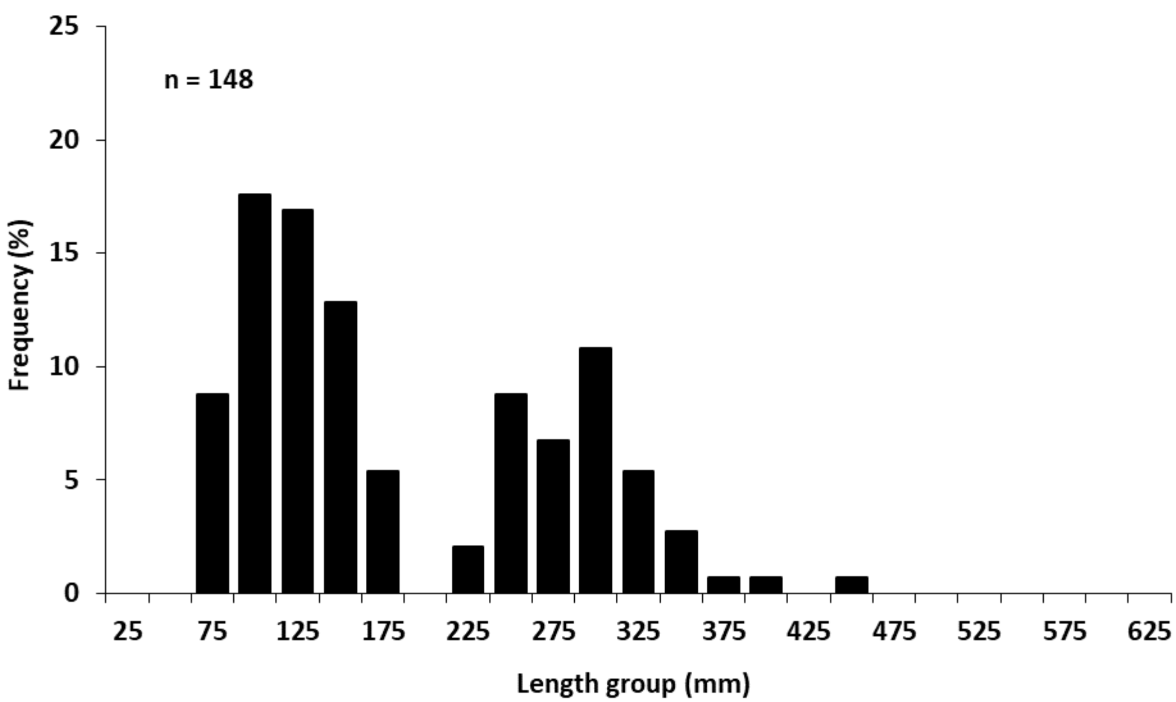

FIGURE 17. Length frequency distribution of Largemouth Bass collected from McKinney Lake by electrofishing, April 2019.

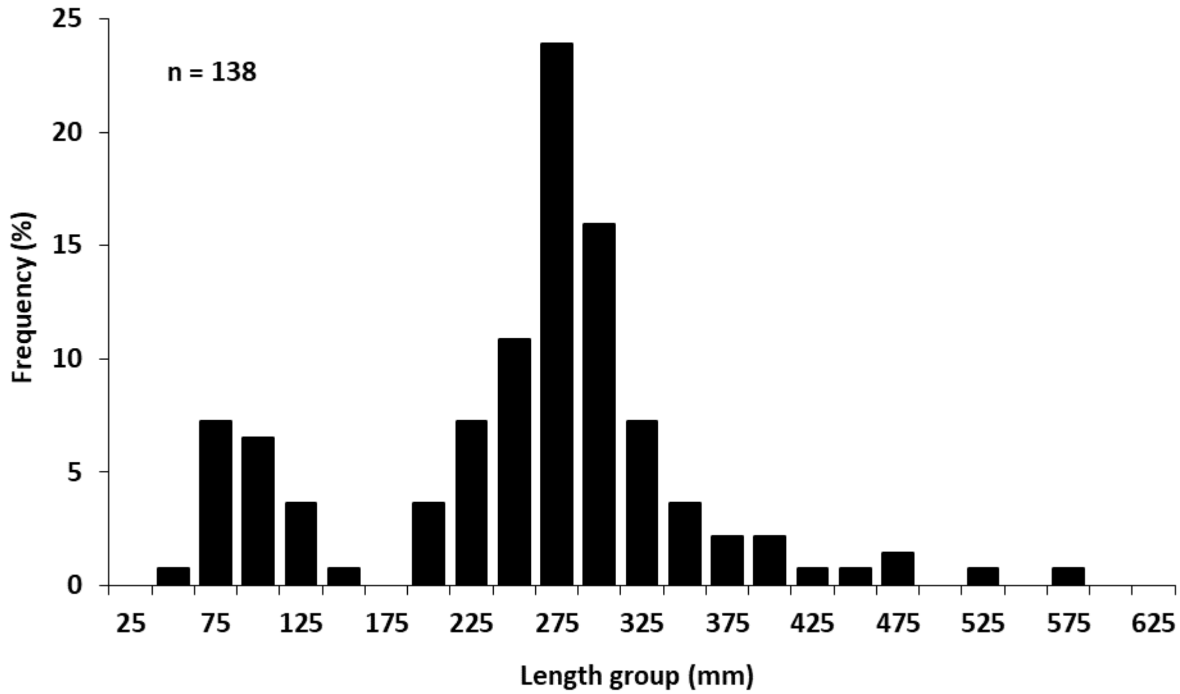

FIGURE 18. Length frequency distribution of Largemouth Bass collected from McKinney Lake by electrofishing, March–April 2021.

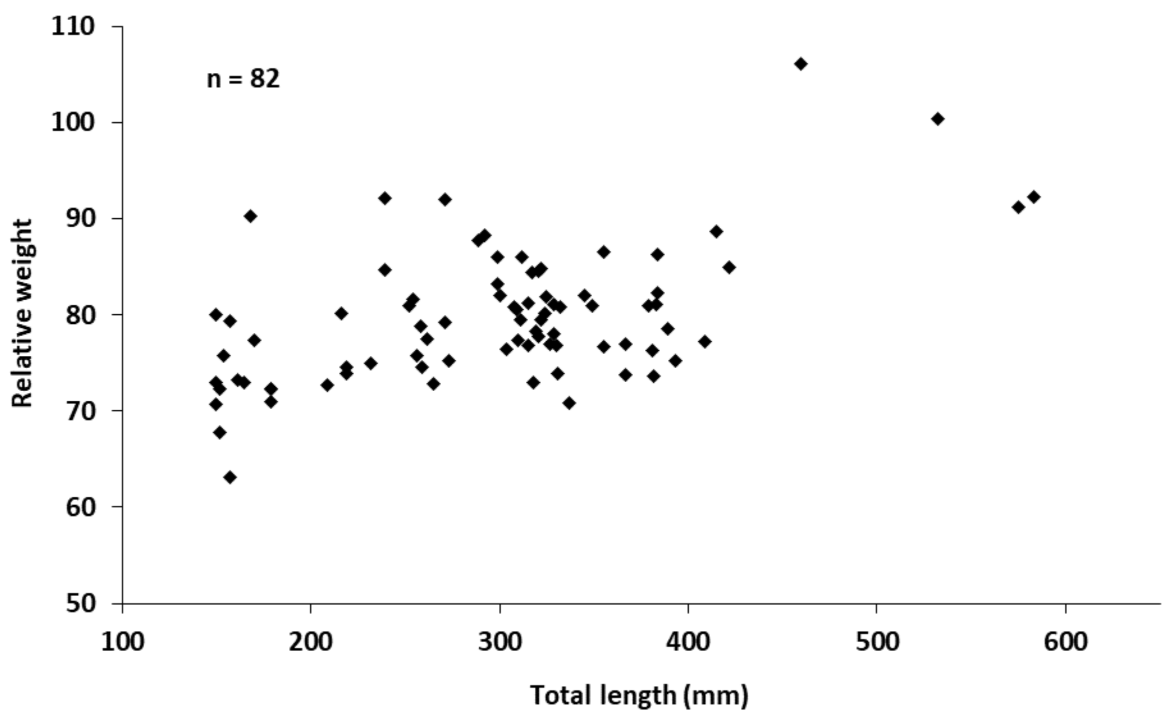

FIGURE 19. Relationship between length and relative weight of Largemouth Bass collected from McKinney Lake by electrofishing, April 2016.

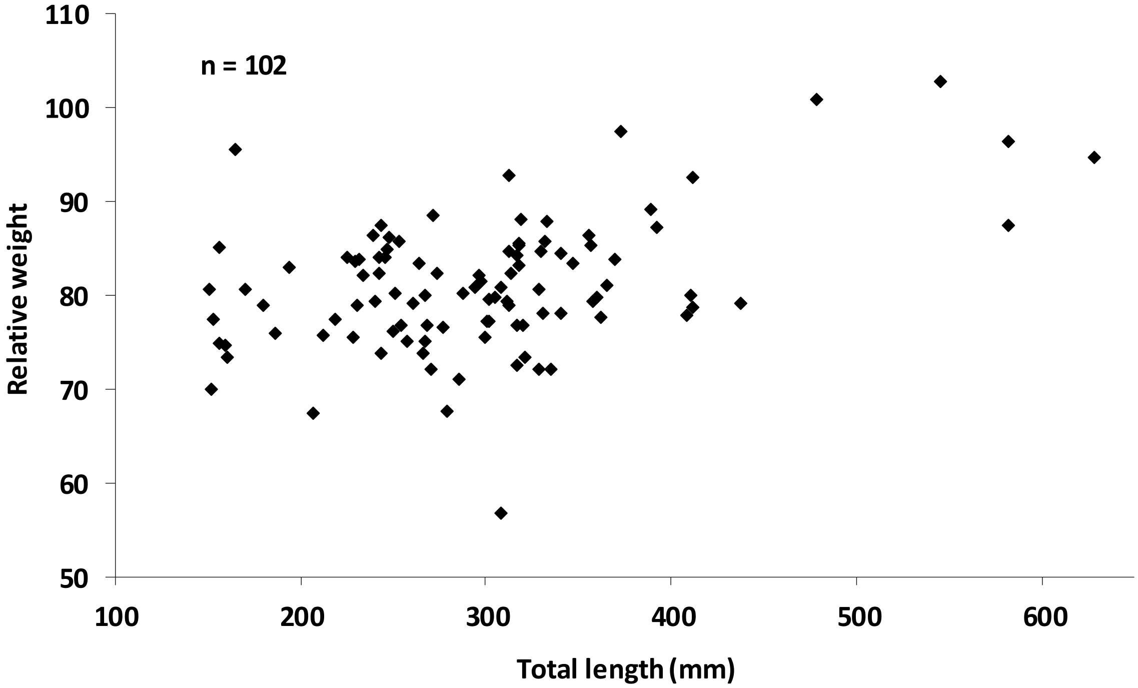

FIGURE 20. Relationship between length and relative weight of Largemouth Bass collected from McKinney Lake by electrofishing, April 2017.

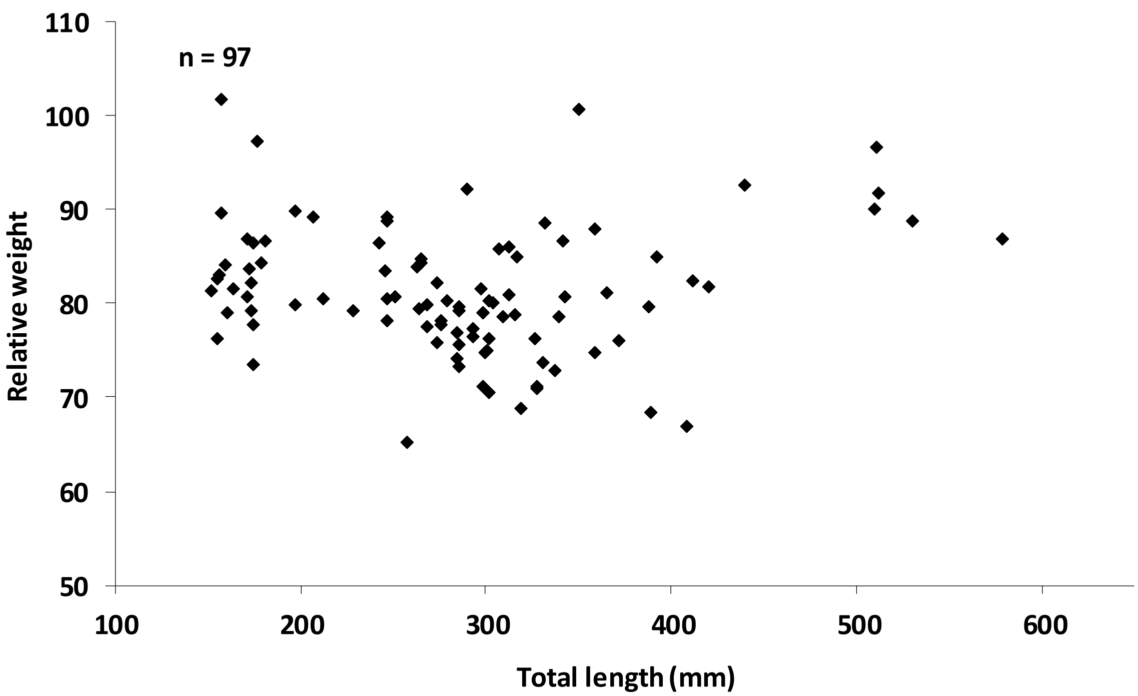

FIGURE 21. Relationship between length and relative weight of Largemouth Bass collected from McKinney Lake by electrofishing, April 2018.

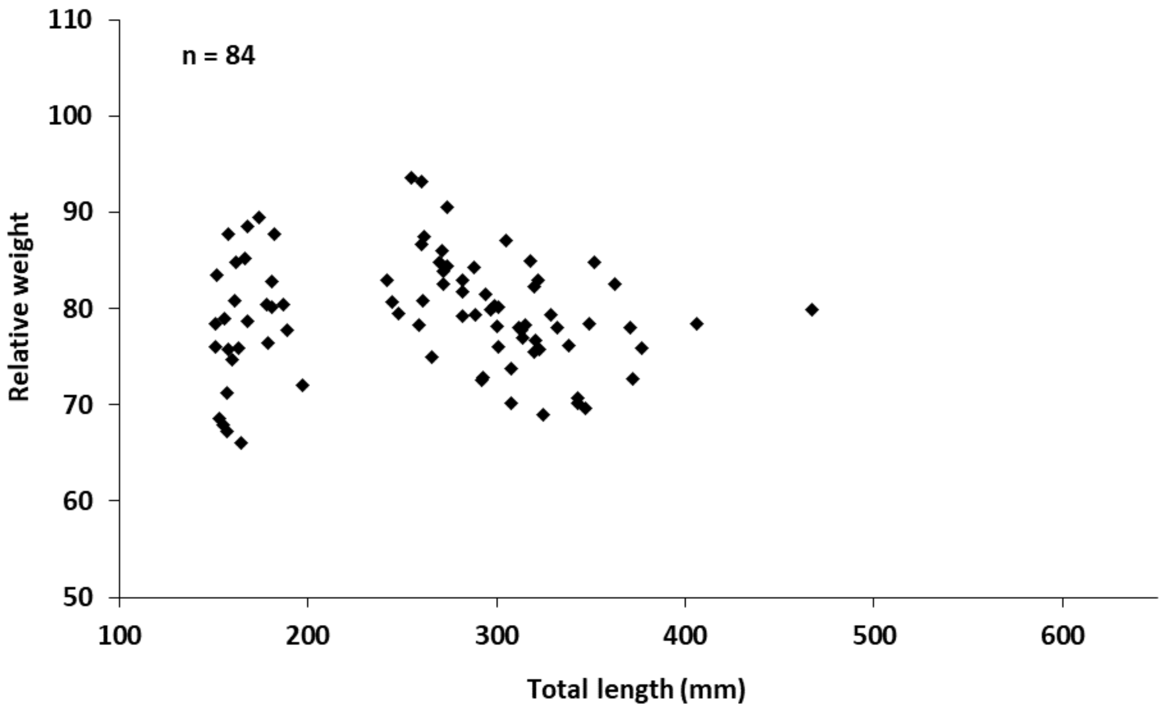

FIGURE 22. Relationship between length and relative weight of Largemouth Bass collected from McKinney Lake by electrofishing, April 2019.

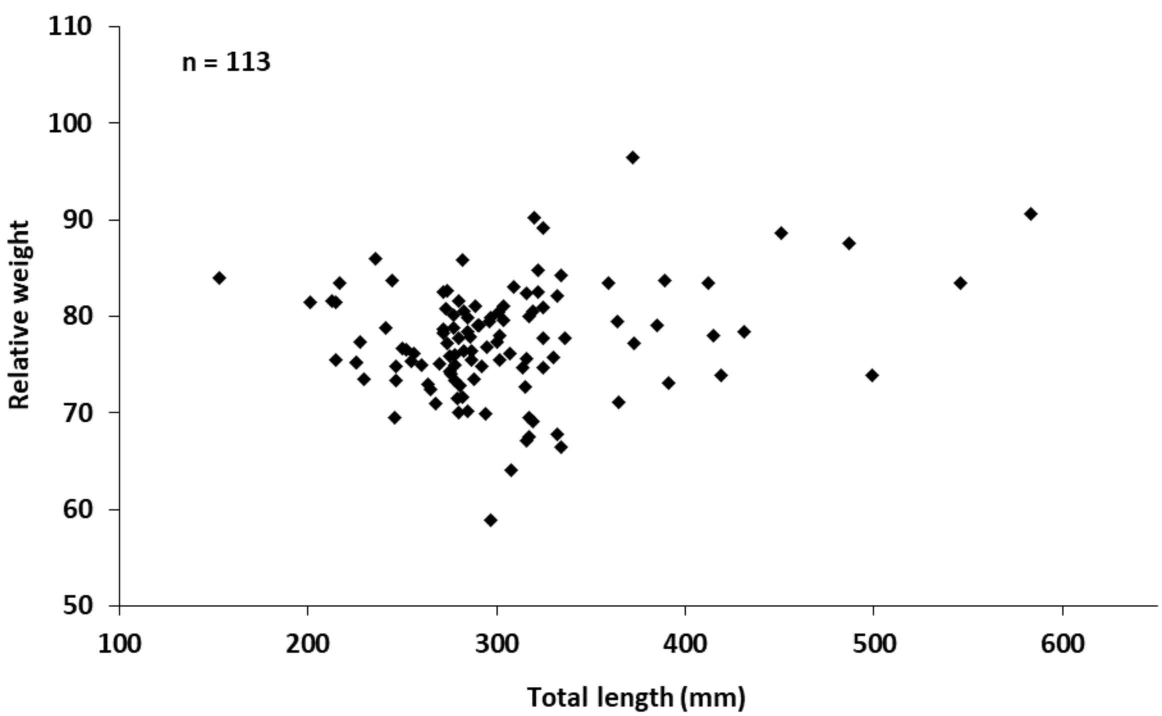

FIGURE 23. Relationship between length and relative weight of Largemouth Bass collected from McKinney Lake by electrofishing, March–April 2021.