Population Dynamics and Diets of Yellow Bass in New Spiro Reservoir, Oklahoma

Richard A. Snow
Oklahoma Department of Wildlife Conservation, Oklahoma Fishery Research Laboratory, Norman, OK 73072

Michael J. Porta
Oklahoma Department of Wildlife Conservation, Oklahoma Fishery Research Laboratory, Norman, OK 73072

Abstract: Yellow Bass (*Morone mississippiensis*) are rare in Oklahoma and little information exists regarding the basic ecology in the state. However, a population exists at New Spiro Reservoir, which was studied in fall 2018 and spring 2019. Our objective was to describe population dynamics (age and size structure, condition, growth, mortality, and age at maturity) and diets (spring and fall) of Yellow Bass in New Spiro Reservoir, Oklahoma. This population was dominated by stock-sized (100 mm TL) fish that were primarily planktivorous in both seasons. Yellow Bass in New Spiro Reservoir is characterized by fast growth rates (L_∞ = 281 mm TL by age-2), short longevity (age-3), rapid maturity (100% mature by age-2), and high annual mortality rates. Relative weights (W_r) of Yellow Bass were average (mean W_r = 96), but W_r increased with fish size (substock = 90, stock = 92, quality = 98, preferred = 105, memorable = 114). This study improves our knowledge of the life history of Yellow Bass in Oklahoma and provides a basis from which future studies can be compared.

Introduction

Yellow Bass (*Morone mississippiensis*) are native to the Mississippi River system of North America (Miller and Robison 2004, Edds 2014), including Oklahoma. However, Yellow Bass have only been documented in a few Oklahoma reservoirs and rivers from three counties (Wagoner, Muskogee, and McCurtain) in the southeast portion of the state (Robison et al. 1974, Pigg and Hill 1974, Pigg et al. 1979, Pigg 1983, Pigg and Peterson 2000, Miller and Robison 2004). Due to their rarity, when Yellow Bass are captured during a survey in Oklahoma they are typically preserved and placed into museum collections (Pigg and Hill 1974, Pigg et al. 1979, Pigg 1983, Pigg and Peterson 2000). Recently, ODWC staff have documented Yellow Bass populations in two additional reservoirs (Robert S. Kerr Reservoir and Sally Jones Lake in Sequoyah County, OK) during standardized gillnet surveys since 2000 (ODWC, unpublished data), but follow-up studies were not conducted. In 2018, Yellow Bass were observed at a third reservoir, New Spiro in Le Flore county, during a spring electrofishing survey in 2018 (Porta 2019). Because little is known about Yellow Bass in Oklahoma, our objectives were to describe population characteristics (age and size structure, condition, growth, mortality, and age at maturity) and seasonal diets (spring and fall) for Yellow Bass from New Spiro Reservoir, Oklahoma.

Methods

Study Area

New Spiro Reservoir is a 100.8 ha impoundment of Holi-Tuska Creek formed in 1963 and is located 4.6 km south of Spiro, Oklahoma in Le Flore County (35º 11′ 35.7″ N, 94º 36′ 59.5″ W; Figure 1). This reservoir serves as a water supply for the city of Spiro and also provides flood control and recreational

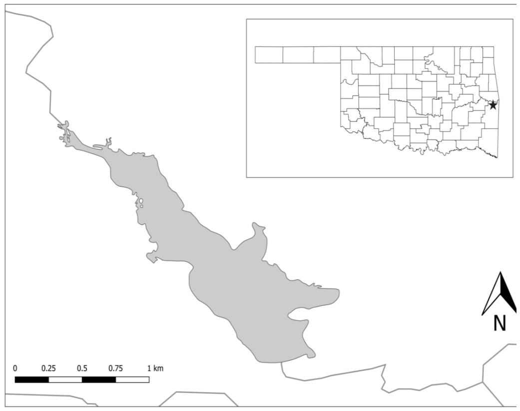

Figure 1. Map of New Spiro Reservoir (35º 11´ 35.7″ N, 94º 36´ 59.5″ W) located in Le Flore County, Oklahoma.

opportunities. At full pool, New Spiro Reservoir has 9.3 km of shoreline, a maximum depth of 6.7 m and a mean depth of 2.5 m (OWRB 2010). The reservoir consists of open water with areas of dense complex stands of submerged and emergent aquatic vegetation, with rock and/or coarse gravel points, and clay or sand substrate. The reservoir is considered hypereutrophic with a mean secchi depth of 47 cm (OWRB 2010).

Study Design

Yellow Bass (Figure 2) were collected from New Spiro Reservoir during October 2018, using experimental gillnets (61 m long x 1.8 m deep and constructed of eight 7.6 m panels [12.7, 15.9, 19.1, 25.4, 38.1, 50.8, 63.5, and 76.2 mm bar mesh]) at 6 randomly selected sites. Additionally, Yellow Bass were collected in April 2019 using boat electrofishing (pulsed DC, high voltage, Smith Root GPP), which was used to sample the entire shoreline. A multiple gear approach was implemented to ensure all age and size classes were represented in the sample (Kuklinski 2007, Porta and Snow 2017). All Yellow Bass were placed on ice immediately after capture, and processed at the Oklahoma Fishery Research Laboratory in Norman, Oklahoma. All fish were measured for total length (TL; mm), weighed (g), dissected to remove stomachs and determine sex, and sagittal otoliths were removed for age estimation. Although sex was determined for all fish collected, only Yellow Bass collected during spring 2019 (n = 165) were used to determine age at maturity as these fish were collected during the spawning season.

Figure 2. Photograph of a Yellow Bass (240 mm TL, 245 g) collected in April 2019 from New Spiro Reservoir, Oklahoma.

Following collection, otoliths were allowed to dry for >24 hrs before processing for age estimation. To estimate age, whole otoliths (concave side up) were submerged in water to reduce glare and viewed with a stereo-microscope (capable of 130x magnification) aided by an external light source to illuminate annuli. Annuli were counted to estimate age. Each otolith was estimated independently by two readers, however if the readers disagreed on the age, a concert read was performed by both readers to determine a final age estimate. If disagreement continued the otolith were broken in a transverse plane and polished using 2000-grit wet/dry sandpaper and re-estimated following the aforementioned process. If disagreement persisted, the sample was removed from the study. Each otolith was evaluated in random order with no reference of TL, weight or sex (Hoff et al. 1997).

To evaluate Yellow Bass diets, stomachs were thawed and prey items were removed, identified, enumerated, and weighed (g). Prey items were identified to order or family for invertebrates and species for fish using taxonomic keys (Oats et al. 1993, Miller and Robison 2004, Merrit et al. 2008, Traynor et al. 2010).

Analysis

Size structure of the Yellow Bass in New Spiro Reservoir was described with length-frequency histograms and by calculating proportional size distribution (PSD) using the size categories described by Anderson and Gutreuter (1983; stock ≥ 100 mm, quality ≥180 mm, preferred ≥230 mm, memorable ≥280 mm). A simple linear regression was used to describe the relationship between $\log_{10}$ weight and $\log_{10}$ length. The relationship of Yellow Bass length to weight was also used to evaluate fish condition by calculating relative weight (W_r) using the standard weight equation (W_s = -5.142 + 3.133($\log_{10}$ TL)) presented by Bister et al. (2000).

Mean length at age was calculated for male and female Yellow Bass. These data were then log transformed to ensure a linear relationship, and differences in growth between sexes was tested using analysis of covariance (ANCOVA). Since growth between sexes was similar ($F_{2, 255}$ = 0.097, P = 0.09) all fish were combined to describe growth using a von Bertalanffy growth model. Total annual mortality of Yellow Bass was estimated using a weighted catch-curve-regression where the slope (instantaneous total mortality [Z]) of the relationship between numbers of fish caught ($\log_e$ transformed) at each age was used to estimate total annual mortality ($A = 1 - e^{-Z}$; Ricker 1975). Age-0 Yellow Bass were removed from catch-curve analysis because they were not fully recruited to the sampling gears. Yellow Bass diets were described using percent occurrence, percent composition by number, and percent weight by season (spring and fall; Bowen 1996).

Results

Population dynamics

A total of 257 Yellow Bass were collected for population assessment. Yellow Bass ranged from age-0 to age-3 and from 81 to 302 mm TL (Figure 3). Slightly more male (54%) than female (46%) Yellow Bass were represented in the sample. The majority (76%) of Yellow Bass reached maturity by age-1 and 100% of Yellow Bass were mature by age-2. The New Spiro population was dominated (74%) by stock-size fish, resulting in a relatively low PSD_q value of 19, but a small proportion of the population reached preferred and memorable sizes (Table 1). The weight-length relationship of Yellow Bass was $\log_{10}$ (W) = 0.2997 ($\log_{10}$ TL) + 1.68 and was highly explanatory (r^2 = 0.99, P < 0.01; Figure 4). Yellow Bass W_r averaged 94 but this value increased with fish size (substock = 90, stock = 92, quality = 98, preferred = 105,– memorable = 114). The von Bertalanffy growth model indicates that Yellow Bass approach L_∞ (281 mm TL) rapidly (k = 0.80), with individuals in the population reaching approximately 70% of the L_∞ by age-1 and 90% of L_∞ by age-2 (Figure 5). The estimated total annual mortality was high (83%) resulting in low longevity (3 years) (Figure 6).

Diet

A total of 257 (92 in the fall and 165 during spring) Yellow Bass were used for stomach content analysis. More Yellow Bass in the fall had empty stomachs (33 of 92; 36%) than those

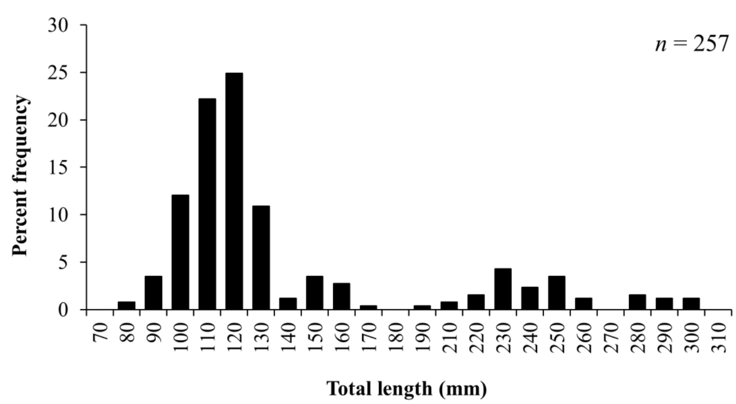

Figure 3. Length frequency histogram utilizing both fall and spring captured Yellow Bass collected from New Spiro Reservoir, Oklahoma.

Table 1. Proportional size distribution (PSD), mean age, and relative weight (Wr) by size category for Yellow Bass collected from New Spiro Reservoir, Oklahoma.

Size Category	*n*	PSD Value (95% CI)	Mean Age (range)	Mean W_r (95% CI)
Sub-stock	20	N/A	0 (0 - 1)	90 (84 - 97)
Stock (≥ 100 mm)	191	81 (73 - 88)	1 (0 - 1)	92 (90 - 93)
Quality (≥ 180 mm)	14	19 (12 - 10)	2 (1 - 3)	98 (94 - 102)
Preferred (≥ 230 mm)	25	14 (5 - 16)	2 (1 - 3)	105 (101 - 109)
Memorable (≥ 280 mm)	7	3 (0 - 6)	2 (2 - 3)	114 (109 - 119)
Overall	257	N/A	1 (0 – 3)	94 (92 – 96)

captured in spring (17 of 165; 10%). Yellow Bass consumed 19 different prey types during spring, but only 9 during fall (Table 2). Yellow Bass were primarily planktivorous regardless of season (86% in fall; 94% in spring).

During fall, zooplankton dominated the diets of Yellow Bass by percent occurrence (63%) and by number (86%), followed by invertebrates (O_i = 21% and N_i = 14%), and fish (O_i = 16% and N_i = 0.12%). However, fish contributed more by weight (64%) than invertebrates and zooplankton that contributed similarly (18%; Table 2). Individually, Copepods (61%) contributed the most to diets of Yellow Bass by percent occurrence followed by Diptera (19%), and shad spp. (13%). All other diet items contributed < 10% by occurrence (Table 2). By number, Copepods were found most often (84%), followed by Diptera (11%). All other prey items represented < 10% by number. Shad (*Dorosoma* spp.) contributed the most by weight (53%) to Yellow Bass diets, followed by Diptera and Copepods (17%), and unidentified fish (11%). The remaining prey items contributed < 10% by weight (Table 2).

Yellow Bass diets were dominated by zooplankton in the spring, contributing the most by occurrence (141%), number (94%), and weight (73%; Table 2). Cladocerans dominated the spring diets of Yellow Bass by percent occurrence (125%), followed by Copepods (14%), Diptera (4%), algae (3.6%), fish eggs (2.5%), and Ostracods (2.3%). All other diet items contributed < 5% by occurrence (Table 2). Cladocerans dominated diets of Yellow Bass by number (86%), followed by Copepods (7%) and fish eggs (2.2%). All other prey items represented < 3% by number. Cladocerans contributed the most by weight (66%) to Yellow Bass diets, followed by Diptera (12%), fish eggs (6.7%), Copepods (6%), and algae (3.3%). The remaining prey items contributed < 3% by

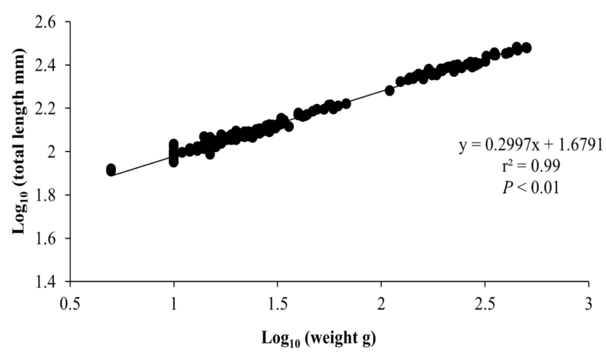

Figure 4. Weight-length relationship for 257 Yellow Bass captured from fall and spring sampling from New Spiro Reservoir, Oklahoma. The logarithmically-transformed weight-length equation is log10 (W) = 0.2997 (log10 TL) + 1.68.

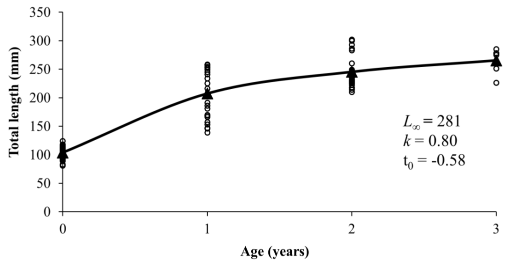

Figure 5. von Bertalanffy growth curve calculated using otolith age estimates for Yellow Bass captured in the fall and spring from New Spiro Reservoir, Oklahoma. L_∞ = predicted maximum total length, *k* = growth constant, and t_0 = theoretical time when total length = 0.

weight (Table 2).

Discussion

Past instances of Yellow Bass in Oklahoma were simply noted as present (e.g., Pigg and Hill 1974, Pigg et al. 1979, Pigg 1983, Pigg and Peterson 2000) but our evaluation is the first to describe population characteristics for this species in Oklahoma. We determined that Yellow Bass grew rapidly in New Spiro Reservoir, with most fish (90%) reaching L_∞ (281 mm) by age-2. Growth of Yellow Bass in New Spiro Reservoir was similar to populations from other parts of the species range (Lake Poygan, Wisconsin; Priegel 1975, Browning Oxbow, Kansas; Stein 2001, Barren River Lake, Kentucky; Zervas 2010, Little Grassy Lake, Illinois; Smith et al. 2011, Upper Baratartia Estuary, Louisiana; Fox et al. 2016) where maximum length approached 300 mm TL. However, growth of Yellow Bass in New Spiro Reservoir exceeded that of Yellow Bass in Crab Orchard Lake, Illinois (L_∞ = 209; Smith et al. 2011). Along with fast growth, Yellow Bass reached sexual maturity at young ages. We observed mature Yellow Bass starting at age-1 and, by age-2, 100% of Yellow Bass were mature. Stein (2001) reported similar maturity rates for Yellow Bass in Browning Oxbow, Kansas (87% by age-1). However, several studies did not observe mature Yellow Bass until they reached age-2 or older (Priegel 1975, Fox et al. 2016).

Catch-curve analysis revealed that total annual mortality was high (83%) for Yellow Bass in New Spiro Reservoir, which was nearly double that observed for other populations (31%, Browning Oxbow, Kansas; Stein 2001; 40%, Barren River Lake, Kentucky; Zervas 2010, 44%, Little Grassy Lake, Illinois; 31%, Crab Orchard Lake, Illinois; Smith et al. 2011). As a result, longevity of Yellow Bass in New Spiro Reservoir was low (age-3), which is considerably lower than previously documented for other populations (6-11 years; Priegel 1975, Stein 2001, Zervas 2010, Smith et al. 2011). Likely, water temperature in the southern climate of New Spiro plays a role in longevity. For example, although the critical thermal maximum is unknown for Yellow Bass, Neill and Magnuson (1974) determined water temperature preference for Yellow Bass was < 29°C in Monona Lake, Wisconsin. In another southern system, upper Barataria Estuary, Louisiana, longevity of Yellow Bass was also low (4 years; Fox et al. 2016). Suggesting that prolonged periods of temperatures exceeding their preference could explain the higher mortality rates and truncated age structure of Yellow Bass in New Spiro Reservoir

Diets of Yellow Bass collected from New Spiro Reservoir consisted of mainly zooplankton, although the breadth of prey

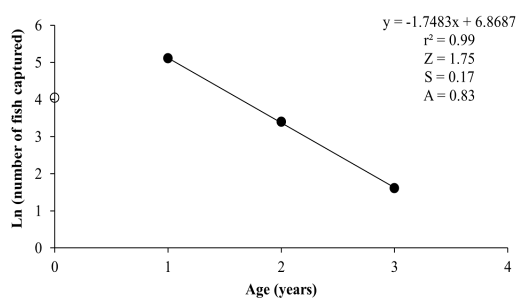

Figure 6. Catch-curve regression used to estimate total annual mortality (A) for Yellow Bass captured in the fall and spring from New Spiro Reservoir, Oklahoma. Z = instantaneous total mortality and S = total annual survival.

Table 2. Seasonal diets (spring and fall) of Yellow Bass from New Spiro Reservoir, Oklahoma described using percent occurrence (%O_i), percent composition by number (%N_i), and percent weight (%W_i).

	Fall			Spring		
Prey Items	%O_i	%N_i	%W_i	%O_i	%N_i	%W_i
Fish:						
Eggs				2.47	2.18	6.66
Gizzard Shad	13.16	0.08	52.79	0.02	0.005	0.02
Unidentified Fish	2.81	0.05	11.47	0.01	0.01	0.02
Total Fish	**15.97**	**0.12**	**64.26**	**2.49**	**2.19**	**6.69**
Invertebrate:						
Amphipod				0.05	0.01	0.01
Coleoptera				0.65	0.01	0.20
Diptera	18.56	10.81	17.08	4.07	2.10	11.85
Ephemeroptera				0.80	0.04	0.14
Grass Shrimp				0.36	0.11	0.42
Hemiptera				0.01	0.002	0.003
Odonta				0.14	0.06	0.20
Oligochaete	0.01	0.02	0.003	0.08	0.01	0.62
Tricoptera				0.33	0.05	0.11
Unidentified Invertebrate	2.76	3.01	0.65	0.66	0.03	0.35
Total Invertebrates	**21.33**	**13.84**	**17.73**	**7.15**	**2.43**	**13.91**
Zooplankton:						
Cladoceran	0.01	0.01	0.002	125.21	85.93	65.84
Copepod	60.79	84.10	17.45	13.96	6.98	6.15
Ostracod	1.43	1.62	0.46	2.25	0.66	0.57
Unidentified Zooplankton	0.47	0.30	0.10			
Total Zooplankton	**62.70**	**86.04**	**18.01**	**141.42**	**93.56**	**72.55**
Other:						
Algae				3.57	1.11	3.27
Detritus				0.40	0.14	0.07
Fishing Lure				0.32	0.002	0.09
Total Other				**4.29**	**1.25**	**3.43**

Shad spp. = Gizzard Shad and Threadfin Shad

items was higher in the spring. This is similar to other studies examining diets of Yellow Bass throughout their range. For example, Van Den Avyle et al. (1983) found that Yellow Bass fed largely on Cladocerans and Copepods, and Collier (1959) and Kraus (1963) found large numbers of Dipterans in diets. Zervas (2010) found Yellow Bass relied mostly on Chironomid larvae and pupae throughout spring, summer, and winter. In summer and in fall, Yellow Bass began feeding heavily on Copepods. For larger Yellow Bass in the spring and summer, diets consisted of young-of-year Gizzard Shad (*Dorosoma cepedianum*). Gizzard Shad were not observed in the diets in fall, probably because of gape limitation from Gizzard Shad growth (Zervas 2010). Larger Yellow Bass are known to consume both zooplankton and small fish (Bulkley 1970), which is similar to our results. However, limited numbers of preferred size and larger Yellow Bass affected our ability to truly estimate their potential for piscivory.

It is unknown how long Yellow Bass have been in New Spiro Reservoir and could represent a robust population of a rare species in Oklahoma. However, it is equally plausible that this Yellow Bass population only recently became established in New Spiro Reservoir, such as during recent large flood events occurring in 2015. Regardless, this population should be routinely monitored to evaluate abundance trends through time and potential effects on the existing fish community. In some instances, Yellow Bass can negatively impact sport fish populations through egg predation (Driscoll and Miranda 1999) or competition for forage resources (Stein 2001) and our observations of fish eggs in the diets suggest this may be happening to some unknown degree. By completing the objectives of this study, we have established important baseline population dynamic and diet information against which future Yellow Bass populations in Oklahoma can be compared.

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