# Population Dynamics of a Stunted Blue Catfish Population in a Small Oklahoma Impoundment

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**Abstract:** Blue Catfish populations create popular recreational fisheries throughout the United States. Many of these populations were introduced due to their popularity as a sportfish. However, Blue Catfish introductions are not always successful, particularly in small reservoirs. In 2017, a Blue Catfish population was discovered in Meeker Reservoir, a small impoundment in central Oklahoma. Because Blue Catfish populations generally do not do well in small impoundments, an evaluation was implemented to describe population characteristics, recruitment dynamics, and estimate abundance of preferred-length (> 760 mm) Blue Catfish in Meeker Reservoir. Blue Catfish in this population have high longevity, slow growth, low annual mortality, and reach sexual maturity at small sizes. Recruitment of Blue Catfish was variable, although fish from 21 year classes were observed, of which three year classes were dominant (combine to make 58% of fish in the sample). Strong year classes were produced in years with higher mean annual temperatures (> 16.5°C). Overall, this population is overcrowded and stunted, but a small proportion of fish still reach preferred size. Slow growth of Blue Catfish in this population may be explained by some combination of competition, genetics, low reservoir productivity, and reproductive strategy. The small size structure of this population creates a challenging management scenario, because most fish are below the size that anglers are willing to harvest. Although this population may be anomalous, our results provide important information regarding Blue Catfish population characteristics and recruitment in a small impoundment.

## Introduction

Blue Catfish (*Ictalurus furcatus*) are a very popular sportfish throughout their range in North America (Graham 1999, Arterburn et al 2002, Reitz and Travnichek 2004, Bodine et al 2013). In Oklahoma, Blue Catfish are native to the Arkansas and Red Rivers, but have been introduced throughout the state as a result of their popularity with anglers (Miller and Robison 2004, Kuklinski and Patterson 2011). However, Blue Catfish introductions are not always successful, particularly in smaller impoundments and in systems where environmental factors negatively affect recruitment (Bartram et al. 2011, Snow et al. 2017). Blue Catfish populations are more successful in larger, deeper rivers or impoundments with large river basins (Burr and Warren 1986, Jenkins and Burkhead 1994, Graham 1999, Distler 2014). These systems likely provide a higher abundance of larger cavity spawning habitats, which is required to accommodate the overall larger body size of the male and female Blue Catfish for successful reproduction (Graham 1999, Wyatt et al 2006).

Although the factors resulting in successful reproduction and recruitment of Blue Catfish are not well known, it is suspected that Blue Catfish make spawning migrations triggered by flow events in large rivers and reservoirs to access spawning habitat (Bartram et al 2011, Snow et al 2017). In a study of 30 Blue Catfish populations in Texas, Bartram et al. (2011) determined that larger reservoir surface area, high productivity and longer growing season promoted establishment of robust Blue Catfish populations. Further, reservoirs with small surface area (mean = 335 ha; range = 166-961 ha) showed no evidence of natural reproduction, suggesting that Blue Catfish fisheries must be sustained through stocking in small impoundments.

In fall 2017, Blue Catfish (N = 114) were captured in fyke nets and hoop nets during a panfish (crappies *Pomoxis* spp. and sunfish *Lepomis* spp.) sampling assessment at Meeker Reservoir, a small impoundment in central Oklahoma (Porta et al. 2020). These fish ranged from 90 – 450 mm TL, and appeared to include multiple year classes. Blue catfish are not stocked into Meeker Reservoir by the Oklahoma Department of Wildlife Conservation, suggesting that this population is naturally reproducing, which is rare in small impoundments (Bartram et al. 2011). Further, Blue Catfish are not typically collected with the sampling methods used by Porta et al. (2020), so an assessment of this population with appropriate sampling techniques was warranted. Therefore, the objectives of this study are to 1) describe population characteristics (age and size structure, condition, growth, mortality, and age and size at maturity) of Blue Catfish in Meeker Reservoir using a multiple gear approach (low-frequency electrofishing, gillnets, and jug-lines), 2) determine environmental factors affecting year class strength of Blue Catfish, and 3) estimate the population size of preferred-length (≥760 mm) Blue Catfish in Meeker Reservoir.

## Methods

### Study Area

Meeker Reservoir is an 85.8 ha impoundment located 2.3 miles southwest of Meeker, Oklahoma in Lincoln County (35º 29′ 46.4″ N, 96º 56′ 10.2″ W; Figure 1). Meeker Reservoir was formed in 1970 by impounding Quapaw Creek. The primary purpose of the reservoir is for municipal water supply, flood control, and recreation. At full pool, Meeker Reservoir has 8 km of shoreline, a maximum depth of 7.4 m and a mean depth of 2.8 m (OWRB 2009). The river-reservoir interface of Quapaw Creek is shallow due to siltation, which has reduced the surface area of the lake by 21% (109.3 ha in 1970) since construction of the reservoir (OWRB 2009). The reservoir consists mostly of open water with areas of emergent aquatic vegetation, limited submerged or exposed standing timber, rock, coarse gravel, and clay or sand substrate. The reservoir is considered mesotrophic and is extremely turbid with a mean secchi depth of 10 cm (OWRB 2009). Salinity values range from 0.10 to 0.11 ppt. The water is neutral to slightly alkaline (7.33 - 8.37 pH).

Since impoundment in 1970, the Oklahoma Department of Wildlife Conservation (ODWC) has stocked Meeker Reservoir with Channel Catfish (*Ictalurus punctatus*), Flathead Catfish (*Pylodictis olivaris*), and Largemouth Bass (*Micropterus salmoides*). The first stocking occurred in 1972 and consisted of 6,000 fingerling Largemouth Bass, 600 fingerling Flathead Catfish, and 6,000 fingerling Channel Catfish. Since the initial stocking in 1972, only Channel Catfish have been stocked periodically (~20,000 fingerlings/year from 1981 – 1989; ~10,000 fingerlings/year from 2009 – 2013) into Meeker Reservoir. Based on ODWC historic stocking records and communication with representatives from the City of Meeker, there are no records of Blue Catfish stocking at Meeker Reservoir. It is possible that Blue Catfish were stocked via a contaminated stocking or an

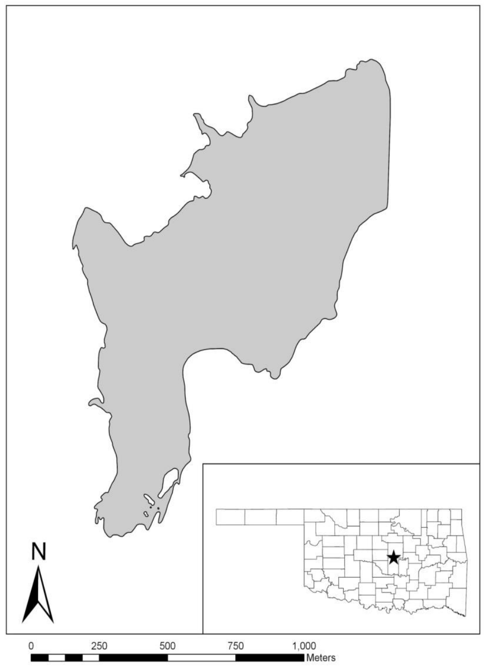


**Figure 1. Map of Meeker Reservoir (35º 29´ 46.4˝ N, 96º 56´ 10.2˝ W) located in Lincoln County, Oklahoma.**

angler introduction.

### Study design

Blue Catfish were collected from Meeker Reservoir during June 2019, using low-frequency electrofishing (15 pulses/sec, pulsed DC, high voltage, Smith Root 7.5 GPP, set for optimal power; Miranda 2009, Bodine et al. 2011) using two chase boats to improve efficiency (ODWC Standardized Survey Protocol manual). Seven sites were chosen at random from the entirety of the reservoir and five-minutes of effort were applied to each site during daylight hours. At the end of each unit, all fish collected were measured for total length (TL; mm) and weighed to the nearest gram (g). Additionally, 20 Blue Catfish per 10-mm TL group were collected for age estimation and sex determination. Fish kept for age estimation and sex determination were placed on ice and processed at the Oklahoma Fishery Research Laboratory in Norman, Oklahoma. Fish were re-measured for total length (TL; mm), weighed (g), sex determined, and lapilli otoliths were removed for age estimation.

Sex determinations of fish kept for aging purposes, were assigned a maturity status (immature or mature) following methods of Davis and Posey (1958) and Perry and Carver (1972). Immature Blue Catfish were those showing no signs of gonadal development, the ovaries and testes are barely distinguishable or are readily distinguishable but not developed. However, mature female Blue Catfish had well developed ovaries that contained yellowish to creamy-yellow eggs or were spent. Mature males were those with enlarged testes that were white in color. These Blue Catfish were sampled and examined during the time of year when spawning typically occurs in Oklahoma (Miller and Robison 2004), which allowed for easy determination of fish maturity.

Lapilli otoliths were extracted from each fish (Long and Stewart 2010) and placed into an individually numbered envelope and allowed to dry for at least 24 h prior to processing (Secor et al. 1992, Snow et al. 2017). Once dried, otoliths were processed according to methods of Buckmeier et al. (2002) and Waters et al. (2020). After processing, otoliths were viewed using a stereo microscope (capable of 130x magnification) with a fiber optic filament attached to an external light source to illuminate annuli (Buckmeier et al. 2002, Waters et al. 2020). Each otolith was estimated in concert by two readers, however if the readers disagreed on the age of the fish, then that otolith was put aside and viewed again at a later date (Hoff et al. 1997). If an otolith was deemed unreadable, the second otolith was processed and age estimated, however if that otolith was also poor or disagreement persisted the fish was removed from the study. Each otolith was evaluated in random order with no reference of TL, weight or sex (Hoff et al. 1997).

Large Blue Catfish appeared to be underrepresented using only low frequency electrofishing, so we employed a multi-gear approach (large mesh gillnets and jug lines) to ensure all size classes of fish were collected and to estimate the population size of preferred-sized (≥760 mm) Blue Catfish. Blue Catfish were sampled from 2 March - 5 March 2020 using 4 gillnets (7.3 m tall with four 15.2 m long panels composed of 76.2, 101.6, 127, and 154.4 mm mesh, respectively) and 15 jug lines (one 8/0 circle hook/jug). Jug lines were baited with Bluegill (*Lepomis macrochirus*), Gizzard Shad (*Dorosoma cepedianum*), or White Crappie (*Pomoxis annularis*). All Blue Catfish were measured for TL(mm) and weighed (g). Blue Catfish ≥760 mm were tagged with a PIT tag (Biomark, Inc., Boise, Idaho), size 3 self-piercing tag (National Band & Tag Co., Newport, Kentucky), and a pelvic fin clip then released. PIT tags were inserted behind the left maxillary barbel and the self-piercing tag was crimped to the posterior side of the adipose fin. All Blue Catfish ≤759 mm were collected for age estimation purposes. Furthermore, on the last day of sampling all Blue Catfish captured were kept for age analysis to fill additional length groups.

**Analysis**

Size structure of the Meeker Reservoir Blue Catfish population was described with length-frequency histograms of all fish captured and proportional size distribution (PSD, stock ≥ 300mm, quality ≥510 mm, preferred ≥760; Anderson and Gutreuter 1983). A simple linear regression was used to describe the relationship between $\log_{10}$(weight):$\log_{10}$(length). The relationship of Blue Catfish length to weight was also used to evaluate fish condition by calculating relative weight ($W_r$) using the standard weight equation $W_s$ = -6.067 + 3.400($\log_{10}$(TL)) (Muoneke and Pope 1999). A logistic regression model was used to determine the relationship between maturity at age for male and female Blue Catfish using binary variables (0 = immature, 1 = mature). Mean length at age was calculated for male and female Blue Catfish. These data were then log transformed data to linearize the relationship, and differences in growth between sexes were tested using analysis of covariance (ANCOVA). Because growth between sexes was similar ($F_{1, 322}$ = 0.485, $P$ = 0.48) all fish were combined to estimate growth rates using a Richard's growth model (Richard 1959, Ogle et al. 2017). Total annual mortality of Blue Catfish was estimated using weighted catch-curve-regression where the slope of the relationship between numbers of fish caught (natural log transformed) at each age (instantaneous total mortality [Z]) was used to estimate total annual mortality ($A = 1 - e^{-Z}$; Ricker 1975). Blue Catfish < age-2 were not fully recruited to the sampling gears, so they were removed from catch-curve analysis.

Annual year-class strength of Blue Catfish was indexed using residuals of catch curves following methods of Maceina (1997). Because Blue Catfish recruitment is irregular (Kuklinski and Patterson 2011, Duck 2020) and to reduce bias caused by infrequent catch of older fish (Dunn et al. 2002), only residuals from the 2007-2017 year classes were used for analyses. Residuals were divided by corresponding $\log_{10}$ number of fish in each year class to calculate deviation between the observed and predicted numbers of fish (DEV), with year-classes having DEV values > 0.5 were considered strong (Catalano et al. 2009).

Residuals calculated from the catch-curve regression were used in a multiple regression equation (ln(catch) = b0 – b1(age) ± b2(exvar)) with the addition of an explanatory variable (exvar) to determine the effects of that variable on recruitment (Maceina and Bettoli 1998). Recruitment of reservoir fishes has been linked to variation in reservoir area, discharge, retention, volume, and productivity (Maceina 1997, Maceina and Bettoli 1998). However, those parameters were not available for Meeker Reservoir. Because environmental variables were limited, we chose to evaluate the effects of annual average rainfall (proxy for hydrological variables), May/June average air temperature (coincides with Blue Catfish spawning times in Oklahoma), and annual average air temperature (proxy for water temperature) on Blue Catfish recruitment. Rainfall affects the hydrology of reservoirs and lakes via runoff and river inflow (Patrick 2016). Suleiman and Ifabiyi (2015) reported a strong and positive correlation between rainfall and several reservoir variables (reservoir inflow, retention, and discharge). Additionally, water temperature is correlated with air temperature, and has been used as an explanatory variable in previous fish studies

(Chambers and Trippel 1997). Rainfall and temperature data were collected from the Shawnee, Oklahoma Mesonet Station #85 (35° 21' 53" N, 96° 56' 53" W) for the period of May 2007 to December 2017. This station is located 14.54 km south of Meeker Reservoir.

The population abundance of preferred-length (≥760 mm) Blue Catfish was estimated using a Schnabel estimator (Seber 1982) with 95% confidence intervals calculated using a Poisson distribution (Krebs 1999). Although the primary assumption of a Schnabel estimator is a closed population (assumes no immigration, emigration, recruitment, or mortality), it is robust to some departure from these assumptions (Ricker 1975). We used a short sampling duration (5 day mark-recapture period) to best ensure the assumptions of a closed system were met. During this time there were no major rain events that affected inflow or outflow from Meeker Reservoir that would allow Blue Catfish immigration or emigration. Additionally, we observed no anglers fishing for Blue Catfish and it is unlikely that other mortality or recruitment events occurred that substantially altered the number of individuals during the 5-day period. The density (fish/ha$^{-1}$) and biomass (kg/ha$^{-1}$) of Blue Catfish ≥760 mm was estimated using the population abundance estimate. All analyses were performed using XLSTST 2020 (Addinsoft Inc., New York City, NY). All significance tests were evaluated at $P \leq 0.05$.

## Results

### Population dynamics

A total of 455 Blue Catfish were collected using all sampling gears combined (Figure 2), of which 323 Blue Catfish were kept for age estimation and population assessment. Blue Catfish used for age analysis ranged from age-1 to age-29 and were 112 - 855 mm TL. More male (57%) than female (43%) Blue Catfish were represented in the sample. Both female and male Blue Catfish reached 100% maturity by age-8 (Figure 3). The earliest that a Blue Catfish reached maturity was age 2, and 50% of all Blue Catfish reached maturity by age 5. There was no significant difference in age at maturity ($X^2$ = 2.057, df = 1, $P$ = 0.15) between sexes of Blue Catfish from Meeker Reservoir

This population was dominated by sub-stock (85%) and stock (11%) sized Blue Catfish (Table 1; Figure 2). As a result, PSD was low (PSDq = 20), but a small proportion of the population exceeded preferred size (PSDp = 6). Stock-length Blue Catfish averaged age-11, quality-length averaged age-19, and an average of 23.5 years was required to reach preferred-length (Table 1). The weight-length relationship of Blue Catfish was $\log_{10}(W) = 0.312(\log_{10}(TL)) + 1.75$, which was highly significant ($r^2 = 0.98$, $P < 0.01$; Figure 4). This weight-length relationship resulted in a mean $W_r$ of 98 (Table 1), which is above average (near the 75$^{th}$ percentile). When

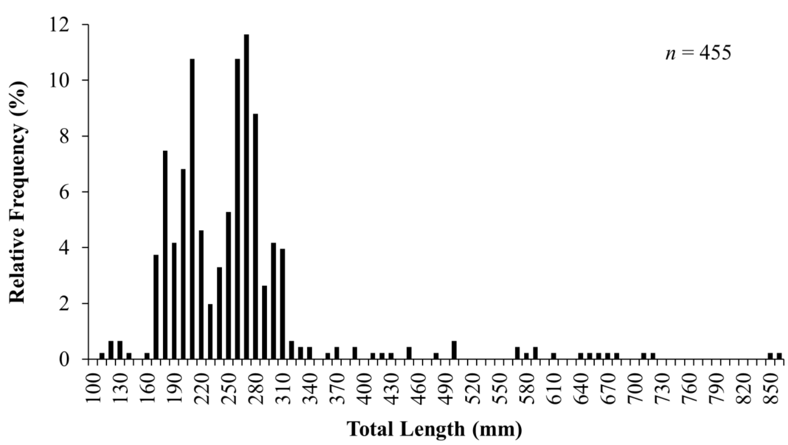


**Figure 2. Length frequency histogram utilizing all gears to capture Blue Catfish collected from Meeker Reservoir, Oklahoma.**

**Table 1. Proportional size distribution (PSD; 95% confidence interval (CI)), mean age (range), and relative weight (Wr; 95% CI) of Blue Catfish by size class collected from Meeker Reservoir, Oklahoma.**

| Size Category | *n* | PSD Value (95% CI) | Mean Age (range) | $W_r$ (95% CI) |
|---|---|---|---|---|
| Sub-stock | 387 | N/A | 5 (1-12) | 99 (98-100) |
| Stock (≥ 300 mm) | 50 | 74 (61-87) | 11 (7-17) | 90 (88-93) |
| Quality (≥ 510 mm) | 14 | 20 (8-32) | 19 (16-29) | 91 (85-98) |
| Preferred (≥ 760 mm) | 4 | 6 (0-13) | 23.5 (23-24) | 95 (81-109) |
| Overall | 455 | N/A | 6.5 | 98 |

evaluated by size classes, $W_r$ ranged from 90 – 99. The Richard's growth model indicates that Blue Catfish approach $L_\infty$ ($L_\infty$ = 736 mm TL; predicted maximum total length) slowly (k = 2.1), with individuals in the population reaching approximately 50% of the $L_\infty$ by age-11 and 75% of $L_\infty$ by age-18 (Figure 5). The estimated annual survival rate was high (87%) and estimated total annual mortality was low (13%) for Blue Catfish in Meeker Reservoir (Figure 6).

**Recruitment**

Recruitment of Blue Catfish in Meeker Reservoir was sporadic and variable. Fish from 21 year-classes were represented in the age sample. Three strong year classes (DEV > 0.05; 2012, 2016, and 2017) comprised a large portion (58%) of the Blue Catfish population in Meeker Reservoir (Table 2). Blue Catfish recruitment patterns were not related to annual rainfall ($F_{2, 8}$ = 0.155, $P$ = 0.86) or May/June air temperature ($F_{2, 8}$ = 0.503, $P$ = 0.63; Table 2). However, Blue Catfish year class strength was positively correlated with annual air temperature ($F_{2, 8}$ = 9.431, $P \leq 0.01$, $r^2$ = 0.71, $P \leq 0.01$; Figure 7), suggesting that strong Blue Catfish year classes formed in warmer years (> 16.5°C ) and weaker year classes formed in colder years (< 16.5°C ). This relationship explained 24.3% (squared Pearson correlation coefficient) of the variation in abundance at age in the model after accounting for the influence of age.

**Abundance of preferred size Blue Catfish**

The estimated abundance, density, and biomass of preferred-length Blue Catfish in Meeker Reservoir were low. During the 5-day mark-recapture effort, we collected a total of 6 preferred-length Blue Catfish (ranging 762 to 855 mm TL), of which 3 (50%) were recaptured. This produced a population estimate of 9 preferred-length Blue Catfish (95% CI = 2.3 - 23.2) in Meeker Reservoir. Using the estimated

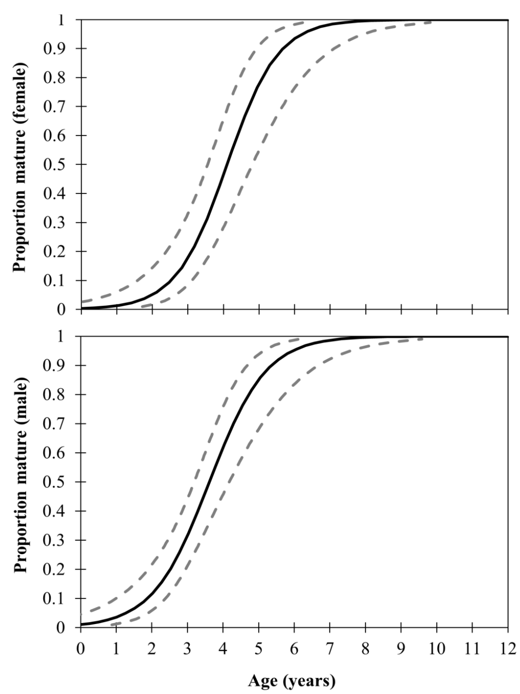


**Figure 3. Results of logistic regression analysis displaying the proportion of mature female (top) and male (bottom) Blue Catfish by age. Only Blue Catfish age-0 to age-12 are presented graphically to allow clear visualization of these relationships. Grey dash lines represent 95% confidence intervals.**

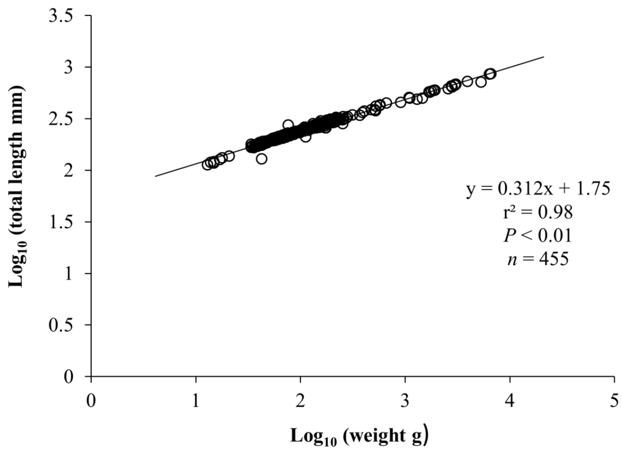


**Figure 4. Weight-length relationship for 455 Blue Catfish collected from Meeker Reservoir, Oklahoma. The logarithmically-transformed weight-length equation is log10 (W) = 0.312 (log10 TL) + 1.75.**

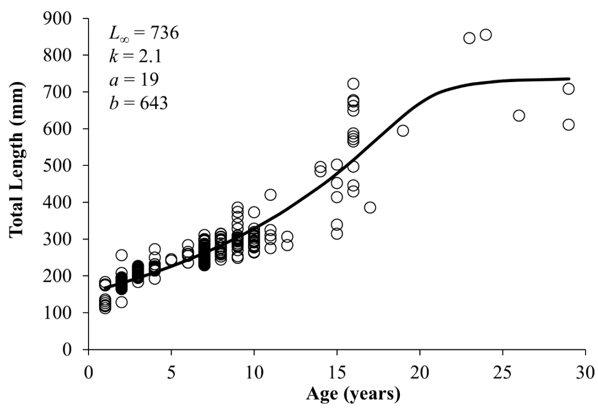


**Figure 5. Richards growth curve calculated from 323 otolith age estimates for Blue Catfish collected from Meeker Reservoir, Oklahoma. L∞ = predicted maximum total length, k = growth constant, a =horizontal position of the inflection point, and b = vertical position of the inflection point.**

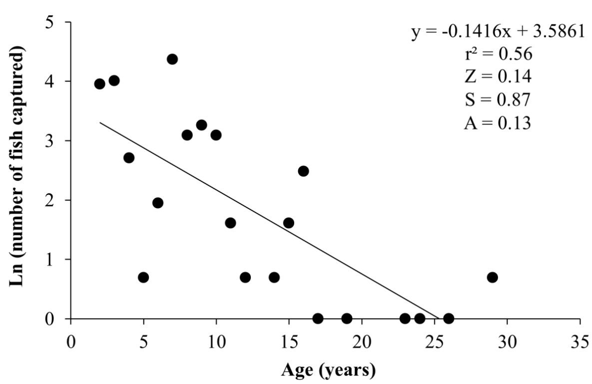


**Figure 6. Weighted catch curve regression used to estimate total annual mortality (A) for Blue Catfish collected from Meeker Reservoir, Oklahoma. Z = instantaneous total mortality and S = total annual survival.**

**Table 2. Number (n) and percent (%) of total Blue Catfish collected by year-class from Meeker Reservoir, Oklahoma. Year-class strength (2007 – 2017) was estimated using catch-curve residuals divided by corresponding log predicted fish number to obtain deviation (DEV). Strong year-classes (DEV values >0.50) are identified in bold. Included are annual average rainfall (cm) and temperature (°C) data, which were used in multiple regression models. These data were collected from the Shawnee, Oklahoma Mesonet Station (35° 21' 53" N, 96° 56' 53" W) located 14.54 km south of Meeker Reservoir from May 2007 through 2017.**

| Year class | *n* | % | DEV | Average rainfall (cm) | Average May/June air temperature (°C) | Average annual air temperature (°C) |
|---|---|---|---|---|---|---|
| **2017** | **52** | **16.1** | **0.77** | **8.4** | **22.5** | **16.7** |
| **2016** | **55** | **17** | **1.88** | **9.4** | **22.6** | **16.7** |
| 2015 | 15 | 4.64 | -2.01 | 37.1 | 22.5 | 16.1 |
| 2014 | 2 | 0.62 | -0.43 | 9 | 22.6 | 15 |
| 2013 | 7 | 2.17 | -0.80 | 16.4 | 22.5 | 15 |
| **2012** | **79** | **24.5** | **1.60** | **7** | **22.9** | **17.8** |
| 2011 | 22 | 6.81 | -1.31 | 4.9 | 23.1 | 17.2 |
| 2010 | 26 | 8.05 | -0.85 | 16.7 | 23.2 | 16.1 |
| 2009 | 22 | 6.81 | -0.57 | 5.9 | 23.2 | 15.6 |
| 2008 | 5 | 1.55 | -0.33 | 14.4 | 23.2 | 15.6 |
| 2007 | 2 | 0.62 | -0.35 | 27.3 | 23.0 | 15.6 |

abundance, preferred-length Blue Catfish density was estimated to be 0.11 fish/ha$^{-1}$ (95% CI = 0.03 – 0.27 fish/ha$^{-1}$) with an estimated biomass of 0.08 kg/ha$^{-1}$ (95% CI = 0.07- 0.08 kg/ha$^{-1}$).

## Discussion

The establishment of a Blue Catfish population in a small impoundment like Meeker Reservoir is rare. In general, Blue Catfish do not do well in reservoirs with small surface area and low productivity. Bartram et al. (2011) found the most robust Blue Catfish populations in reservoirs with high productivity (Secchi depth < 65 cm) and large surface area (> 1,466 ha). Although water clarity of Meeker Reservoir is poor (mean secchi depth = 10 cm), it is the result of large amounts of suspended sediments and not productivity. Meeker Reservoir has low to moderate productivity, and has been classified as mesotrophic (OWRB 2009). The establishment of a Blue Catfish population in Meeker Reservoir appears anomalous, as conditions that typically result in robust Blue Catfish populations are not present. However, spawning habitat appears to be available and utilized, given year classes of Blue Catfish are produced in most years.

A combination of low reservoir productivity and high recruitment rates may explain the overabundant and slow growing Blue Catfish in Meeker Reservoir. In systems with low productivity, competition for forage resources may be high, resulting in reduced growth rates of fish (Andersen et al. 2017). Michaletz (2009) found that Channel Catfish growth was slow when fish density was high and lake productivity was low. Further, Nepal and Fabrizio (2020) suggested that juvenile Blue Catfish growth rates in the York River, Virginia may have been lower than those in other rivers evaluated in that study due to lower productivity in that system. Reproductive strategy may also explain the slow growth of Blue Catfish in Meeker Reservoir. Fishes that allocate energy towards

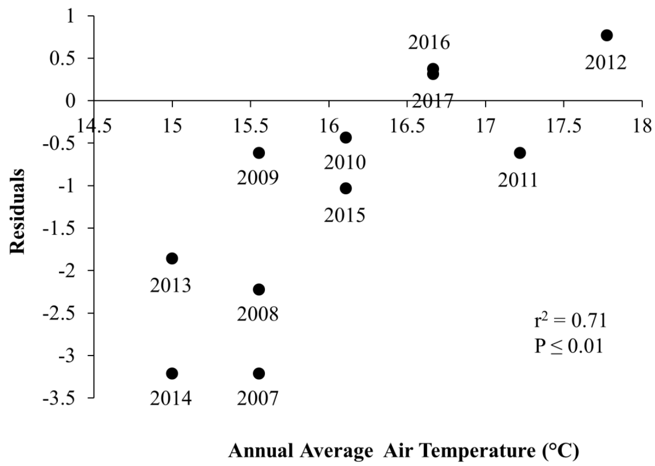


**Figure 7. Relationship between catch-curve residuals annual air temperature (°C). Data points represent year classes.**

reproduction rather than growth typically reach maturity at smaller sizes, which ultimately affects their overall growth potential (Enberg et al. 2012). Blue Catfish in Meeker Reservoir reached sexual maturity at smaller sizes than observed in other populations. We observed mature fish as small as 180 mm TL (age-2) and 50% of age-5 fish were mature (243 mm TL). Perry and Carver (1972) did not observe mature Blue Catfish until they exceeded 400mm TL in Louisiana. Hale and Timmons (1989) did not observe mature Blue Catfish until they were >445mm TL in Kentucky Lake, Kentucky. Graham (1999) reported mature Blue Catfish at lengths ranging 350-662 mm TL (age-4 to age-7). Overall, it appears a combination of factors are affecting growth of Blue Catfish in Meeker Reservoir resulting in growth rates that are much slower than other reservoir populations in Oklahoma (Boxrucker and Kuklinski 2006), and other areas of the United States (Graham 1999).

Growth of Blue Catfish in Meeker Reservoir was not consistent among age classes. Year-to-year changes in length between younger fish (< age-12) were smaller than year-to-year changes of older fish (> age-12). The observed differences in growth patterns between age classes required the use of a Richard's growth model instead of the more traditional von Bertalanffy growth model to describe growth of Blue Catfish from Meeker Reservoir. One possible explanation for the differences in growth between age groupings is the larger fish in this population may represent Blue Catfish that were originally stocked into Meeker Reservoir. Although it is unknown how and when Blue Catfish entered Meeker Reservoir, it is possible that these fish were transplanted from another system where Blue Catfish growth is faster, or that the initial small population size allowed ample growth for the first several years of this population's existence in Meeker Reservoir. Further, if fish were transplanted into Meeker Reservoir, it is possible that progeny produced from a small founder population are impacted by inbreeding depression that is negatively affecting growth, which has been observed for Channel Catfish (Bondari and Dunham 1987). Finally, size-specific differences in diet may explain the differences in growth between the age classes of Blue Catfish in Meeker Reservoir. Although our sample is limited (only fish captured for aging purposes were dissected to identify stomach contents), small Blue Catfish (ranging 112 – 496 mm) predominately consumed invertebrates (mayflies), while larger Blue Catfish (ranging 374 – 708) were able to consume fish (primarily small [< 150 mm TL] Blue Catfish), which has been described for other Blue Catfish populations (Edds et al. 2002). Larger fish have an advantage in that they can consume prey of a wider range of sizes, including fish, which would allow them to grow to larger sizes (Vanni et al. 2009). Although the exact mechanism is unknown, divergence in growth among age classes is apparent in Meeker Reservoir.

In addition to slow growth, total annual mortality of Meeker Reservoir Blue Catfish was low (13%) compared to other populations. Boxrucker and Kuklinski (2006) observed a 26% average mortality rate across 9 Blue Catfish populations in Oklahoma. Similarly, Kuklinski and Patterson (2011) documented an average total annual mortality rate of 24% for Blue Catfish populations from 14 reservoirs in Oklahoma. Our mortality estimate for Meeker Reservoir fell at the lower end of the range (12-63%) reported by Graham (1999) for Blue Catfish populations across the U.S. However, the mortality estimates reported by Graham (1999) resulted from the use of multiple aging methods (i.e. otoliths and spines) that may affect the mortality estimates across populations' calculations (Boxrucker and Kuklinski 2006). Regardless, our mortality estimates for the Blue Catfish population in Meeker Reservoir are low compared to other Oklahoma reservoir populations that were described using similar aging methods (Boxrucker and Kuklinski 2006, Kuklinski and Patterson (2011).

The Meeker Reservoir Blue Catfish population was dominated (58%) by three year classes. Variable recruitment in Blue Catfish populations in Oklahoma is not uncommon (Kuklinski and Patterson 2011, Duck 2020). Similarly, Goeckler et al (2003) found 74% of the Blue Catfish population in a large reservoir in Kansas was comprised of two year classes. We found strong year classes of Blue Catfish were formed in Meeker Reservoir during years with higher average temperatures. Nepal and Fabrizio (2020) described increased growth of age-0 Blue Catfish in several tributaries to Chesapeake Bay during years when average temperatures were the warmest. Fish that attain larger sizes during their first year of life have a higher survival rate, which translates into increased year-class strength (Ludsin and DeVries 1997, Phelps et al. 2008). Improved growth of age-0 Blue Catfish in years with higher temperatures in Meeker Reservoir may explain the associations we found in this study. This is supported by findings of Bartram et al. (2011) that found growing season positively influenced Blue Catfish populations in Texas.

The Meeker Reservoir Blue Catfish population is dominated by a high abundance of slow growing fish. This creates a challenging management scenario because few fish exceed 406 mm TL, which is what catfish anglers consider to be eating size (Hunt and Hutt 2010). Therefore, it is unlikely that angler exploitation will be high enough to reduce competition and promote growth of this overcrowded, stunted population. An alternative option is for fisheries managers to manually remove small Blue Catfish from the Meeker Reservoir population in hopes that the reduction in biomass would result in reduced competition for forage resources and increased growth. To our knowledge there is limited information on targeted removals of catfish. Bonvechio et al. (2011) documented changes in the age structure, condition, size structure, and biomass of invasive Flathead Catfish in Satilla River, Georgia. Additionally, other species removal efforts have been successfully used to reduce biomass, for example Common Carp (*Cyprinus carpio*; Bajer et al. 2009). Although removal efforts are usually effective, they require a lot of labor intensive work.. Despite creating a challenging management scenario, our results provide important information regarding Blue Catfish population characteristics and recruitment in a small impoundment, which is a rare phenomenon.

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