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Overwinter Habitat Use of Shovelnose Sturgeon in the Kansas River

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Abstract.—Overwinter habitat use of shovelnose sturgeon *Scaphirhynchus platorynchus* in the Kansas River was determined by radiotelemetry from November 1996 to March 1997 at water temperatures of 2–9°C. Eighty percent of the shovelnose sturgeon locations were in water depths of 1.0–2.0 m, where current velocities were 0.01–1.11 m/s at the surface and 0.02–0.79 m/s at the bottom. Depths and surface current velocities at fish locations were positively related to discharge (r = 0.47, P = 0.0001; r = 0.60, P = 0.0001, respectively); bottom current velocities were not significantly correlated (r = 0.08, P = 0.31) with discharge. Water depths, surface current velocities, and bottom current velocities were not significantly related to water temperature ($P > 0.05$). Ninety-two percent of the shovelnose sturgeon locations were over sand substrate. Inside-bend macrohabitats were used in proportion to their abundance ($P > 0.05$), whereas channel crossovers were used in greater proportion than their availability ($P \leq 0.05$); outside-bend habitats were avoided ($P \leq 0.05$). During high discharge (>150 m^3/s), shovelnose sturgeon appeared to move near shore or downstream of instream cover. Most shovelnose sturgeon moved less than 2 km during the study period, but one fish moved more than 8 km. Movement (km/d) and directional movement (i.e., upstream or downstream) were not related to discharge or water temperature ($P > 0.05$). These data indicate that shovelnose sturgeon use channel-crossover macrohabitats and areas with bottom velocities of 0.02–0.79 m/s, independent of discharge. In addition, it appears that shovelnose sturgeon do not congregate in deep areas at water temperatures less than 9°C.

Shovelnose sturgeon *Scaphirhynchus platorynchus* are adapted to large, lotic ecosystems and occur throughout the Mississippi–Missouri River drainage (Bailey and Cross 1954). They are a bottom-dwelling species associated with areas of current and sand substrate (Bailey and Cross 1954; Hurley et al. 1987) but may use gravel and cobble substrates if available (Bramblett 1996). In Kansas, their distribution is limited to large rivers having broad, sandy channels, such as the Blue, Kansas, and Missouri rivers (Cross and Collins 1995).

Of the North American sturgeon (Acipenseridae) species, 67% are either endangered, threatened, or of special concern, indicating the magnitude of the problems facing this family of fishes that depends on the integrity of large river systems (Williams et al. 1989). Bailey and Cross (1954) stated that the distribution and abundance of shovelnose sturgeon has decreased due to overfishing, water pollution, and habitat modifications across their native range. There is a lack of information regarding the historical abundance of benthic fishes, including shovelnose sturgeon, in the Kansas River. Sanders et al. (1993) identified impoundments and commercial sand dredging as potential threats to the fish community and ecosystem function in the Kansas River. Large federal reservoirs and numerous small impoundments have altered the natural hydrograph and sediment load. Reduced peak flows do not scour the channel and allow fine-grained particles to accumulate. Cross and Moss (1987) observed compaction of sand and gravel substrates in the lower Kansas River as a consequence of these fine-grained particles. Channel scouring also helps to maintain shallow, braided channels and associated backwaters that numerous species require for all or a portion of their life cycle (Cross and Moss 1987; Wenke et al. 1993; Cross and Collins 1995). Commercial sand dredging in the lower Kansas River has resulted in riverbed degradation, bank erosion, and channel widening (Sanders et al. 1993). Such habitat modifications have resulted in decreased abundance and distribution of native fishes, most of which are benthic species.

Movement patterns, food habits, and habitat use of shovelnose sturgeon have been studied in the

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Missouri (Held 1969; Modde and Schmulbach 1977; Moos 1978; Bramblett 1996), Mississippi (Helms 1974; Hurley et al. 1987), and Yellowstone rivers (Bramblett 1996); however, little is known of the habitat use of shovelnose sturgeon in the Kansas River. In addition, most radiotelemetry studies have been conducted during the spring and summer (Hurley et al. 1987; Curtis et al. 1997), rather than winter. Bramblett (1996) studied shovelnose sturgeon habitat use and movement in the Missouri and Yellowstone rivers; however, only movement patterns were described on a seasonal basis, with limited information during winter.

The objectives of this study were to (1) describe winter (i.e., water temperatures of 2–9°C) habitat use of shovelnose sturgeon in the Kansas River, (2) determine if shovelnose sturgeon use specific macrohabitats (i.e., inside bends, outside bends, channel crossovers) during the winter, and (3) assess the effects of varied discharges and temperatures on habitat use (specifically bottom current velocity) during the winter. Although not one of our primary objectives, we also examined winter movement patterns. We hypothesized that shovelnose sturgeon would be located over sand substrate and would use similar bottom current velocities regardless of discharge. Hesse and Newcomb (1982) found that many benthic species overwinter in deep pools in the Missouri River; therefore, we hypothesized that shovelnose sturgeon would congregate in deep pools downstream of finger dikes or instream structure (e.g., woody debris) located along outside bends.

Study Area

The Kansas River system originates in eastern Colorado and flows east approximately 770 km until it enters the Missouri River at Kansas City, Kansas. Total drainage area covers approximately 159,000 km^2 (11.6% of the Missouri River watershed) and includes portions of northeastern Colorado, southern Nebraska, and the northern half of Kansas (Metcalf 1966). Climate varies across the drainage, from the western, semiarid plains with less than 41 cm average annual precipitation and less than 1 cm of runoff to the humid eastern edge with more than 90 cm of precipitation and greater than 20 cm of annual runoff (Colby et al. 1956; Putnam et al. 1995). In general, about two-thirds of the total annual precipitation occurs during April through September (Colby et al. 1956).

The main-stem Kansas River is formed by the confluence of the Smoky Hill and Republican rivers at Junction City, Kansas. Eighteen federal reservoirs and more than 13,000 small impoundments control discharge from the entire drainage area; however, Bowersock Dam (river kilometer, rkm, 83.4 from the confluence with the Missouri River) in Lawrence, Kansas, is the only main-stem dam and is characterized as a low-head dam. Although the main channel has received little modification, nearly 16% of the main stem has been modified with bank stabilization structures (Sanders et al. 1993). Sanders et al. (1993) provides a detailed review of the physiography, land uses, historical channel migration, physical modifications, water quality, and changes in fish communities in the Kansas River basin.

We studied the portion of the Kansas River located on Fort Riley Military Reservation (rkm 263–274) immediately downstream of the confluence of the Smoky Hill and Republican rivers. The annual hydrograph is altered by numerous small impoundments and reservoirs; thus, the river rarely exceeds bank-full width. The study area has a drainage area of approximately 116,000 km^2 and an average annual runoff of about 2.6×10^9 m^3 (Putnam et al. 1995). Mean annual discharge (1964–1995) is approximately 82 m^3/s. Extremes of 4 and 2,481 m^3/s were reported in 1966 and 1993, respectively. Generally, discharges average 43 m^3/s during winter. Discharges were typically below 50 m^3/s during the study period; however, water levels were controlled by Milford Dam, which impounds the Republican River approximately 12 km upstream of the study area.

Shallow subsidiary channels, vegetated islands, and sand bars were common. The primary source of instream structure was woody debris (e.g., log complexes) along the river margins in channel crossovers, but several finger dikes were present in the study area. A detailed description of the fish community in our study area is given by Wenke et al. (1993).

Methods

Shovelnose sturgeon were collected using a bottom-drifting multifilament trammel net (9.1-m long; inner wall: 2.4-m deep, 2.5-cm-bar mesh; outer wall: 1.8-m deep, 20.3-cm-bar mesh). Trammel nets were drifted perpendicular to the current for approximately 150 m. Collected shovelnose sturgeon were transported to an instream enclosure.

Transmitters (Advanced Telemetry Systems) had frequencies between 48.170 and 48.951 MHz and a lifespan of approximately 4 months. A transmitter and the attached 25.4-cm wirewhip antenna weighed 3.0 g in air; at 0.4–0.7% of the fish weight, this was less than the maximum 2.0% of fish weight in air recommended by Winter (1996). The receiving antenna was a loop antenna (35–50 MHz) and the receiver (Advanced Telemetry Systems, Challenger model R2000) automatically scanned through the programmed series of radio frequencies during tracking.

Before transmitter implantation, fork length (nearest mm) and weight (nearest 0.1 g; Acculab V-1200) were measured. Transmitters were surgically implanted in 17 fish on 1 November and 9 fish on 8 November. Fish were held with their head in the river while an anterior–posterior incision (approximately 2-cm long) was made in the ventral body wall slightly off the longitudinal axis of the body. A 10-gauge needle was inserted anteriorly into the body cavity 2–3 cm posterior to the incision until visible in the incision. The transmitter was inserted into the body cavity, and the antenna was threaded through the needle. The needle was then removed, leaving the antenna trailing the incision. The incision was then sutured using monofilament nylon suture material attached to a 19-mm curved, cutting needle. Following surgery, the fish were held in an instream enclosure for about 1 h and released.

Because sample size in telemetry studies is a function of the frequency of sampling, sample size can be inflated by increasing the number of times an individual fish is tracked (White and Garrott 1990). We believed that weekly sampling was sufficient to describe habitat use during winter. Therefore, shovelnose sturgeon were located weekly from 8 November 1996 to 8 March 1997. Fish were not tracked during the last 2 weeks of December and January because of unstable ice cover on the river. We determined the position of radio-tagged fish in the channel by boat during the day. When a fish was located, its position was confirmed by drifting downstream from above the fish. With the motor turned off, the boat was maneuvered to drift directly over the fish. Blind tests with transmitters placed in the river showed this technique to be accurate to within about 2 m of the actual location of the fish.

All habitat measurements were recorded from an anchored boat positioned directly over the fish. Locations were plotted on U. S. Geological Survey (USGS) quadrangle maps (1:24,000; magnified 400%). Macrohabitat type (i.e., channel crossover, inside bend, and outside bend), water temperature, and water depth were recorded at each location. Channel crossovers were defined as the portion of the river where the thalweg crossed from one concave side of the river to the other concave side (Leopold and Langbein 1966). Inside bends were identified as the concave side of a river bend, whereas outside bends were opposite the inside bends (i.e., convex side). In addition, surface (30 cm below the surface) and bottom (10 cm above the substrate) current velocities were measured to the nearest 0.01 m/s with a Marsh-McBirney Flowmate 2000 flowmeter. Substrate type was determined by probing the substrate with a wading rod (Kieffer and Kynard 1996). Substrate categories (i.e., silt, sand, gravel, cobble, and boulder) were similar to those reported by Kieffer and Kynard (1996). Movements (km/d) of individual fish were calculated by measuring the distance between successive locations. Directional movements were determined as the net upstream or downstream movement between successive locations. Only fish located within a 14-d period were used in the movement analyses. River discharges were measured at the USGS Fort Riley Gauging Station located 2.6 rkm downstream of the confluence of the Smoky Hill and Republican rivers.

Regression and correlation analyses were used to determine relations of water depth, surface current velocity, and bottom current velocity with discharge and temperature. Availability of various water depths, velocities, and substrates was not determined; however, availability of macrohabitats was obtained from USGS quadrangle maps (1: 24,000 scale). Preference, avoidance, or proportional use was determined using Bonferroni's inequality (Byers et al. 1984; Lobb and Orth 1991). Movement, discharge, and temperature data were analyzed using regression and correlation techniques. Relations between directional movement (i.e., upstream and downstream), discharge, and temperature were tested using Fisher's exact test. The Statistical Analysis System (SAS Institute 1989) and StatXact (Mehta and Patel 1995) were used for data analyses. A probability level of 0.05 was used as the level for rejection of the null hypothesis in all statistical tests.

Results

We collected 141 observations from 8 November 1996 to 8 March 1997 on 26 radio-tagged shovelnose sturgeon, 504–602 mm (mean = 553 mm) long and weighing 426.5–766.6 g (mean = 624.9 g). Individual fish were located 1–16 times (mean = 8). Water temperatures varied from 2°C in February 1997 to 9°C in March 1997 (mean = 4.6°C); discharge varied from 18.7 m^3/s in January 1997

TABLE 1.—Minimum, maximum, mean, and coefficient of variation (CV = 100 × SD/mean) of movements of radio-tagged shovelnose sturgeon and water depth, surface current velocity, and bottom current velocity at radio-tagged shovelnose sturgeon locations in the Kansas River. Discharge represents the entire study period (8 November 1996 to 8 March 1997), but temperature does not include the last 2 weeks of December and January.

Variable	Minimum	Maximum	Mean	CV
Movement (km/d)				
Overall	0.0	0.9	0.2	97.9
Upstream	0.0	0.9	0.1	86.4
Downstream	0.0	0.9	0.2	89.7
Water depth (m)	0.1	4.6	1.4	46.4
Surface current velocity (m/s)	0.01	1.11	0.48	45.80
Bottom current velocity (m/s)	0.02	0.79	0.34	48.40
Discharge (m^3/s)	18.7	383.9	94.9	106.4
Temperature (°C)	2.0	9.0	4.6	52.1

to 383.9 m^3/s in December 1996 (mean = 94.9 m^3/s; Table 1). In general, discharge was less than 90 m^3/s during the study period.

Radio-tagged shovelnose sturgeon were located where water depths were 0.1–4.6 m (mean = 1.4 m; Table 1), but more than 80% of the observations were in depths of 1.0–2.0 m. Surface current velocities varied from 0.01 to 1.11 m/s (mean = 0.48 m/s; Table 1), and 60% of the observations were between 0.3 and 0.6 m/s. Bottom current velocities were slower, varying from 0.02 to 0.79 m/s (mean = 0.34 m/s; Table 1); however, more than 45% of the locations were between 0.2 and 0.3 m/s.

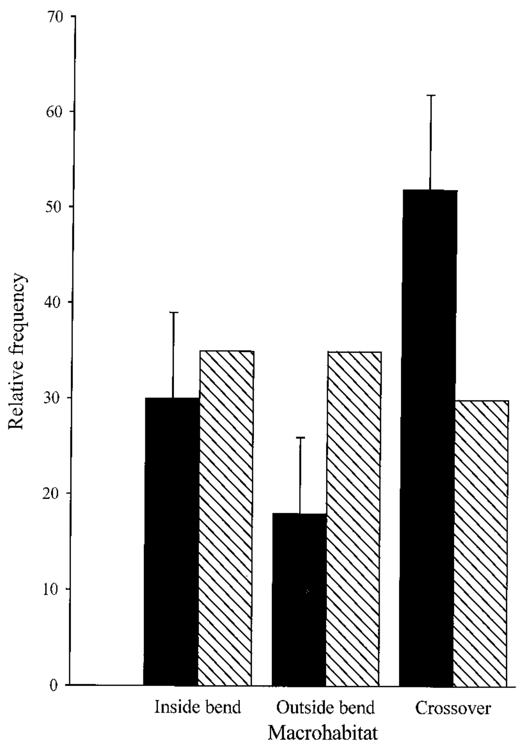

FIGURE 1.—Plot of observed frequency (solid bars) and expected frequency (hatched bars) of macrohabitat use by radio-tagged shovelnose sturgeon in the Kansas River from 8 November 1996 to 8 March 1997. Bars on observed frequencies indicate Bonferroni (95%) confidence intervals.

Ninety-two percent of the located fish were over sand substrate, followed by silt (5.0%), cobble (2%), gravel (0.8%), and boulder (0.2%) substrates. Shovelnose sturgeon were most often located in channel-crossover macrohabitats (52.0%), followed by inside (29.6%) and outside bends (18.4%; Figure 1). Based on the availability of macrohabitats, we determined that channel crossovers were used in greater proportion than their availability ($P \leq 0.05$), outside bends were avoided ($P \leq 0.05$), and inside bends were used in proportion to availability ($P > 0.05$). The majority of sand bars, islands, and instream woody debris occurred in channel crossovers. Consequently, most fish were located in association with shallow pools downstream of sand bars and islands in areas with instream cover, especially during high flows.

High discharge was observed during the last week of November 1996 and the first week of December 1996. Variation in discharge was caused by releases from Milford Dam related to repairs to the stilling basin. At fish locations, depth increased with increasing discharge ($r = 0.47$, $P = 0.0001$). Similarly, a significant positive relationship occurred between surface velocity at shovelnose sturgeon locations and discharge ($r = 0.60$, $P = 0.0001$); however, bottom velocities at fish locations were not correlated with discharge ($r = 0.08$, $P = 0.31$). No relations were found between temperature and habitat use ($P > 0.05$).

Although we were primarily interested in overwinter habitat use, we were able to discern limited movement patterns of fish during the study period.

Shovelnose sturgeon moved between 0.0 and 0.9 km/d (mean = 0.2 km/d; Table 1). One fish moved more than 8 km, but most moved less than 2 km ($N = 20$). We found that movement (km/d) of shovelnose sturgeon and direction of movement (i.e., upstream and downstream) were not significantly related to discharge or temperature ($P > 0.05$).

Discussion

Bottom current velocity is probably an important variable influencing the distribution of benthic species such as shovelnose sturgeon (Bailey and Cross 1954). We found that bottom velocities at fish locations averaged 0.34 m/s. Our results are similar to those in the upper Mississippi River where average bottom current velocities at shovelnose sturgeon locations were 0.23 m/s (Curtis et al. 1997) and 0.33 m/s (Hurley et al. 1987). In a study throughout 2,460 km of the Missouri River, shovelnose sturgeon were generally found between 0.4 m/s and 0.7 m/s during the late summer and fall (Dieterman et al. 1996). The lack of a relationship between bottom current velocities and discharge does not directly indicate preference for specific bottom velocities but does support the findings of Hurley et al. (1987). They found that shovelnose sturgeon moved from the main channel to nearshore areas with structures (e.g., wing dams) during high flows. Although we did not quantify associations with instream cover, we observed that fish were often located downstream of woody debris during high discharge (i.e., >150 m^3/s), suggesting the importance of instream structures to shovelnose sturgeon.

Substrate is also an important factor influencing the distribution of shovelnose sturgeon (Hurley et al. 1987; Bramblett 1996). Bramblett (1996) found that shovelnose sturgeon in the Yellowstone and Missouri rivers used gravel and cobble substrates in greater proportion than were available and avoided fine substrates such as sand and silt. In the upper Mississippi River, shovelnose sturgeon were usually found over sand substrate, but were commonly located near rocky substrates (e.g., wing and closing dams) during spring and summer (Hurley et al. 1987). In our study, shovelnose sturgeon were most often located over sand substrate. Based on our observations, rocky substrates were available to fish but were seldom used during winter. Similarly, a concurrent study on the Kansas River suggests that shovelnose sturgeon use rocky substrates during the fall and summer. Differences in substrate use are probably due to higher benthic invertebrate productivity in larger substrates compared with shifting-sand substrates (Allan 1995). During the winter, shovelnose sturgeon are probably not actively feeding and substrate use probably reflects this behavior.

Bramblett (1996) found that shovelnose sturgeon used depths varying from 0.9 to 8.8 m in the Yellowstone River, 4.3–10.1 m in the upper Missouri River, and 1.2–5.8 m in the Missouri River upstream from Lake Sakakawea. In the upper Mississippi River most fish have been located at depths between 4 and 6 m (Hurley et al. 1987; Curtis et al. 1997). Similarly, surface current velocities as low as 0.01 m/s and as high as 2.16 m/s have been reported at shovelnose sturgeon locations (Bramblett 1996; Curtis et al. 1997). The variation in these results suggest shovelnose sturgeon are not seeking specific depths or surface velocities.

Bramblett (1996) described winter movement of shovelnose sturgeon in the Missouri and Yellowstone rivers and reported that movement in winter was less than during spring, summer, and fall. Across their range, shovelnose sturgeon are capable of rapid, long-distance movements (Moos 1978; Berg 1981; Hurley et al. 1987), but limited movement is most typical of the species (Helms 1974; Hurley et al. 1987). Our data suggests that shovelnose sturgeon are relatively sedentary during the winter months, but they do not congregate in deep pools, as we had hypothesized.

Discharge and habitat are dissimilar in the Yellowstone, Missouri, Mississippi, and Kansas rivers. The Yellowstone, Missouri, and Mississippi rivers typically have higher discharge (Hurley et al. 1987; Bramblett 1996) than the Kansas River. In the Yellowstone, unchannelized Missouri, and Kansas rivers, the habitat is heterogeneous (Moos 1978; Bramblett 1996) compared with the upper Mississippi and lower Missouri rivers where natural habitat complexity has been modified (Funk and Robinson 1974; Hurley et al. 1987; Curtis et al. 1997). Despite these differences in discharge and habitat, shovelnose sturgeon tend to use similar habitat regardless of season, indicating that management of shovelnose sturgeon may be relatively similar among large river ecosystems.

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