Largemouth Bass Fishery Characteristics in the Arkansas River, Arkansas

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Abstract: The Arkansas River largemouth bass (*Micropterus salmoides*) fishery has not been intensively managed or studied, especially downstream of Lake Dardanelle. Recent issues that have potentially affected the fishery necessitated a comprehensive assessment of populations throughout the entire Arkansas portion of the river. During 2004–2005, largemouth bass populations were assessed in all 11 Arkansas navigation pools of the river using boat-mounted, nighttime electrofishing. Populations were young with 94% of the individuals consisting of ages 1–4. Across years and pools, size structure measures were within acceptable ranges for largemouth bass (mean $PSS_Q = 51$, range 28–72; mean $PSS_P = 18$, range 8–36), though theoretical maximum sizes generated from growth models were generally smaller than average (mean $L_\infty = 474$ mm TL, range 414–530). Populations exhibited above-average condition and growth rates, with total annual interval mortality approximated from catch curves averaging 48% (range 25%–66%). Short-term recruitment of largemouth bass (as mean catch-per-unit-effort of age-1 bass) varied three-fold between the two years sampled, though longer-term recruitment (as quantified by the Recruitment Variability Index) suggested recruitment to be relatively stable through time. Population statistics generally suggested that Arkansas River largemouth bass populations were comparable to similar impounded river systems in the southeastern United States.

Keywords: largemouth bass, fishery characteristics, population dynamics, Arkansas River

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The Arkansas River supports one of Arkansas' most important largemouth bass fisheries (Limbird 1993). However, the largemouth bass fishery in the river has not been intensively managed or studied historically, especially downstream of Lake Dardanelle in western Arkansas. The Arkansas Game and Fish Commission (AGFC) has enforced a daily creel limit of 10 black bass (all species combined) since impoundment was completed 40 years ago. Since 1998, a 381-mm minimum-length limit (MLL) has been in effect throughout the Arkansas portion of the river. Quinn and Limbird (2008) analyzed electrofishing datasets collected from Lake Dardanelle (Arkansas River Pool 10) and reported that both total catch-per-unit-effort (CPUE) of largemouth bass and CPUE of largemouth bass ≥381 mm TL increased following the MLL implementation. However, the CPUE of largemouth bass ≥533 mm TL and frequency of largemouth bass >450-mm TL decreased following MLL implementation. Overall, the effects of the MLL regulation have been mixed, with some evidence of an improved size structure concurrent with a decrease in the abundance of larger-sized largemouth bass.

During the last decade, there have been concerns raised by both Arkansas River anglers and fisheries managers that have been unrelated to management regulations. In 2000, largemouth bass virus (LMBV) was detected in Lake Dardanelle and the exotic zebra mussel was first discovered in the Arkansas River (Quinn and Limbird 2008). Both of these events occurred approximately two years after the MLL regulation was imposed, and may have negatively affected size structure of the population. Concurrent data compiled by the Arkansas Tournament Information Program (ATIP) during 2000–2003 also indicated that the quality of the Arkansas River largemouth bass population was in decline at the time. Specifically, ATIP reported that the mean number of tournament angling hours required to catch a largemouth bass > 2.3 kg in the Arkansas River increased from approximately 300 h during the period 1990–1999 to over 1,000 h by 2003. This trend reversed in subsequent years, when estimates for the period 2005–2009 averaged 391 h (ATIP 2009). However, these data generated concern among anglers and fisheries managers, especially considering the paucity of largemouth bass population data collected throughout most of the Arkansas River.

In response to the lack of data and concerns regarding the Arkansas River largemouth bass fishery, the primary goal of this study was to quantify basic largemouth bass population dynamics throughout the Arkansas River. Specifically, we quantified size structure, condition, age structure, growth, abundance (as CPUE), recruitment, and annual mortality of largemouth bass populations in all 11 navigation pools in the Arkansas portion of the river (treated as individual populations). A secondary goal of this study was to compare the Arkansas River largemouth bass fishery to those in other comparable impounded river systems. Results of this study will be useful to the AGFC and other fisheries managers in supporting largemouth bass management in the Arkansas River. Furthermore, findings can serve as a baseline for future management of the Arkansas River fishery.

Methods

Study Area

The study area for this project included all of the impounded lower Arkansas River within the state of Arkansas. This area encompassed 472 km of river channel and associated off-channel habitats beginning in northwestern Arkansas at Ft. Smith (Pool 13) and ending at Lake Merrisach in the Arkansas Post Canal (downstream end of Pool 2). This reach of the Arkansas River is contained entirely within the McClellan-Kerr Arkansas River Navigation System (MKARNS). There is no Pool 11 in the MKARNS. However, Lake Dardanelle (Pool 10), which is the largest MKARNS pool, was subdivided into its riverine (above RKm 393) and lacustrine (below RKm 393) sections for analysis. The upstream section was referred to as Pool 11, with the downstream section referred to as Pool 10. Using this scheme, the 12 pools of the MKARNS range in size from approximately 1,500 ha (Pool 3) to more than 11,000 ha (Pool 10; Table 1). With the exception of Pool 10, navigation pools within the MKARNS typify "run of the river" reservoirs, with main channel habitat averaging 66% (range 58%–82%) of the total aquatic habitat in each pool (Schramm et al. 2008).

Table 1. Information for individual pools of the McClellan-Kerr Arkansas River Navigation System (MKARNS). Pools in the system are numbered from downstream (2) to upstream (13). Number of samples represents the number of individual electrofishing samples taken each year.

Pool	Common name	Length (km)	Area (ha)	Number of samples
2[a]	Dumas	58	4,290	18
3	Rising Star	26	1,485	8
4	Pine Bluff	32	2,300	10
5	Redfield	34	2,700	10
6	Little Rock	27	1,905	10
7	Murray	50	3,925	12
8	Toad Suck	34	1,670	10
9	Ormond-Morrilton	45	1,990	10
10	Dardanelle (lake)	48	11,100	10
11	Dardanelle (river)	34	2,776	8
12	Ozark	56	3,560	10
13	Fort Smith	43[b]	2,760	8
Mean		43	3,372	10.3

a. There is no "Pool 1" in the MKARNS system.
b. 24 km located in Arkansas.

Fish Collections

Largemouth bass populations were sampled using boat-mounted, nighttime electrofishing during May–July 2004 and April–June 2005. Sampling was conducted at 8–18 randomly selected 10 min electrofishing samples per navigation pool. Sample sites were selected using a stratified random scheme (Zar 1999), with main channel border and off-channel macrohabitats representing the strata. For any given navigation pool, the river channel kilometers contained within that pool were treated as sampling units. Individual river kilometers were randomly selected for sampling, with the first *n* main channel sites and the first *n* off-channel sites actually sampled. Because of the limited number of samples taken per pool (mean 10.3), sampling effort was allocated equally between main channel and off-channel macrohabitats to avoid the likelihood of generating biased population statistics. Sites were selected using this same scheme each of the two years. Other aspects of the sampling design used can be found in Batten (2008).

Electrofishing was conducted from approximately sunset to just before sunrise using a Smith-Root Model 7.5 GPP and standard Smith-Root electrofishing equipment (16-HP Briggs and Stratton AC generator, booms, wiring, and dropper arrays). Electrofishing settings were standardized based on water temperature and conductivity of each river location to achieve an approximate power output of at least 3,000 W during all sampling (Burkhardt and Gutreuter 1995). Typically, settings of 500-V DC and 60 Hz at observed Arkansas River conductivities (250–350 μS/cm) produced an output of 7–10 amps, which achieved the desired power output. All largemouth bass collected were returned on ice to the laboratory and frozen for later processing. In the laboratory, bass were thawed with individuals measured for total length (TL) to the nearest mm and weighed for total weight to the nearest g. Sagittal otoliths were removed for aging using standard procedures (Schramm et al. 1992, Buckmeier and Howells 2003).

Population Metrics

Size Structure Population size structure was assessed using proportional size structure (PSS; Guy et al. 2006) indices for quality-sized and preferred-sized bass. Proportional size structure (PSS_Q) values were calculated as:

$$PSS_Q\,(\%) = \frac{\text{number} \geq \text{quality size}}{(\text{number} \geq \text{stock size})} \times 100$$

Proportional size structure values for preferred-size fish (PSS_P) were similarly calculated using the number of bass greater than or equal to the preferred size as the numerator. Largemouth bass stock, quality, and preferred sizes were 200, 300, and 380 mm TL, respectively, following Anderson and Neumann (1996). All bass from a given pool were combined to calculate pool-specific size structure values. Standard errors (SE) for PSS estimates were calculated using standard binomial procedures as $SE = [p(1-p)/n]^{0.5}$, where p = proportion and n = number of fish greater than or equal to stock size (Zar 1999).

Condition Relative weights (W_r) were used to characterize fish condition. Relative weights were calculated for each individual fish as:

$$W_r = \frac{W}{W_s} \times 100$$

where W = observed fish weight and W_s = predicted "standard" weight for largemouth bass for a given TL (Anderson and Neumann 1996, Blackwell et al. 2000). Individuals <150 mm TL were excluded from W_r computations as recommended by Wege and Anderson (1978). Pool-specific means and standard errors were generated by combining all bass from a given pool.

Age Structure and Growth All otoliths were blind double-read whole-view for verification purposes and assessment of reader bias. For bass ≥ age 3, otoliths were cracked with the cross-sections re-read following Buckmeier and Howells (2003), which has been validated for aging largemouth bass up to 16 years old. In the case of these older bass, cracked otoliths also were blind double-read, with ages generated from the cracked otoliths regarded as the correct ages. Validation of bass ages against known-age bass was not possible for this study. Von Bertalanffy growth curves (Ricker 1975) were fitted separately for populations in each navigation pool using nonlinear modeling procedures (SAS Institute 2003). The von Bertalanffy growth model has the form of:

$$l_t = L_\infty \times (1 - e^{(-K(t - t_0)})$$

where l_t = fish length at age t, K = population growth parameter, L_∞ = population maximum possible total length, and t_0 = theoretical age at which the fish would have a TL of zero.

Abundance and Recruitment Catch-per-unit-effort (CPUE) was defined as the mean bass catch per hour of electrofishing. Catch-per-unit-effort was computed for individual sites and averaged for each pool (± SE), and used as a general index of bass density (all age classes pooled – termed "cumulative" CPUE). Recruitment was assessed using two methods that differed in temporal scale. First, CPUE of age-1 bass was calculated as prescribed by AGFC in their sportfish management plans (AGFC 2002). This metric quantifies fish recruitment in a "snapshot in time" fashion. Second, recruitment variability index (RVI) values were calculated for each pool following Guy and Willis (1995). The RVI was calculated as:

$$RVI = [S_N / (N_m + N_p)] - (N_m / N_p)$$

where S_N = the summation of the cumulative relative frequencies of all age classes used in analyses, N_m = the number of age-groups missing from the sample that should be present, and N_p = the number of age-groups present in the sample. Even though this method of estimating recruitment has been criticized for being overly sensitive to missing year classes (e.g., Quist 2007), it does provide a general index of bass recruitment and can easily be re-calculated for comparison to future samples or other existing age-structured data from the river (Guy and Willis 1995).

Mortality Largemouth bass total annual mortality (*A*) was assessed both years using standard catch-curve analyses (Ricker 1975) for each pool. This process requires exclusion of catches of age-0 and age-1 individuals to adjust for sampling bias relative to underrepresentation of these cohorts (Miranda and Bettoli 2007). Additionally, to remove the influence of older, less abundant age classes, "truncated" catch curves (Miranda and Bettoli 2007) were constructed that included only ages 2–6, which were the most abundant age classes collected. For each navigation pool, $\log_{10}$-transformed mean CPUE of age classes were regressed on age using least-squares weighted linear regression techniques. Instantaneous total mortality rates (*Z*) were taken from the slopes of catch-curve regressions (i.e., b = *Z*), with total annual interval mortalities (*A*) derived as $A = 1 - e^Z$ for each pool and year following Ricker (1975). All statistical analyses were conducted using the Statistical Analysis Software (SAS Institute 2003).

Results

A total of 1,750 largemouth bass were collected and processed in the laboratory during 2004 and 2005. Bass were collected from 269 individual electrofishing samples, which encompassed almost 45 h of sampling effort. Both PSS_Q and PSS_P values were slightly below average in the Arkansas River, but still within expected ranges for largemouth bass populations. Across years and pools, PSS_Q and PSS_P averaged 51 (± SE of 2) and 18 (± 3), respectively. Variation in PSS_Q and PSS_P was much greater among pools than between years. In 2004, mean PSS_Q was 49 (± 0.03), and ranged from 35 (± 10) in Pool 8 to 72 (± 6) in Pool 2 (Figure 1). Mean PSS_Q was 52 (± 0.03) in 2005, ranging from 28 (± 6) in Pool 5 to 64 (± 6) in Pool 2 (Figure 2). In 2004, PSS_P averaged 15 (± 0.02), and ranged from 8 (± 2) in Pool 4 to 34 (± 6) in Pool 2 (Figure 1). Mean PSS_P was 20 (± 0.03) in 2005, ranging from 9 (± 7) in Pool 8 to 36 (± 6) in Pool 2 (Figure 2). Pools 12 and 13 were excluded due to inadequate sample sizes to generate reliable estimates of PSS_Q and PSS_P.

Relative weights of Arkansas River largemouth bass averaged 103.5 (± 0.3) across all pools and years, which suggested the population was in above average condition. Mean W_r values were similar between years, averaging 104.3 (± 0.4) in 2004 and 102.4 (± 0.4) in 2005 (Figure 3). Generally, mean W_r values were considered

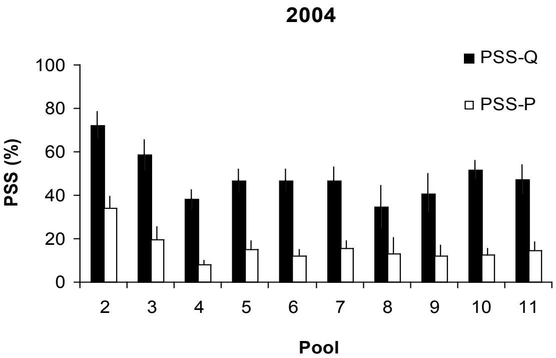

Figure 1. Largemouth bass size structure index means by pool, 2004. Pools numbered left to right correspond to most downstream (2) to most upstream (11). Pools 12 and 13 excluded due to inadequate sample size. Vertical bars represent standard errors.

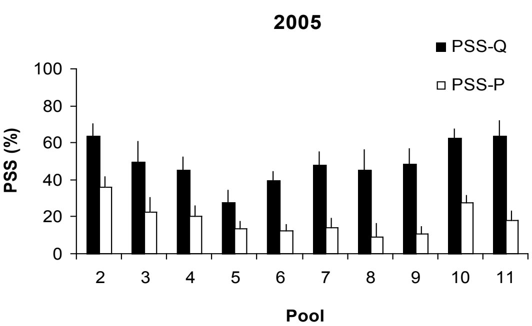

Figure 2. Largemouth bass size structure index means by pool, 2005. Pools numbered left to right correspond to most downstream (2) to most upstream (11). Pools 12 and 13 excluded due to inadequate sample size. Vertical bars represent standard errors.

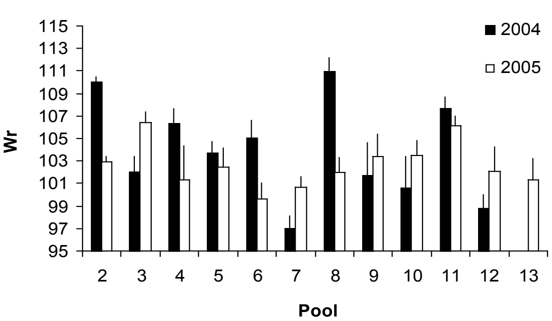

Figure 3. Largemouth bass mean relative weights (W_r) means by pool and year. Pools numbered left to right correspond to most downstream (2) to most upstream (13). Vertical bars represent standard errors.

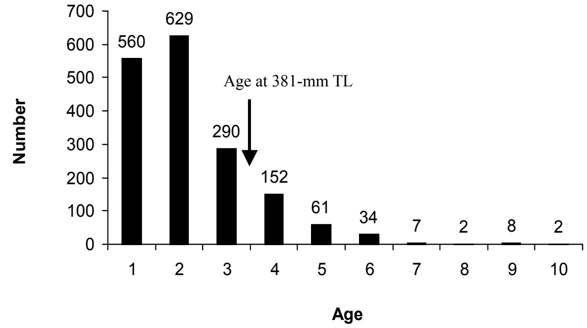

Figure 4. Overall largemouth bass age frequency distribution with years 2004–2005 combined. The predicted age at 381-mm TL (3.3 years) was based on growth model results.

good to excellent for largemouth bass populations throughout all pools of the river.

Between-reader agreement on ages of double-read, whole-view otoliths was extremely high for young bass, with agreements being 98% and 96% for ages 1 and 2, respectively. Between-reader agreement decreased with increasing age, being 86%, 83%, 71%, and 65% for ages 3–6, respectively. Between-reader agreement on age 7–12 bass ranged 0–50%, though total sample size for these ages was small ($n = 20$). Generally, whole-view read and cracked-otolith readings were comparable, with overall agreement being 90%. Cracked versus whole-read otolith agreement for age-3 to age-12 largemouth bass (no age-11 bass were collected) was 99%, 90%, 72%, 61%, 86%, 33%, 25%, 50%, and 0%, respectively.

Largemouth bass populations in the Arkansas River were relatively young, with ages 1–4 comprising 94% of the population (Figure 4). Age-2 bass represented the greatest overall percentage of the total catch (36%) when years were combined. The 2003 year class appeared particularly strong throughout the Arkansas River as that cohort comprised the greatest percentage of the total catches in 2004 (42%) and 2005 (41%).

Largemouth bass mean lengths at age followed a normal asymptotic pattern. In 2004, mean lengths at ages 1–5 were 205 (± 5), 289 (± 5), 345 (± 5), 400 (± 9) and 423 (± 12) mm TL, respectively. In 2005, mean lengths at age were 167 (± 3), 264 (± 4), 340 (± 6), 386 (± 9) and 432 (± 9) for ages 1–5, respectively. The smaller sizes of ages 1 and 2 in 2005 may have been due to a slight asynchrony in the timing of sampling between years. Von Bertalanffy growth models were fitted for populations in each pool each year. In three cases (Pool 8 in 2004 and Pool 13 both years), no non-linear model could be fitted or the solution reached was not reasonable (e.g., L_∞ >1,000 mm TL). These models were subsequently removed from further analysis. As with PSS, mean values of model parameters were similar between years, but variable across pools (Table 2).

Table 2. Von Bertalanffy growth model parameters and Recruitment Variability Index (RVI) values for Arkansas River largemouth bass populations by pool and year. Missing values indicate that model solution was not found.

	2004				2005				Years combined			
Pool	L_∞	K	t_0	RVI	L_∞	K	t_0	RVI	L_∞	K	t_0	RVI
2	483	0.40	–0.27	0.64	568	0.32	–0.03	0.56	526	0.36	–0.15	0.60
3	497	0.35	–0.65	0.44	538	0.38	0.10	0.90	517	0.37	–0.28	0.67
4	450	0.45	–0.49	0.95	454	0.57	0.14	0.37	452	0.51	–0.18	0.66
5	442	0.54	–0.19	0.91	619	0.20	–0.52	0.91	530	0.37	–0.36	0.91
6	442	0.45	–0.36	0.11	448	0.41	–0.12	0.33	445	0.43	–0.24	0.22
7	445	0.43	–0.27	0.87	490	0.35	–0.31	0.32	468	0.39	–0.29	0.59
8	–	–	–	0.35	488	0.42	0.02	–	488	0.42	0.02	0.35
9	459	0.56	–0.05	0.56	395	0.82	0.33	–0.11	427	0.69	0.14	0.22
10	370	1.20	0.24	0.37[a]	458	0.47	–0.02	0.61[a]	414	0.84	0.11	0.49[a]
11	400	0.72	0.03	–	458	0.40	–0.09	–	429	0.56	–0.03	–
12	505	0.34	–0.17	–	535	0.31	–0.16	0.75	520	0.33	–0.17	0.75
13	–	–	–	–	–	–	–	0.74	–	–	–	0.74
Mean	449	0.54	–0.22	0.58	496	0.42	–0.06	0.54	474	0.48	–0.13	0.56

a. RVI values reported for Pool 10 represent Pool 10 (Lake Dardanelle lacustrine zone) and Pool 11(Lake Dardanelle riverine zone) combined.

Means of model parameters across years were 474 (± 13) mm for L_∞, 0.48 (± 0.05) for K, and –0.13 (± 0.05) for t_0 (Table 2). The L_∞ estimate for Pool 10 (Lake Dardanelle) in 2004 (370 mm) was suspected to be underestimated because the largest several bass collected during sampling were age 4 despite that older bass were present in the population. Given these generalized estimates, Arkansas River largemouth bass populations were predicted to reach quality size (304 mm) at 2.0 years and minimum legal harvest length (381 mm) at 3.3 years (Figure 4). Overlaying this latter prediction with age structure data suggested that approximately 27% (range 15%–32%) of the population was of legal harvest size on average.

Largemouth bass cumulative CPUE varied widely among pools and between years (Figure 5). Overall, mean CPUE across pools and years was 37.8 (± 2.6) bass/h. In 2004, mean CPUE was 46.3 (± 4.8) bass/h, ranging from 6.3 (± 2.9) bass/h in Pool 12 to 91.2 (± 23.3) bass/h in Pool 10. In 2005, CPUE averaged 31.0 (± 2.6) bass/h and ranged from 10.2 (± 3.6) bass/h in Pool 12 to 58.8 (± 7.9) bass/h in Pool 6. Generally, CPUE values were greater in 2004 than 2005. CPUE values each year were consistently greatest in pools 4, 5, 6, and 10 (Figure 5), possibly reflecting better habitat or local productivity in those reaches of the river.

Mean age-1 CPUE of largemouth bass varied three-fold between years, and like cumulative CPUE, varied greatly among pools. In 2004, mean age-1 CPUE averaged 19.2 (± 2.3) bass/h compared to 6.4 (± 0.9) bass/h in 2005. This finding is consistent with age structure analyses, which suggested a relatively strong 2003 largemouth bass year class in the Arkansas River. In 2004, age-1 CPUE ranged from 3.0 (± 3.0) in Pool 13 to 43.6 (± 10.8) bass/h in Pool 4. Mean CPUE of age-1 largemouth bass in 2005 ranged from 0.0 (± 0.0) in Pool 12 to 12.8 (± 4.7) in Pool 4.

Recruitment Variability Index values indicated that largemouth bass recruitment was similar between years. Mean RVI was 0.56 (± 0.07) across pools and years; mean RVI values were similar between years at 0.58 (± 0.10) in 2004 and 0.54 (± 0.10) in 2005 (Table 2). Values across pools were variable, but positive in all but one case (Pool 9 in 2005; Table 2). Results generally indicated that recruitment of largemouth bass in the Arkansas River had been relatively stable for at least 5–6 years prior to this study (1999 – 2005).

Total annual interval mortality of largemouth bass populations from truncated catch-curve analyses averaged 49% and 48% across pools in 2004 and 2005, respectively. Mortality estimates ranged from 36%–66% in 2004 and 25%–64% in 2005 (Figure 6). When all ages were included in catch curves, annual mortality estimates were generally about 5%–8% lower. Overall across both years, average annual mortality in pools 4, 5, 6, 9, and 10 exceeded 50%, with the lowest annual mortality (32%) observed in Pool 2 (Figure 6).

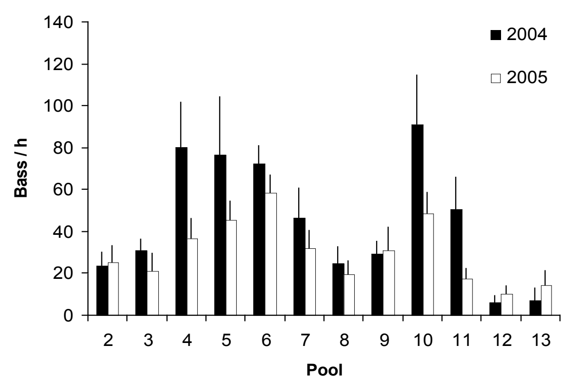

Figure 5. Largemouth bass mean cumulative CPUE by pool and year. Pools numbered left to right correspond to most downstream (2) to most upstream (13). Vertical bars represent standard errors.

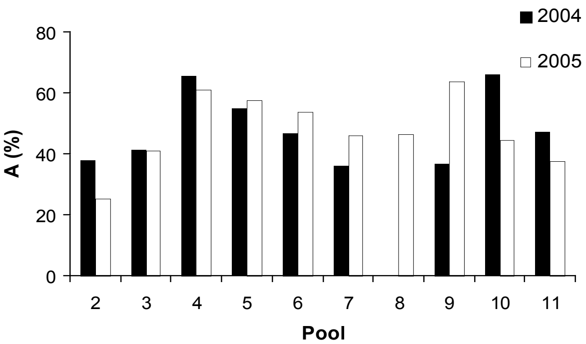

Figure 6. Largemouth bass total annual mortality *A* (%) calculated using all ages 2–6 and no zero correction by pool and year. Pools numbered left to right correspond to most downstream (2) to most upstream (11). Pool 8 in 2004, and Pools 12 and 13 were excluded due to inadequate sample sizes that yielded unrealistic *A* values.

Discussion

In comparison to other impounded river systems in the southeastern United States, the Arkansas River largemouth bass fishery had slightly below average size structure metrics. Mean PSS_Q and PSS_P values of 49% and 17%, respectively, for the Arkansas River compared to overall averages from comparable systems of 57% and 23% (Table 3). Similarly, mean L_∞ values from von Bertalanffy growth models (474 mm TL) were less on average than both the Arkansas average (543 mm TL) and North American average (599 mm TL) reported in Beamesderfer and North (1995). However, sampling objectives and designs from individual studies may have partly influenced this observation. Suggested values for PSS_Q range from 40%–70% (Reynolds and Babb 1978, Anderson and Neumann 1996), though these ranges were developed for small impoundments and not necessarily large reservoirs or river systems. But given how PSS metrics are calculated and the information they convey, values from impounded river systems should be equally valid. Because our mean PSS_Q and PSS_P values fell within the recommended ranges, benchmark size structure values established for small impoundments also may be appropriate for impounded river systems such as the Arkansas River.

Fish condition throughout the Arkansas River was comparable to, and usually greater than, values from other impounded river systems. Mean W_r was 104, compared to an average of 96 from comparable impounded river systems (Table 3) and a North American average of 93 (Beamesderfer and North 1995). Relative weight values in the Arkansas River consistently reflected above-average condition and were in the top quartile of U.S. populations. Arkansas River mean values were exceeded only by the Ohio River, which averaged 106 (Xenakis 2005).

Abundance estimates (cumulative CPUE as bass/h) in the Arkansas River were below average compared to a very broad range of CPUE values from other impounded river systems. Arkansas River mean CPUE of 37.8 bass/h (range 8.3–65.7) exceeded values from the Ohio River (13.0 bass/h) and Tennessee-Tombigbee Waterway (20.4 bass/h), but were less than half of that observed in the Tennessee and Cumberland rivers (>85 bass/h; Table 3). Abundance estimates in the Arkansas River were the most highly variable measure recorded. Abundance is by far the most difficult variable to compare across systems because of numerous sampling considerations involving equipment, crew experience, water chemistry, local habitat, and sampling goals and design (Hardin and Connor 1992). Additionally, studies have shown mixed results concerning the actual relationship between CPUE data and true largemouth bass abundance in some systems (e.g., Coble 1992,

Table 3. Population structure and length at age data for largemouth bass populations from other impounded southeastern U.S. river systems.[a] Means in last row exclude the lower Arkansas River. TL = total length in mm.

River system	State	Years	*n*	PSS_Q	PSS_P	W_r	CPUE (bass/h)	TL at age 1	TL at age 2	TL at age 3	TL at age 4	TL at age 5
Lower Arkansas (present study)	AR	2004–2005	1,750	53	19	104	37.8	186	277	343	393	428
Middle Arkansas	OK	1997–2002	1,333	72	38	99	53.7	–	–	–	–	–
Tennessee-Tombigbee	MS	1993–2006	–	51	20	88	20.4	157	243	315	381	438
Ohio[b]	WV/OH/KY/IN/IL	1999–2004	1,255	42	9	106	13.0	254	301	324	326	294
Upper	WV/OH	1999–2004	415	42	10	105	7.8	253	291	319	321	294
Middle	KY	2001–2004	250	45	8	103	14.4	258	313	327	–	–
Lower	KY/IN/IL	2001–2004	590	40	8	107	22.4	250	305	328	335	–
Cumberland	TN/KY	1990–2006	11,958	58	25	93	98.3	172	261	320	362	400
Tennessee	TN/KY	1990–2006	14,754	61	22	94	87.2	165	260	321	364	395
Upper	TN	1998–2006	7,604	60	20	93	82.7	–	–	–	–	–
Lower	TN/KY	1998–2006	7,150	62	25	95	91.9	165	260	321	364	395
Means			7,325	57	23	96	54.5	188	267	319	375	382

a. Estimates were generated from comparative datasets provided by the Mississippi Department of Parks and Wildlife (Tennessee-Tombigee), Tennessee Wildlife Resources Agency (Tennessee), Kentucky Department of Fish and Wildlife (Tennessee, Cumberland, and Ohio), Ohio Department of Natural Resources (Ohio), West Virginia Division of Natural Resources (Ohio), Indiana Department of Natural Resources (Ohio), Illinois Department of Natural Resources (Ohio), and Oklahoma Department of Wildlife Conservation (Middle Arkansas).

b. Estimates from the Ohio River provided by Xenakis (2005).

Buynak and Mitchell 1993, McInerny and Degan 1993). In this study, there was incomplete information available from the different agencies concerning the exact sampling designs used to generate CPUE statistics. These types of concerns are common with many state fisheries management agencies, which has led to widespread calls for management agencies to develop standardized sampling protocols (e.g., Bonar and Hubert 2002, Bonar et al. 2009). Thus, direct comparisons of CPUE data may be tenuous due to the lack of specific information concerning research objectives and sampling designs used in other systems.

Mean lengths at age for Arkansas River largemouth bass populations were similar to those in other impounded river systems through age 2, but up to 10% greater for ages 3–5 (Table 3). However, compared to estimates in Beamesderfer and North (1995), mean lengths at age of Arkansas River largemouth bass exceeded 13 other Arkansas bass populations by 10%–40% through age 5. Webb and Reeves (1975) published largemouth bass length at age ranges for what they classified as "southern U.S." waters. Using these criteria, Arkansas River largemouth bass populations generally fell within reported length ranges for ages 1–5 (147–173 mm TL for age 1, 274–295 mm TL for age 2, 333–358 mm TL for age 3, 381–401 mm TL for age 4, 429–460 mm TL for age 5), with length at age 1 being greater and length at age 5 being less. It was not possible to test whether these differences were significant due to the lack of raw data and differences in sampling methods. However, Arkansas River bass populations generally exhibited better growth compared to populations from other impounded river systems or other Arkansas waters. This finding was especially true for the younger age classes.

Growth, as depicted by von Bertalanffy growth coefficients (K), suggested that Arkansas River largemouth bass exhibited well above-average growth compared to other bass populations. Growth coefficients averaged 0.48 across pools and between years, which were much greater than the Arkansas average of 0.29 reported by Beamesderfer and North (1995). Furthermore, the mean K reported from this study was more than twice that reported (0.21) from 698 North American largemouth bass populations by Beamesderfer and North (1995). Arkansas River largemouth bass populations also had an age at quality size (A_q) of 2.0 years, which was just over half of the 3.6-year average reported by Beamesderfer and North (1995). Thus, the Arkansas River largemouth bass population appears to be achieving quality size (304 mm) nearly twice as fast as the average North American bass population, though may not be reaching the large sizes (mean $L_\infty = 474$) found in populations from other systems.

Age structures indicated that largemouth bass throughout the Arkansas River were relatively young, with ages 1–4 years constituting 94% of the populations. One possible explanation for a young age structure was the LMBV outbreak that occurred in the early 2000s (Quinn and Limbird 2008). This virus tends to affect larger bass disproportionately (Grizzle and Brunner 2003). Thus, the population sampled during 2004–2005 may still have been recovering from the elimination of older, larger individuals lost during that outbreak, which had occurred just 4–5 years before. Alternatively, younger age structures also might suggest relatively high exploitation rates. However, recent tag-reward studies conducted during 2007–2009 by Fontaine (2009) have indicated low exploitation rates in pool 2 and 4 ranging 12%–14%. These estimates were below thresholds (25%) established by AGFC in their Largemouth Bass Management Plan (AGFC 2002) and also consistent with national largemouth bass angling trends, which have largely become catch-and-release fisheries (Allen et al. 2008).

The effects of the largemouth bass MLL regulation that has been in effect throughout the Arkansas River for 12 years have been mixed. Results also may have been influenced by the LMBV outbreak that occurred in 2000. Quinn and Limbird (2008) analyzed electrofishing datasets collected from Lake Dardanelle (Arkansas River Pool 10) before (1991–1997) and after (1999–2006) the regulation was implemented. Both total CPUE of largemouth bass and CPUE of largemouth bass ≥381 mm TL increased 30% following the MLL implementation. Similarly, the frequency of largemouth bass between 350 and 400 mm TL increased in electrofishing samples post-MLL. However, their research also indicated a decrease in the CPUE of largemouth bass ≥533 mm TL and frequency of largemouth bass greater than 450-mm TL. Thus, although there was some evidence of an improved size structure, there was a concurrent decrease in the abundance of memorable-sized (TL ≥ 510 mm) and trophy-sized (TL ≥ 630 mm) largemouth bass. These results are generally consistent with the findings from this study (data collected 6–7 years post-MLL), whereby Arkansas River size structures were comparable to expected norms for largemouth bass (mean $PSS_Q = 51$, mean $PSS_P = 18$), though they did not contain high abundances of larger fish (mean $L_\infty = 474$ mm). Both of these latter findings suggested fewer larger largemouth bass, which would be consistent with an LMBV outbreak in the recent past.

In summary, our results from this comprehensive assessment indicate that the Arkansas River largemouth bass population is relatively healthy with better than average condition and growth. Size structures were smaller than average compared to other impounded southeastern U.S. river systems, but still within expected normal ranges. Furthermore, when benchmarks from the AGFC's Largemouth Bass Management Plan are considered, including growth, size structure, and exploitation, the Arkansas River system as a whole is classified as a borderline "high potential fishery" (AGFC 2002). Future research should focus on further assessment of exploitation and modeling the effects of the MLL regulation that has been in effect for the fishery since 1998.

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