# Largemouth Bass Population Characteristics in a Densely Vegetated Small Impoundment

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**Abstract:** Elmer Thomas Reservoir is a small impoundment in southwest Oklahoma that contains a high abundance of the invasive plant Eurasian Milfoil. Because dense vegetation can negatively affect Largemouth Bass, population characteristics (condition, growth, and mortality) of Elmer Thomas Reservoir Largemouth Bass were described. Dense vegetation can impact Largemouth Bass foraging and may reduce angler success, so diet and presence of angler hooking wounds (index of angler catchability) were evaluated on a subset of Largemouth Bass. Condition (mean relative weight) of Largemouth Bass was below average ($W_r$ = 88), which may explain the size distribution skewed towards smaller fish (most Largemouth Bass between 275-400 mm TL). Catch-curve analysis indicates that survival of Largemouth Bass is high (77%). Although high survival estimates suggest that angler exploitation (fishing mortality) is low, it appears that angler catchability is still high (35% of Largemouth Bass had hooking injuries; 45% when corrected for imperfect hooking wound detection). Largemouth Bass diets consisted mainly of fish (76% by number), more specifically age-0 Largemouth Bass comprised 28% by number and occurred in 20% of the diets. High incidence of age-0 Largemouth Bass in diets suggests a change in behavior as a result of dense vegetation and may help to explain the poor condition and growth of Largemouth Bass. This study suggests that Largemouth Bass are negatively affected by vegetation abundance at Elmer Thomas Reservoir. A vegetation management plan to reduce the vegetation to intermediate abundance levels (~30%) would likely benefit the Elmer Thomas Reservoir fish community and increase shoreline fishing opportunities for anglers.

## Introduction

Largemouth Bass *Micropterus salmoides* are one of the most important recreational species in North America (USFWS 2016). Largemouth Bass are also ecologically important, as they are a keystone species in most aquatic systems and shape fish communities through top-down predation (Miranda and Pugh 1997). For these reasons, Largemouth Bass are intensively managed by many natural resource agencies. Therefore, fishery managers rely on consistent natural recruitment to maintain robust Largemouth Bass populations.

First year growth is an important factor affecting recruitment of age-0 Largemouth Bass to adulthood (Goodgame and Miranda 1993; Ludsin and DeVries 1997). Largemouth Bass that grow to larger sizes during their first year often have a competitive advantage over smaller fish of the same cohort (Goodgame and Miranda 1993; Ludsin and DeVries 1997). Larger juvenile fish have an advantage over smaller fish because they can transition to piscivory sooner (Ludsin and DeVries 1997, Mesing et al. 2008) and may avoid predation, thereby reducing mortality rates (Santucci and Wahl 1993). Juvenile Largemouth Bass that attain a greater size prior to their first winter (an important survival bottleneck in their early life history), typically have increased recruitment to age-1 (Ludsin and DeVries 1997).

Survival of Largemouth Bass has been associated with increased habitat complexity (Miranda and Pugh 1997). Increased habitat complexity provides cover to juvenile fish, aiding in escapement from predation while providing foraging areas (due to increased invertebrate abundance associated with habitat) for young bass or sunfish *Lepomis* sp. prey. However, excessive habitat complexity can negatively impact Largemouth Bass fisheries (Bettoli et al. 1992). When aquatic vegetation becomes too dense, juvenile Largemouth Bass do not transition to piscivory, resulting in depressed growth (Bettoli et al. 1992). Also, competition with abundant sunfish for forage may increase in heavily vegetated systems, further reducing growth rates of juvenile Largemouth Bass (Miranda and Pugh 1997). Stymied growth rates caused by overabundant vegetation can ultimately affect Largemouth Bass recruitment to adulthood.

Adult Largemouth Bass are also impacted by dense aquatic vegetation. In systems with dense beds of aquatic vegetation, Largemouth Bass can become stunted (Brown and Maceina 2002). Although prey abundances are usually high in heavily vegetated systems, foraging efficiency of adult Largemouth Bass is affected because forage fish have ample refuge resulting in decreased foraging rates (Savino and Stein 1982, Savino and Stein 1989). Further, stockpiling of adult fish occurs because predator-induced mortality of small fish is low (Savino and Stein 1982). Increased population density results in competition for forage resources that are mostly inaccessible due to the high vegetation densities.

Because high densities of aquatic vegetation negatively impact fish populations, our primary objective is to evaluate population characteristics of Largemouth Bass in Elmer Thomas Reservoir, Oklahoma, a small impoundment with a high abundance of Eurasian Milfoil *Myriophyllum spicatum*. Further, because dense vegetation can negatively affect angling (reduced catch rates), we inspected all adult Largemouth Bass for presence of hooking scars to attain a basic understanding of catchability of Largemouth Bass in this system. Finally, although it only represents a brief temporal span, diet of a subset of Largemouth Bass will be presented as foraging can be affected in heavily vegetated environments.

## Methods

### Study area

Elmer Thomas Reservoir (Figure 1), is a 135-ha reservoir located in southwest Oklahoma on the Wichita Mountains National Wildlife Refuge near Lawton, Oklahoma. The surrounding land area is composed of a cobblestone/granite substrate with little runoff influence from intermittent, ephemeral drainages resulting in minimal amounts of organic inflow to the watershed, hence the mesotrophic status of this system (OWRB 2016). The littoral portion of the lake is covered with dense beds of Eurasian Milfoil and intermittent pond weed *Potamogeton* spp. in water depths ranging from 0.3-4.6 m. Eurasian Milfoil became established in Elmer Thomas Reservoir prior to 1965 (Couch and Mace 1978). The coverage area of Elmer Thomas Reservoir by Eurasian Milfoil is 44.4% (vegetated area [60 ha]/total reservoir surface area [135 ha] x 100).

### Study approach

Largemouth Bass were collected from Elmer Thomas Reservoir in April and August 2018 using boat electrofishing (pulsed DC, high voltage, Smith Root 7.5 GPP). The majority (~80%) of the littoral portion of the reservoir was surveyed between both seasonal sampling efforts to ensure that all size and age classes were represented in the sample. Our goal was to collect ten fish per 25 mm length bins to

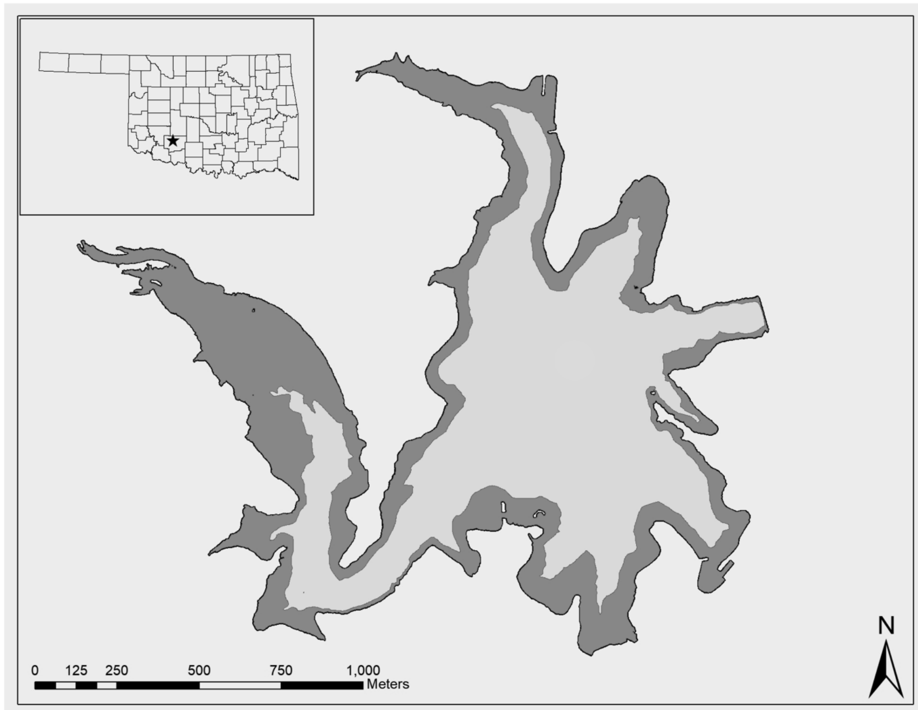


**Figure 1. Map of Elmer Thomas Reservoir in Comanche County, Oklahoma. The dark gray area represents the extent of Eurasian Milfoil coverage.**

ensure all ages were represented in the sample. Fish were measured for total length (TL; mm) and placed on ice to be processed at the J.A. Manning State Fish Hatchery (April) or the Oklahoma Fishery Research Laboratory in Norman, Oklahoma (August). In the laboratory, each Largemouth Bass was measured for TL, weighed (g) and sagittal otoliths removed for aging purposes.

Once otoliths were removed from fish collected during August, fish were then dissected to remove stomach contents from each fish. Diet items present in each stomach were identified to the finest taxonomic level possible, and enumerated. Largemouth Bass diets were described using percent occurrence, percent composition, and percent weight of prey items (Bowen 1996). Following dissection, fish were also inspected for presence of hooking scars or injuries, and any angling related damage was recorded, which was used to calculate angling hooking rate. Because the detection rate of known hook and line caught Largemouth Bass is imperfect (84%), the hooking rate of Largemouth Bass collected from Elmer Thomas Reservoir was corrected using a 1.19 multiplicative correction factor (Fernholz et al. 2018).

Otoliths were broken in the transverse plane by breaking it through the nucleus and polished with 2,000 grit wet/dry sandpaper. The broken otoliths were stood polished-side up in a black, clay filled dish, submersed in water, and viewed with a fiber optic light source under a dissecting microscope. Otoliths were viewed in random order by two independent readers and an age was estimated for each fish. When both readers disagreed on an estimated age, the otolith was reexamined by both readers to determine a final consensus age.

Size structure for Largemouth Bass was described using a length-frequency histogram and proportional size distribution (PSD, stock ≥ 200 mm, quality ≥ 300 mm, preferred ≥ 380 mm, memorable ≥ 510 mm; Gabelhouse 1984). Condition of Largemouth Bass was evaluated by calculating relative weight ($W_r$) using standard weight equations ($W_s$ = -5.316

+ 3.191 × log10 TL) presented by Wege and Anderson (1978). Largemouth Bass growth was described with a von Bertalanffy growth model. Catch curves (Ricker 1975) were used to estimate instantaneous total mortality (*Z*) of Largemouth Bass. Total annual mortality (A) was then calculated as $1\text{-}e^{-z}$. Largemouth Bass < 2 years old were omitted from the catch-curve analysis as they are not fully recruited to the sampling gear. Further, any age groups having < 5 individuals were not included in the analyses (Miranda and Bettoli 2007).

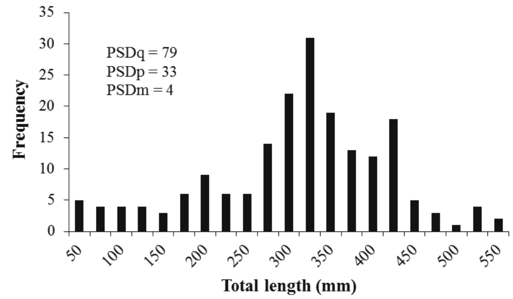


**Figure 2. Length frequency distribution of Largemouth Bass collected from Elmer Thomas Reservoir during April and August 2018.**

## Results and Discussion

A total of 191 Largemouth Bass were collected during the April (N=89) and August (N=102) sampling events to describe population characteristics at Elmer Thomas Reservoir. Largemouth Bass size ranged from 63 to 573 mm TL (Figure 2) and fish ages 0-13 years old were present in the sample. Because age-0 Largemouth Bass were not well represented in these samples, a separate collection of age-0 Largemouth Bass was conducted in late August to describe size structure of young-of-the-year fish. A total of 217 age-0 Largemouth Bass were collected in late August that ranged from 44 to 140 mm TL (mean TL = 63.4 mm; Figure 3).

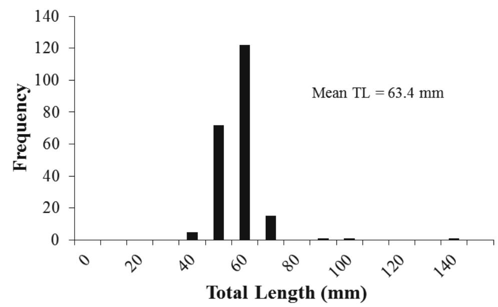


**Figure 3. Length frequency distribution of age-0 Largemouth Bass collected from Elmer Thomas Reservoir during August 2018.**

Vegetation density appears to be affecting age-0 fish growth in Elmer Thomas Reservoir. Mean TL of age-0 Largemouth Bass captured during August at Elmer Thomas Reservoir was 63 mm, compared to a mean TL of 85 mm observed for other Oklahoma populations in August (Carlander 1977). Similarly, dense vegetation impacted feeding efficiency and first year growth of Largemouth Bass in Lake Conroe, Texas (Betolli et al. 1992), which can negatively affect first year survival (Ludsin and DeVries 1997). Although dense vegetation appears to be limiting growth of age-0 Largemouth Bass in Elmer Thomas Reservoir, this complex habitat can also promote age-0 fish survival through decreased predation and increased invertebrate forage, which may result in increased recruitment to age-1 (Savino and Stein 1982, Miranda and Pugh 1997).

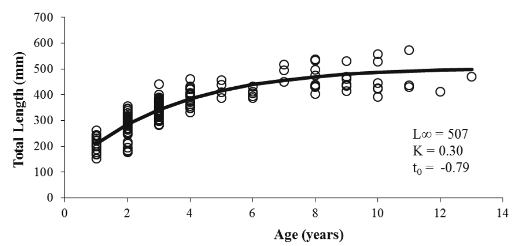


**Figure 4. Von Bertalanffy growth curve for Largemouth Bass collected from Elmer Thomas Reservoir during April and August 2018.**

Largemouth Bass that reach adulthood in Elmer Thomas Reservoir appear to stockpile between quality (≥ 300 mm) and preferred (≥ 380 mm) size classes, based on the high PSD (PSDq = 79). The length distribution for Largemouth Bass from Elmer Thomas Reservoir mirror the size structure of Largemouth Bass from the Spring Creek arm of Lake Seminole, Georgia

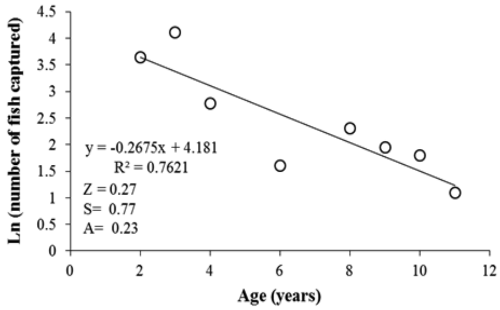


**Figure 5. Catch-curve regression and total annual mortality (*A*) calculated from otolith age estimates for Largemouth Bass collected from Elmer Thomas Reservoir during April and August 2018.**

where dense vegetation coverage has resulted in a length distribution skewed towards smaller fish (Brown and Maceina 2002). Largemouth Bass in the quality and preferred size classes range from ages 2-4, and the minimum length limit (355 mm TL) is reached in 3.43 years on average based on growth rates of this population (Figure 4). Condition of adult Largemouth Bass was well below average for fish collected from Elmer Thomas Reservoir (mean $W_r$ = 88 in April and August). Similarly, Colle and Shireman (1980) documented lower Largemouth Bass condition in Florida lakes when vegetation coverage exceeded 40%. Decreased foraging success caused by high density of Eurasian Milfoil likely resulted in decreased growth and condition of the Elmer Thomas Reservoir Largemouth Bass.

Diet of adult Largemouth Bass from Elmer Thomas Reservoir may provide some insight to the overall poor condition of this population. Largemouth Bass diets were dominated by fish prey (Table 1), with age-0 Largemouth Bass dominating the diets by number (27.8%) and occurrence (19.6%). Summers (1980) also documented a high occurrence of age-0 Largemouth Bass in the August diets of adult Largemouth Bass in a densely vegetated small impoundment in Oklahoma. In that study, both adult and juvenile Largemouth Bass were observed on the outside edge of the vegetation, making the juvenile fish easy prey for the adults (Summers 1980). This observation may have resulted from a switch to an ambush feeding behavior to cope with high vegetation densities, which results in decreased foraging success (Savino and Stein 1982).

Catch-curve analysis indicated high survival (77%) of adult Largemouth Bass in Elmer Thomas Reservoir (Figure 5). The survival estimate of 77% at Elmer Thomas Reservoir was intermediate to survival estimates of 84% in the

**Table 1. Diet of Largemouth Bass (N = 102) collected from Elmer Thomas Reservoir during August 2018 described using percent composition by number (%$N_i$), percent weight (%$W_i$), and percent occurrence (%$O_i$).**

| Diet Item | %$N_i$ | %$W_i$ | %$O_i$ |
|---|---|---|---|
| **Fish** | | | |
| Bluegill *Lepomis macrochirus* | 16.7 | 35.4 | 11.8 |
| Channel Catfish *Ictalurus punctatus* | 1.4 | 2.0 | 1.0 |
| Green Sunfish *Lepomis cyanellus* | 1.4 | 3.1 | 1.0 |
| Largemouth Bass *Micropterus salmoides* | 27.8 | 22.1 | 19.6 |
| Sunfish *Lepomis sp.* | 5.6 | 3.6 | 3.9 |
| Unidentified Fish | 23.6 | 8.3 | 16.7 |
| **Invertebrate** | | | |
| Crayfish | 22.2 | 18.8 | 15.7 |
| **Other** | | | |
| Fishing Lure | 1.4 | 6.7 | 1.0 |
| **Empty** | | | 50.0 |

Spring Creek arm (76% vegetation coverage) and 72% in the Flint-Chattahoochee arms (26-32% vegetation coverage) of Lake Seminole, Georgia (Brown and Maceina 2002). Higher Largemouth Bass survival rates are attributed to poor angler accessibility caused by dense vegetation coverage (Maceina and Reeves 1996, Brown and Maceina 2002). Higher survival may also result from a reduction in angler effort towards Largemouth Bass in response to increases in vegetation coverage (Slipke et al. 1998). Although vegetation coverage at Elmer Thomas Reservoir was high (44%), catchability of Largemouth Bass appears high (38%; 37 of 98 fish) based on the number of hooking scars present on fish ≥ 200 mm. When corrected for imperfect detection, 45% of Largemouth Bass inspected had hooking wounds. Furthermore, fishing lures were also found in diets of Largemouth Bass, suggesting that anglers are encountering Largemouth Bass at Elmer Thomas Reservoir.

These results suggest that the population characteristics of Largemouth Bass are negatively affected by vegetation abundance at Elmer Thomas Reservoir. A reduction in vegetation abundance could benefit Largemouth Bass by improving foraging efficiency that may improve condition and growth rates of this population. Further, a reduction in aquatic vegetation abundance would also improve shoreline fishing opportunities at Elmer Thomas Reservoir. Vegetation management using biological control (Grass Carp *Ctenopharyngodon idella*), herbicide application, or mechanical harvest should target an intermediate (~30%) vegetation coverage as a management goal. Largemouth Bass collections to evaluate changes in population characteristics should coincide with any efforts to manage vegetation densities at Elmer Thomas Reservoir.

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