Spotted Bass Population Characteristics and Relationships with Macrohabitat Variables in the Arkansas River, Arkansas

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Abstract: Despite its importance to anglers, the Arkansas River spotted bass (*Micropterus punctulatus*) fishery has not been intensively studied or managed. Thus, spotted bass populations in the lower nine navigation pools of the Arkansas River were assessed during 2004–2005 using nighttime boat-mounted electrofishing. Across years and pools, size structure measures were within acceptable ranges for black basses (mean $PSD_Q = 38$, range 21–56; mean $PSD_P = 10$, range 0–19). Theoretical maximum sizes generated from growth models were not large for spotted bass (mean $L_\infty = 395$ mm TL, range 351–429 mm total length), though populations exhibited good condition and growth. Total annual mortality estimated from catch curves averaged 49% and ranged from 43%–57% across pools. Although population metrics exhibited few longitudinal relationships within the Arkansas River, spotted bass populations compared favorably to other populations from similar impounded river systems. Spotted bass populations exhibited significant relationships with macrohabitats in the river. Spotted bass catch-per-unit-effort was directly correlated to long-term areal and proportional increases in main channel and dike pool habitats, whereas condition was inversely correlated to area of diked secondary channel habitat. In light of the documented long-term (1973–1999) macrohabitat changes, results suggested that main channel and associated habitats may be important for the continued health of spotted bass populations in the Arkansas River.

Key words: spotted bass, fishery characteristics, population dynamics, Arkansas River

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Spotted bass (*Micropterus punctulatus*) are a popular sport fish throughout streams and reservoirs in the southeastern United States. However, most state agencies have historically devoted their black bass management efforts towards largemouth bass (*M. salmoides*) and smallmouth bass (*M. dolomieu*) (Tillma et al. 1998). Despite co-inhabiting many of the same waters as the other black basses, spotted bass are commonly a lower management priority due to their smaller sizes. The Arkansas River supports one of Arkansas' most important largemouth bass fisheries (Eggleton et al. 2010). However, the river also supports a significant spotted bass fishery that has been little studied. Spotted bass in the Arkansas River are regulated by the statewide harvest restriction of 10 black basses per day (largemouth, spotted, and smallmouth combined). Competitive black bass tournaments in the Arkansas River also usually impose a 304-mm minimum-length limit (MLL) for weigh-in purposes (C. Dennis, Arkansas Game and Fish Commission, personal communication). Unlike largemouth bass, there is no MLL regulation for spotted bass in the Arkansas River, although populations in several Arkansas reservoirs are regulated with both 304-mm and 331-mm MLLs and lower creel limits (often six black basses combined per day). Few datasets exist for Arkansas River spotted bass, and thus, little is known concerning the current fishery status or management potential.

The primary objective of this study was to quantify basic population dynamic statistics for spotted bass in the lower nine navigation pools of the Arkansas River. Fish collected from these pools were treated as separate populations, and data collected during 2004–2005 for each pool were combined during all analyses. A secondary objective was to assess relationships between spotted bass populations and pool macrohabitat characteristics where populations were sampled. Results of this study will support black bass management in the Arkansas River and serve as a baseline for future management of the fishery and the river.

Methods

Study Area

The study area for this project included the impounded Arkansas River within the state of Arkansas. This section of the river contains 11 navigation pools and is contained entirely within the McClellan-Kerr Arkansas River Navigation System (MKARNS). Individual navigation pools (herein referred to as "pools") of the MKARNS in Arkansas range in size from approximately 1,500 ha to almost

Table 1. Macrohabitat variables used in correlation analyses with spotted bass population metrics. Estimates, means, and descriptive statistics were generated from navigation pools 2–10 in the Arkansas River, and reported in Schramm et al. (2008). Occurrence of open secondary channels, sloughs, and remote backwaters was low in all pools and excluded from this summary. "Extrachannel" habitat is a composite category that includes diked secondary channels and adjacent backwaters. "Change" variables refer to area and proportional differences in the macrohabitat during 1973–1999.

Variable	Units	Mean	SE	Minimum	Maximum
Macrohabitat area					
Navigation pool number[a]	–	6	1	2	10
Main channel habitat area	ha	2,430	740	1,218	8,185
Dike pool area	ha	55	20	0	180
Extrachannel habitat area	ha	1,177	534	251	5,371
Diked secondary channel area	ha	423	105	101	982
Adjacent backwater area	ha	672	489	0	4,523
Total navigation pool area	ha	3,662	1,262	1,520	13,356
Proportion of macrohabitat to total area					
Main channel area / total area	%	70	3	58	82
Dike pool area / total area	%	2	1	0	6
Extrachannel habitat area / total area	%	28	3	17	42
Diked secondary channel area / total area	%	16	5	2	42
Adjacent backwater area / total area	%	9	4	0	33
Macrohabitat Change					
Change in main channel habitat area	ha (%)	−83 (−1)	103 (3)	−818 (−14)	104 (8)
Change in dike pool area	ha (%)	−22 (−33)	17 (17)	−139 (−100)	36 (52)
Change in extrachannel habitat area	ha (%)	−202 (−25)	39 (3)	−341 (−39)	22 (0.4)
Change in diked secondary channel area	ha (%)	−113 (−23)	33 (5)	−268 (−40)	2 (0.6)
Change in adjacent backwater area	ha (%)	−55 (−17)	47 (6)	−342 (−43)	113 (3)
Change in total navigation pool area	ha (%)	−306 (−8)	79 (1)	−826 (−16)	−70 (−4)

a. Reflects longitudinal position in the lower Arkansas River.

14,000 ha (see Table 1 in Eggleton et al. 2010). Pools are numbered sequentially from downstream (2) to upstream (13); downstream pools are located in southeastern Arkansas with upstream pools located in central and west-central Arkansas. Most 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). Conversely, the largest pool (10) is Lake Dardanelle in west-central Arkansas. This pool differs from the others and is more typical of a traditional reservoir with distinct riverine, transitional, and lacustrine zones. Extrachannel habitats (i.e., habitats outside of the main river channel; Schramm et al. 2008) comprise approximately 40% of the total pool surface area in Lake Dardanelle compared to 20% in the other pools.

Fish Collections

Spotted bass populations were sampled using nighttime boat-mounted electrofishing conducted during May–July 2004 and April–June 2005. Ten-minute electrofishing transects were conducted at 8–18 randomly selected sites per pool. Samples were taken in Pool 2 upstream through Pool 10. Sample sites within pools were stratified equally within main channel border and off-channel macrohabitats using a stratified random scheme (Zar 1999). Additional information on sampling design, site selection, and electrofishing procedures can be found in Eggleton et al. (2010). All spotted bass collected were returned on ice to the laboratory and frozen for later processing. In the laboratory, spotted bass were thawed, measured for total length (TL) to the nearest mm and weighed for total weight to the nearest g. Sagittal otoliths were removed for aging following standard procedures.

Population Metrics

In all cases, spotted bass samples taken in 2004 and 2005 were combined and analyzed by individual pool. Size structure was assessed using proportional size distribution (PSD) indices for quality-sized (PSD_Q) and preferred-sized (PSD_P) fish (Guy et al. 2007). Spotted bass stock, quality, and preferred sizes used in computations were 180, 280, and 350 mm TL, respectively (Anderson and Neumann 1996). Standard errors (SE) for PSD estimates were calculated using standard binomial procedures as $SE = [p(1-p)/n]^{0.5}$, where p = proportion and n = number of fish ≥ stock size (Zar 1999). Spotted bass condition was assessed by calculating relative weights (W_r) (Wege and Anderson 1978) using the revised spotted bass standard weight (W_s) equation of Weins et al. (1996) for individuals ≥100 mm TL.

All spotted bass otoliths were blind double-read whole-view for verification purposes and assessment of reader bias. Otoliths from spotted bass ≥ age 3 were reread in cross-section using the methods of Buckmeier and Howells (2003). Ages generated from the cracked otolith cross-sections were considered to be the correct ages. Von Bertalanffy growth curves were fitted for populations in each pool using standard nonlinear modeling procedures (SAS Institute 2008).

Catch-per-unit-effort (CPUE; fish h^{-1}) was defined as the mean spotted bass catch per hour of electrofishing. CPUE was computed for individual sites, averaged for each pool (± SE), and used as a general index of spotted bass density (all age classes pooled—termed "total" CPUE). Instantaneous total mortality (Z) and total annual mortality (A) of spotted bass were estimated using standard catch-curve analysis. For each pool, $\log_{10}$-transformed frequencies of each age class were regressed against age using weighted ordinary least-squares linear regression (Miranda and Bettoli 2007). Spotted bass younger than age 2 were excluded due to underrepresentation of these cohorts during electrofishing sampling, and one was added to individual age-class catches for $\log_{10}$-transformation purposes. Upper and lower 95% confidence limits on A estimates were generated by nonparametric bootstrapping of the regression residuals.

Age frequency data also were used to assess spotted bass recruitment using the Recruitment Variability Index (RVI). Values for RVI were calculated for each pool following Guy and Willis (1995). The RVI was calculated as:

$$\text{RVI} = [S_N / (N_m + N_p)] - (N_m / N_p),$$

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. The RVI was used to provide a general index of spotted bass recruitment in the Arkansas River that reflected the previous 7–8 years.

To compare spotted bass populations longitudinally within the Arkansas River, individual pools were classified into three "pool groups" that corresponded with longitudinal position in the river. These pool groups were termed "lower" (i.e., pools 2–4), "middle" (pools 5–7), and "upper" (pools 8–10). Completely randomized one-way ANOVAs were used to test for among-pool group differences in spotted bass population metrics. Differences among means were assessed post hoc for significant ANOVAs using least-squares mean tests, with an alpha (α) level of 0.05 used for significance testing.

Relationships with Pool Macrohabitats

Pool macrohabitat characteristics throughout the Arkansas portion of Arkansas River were quantified previously by Schramm et al. (2008). Macrohabitats were quantified using satellite imagery collected in 1973 (shortly after closure of the MKARNS) and 1999 (approximately 25 yrs post-impoundment). Satellite imagery was obtained from the U.S. Geological Survey EROS Data Center (1973) and the Arkansas Geostor data warehouse (1999) (Schramm et al. 2008). Seven Arkansas River macrohabitats were quantified for each pool—main river channel, open secondary channel, diked secondary channel, slough, dike pool, adjacent backwater, and remote backwater—as described in Schramm et al. (2008). For each macrohabitat, the total area of the habitat in 1999, the proportion of the habitat's area to the total pool area in 1999, and the net change and proportional change in the habitat's area between 1973 and 1999 were quantified for each pool (Table 1). Given that 1999 was only 5–6 years previous to this assessment (2004–2005), macrohabitat data should have accurately reflected habitat conditions during the fish surveys. Additional details concerning macrohabitat quantification can be found in Schramm et al. (2008).

Associations between pool-specific spotted bass population metrics collected during 2004–2005 and pool-level macrohabitat variables were assessed using Spearman rank correlation coefficients. Significance level for these analyses was set at an α level of 0.10, to guard against excessive Type II error due to the relatively small sample sizes used (n = 18) and limited power of each analysis. All statistical analyses were conducted using the Statistical Analysis Software v.9.2 (SAS Institute 2008).

Results

Population Metrics

Spotted bass (n = 704) were collected from 236 individual electrofishing samples that encompassed almost 40 h of sampling effort. Total lengths of individual spotted bass collected averaged 238 (± SE of 2.6) mm TL, and ranged from 96–427 mm (Figure 1). Weights of spotted bass ranged from 9–1,332 g with a mean of 250 g (± 8.1). Mean total lengths and weights of spotted based were greater in lower pools than middle pools (total length: P = 0.021; total weight: P = 0.021) (Figure 1). Conversely, spotted bass mean length and weight in upper pools did not differ with middle or lower pools.

Spotted bass PSD_Q and PSD_P values averaged across pools were 38 (± 1.8) and 10 (± 1.1), respectively, in the Arkansas River. PSD_Q values ranged from 56 (± 4.2) in Pool 2 to 21 (± 4.3) in Pool 5 (Figure 2). PSD_P values exhibited a similar trend, ranging from 19 (± 3.3) in Pool 2 to 0 (± 0.0) in Pool 5 (Figure 2). PSD_Q values of spotted bass were greater in lower pools than middle (P = 0.001) and upper (P = 0.014) pools. Pool group mean PSD_P values ordered similarly as PSD_Q values, though no differences were detected. PSD_Q values were inversely correlated with pool number (r = –0.50, P = 0.03), which indicated a weak longitudinal trend within spotted bass populations in the Arkansas River.

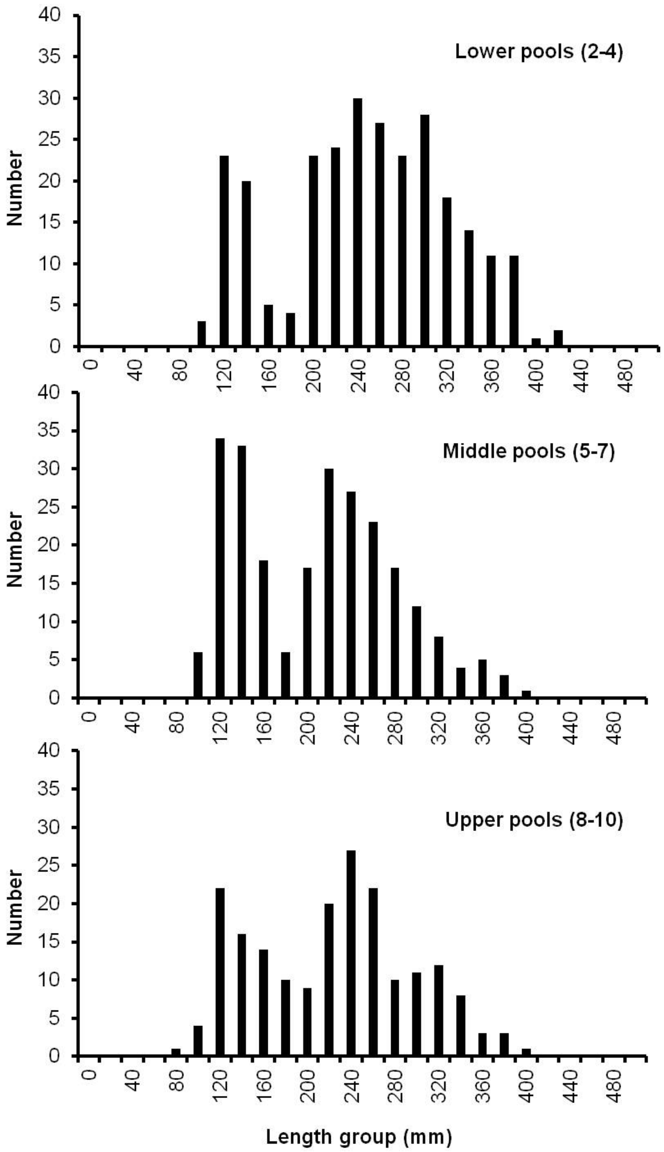

Figure 1. Spotted bass length-frequency distributions by pool groups from the Arkansas River, 2004–2005. Individual fish were classified into 20-mm length groups. Numbers in parentheses represent navigation pool numbers included in each group.

Relative weights of Arkansas River spotted bass averaged 103.4 (±0.7) across all pools and years, suggesting that populations were in good condition. Mean W_r values ranged from 100.2 (±1.7) in Pool 4 to 106 (±0.9) in Pool 2 (Figure 2). Mean W_r values did not vary across pool groups and exhibited no longitudinal relationship within the river.

Age structure for spotted bass indicated that ages 1–4 comprised 94% of the populations, with the oldest individual aged 8 yrs. Ages 1 and 2 represented the greatest overall percentage (66%) of the total spotted bass catch (Figure 3). Spotted bass mean lengths at age followed a normal asymptotic pattern. Mean lengths (±SE) at ages

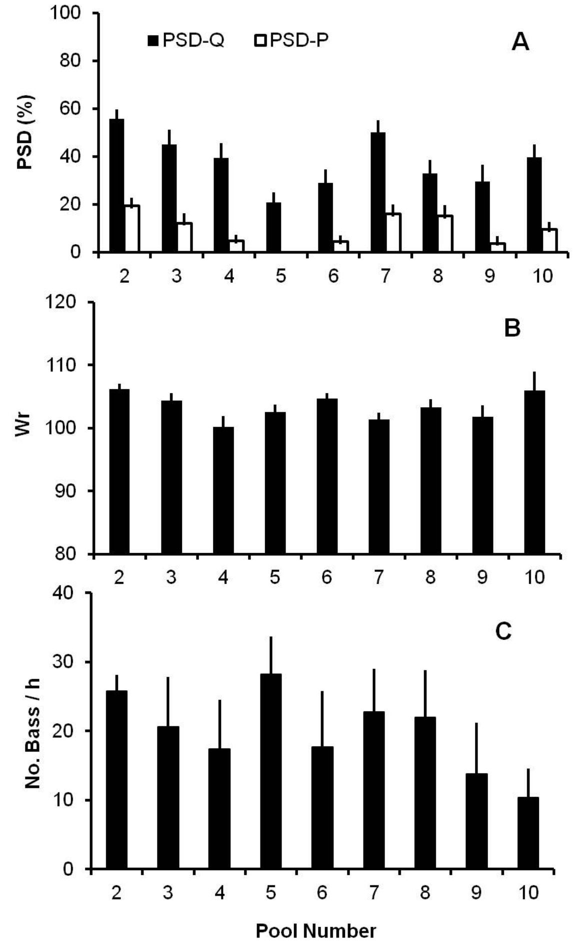

Figure 2. Spotted bass size structure indices (A), mean relative weights (W_r) (B), and mean total CPUE (C) by pool in the Arkansas River, 2004–2005. Pools numbered left to right correspond from downstream (2) to upstream (10). Vertical bars represent standard errors.

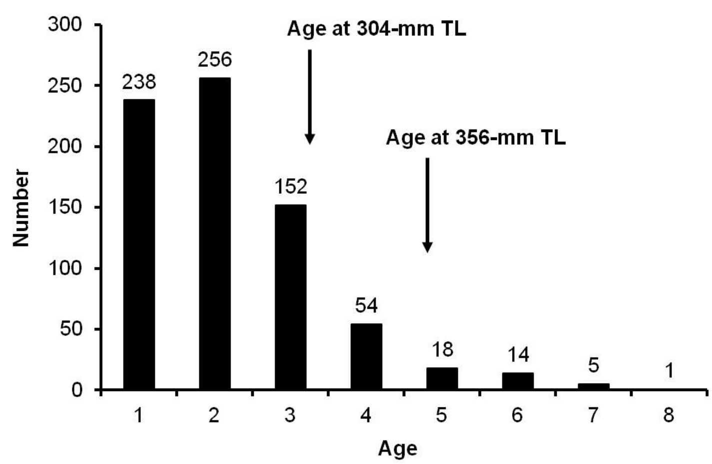

Figure 3. Overall spotted bass age frequency distribution with years 2004–2005 combined. Ages used on fish age 3+ were taken from cracked otolith cross-sections. The predicted ages at 304-mm TL (3.1 yrs) and 356-mm TL (4.6 yrs) were based on growth model results.

Table 2. Von Bertalanffy growth model parameters, predicted age at 304-mm TL, and Recruitment Variability Index (RVI) values for Arkansas River spotted bass populations, 2004–2005.

	Von Bertalanffy model parameters				
Pool	L_∞	K	t_0	Age at 304-mm TL	RVI
2	407	0.44	0.07	3.2	0.82
3	420	0.42	0.03	3.1	0.85
4	429	0.36	–0.26	3.2	0.39
5	351	0.60	0.03	3.4	0.95
6	375	0.48	–0.02	3.4	0.47
7	399	0.46	–0.02	3.1	0.49
8	384	0.55	0.06	2.9	0.39
9	388	0.51	0.19	3.2	0.46
10	404	0.45	–0.03	3.1	0.65
Means	395	0.47	0.01	3.1	0.61

1–8 were 151 (±2), 242 (±2), 298 (±3), 328 (±5), 355 (±6), 371 (±8), 392 (±9), and 398 (±0) mm, respectively. Von Bertalanffy growth model parameters generated for each pool averaged 395 mm for L_∞ (range 351–429), 0.47 for K (range 0.36–0.60), and 0.01 for t_0 (range –0.26–0.19) (Table 2). Spotted bass required an average of 3.1 yrs to achieve 304-mm TL (Table 2). Time required to attain 304-mm TL, L_∞, and K values did not exhibit any longitudinal relationship within the river and did not differ among pool groups.

Spotted bass CPUE varied across pools and averaged 19.9 (±0.3) bass h^{-1} (Figure 2). Spotted bass total CPUE values were inversely correlated with pool number ($r = -0.57$, $P = 0.01$), which indicated a longitudinal trend within the river. Total CPUE of spotted bass was higher in the middle pools than in upper pools ($P = 0.037$), but lower pools were similar to both. RVI values indicated that spotted bass recruitment was relatively stable in recent years. Mean RVI averaged 0.61 (±0.07) across pools, but varied more than two-fold ranging from 0.39 in pools 4 and 8 to 0.95 in Pool 5 (Table 2). RVI values exhibited no longitudinal relationship within the river, but generally indicated that spotted bass recruitment had been relatively stable for at least 5–6 years prior to this assessment.

Total annual mortality of spotted bass populations from catch-curve analyses averaged 49% (95% CL 41–58) (Table 3). Mortality estimates ranged from 43% in pools 2 and 7 to 57% in Pool 9. Annual mortality of spotted bass exceeded 50% in only three of the nine pools studied (3, 4, and 9), with the lowest annual mortality observed in pools 2 and 7 (Table 3). Annual mortality estimates did not vary across pool groups and exhibited no longitudinal relationship within the river.

Relationships with Pool Macrohabitats

Some spotted bass population metrics were related to macrohabitat variables in the lower Arkansas River. Increased spotted bass total CPUE was observed in pools with the greatest net increases ($r = 0.58$, $P = 0.01$) and proportional increases ($r = 0.49$, $P = 0.04$) in main channel habitats. Spotted bass total CPUE was also increased in pools with greater present-day levels of dike pool habitat ($r = 0.57$, $P = 0.01$) and those pools that had experienced large proportional increases in dike pool habitat during the 1973–1999 period ($r = 0.60$, $P = 0.008$). Total CPUE of spotted bass was consistently greater in pools that had experienced the largest losses of extrachannel habitats ($r = -0.64$, $P = 0.004$). Spotted bass condition (as W_r) was inversely correlated to the total surface areas of diked secondary channels ($r = -0.48$, $P = 0.04$), and the proportional contribution of those areas to total pool area ($r = -0.56$, $P = 0.01$). However, spotted bass W_r values were generally greater in pools with greater total amounts of adjacent backwater ($r = 0.43$, $P = 0.07$) and proportional contribution of these habitats to total pool area ($r = 0.43$, $P = 0.07$). In general, spotted bass size structure (PSD_Q and PSD_P) and growth (L_∞ and K) were not strongly related to any macrohabitat variables or changes in those variables through time.

Table 3. Spotted bass age frequencies and annual mortality estimates (*A*) calculated from catch-curve analyses from different navigation pools of the lower Arkansas River, Arkansas. One was added to each catch prior to analysis. Data were pooled from collections made during 2004 and 2005. Pools numbered sequentially from downstream (2) to upstream (10). 95% confidence limits (CL) on *A* were determined by nonparametric bootstrapping of residuals.

Navigation pool	*n*	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Z	A%	95% CL
2	143	18	41	46	19	10	3	4	1	–0.562	43.0	36–48
3	62	13	25	16	6	2	0	0	0	–0.782	54.2	30–68
4	62	22	20	15	3	1	1	0	0	–0.809	55.5	34–61
5	88	35	40	11	2	0	0	0	0	–0.616	46.0	31–60
6	65	22	26	10	5	0	2	0	0	–0.687	49.7	25–66
7	91	42	19	17	4	3	3	1	0	–0.563	43.1	35–53
8	66	26	27	5	4	1	3	0	0	–0.589	44.5	22–54
9	42	20	14	6	1	0	1	0	0	–0.847	57.1	31–72
10	85	27	29	20	8	0	1	0	0	–0.620	46.2	35–62
Totals/means	704	225	241	146	52	17	14	5	1	–0.675	49.0	41–58

Table 4. Population structure and length at age data for spotted bass populations from other impounded southeastern U.S. river systems.[a] Means in last row exclude the present study. TL = total length in mm.

River system	State	Years	*n*	PSD_Q	PSD_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)[b]	AR	2004–2005	704	38	10	104	19.9	151	242	299	328	355
Middle Arkansas	OK	1997–2002	245	54	17	94	11.0	–	–	–	–	–
Ohio[c]	WV/OH/KY/IN/IL	1999–2004	599	32	6	103	10.0	215	257	315	336	324
Upper	WV/OH	1999–2004	187	29	2	100	4.2	216	260	301	321	324
Middle	KY	2001–2004	142	17	2	103	17.6	–	–	–	–	–
Lower	KY/IN/IL	2001–2004	412	33	7	104	18.7	234	279	328	342	–
Cumberland	TN/KY	1990–2006	–	57	–	–	4.2	–	–	–	–	–
Tennessee	TN/KY	1990–2006	–	53	12	94	10.1	117	180	231	272	307
Ouachita	AR	2006	–	–	–	–	–	138	194	252	280	307
Means			1,585	39	8	100	10.8	184	234	285	310	319

a. Estimates were generated from comparative datasets provided by the Tennessee Wildlife Resources Agency (Tennessee and Cumberland), 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. Estimated mean lengths at ages 6–8 were 371, 392, and 398 mm TL, respectively.

c. Estimates for upper reach generated from data contained in Xenakis (2005).

Discussion

Population Metrics

The weak or non-existent longitudinal trend with most spotted bass population metrics was consistent with the lower Arkansas River being a serial lock-and-dam navigation system. Although there was some indication that size structure was greater in the lower pools of the river and that total CPUE was greatest in middle pools, the lack of consistent longitudinal trends may have been expected. The macrohabitats in the present-day navigation system have become increasingly homogenized (Limbird 1993, Schramm et al. 2008). The Arkansas River is isolated from much of its historical floodplain by a levee system, and recent research has demonstrated detectable losses in the amounts of extrachannel habitat and total aquatic habitat in each pool that have occurred since the navigation systems was closed in the early 1970s (Schramm et al. 2008).

Key population metrics for Arkansas River spotted bass compared favorably with similar populations in other impounded river systems despite the macrohabitat losses. Mean spotted bass PSD_Q (38%) and PSD_P (10%) values for the Arkansas River were similar to averages from comparable systems (Table 4). Although there are no established size structure ranges to serve as management benchmarks for spotted bass, suggested size structure ranges other *Micropterus* species should be applicable. Observed PSD_Q values for Arkansas River spotted bass fell within acceptable ranges for both largemouth bass (40%–70%; Anderson and Neumann 1996) and smallmouth bass (30%–60%; Anderson and Weithman 1978). Both PSD_Q and PSD_P values suggested relatively healthy size structures in the Arkansas River, which was similar to findings reported for largemouth bass in Eggleton et al. (2010). Spotted bass condition throughout the Arkansas River (mean 104, range 100–106) was comparable to values from other impounded river systems (mean 100, range 94–104), and also suggested healthy populations. Arkansas River W_r values for spotted bass reflected good condition for all populations, and were in the top quartile of U.S. populations (Anderson and Neumann 1996).

Estimates of CPUE of Arkansas River spotted bass were high compared to values from other impounded river systems, and exceeded estimates from the Arkansas River in Oklahoma, Tennessee River, and Ohio River by nearly two-fold (Table 4). Direct comparisons of CPUE data among studies can be tenuous due to varying research objectives and sampling designs (Eggleton et al. 2010). Regardless, CPUE estimates suggested that most pools in the lower Arkansas River contained better-quality habitats for this species, and that joint management in concert with largemouth bass may be appropriate in some cases.

Spotted bass growth in the Arkansas River was average to above-average in comparison to other similar populations. In general, spotted bass growth was lower through age 1, then increased at older ages (Table 4). Arkansas River estimates also were high compared to a free-flowing reach of the nearby Ouachita River, Arkansas (Wilberding 2007) (Table 4). Von Bertalanffy growth parameters for Arkansas River spotted bass similarly suggested high growth, with a mean K of 0.47. Maximum size was not large (395-mm TL), though populations on average achieved weigh-in size for tournaments (i.e., 304-mm TL) at 3.1 yrs, and preferred size (i.e., 350-mm TL) at 4.6 yrs. However, spotted bass needed 6.6 yrs to reach 380-mm TL, with fish older than this age comprising <1% of the Arkansas River populations. Although comprehensive spotted bass datasets like those found for largemouth and smallmouth bass in Beamesderfer and North (1995) are lacking, it is probable that Arkansas River growth rates are at the higher end of the range for this species.

Relationships with Pool Macrohabitats

There was evidence that spotted bass populations have responded to long-term macrohabitat changes occurring in the Arkansas River. In particular, spotted bass total CPUE was lower in pools that suffered the greatest long-term (1973–1999) losses in main channel habitat. Schramm et al. (2008) reported that total aquatic habitat in the lower Arkansas River had declined by an average of 9% per pool (range 4%–16%) during the 1973–1999 period. Of these losses, the largest losses of main channel habitat occurred in pools 9 and 10, which are the furthest upstream in west-central Arkansas and also contained the lowest spotted bass abundances. These pools exhibited long-term losses in main channel habitat that far exceeded the other pools (345 and 818 ha, respectively), which gained on average 60 ha (range 33–104 ha) of main channel habitat during the same time period (Schramm et al. 2008). However, these main channel habitat gains in middle and lower Arkansas River pools constituted only 1%–8% increases in the macrohabitat gain on pool-wide basis. Given that spotted bass are a habitat generalist with an affinity for more lotic habitats and rockier substrates without vegetation (Sammons and Bettoli 1999), this association may have been expected. However, our results also suggested that the maintenance of present-day main channel border and associated habitats may serve to enhance spotted bass populations in the Arkansas River. Additionally, in-river activities that affect the Arkansas River main channel (e.g., dredging, dikes, and bank revetments) have the potential to significantly impact spotted bass populations.

Although not common in the lower Arkansas River, dike pool habitats may have some value to spotted bass, and play an important role in affecting their population abundances (as CPUE). Dike pool habitat is not widely available in the present-day Arkansas River, especially upstream of Pool 7 (see Table 4 in Schramm et al. 2008). In fact, only two of the nine Arkansas River pools included in this study (2 and 6) contained >100 ha of dike pool habitat (Schramm et al. 2008). Pool 7 has lost >100 ha of its dike pools since 1973, but still contains almost 80 ha of the habitat, which is above average for the lower Arkansas River (mean 55 ha, range 0–180 ha; Table 1). Pools 9 and 10 have lost 100% of their dike pool habitats during the 1973–1999 period, though neither pool ever contained large amounts (<35 ha) of the habitat, and Pool 8 has historically contained no dike pool habitat. However, consistently greater spotted bass abundances were observed in pools 2 and 5, which were the only Arkansas River pools to experience increases in dike pool habitat during the 1973–1999 period. Spotted bass CPUE was greatest in the middle pools of the Arkansas River, which included pools 5–7 where dike pools were more abundant. This finding was surprising considering that Schramm et al. (2008) reported that nearly 80% of the areas in Arkansas River dike pools were ≤0.9 m deep, which would seem unsuitable habitat for spotted bass. The specific characteristics of dike pools that may be valuable to spotted bass are unclear from this study, but the close proximity of dike pools to the main channel habitats that contain more preferred flow and substrate characteristics (e.g., dikes and bank revetments) may partly explain the association.

Spotted bass condition (as W_r) metrics were healthy and high throughout the lower Arkansas River. However, spotted bass condition tended to be lower in pools where diked secondary channels comprised larger proportions of the total aquatic habitat. Pools 4 and 5 contained the largest amounts of these habitats (42% and 37%, respectively), though each pool contained one particularly large diked secondary channel. In fact, 50% of this macrohabitat throughout Arkansas River pools 2–10 was located in these two pools alone. Diked secondary habitats have little flow, except at the greatest river stages, and generally contain more lentic habitats that are clearer (Pennington and Shields 1993). Schramm et al. (2008) further reported that nearly 70% of the total areas in diked secondary channels in the Arkansas River had undergone significant shallowing through time and were ≤0.9 m deep. These conditions would likely be less conducive to spotted bass (Sammons and Bettoli 1999), which may explain the inverse association of spotted bass condition and this macrohabitat.

In summary, our assessment of spotted bass indicates that the Arkansas River populations are healthy with acceptable size structure and better than average condition and growth. Spotted bass populations exhibited significant relationships with several river macrohabitat variables, especially those associated with macrohabitat changes that have occurred at decadal time scales in the lower Arkansas River. Most of the changes documented in the lower Arkansas River are related to excessive shallowing of some macrohabitats and net losses of total aquatic habitat related to extensive sedimentation (Schramm et al. 2008). These characteristics are similar to those associated with the aging phenomenon that has been widely observed in reservoirs (Kimmel and Groeger 1986). Thus, it may be likely that serial lock-and-dam navigation systems like the lower Arkansas River undergo similar aging processes as described in Schramm et al. (2008). Sediment accretion occurs mostly in low-flow habitats such as secondary channels, dike pools, and backwaters and results in a net reduction in usable aquatic habitat (Limbird 1993). These effects are usually irreversible due to river regulation practices and create large areas of extremely shallow water over long-term time scales (Schramm et al. 2008).

The long-term effects on fisheries in these systems have not been widely studied, though consensus appears to be that backwater-obligate fishes will be reduced or eliminated (Patton and Lyday 2008, Schramm et al. 2008). Furthermore, recreational fishing will be hampered because critical sport fish habitats will either be lost or become separated from the main channel and not accessible to anglers (Slipke and Maceina 2006). In any event, a more generalist species like spotted bass with an affinity for Arkansas River macrohabitats that are increasing or otherwise decreasing at low rates (e.g., main channel) might become a more significant component of the future black bass sport fishery in the lower Arkansas River.

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