Spatial Variation in Population Characteristics of Shovelnose Sturgeon in the Kansas River

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ABSTRACT -- Shovelnose sturgeon (*Scaphirhynchus platorynchus*) were sampled from the Kansas River during August 1997 from sites near Fort Riley Military Reservation and Lawrence, Kansas. Catch per unit effort (CPUE, number/100 m) of shovelnose sturgeon was highest at Lawrence ($P = 0.02$), but was highly variable among length categories and macrohabitats. Catch per unit effort of quality- to preferred- (Q-P) and preferred- to memorable-length (P-M) fish was generally higher than CPUE of other length categories. Catch per unit effort was highest in channel crossover macrohabitats at both locations. The number of drifts required for the coefficient of variation to equal 20% of the mean varied from 20 to 2,642. Fewer drifts were required to estimate CPUE of Q-P and P-M shovelnose sturgeon than for other length categories. Mean relative weight (W_r) was significantly higher at Lawrence ($P = 0.006$); however, W_r of P-M and stock- to quality-length (S-Q) fish were similar between locations ($P > 0.05$). Proportional stock density was significantly higher at Fort Riley ($P = 0.003$), but relative stock density (RSD) of S-Q fish and RSD Q-P were significantly higher at Lawrence ($P \leq 0.003$). Shovelnose sturgeon sampled from Lawrence had significantly higher mean back-calculated lengths-at-age ($P \leq 0.05$, all ages) and mean annual growth increments ($P \leq 0.05$, except ages 11 and 12). These data suggest that population characteristics of shovelnose sturgeon vary longitudinally and that management strategies may need to differ among river reaches.

Key words: abundance, condition, growth, Kansas River, sample size estimation, *Scaphirhynchus platorynchus*, shovelnose sturgeon, size structure.

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Nongame species often dominate fish communities in large, lotic ecosystems throughout the midwestern United States (e.g., Barnickol and Starrett 1951); however, there is a paucity of information regarding the population characteristics of these species in large rivers. Shovelnose sturgeon (*Scaphirhynchus platorynchus*) are common in large midwestern rivers, but few studies have examined population characteristics of the species, especially in Kansas. In addition, few researchers have studied longitudinal variation in size structure, condition, and growth of fishes in large river systems. Therefore, the objectives of our study were to describe spatial differences in relative abundance, condition, size structure, and growth of shovelnose sturgeon from the Kansas River.

METHODS AND MATERIALS

The Kansas River is formed by the confluence of the Smoky Hill and Republican rivers near Junction City, Kansas. The entire drainage area covers nearly 160,000 km^2, encompassing portions of northeastern Colorado, southern Nebraska, and the northern half of Kansas (Metcalf 1966), and constitutes approximately 12% of the Missouri River watershed. Eighteen federal reservoirs and over 13,000 small impoundments control discharge in the drainage basin. Bowersock Dam at river kilometer (rkm) 83, near Lawrence, Kansas, is the only mainstem dam and is characterized as a low-head dam. Consequently, the Kansas River rarely exceeds bank-full discharge due to the altered hydrograph. Sanders et al. (1993) provide a detailed review of the physiography, land uses, water quality, habitat alterations, and changes in the fish communities within the Kansas River basin.

We studied the portions of the Kansas River located on Fort Riley Military Reservation (rkms 263 to 274) near Ogden, Kansas, and below Bowersock Dam (rkms 63 to 75). The Kansas River at Fort Riley has a drainage area of approximately 116,000 km^2 with an average annual runoff of about 2.6×10^9 m^3 (Putnam et al. 1996). Mean annual discharge (1964 to 1996) is approximately 82 m^3/s. At Lawrence, the drainage area is approximately 151,000 km^2 and annual runoff is about 6.6×10^9 m^3. Mean annual discharge (1937 to 1996) is approximately 209 m^3/s.

Water levels at Fort Riley are influenced by Milford Dam, which impounds the Republican River 12 km upstream of the study site. Bowersock Dam is located 8 km upstream of the lower site, but the influence of this low-head dam on discharge is negligible. Vegetated islands, sand bars, and shallow secondary channels were present at both locations. The primary sources of instream cover were log complexes and other woody debris; however, small finger dikes were also common along outside bend macrohabitats on Fort Riley.

Using a bottom-drifting, multi-filament trammel net (9.1-m long; inner wall 2.4-m deep, 2.5-cm bar mesh; and outer wall 1.8-m deep, 20.3-cm bar mesh), we sampled hovelnose sturgeon from 11 August to 16 August 1997 at Fort Riley and from 18 August to 23 August 1997 at Lawrence. Sampling was standardized to facilitate :omparisons between sites by drifting trammel nets over a location until shovelnose turgeon were no longer collected. For example, if we drifted a trammel net and failed o collect a shovelnose sturgeon, regardless of other fish species, we moved to a new ocation; however, if we were successful in capturing a shovelnose sturgeon, we :ontinued to sample the same location until no additional shovelnose sturgeon were :ollected. Using known distances and drift times, we timed all drifts and estimated listances. Sampled fish were weighed to the nearest 0.1 g (Acculab V-1200) and neasured to the nearest millimeter (fork length).

Catch per unit effort (CPUE) was calculated as the number of fish per 100 m lrifted. The number of drifts required for the coefficient of variation of the mean ($CV_{\bar{x}}$ = 100 × standard error/mean) to equal 20% was calculated as:

$$N = (CV_x/CV_{\bar{x}})^2$$

vhere, CV_x is the coefficient of variation of samples (CV_x = 100 × standard leviation/mean). Neumann et al. (1995) used similar techniques to determine precision of various gears for sampling percichthyids, i.e., *Morone* spp., in Lake Texoma,)klahoma and Texas.

Size structure was assessed by determining proportional stock density (PSD) and elative stock densities (RSD). Proportional stock density is the proportion of stock-ength (≥ 250 mm) shovelnose sturgeon that are also quality-length (≥ 380 mm) and RSD is the proportion of stock-length fish that are greater than a specified length, i.e., tock- to quality- (S-Q, 250 to 379 mm), quality- to preferred- (Q-P, 380 to 509 mm), referred- to memorable- (P-M, 510 to 639), and memorable- to trophy-length (M-T, 540 to 809; Gabelhouse 1984, Quist et al. 1998). Condition was assessed by using elative weight (W_r, Wege and Anderson 1978, Quist et al. 1998). We calculated mean overall W_r, as well as incremental W_r for length categories represented by at least five ndividuals.

The marginal-right pectoral fin ray was collected from each fish and allowed to ir dry before being processed for age and growth analysis. A low-speed diamond saw Buehler Isomet) was used to cut transverse sections 0.3 to 0.5 mm thick through the listal portion of the cartilaginous knuckle. We read annuli with the aid of a dissecting nicroscope coupled with an image analysis system. Guidelines for aging followed hose described by Currier (1951) and Brennan and Cailliet (1989). The direct roportion method was used to determine mean back-calculated length-at-age estimates ind to facilitate comparisons with other studies. Mean back-calculated length-at-age stimates were weighted by sample size at each age to decrease the influence of older ind rarer fish in the analyses.

Using analysis of variance (ANOVA), we compared CPUE, W_r, mean back-calculated lengths-at-age, and mean annual growth increments among locations and length categories (SAS 1989). When the analysis was extended to include macrohabitats, a factorial ANOVA was conducted to test for differences in CPUE among length categories within macrohabitats. Multiple comparisons were conducted by using least-squares means. Using a chi-square test, we compared size structure between populations. A probability level of 0.05 was used to determine statistical significance. Power analysis was conducted on non-significant comparisons to determine the probability of not committing a type-II error (Peterman 1990, Borenstein et al. 1997).

RESULTS AND DISCUSSION

Shovelnose sturgeon varied in length from 309 to 648 mm (N = 128) at Fort Riley and from 122 to 669 mm (N = 113) at Lawrence. Catch per unit effort of shovelnose sturgeon varied from 0.00 to 9.01 fish/100 m (mean = 2.04) at Fort Riley and from 0.00 to 10.02 fish/100 m (mean = 3.52) at Lawrence and was significantly higher at Lawrence (Table 1, P = 0.02). Catch per unit effort of shovelnose sturgeon by length category was similar among macrohabitats for both locations (non-significant interaction, P > 0.05). Quality- to preferred- and P-M fish were most abundant at both locations and CPUE was highest in channel crossover macrohabitats (Table 1). The difference in shovelnose sturgeon catch rates among macrohabitats indicates that shovelnose sturgeon are not uniformly distributed among macrohabitats. Channel crossovers typically had diverse habitat consisting of a braided channel with abundant instream cover, primarily woody debris. Higher CPUE values in channel crossovers is likely a function of habitat. Shovelnose sturgeon tend to congregate downstream of sand bars and vegetated islands (Schmulbach et al. 1975, Moos 1978, Quist et al. 1999), both of which were most common in channel crossover macrohabitats. Outside bends typically have higher velocities than either inside bends or channel crossover macrohabitats (Allan 1995); consequently, fish collected from outside bends were often in low-velocity areas downstream of finger dikes or log complexes.

Number of drifts required for the $CV_{\bar{x}}$ to equal 20% varied from 20 to 2,642 and was dependent on macrohabitat type and length category (Table 1). In general, the number of drifts required to estimate CPUE of SS, S-Q, and M-T shovelnose sturgeon was higher than for Q-P and P-M fish. This trend was consistent between locations and among macrohabitats.

Quist et. al. (1998) proposed target W_r values of 80 to 90 for shovelnose sturgeon from populations other than those in Montana. Individuals from both populations in the Kansas River were within the suggested target values, except for S-Q fish (Table 2). Mean overall W_r of shovelnose sturgeon sampled from Lawrence was significantly higher than those from Fort Riley (P = 0.006). Conversely, W_r of S-Q and P-M

Table 1. Mean catch per unit effort (number/100 m) of substock- (SS, < 250 mm), stock- to quality- (S-Q, 250 to 379 mm), quality- to preferred- (Q-P, 380 to 509 mm), preferred- to memorable- (P-M, 510 to 639 mm), and memorable- to trophy-length (M-T, 640 to 809) shovelnose sturgeon and required number of drifts (N_d) for the coefficient of variation of the mean ($CV_{\bar{x}}$ = 100 × standard error/mean) to equal 20% for shovelnose sturgeon sampled from the Kansas River at Fort Riley and Lawrence in August 1997. Values in parenthesis are the coefficient of variation of the sample (CV_x = 100 × standard deviation/mean). P-values represent analysis of variance comparisons between locations and power analysis (1 - β) was only conducted for non-significant tests (Peterman 1990).

	Fort Riley	N_d	Lawrence	N_d	*P*	1 - β
All macrohabitats						
All fish	2.04 (191)	91	3.52 (148)	55	0.02	
SS	0		0.11 (442)	487	0.02	
S-Q	0.02 (725)	1311	0.31 (316)	249	0.005	
Q-P	0.17 (448)	501	0.77 (194)	94	0.001	
P-M	1.84 (187)	87	2.26 (192)	92	0.12	0.44
M-T	0.01 (1029)	2642	0.07 (678)	1147	0.19	0.25
Channel crossover						
All fish	2.67 (169)	71	4.70 (143)	51	0.02	
SS	0		0.12 (458)	523	0.07	0.47
S-Q	0		0.30 (257)	164	0.02	
Q-P	0.17 (504)	634	0.84 (175)	76	0.004	
P-M	2.49 (160)	64	3.36 (169)	71	0.24	0.20
M-T	0.02 (843)	1773	0.08 (640)	1022	0.35	0.15
Inside bend						
All fish	1.13 (164)	67	2.04 (93)	22	0.46	0.11
SS	0		0.17 (325)	263	0.06	0.43
S-Q	0.10 (331)	273	0.07 (557)	774	0.06	0.08
Q-P	0.21 (285)	203	0.63 (195)	95	0.17	0.16
P-M	0.82 (192)	93	1.17 (90)	20	0.73	0.06
M-T	0		0		1.00	0.05

Table 1. Cont.

	Fort Riley	N_d	Lawrence	N_d	*P*	1 - β
Outside bend						
All fish	0.08 (390)	379	3.39 (143)	51	0.04	0.11
SS	0		0		1.00	0.05
S-Q	0		0.68 (247)	152	0.006	
Q-P	0.08 (390)	379	0.84 (225)	126	0.07	0.37
P-M	0		1.71 (0)	135	0.21	0.22
M-T	0		0.15 (458)	523	0.21	0.22

shovelnose sturgeon did not differ between locations. However, these results may be a reflection of low sample size or high variability, suggested by low statistical power to detect differences (1 - β < 0.15). The variation in condition may be related to substrate and secondary productivity. For example, we observed that sand substrate dominates the Fort Riley site and soft-bottoms, i.e., silt and detritus, and rocky substrate, i.e., cobble and gravel, are scare. The Lawrence site has a large proportion of silt and detrital substrate. The shovelnose sturgeon is a benthic-insectivore (Bailey and Cross 1954, Modde and Schmulbach 1977) and a decrease in condition may be a reflection of prey availability, because sand substrate is typically lower in benthic invertebrate productivity than soft-bottom or rocky substrates (Ward 1992). Bramblett (1996) found that shovelnose sturgeon used gravel and cobble substrates in greater proportion than available (Yellowstone and Missouri rivers), and avoided fine substrates such as sand. In the upper Missouri River, the shovelnose sturgeon is most commonly located over sand substrate, but is often associated with rocky substrates (Hurley et al. 1987). Although we did not quantify substrate, we did notice that shovelnose sturgeon were commonly located over gravel or rocky substrates.

Size structure was variable and differed between locations (Table 2). For example, PSD was significantly higher at Fort Riley than Lawrence ($P = 0.003$). Conversely, the population at Fort Riley was comprised of a significantly smaller proportion of fish less than preferred length ($P \leq 0.003$). These differences in size structure are likely a function of growth.

Age determination and growth analysis were conducted on 109 and 127 shovelnose sturgeon from Fort Riley and Lawrence, respectively. Fish varied from age 2 to age 16 at Fort Riley and from age 1 to age 12 at Lawrence. Over 72% of the shovelnose sturgeon collected from Fort Riley were between age 6 and age 10, compared to only 41% from Lawrence. Most of the fish sampled from Lawrence were age 2 to age 8 (80%). Mean back-calculated lengths-at-age were significantly greater

($P \leq 0.05$) for fish at Lawrence than those collected from Fort Riley for all ages (Fig. 1). Similarly, mean annual growth increments were significantly greater ($P \leq 0.05$) for fish collected from Lawrence, except ages 11 and 12 (Fig. 1). High variability observed in mean back-calculated lengths and mean annual growth increments after age 10 at both locations is probably a function of low sample size, i.e., less than 4 fish.

Table 2. Mean population relative weight (W_r), and W_r of substock- (SS, < 250 mm), stock- to quality- (S-Q, 250 to 379 mm), quality- to preferred- (Q-P, 380 to 509 mm), preferred- to memorable- (P-M, 510 to 639 mm), and memorable- to trophy-length (M-T, 640 to 809 mm) shovelnose sturgeon, proportional stock density (PSD), and incremental relative stock densities (RSD) of shovelnose sturgeon sampled from the Kansas River during August 1997. Values in parenthesis are the coefficient of variation of the sample (CV_x = 100 × standard deviation/mean) for W_r values and 95% confidence intervals for PSD and incremental RSD. Power analysis (1 - β) was only conducted for non-significant tests (Peterman 1990).

Index	Fort Riley	Lawrence	*P*	(1 - β)
W_r				
Overall	82 (12)	85 (15)	0.006	
SS	[a]	[a]		
S-Q	78 (4)	92 (13)	0.28	0.11
Q-P	[a]	83 (7)		
P-M	83 (8)	84 (8)	0.41	0.14
M-T	[a]	[a]		
Size structure				
PSD	99 (5)	90 (6)	0.003	
RSD S-Q	1 ([b])	10 ([b])	0.003	
RSD Q-P	7 ([b])	24 (17)	0.001	
RSD P-M	91 (7)	64 (12)	0.43	0.09
RSD M-T	1 ([b])	2 ([b])	[c]	

[a] Relative weight (W_r) was not calculated for length categories represented by less than 5 individuals.

[b] Unable to calculate reliable confidence interval.

[c] Chi-square test not conducted due to the lack of trophy-length fish.

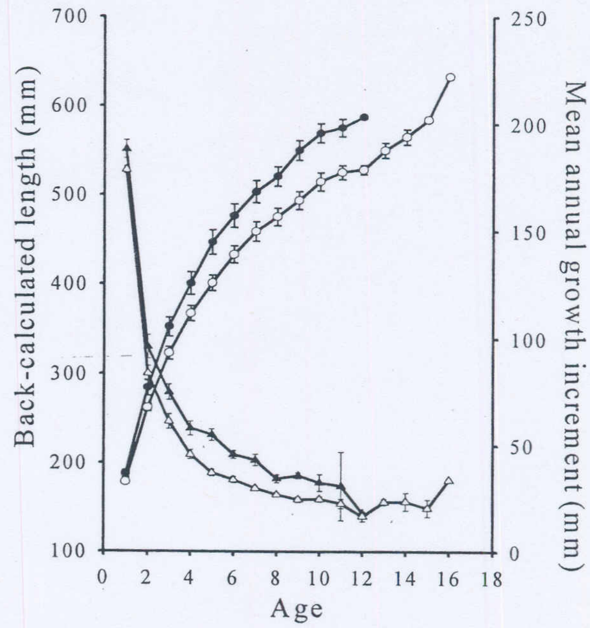

Figure 1. Mean (± standard error) back-calculated length-at-age (circles) and mean annual growth increment (triangles) for shovelnose sturgeon sampled from the Kansas River at Fort Riley (open symbols) and Lawrence (solid symbols) during August 1997. All mean back-calculated lengths are significantly different ($P \leq 0.05$) between locations. Mean annual growth increments are significantly different ($P \leq 0.05$) between locations, except for ages 11 and 12.

Helms (1973) reported mean back-calculated lengths-at-age for shovelnose sturgeon in the Mississippi River, Iowa. Mean back-calculated lengths were greater at all ages in the Mississippi River than the Kansas River populations. Conversely, shovelnose sturgeon from the Kansas River grew faster than those in the Missouri River, South Dakota (Fogle 1963).

Similar to condition, variation in growth rate is probably a function of prey availability. If density-dependent factors influenced growth and condition, we would expect lower growth and condition for fish sampled at Lawrence than at Fort Riley, but this was not the case. Instead, these data suggest that longitudinal variation in abiotic factors influenced food production for shovelnose sturgeon. In addition, our study indicates that shovelnose sturgeon population characteristics vary longitudinally with regards to abundance, size structure, condition, and growth. Thus, management strategies of shovelnose sturgeon will likely differ within a river based on longitudinal variation in abiotic factors.

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