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Short Research Note

Habitat use of juvenile white sturgeon in the Kootenai River, Idaho and British Columbia

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Abstract

Ultrasonic telemetry was used to assess habitat features utilized by 36 endangered juvenile white sturgeon, *Acipenser transmontanus*, in the lower 120 km of the Kootenai River of Idaho, USA and British Columbia, Canada during the summer and early fall of 1999 and 2000. All 36 fish were initially captured in pools using gillnets and released there, but most of the subsequent telemetry contacts were in glides, indicating these fish moved freely between the two macro-habitats. The low electivity indices indicated little preference between glides and pools. Most contacts were in glides, in the outside bend of the river channel (50%), and in or near a visually defined thalweg. Contacts were most often associated with sand substrates and no cover. Physical habitat characteristics (nose [bottom] water velocity, depth, substrate, and cover) were recorded at 168 contact locations. The combination of significantly greater velocities and depths at contact sites vs. non-contact sites ($p < 0.01$) indicated these fish actively found and used areas of higher velocity and greater depth within the Kootenai River. There was little cover found for fish in the river other than large sand dunes and depth. The combination of depth and nose velocity data supported the idea that large sand dunes are providing refugia in the form of velocity breaks.

Introduction

The stock of white sturgeon, *Acipenser transmontanus*, native to the Kootenai River drainage of Montana and Idaho, USA and British Columbia, Canada (Brown, 1971) has been geographically isolated from other stocks since the end of the last ice age (Northcote, 1973). This isolation combined with lack of recruitment, threats from reduced biological productivity, poor water quality and toxic contamination from mining contributed to the stock being listed as an endangered species in 1994 (US Fish and Wildlife Service, 1994).

Studies in the Columbia, Snake, and Fraser rivers have documented juvenile white sturgeon using sand bottoms in or near the thalweg, as well as off-channel habitats. Juvenile white sturgeon in the lower Columbia River, USA have been documented to prefer sand bottoms in the thalweg, in depths of 2–58 m (Parsley et al., 1993). Sampling adjacent to the thalweg in shallow waters resulted in few juveniles being captured, but both juveniles and adults may make feeding forays from the deep thalweg into the adjacent shallow areas (Parsley et al., 1993). In the Snake River, Coon (1978) captured juveniles in sandy areas, and Lepla (1994) found sand to be the most commonly used substrate, although larger substrates were also present where sand was dominant. Studies in the Fraser River, Canada have confirmed the use of sloughs and backwaters during the summer months by juvenile sturgeon (Echols, 1995).

In the spring of 1991, the Kootenai Tribe of Idaho began operating the Experimental White Sturgeon Facility in Bonners Ferry, Idaho (Bonneville Power Administration, 1997; Ireland et al., 2002). Hatchery-reared juvenile white sturgeon have been marked by scute removal, and by Passive Integrated Transponder (PIT) tagging, which has allowed identification of year class, family, and hatchery origin (Kincaid, 1993; Bonneville Power Administration, 1997; Ireland, 2000). Fish directly from the hatchery, hatchery-reared fish captured in the river, and wild fish have therefore been available to study and evaluate habitat features used by juvenile white sturgeon. Knowledge of habitat use by immature white sturgeon is important for their recovery.

It was hypothesized that Kootenai River juvenile white sturgeon used sand bottoms in the thalweg, as juvenile white sturgeon have been shown to do in the Snake River (Coon, 1978; Lepla, 1994) and Columbia River (Parsley et al., 1993). The specific objective of this study was to determine habitat features used by juvenile wild and hatchery-reared white sturgeon in the Kootenai River.

Description of sites studied

Habitat features used by juvenile fish were investigated in the area downstream from Bonners Ferry, Idaho to the delta of Kootenay Lake, near Creston, British Columbia (Fig. 1). This sinuous section of river flows approximately 120 km, and is characterized by sandy substrates, and deep (>30 m) pools connected by long, deep (>7 m), relatively straight sections connecting pools hereafter referred to as glides.

Materials and methods

Fish capture and tagging

During July and August 1999, and July 2000, white sturgeon were captured using experimental gillnets. The nets were placed perpendicular to the thalweg and allowed to fish for approximately 1 h. Captured fish were identified as juveniles based upon the range of lengths identified by Parsley et al. (1993) in the Columbia River (150–1030 mm FL). Captured fish were checked for evidence of prior PIT tagging and marking by scute removal. Fish lacking a PIT tag and possessing all scutes were assumed to be wild. Data recorded for each fish were capture location, total length (mm), fork length (FL; mm), and weight (g).

Forty-two juvenile fish were captured in pools and externally fitted with ultrasonic transmitters. Twenty-one fish were tagged with transmitters in

Figure 1. Map of study area.

each year of the study. Only two wild fish were tagged, both in 1999. The tagging of only two wild fish did not allow comparisons to be made between wild and hatchery-reared fish.

The method of external attachment was the same for both years, but transmitter size differed between years. Smaller transmitters were used in 2000 due to the difficulty of obtaining fish large enough to tag to meet the 2% rule (Winter, 1996) in 1999. After being fitted with a transmitter all puncture wounds were treated with a topical antiseptic and the fish was allowed to recover in a tub of water before release.

After release, tagged fish were contacted from a boat using a directional hydrophone and receiver. The use of a directional hydrophone allowed the fish's position to be triangulated. At the triangulated point the signal should be omnidirectional and was verified using the hydrophone. An omnidirectional signal indicated the boat was less than 4 m from the fish (Winter, 1996).

The boat was anchored over each telemetry contact using multiple anchors allowing for precise positioning of the boat. After the boat was securely anchored, the river kilometer (to the nearest 0.1) and habitat features (macro-habitat type, river position, depth and velocity) were recorded.

Habitat features

At each contact point in the river, the channel location was identified as either a pool or glide macro-habitat. Fish were not contacted in any other type of macro-habitat. Identification of the contact longitudinally allowed comparisons of macro-habitat features such as electivity to be made.

The contact site, or fish position (FP) was identified as outside bend, middle, or inside bend and habitat measurements were taken at the contact site, as well as in the other two thirds of the river (non-contact sites). Depth, nose velocity, substrate and cover were recorded in each third of the river. When FP was associated with the thalweg it was also noted. Means and variances of habitat characteristics were tested for significance ($\alpha = 0.05$) by year, macro-habitat, and FP using a *t*-test.

Depth and velocity measurements were obtained using a suspension system attached to the front of the boat. Depth measurements were obtained from the sounding reel and measured to the nearest 0.03 m. Velocity measurements were obtained from a meter attached to the sounding reel. Velocities (m s^{-1}) were taken at the bottom, $0.2 \times$ depth and $0.8 \times$ depth. If no velocity was obtained from the meter after two attempts of 180 s duration, the velocity was recorded as zero.

Substrate and cover were classified into nine categories (Table 1). Substrate and cover values were assessed with SCUBA dives or underwater videography. Logistical constraints often lead to substrate and cover values being recorded on different days than depth and velocity measurements. SCUBA diving was used primarily in 1999, but hazardous diving conditions and lack of suitably experienced diving partners lead to the adoption of underwater videography in 2000.

Substrate and cover data was obtained from a transect perpendicular to the thalweg. The divers

Table 1. Categories and values of habitat features recorded from SCUBA dives and underwater videography

Category	Value
Substrate	1. Plant detritus
	2. Clay/silt/mud
	3. Sand (0.06–2 mm)
	4. Small gravel (3–25 mm)
	5. Gravel (26–75 mm)
	6. Sm. cobble (76–150 mm)
	7. Lg. cobble (151–300 mm)
	8. Boulder (>301 mm)
	9. Bedrock
Cover	1. No cover
	2. Rock
	3. Velocity break
	4. Sub. logs and root wads
	5. Canopy
	6. Undercut bank
	7. Wood and brush
	8. Turbulence
	9. Sub. non-woody vegetation
Embeddedness	
	1. 0–25%
	2. 26–50%
	3. 51–75%
	4. 76–100%

either crawled across the bottom or the boat dragged the camera along the bottom and values were recorded for each third of the river.

The usage of glides and pools by juvenile sturgeon in relation to availability of these macro-habitats was evaluated with Ivlev's electivity index (Ivlev, 1961). The index, described by Strauss (1979) as the degree of selection, was expressed as $E = (r_i - p_i) \times (r_i + p_i)^{-1}$, where E is the measure of electivity, r_i is the percentage macro-habitat type associated with telemetry contacts, and p_i is the percentage of the same macro-habitat type found in the environment. The index yields values between −1 and 1, where negative values indicate avoidance or inaccessibility, positive values indicate active selection, and zero indicates random selection (Ivlev, 1961; Strauss, 1979). Macro-habitat availability data used to calculate the electivity index for macro-habitat had previously been collected in another study as part of habitat mapping in the river (MFWP, unpublished data).

Results

Fish capture and tagging

Fish tagged in 1999 had a mean length of 612.2 mm FL and a mean weight of 1531 g. Fish tagged in 2000 were significantly smaller ($p < 0.05$) than in 1999 with a mean length of 459.0 mm FL and a mean weight of 638.0 g.

Thirty-six of the 42 tagged fish were contacted at least once during the study for a total of 168 contacts. Ninety-seven contacts were made in August and September of 1999, and 71 contacts were made in July and August of 2000. Only one of the wild fish tagged was contacted.

Habitat features

Macro-habitat

Of the 168 contacts, 59.5% were located in glides and 40.5% were in pools.

For habitat selection, electivity for glides was only slightly positive (0.02), as was that for pools (0.12). No selection for or against glides or pools was found.

Fish position in channel

The outside bend was the most common location of a contact (50.0%) followed by the middle of the river (27.4%) and the inside bend (22.6%). The pattern of most contacts in the outside bend followed by the middle and inside bend was found in both glides and pools. Just over half (52.4%) of all contacts were associated with a visually definable thalweg.

Depth

Fish were contacted over wide range of depths. Mean, minimum, maximum and 95% confidence interval values for contact depths are shown in Table 2. Mean depth was significantly greater ($p < 0.01$) in 1999 than in 2000 and significantly greater ($p < 0.01$) in pools than in glides. Mean telemetry contact depth was significantly deeper ($p < 0.01$) in outside bend FP than inside bend FP. Mean telemetry contact depth was significantly greater ($p < 0.01$) in middle FP than inside bend FP ($p < 0.01$), but not significantly different between outside bend FP and middle FP

Table 2. Macro-habitat descriptive statistics for depth (m), nose velocity (m s^{-1}), mean water column velocity (m s^{-1}), substrate, cover and fish position in the river channel

	Glide	Pool	All
Depth[a] (m)	10.03	13.68	11.51
	(3.11–20.15)	(3.11–23.01)	(3.11–23.01)
	(9.3–10.8)	(12.8–14.7)	(10.9–12.1)
Nose velocity[a] (m s^{-1})	0.20	0.14	0.17
	(0.0–0.52)	(0.0–0.35)	(0.0–0.52)
	(0.18–0.22)	(0.12–0.16)	(0.16–0.19)
Mean velocity[a] (m s^{-1})	0.21	0.15	0.19
	(0.03–0.47)	(0.0–0.40)	(0.0-0.47)
	(0.20–0.23)	(0.13–0.18)	(0.18-0.20)
Substrate[b]	Sand	Sand	Sand
Cover[b]	No cover	No cover	No cover
Fish position in Channel[b]	Outside bend	Outside bend	Outside bend

Telemetry contacts were grouped according to macro-habitat type.

[a] The first value is the mean, the second is the range and the third is the 95% confidence interval.

[b] The modal observation.

($p > 0.01$). Mean depth for all contacts was 11.5 m.

Nose velocity

Contacts had a wide range of nose velocities, and differed significantly between macro-habitats and FP. Mean, minimum, maximum and 95% confidence interval values for contact nose velocities are shown in Table 2. Nose velocity did not differ significantly ($p > 0.01$) between 1999 and 2000. Nose velocity was significantly greater ($p < 0.01$) in glides than in pools. Nose velocity was significantly lower ($p < 0.01$) in the outside bend FP than middle FP, and inside bend FP. Nose velocity did not differ significantly between middle and inside bend FP ($p > 0.01$). Mean nose velocity for all contacts was 0.17 m s^{-1}.

Substrate

Tagged fish were contacted over six substrate types. Of the 168 contacts, most were associated with sand (61.3%) followed by, clay/silt/mud (25.6%), small cobble (7.7%), large cobble (3.0%), gravel (1.2%), and boulder (1.2%). In glides most contacts were associated with sand substrate (68%), followed by clay/silt/mud (17%), small cobble (13%), gravel (1%), and large cobble (1%). In pools, the majority of contacts were associated with sand substrate (51.5%), followed by clay/silt/mud (38.2%), large cobble (5.9%), and boulder (2.9%).

Cover

Tagged fish were contacted over six cover types. There was often more than one cover type associated with a contact, resulting in 220 cover values being recorded at the 168 contact locations. A contact was most often associated with no cover (41.8%), followed by a velocity break (29.5%), submerged logs and root wads (9.0%), rock (7.7%), wood and brush (6.0%), and submerged non-woody vegetation (6.0%). In glides, a contact was most often associated with no cover (46.0%), followed by a velocity break (28.6%), rock (8.7%), submerged logs and root wads (7.9%), wood and brush (5.6%), and submerged non-woody vegetation (3.2%). In pools, a contact was most often associated with no cover (36.2%), followed by a velocity break (31.9%), submerged non-woody vegetation (14.9%), submerged logs and root wads (10.6%), and rock (6.4%).

Discussion

Fish capture and tagging

The number of wild fish captured during this study supports the lack of recruitment to the stock as cited in the listing of the species (US Fish and Wildlife Service, 1994). Three wild fish were captured; two were large enough to tag. The scarcity of wild fish in this study did not permit us to assess if a difference in habitat use existed between wild and hatchery-reared fish.

Eight of the forty-two tagged fish were never contacted after release. The reasons for this absence of contacts are unknown. All transmitters were tested for proper functioning at the time of release, so it is possible that they failed shortly after being deployed. Another possibility is the fish traveled far down river rapidly after tagging and entered Kootenay Lake. After reaching the lake the fish could easily enter water too deep to receive a signal and/or swim out of the area that was regularly monitored.

Habitat features

Results from this study support the hypothesis that Kootenai River juvenile white sturgeon use sand bottoms in the thalweg. In this study, the majority of contacts were in glides, in the outside bend of the river, in the thalweg and over a sand substrate with no cover. In two studies in the Snake River, Idaho small sturgeon were commonly found in areas with sand being the dominant substrate (Coon, 1978; Lepla, 1994). High catch rates of small sturgeon were associated with the thalweg (Lepla, 1994). In the lower Columbia River Parsley et al. (1993) reported nearly all juvenile sturgeon were captured over a sand substrate. The use of sand dominated bottoms and the thalweg by juvenile Kootenai River white sturgeon thus agrees with the findings of researchers in the Snake and Columbia rivers.

As noted above, most contacts were in glides in the outside bend of the river, in the thalweg and over a sand substrate with no cover. Fish were contacted throughout all areas of the river, however. All fish were captured in pools, but the majority of contacts were in glides. The movement of fish freely between pools and glides indicates a high tolerance by the sturgeon for different habitat types and conditions in the Kootenai River.

Mean values for nose velocities used by Kootenai River white sturgeon were typically in the lower half of the range reported for juvenile sturgeon in the lower Columbia River (Parsley et al., 1993). Kootenai River fish were contacted in nose velocities of 0.0–0.52 m s^{-1}, whereas Parsley et al. (1993) reported a range of near substrate velocities (comparable to nose velocities) of 0.1–0.8 m s^{-1}. The difference may merely reflect availability.

The high percentage of contacts associated with the outside bend and thalweg indicate juvenile white sturgeon are actively seeking and using deep areas of the Kootenai River. Depth was significantly greater ($p < 0.01$) in outside bend FP than middle and inside bend FP and mean depth at outside bend and middle FP was significantly greater ($p < 0.01$) than mean depth at non-contact sites. Outside bend contacts had the greatest depths, but had lower velocities than middle or inside bend contacts. These results suggested that depth may be more important to these fish than velocity.

The significant yearly difference in mean contact depth ($p < 0.01$) is the result of extensive water releases from Libby Dam in 1999. There was significantly more ($p < 0.01$) water released from the dam in 1999 than in 2000, over the period of June 1 through September 30. The fish were using the same areas of the river in 1999 and 2000, but there was significantly less water in the river in 2000.

Although micro-habitat variables were recorded during this study, electivity for micro-habitat type could not be determined. The total amount of micro-habitats available for use of each substrate and cover type as well as the range of available velocities was not known. As a result it was not possible to determine if these fish were selecting for the observed combination of macro-habitat, river channel position and micro-habitat. It is possible these fish are forced to use this combination of habitat conditions due to the relatively homogenous sandy river bottom.

In the Kootenai River, little cover was available for these fish other than depth and large sand dunes. Although no fish were observed using sand dunes during dives or with videography, the contact depth, nose velocity data and observations made during dives suggest the large dunes are providing refugia in the form of velocity breaks. Velocity breaks are created as water accelerates over the crest of the sand dune and decelerates over the trough resulting in velocities typically one half to one third the mean river velocity (Shen, 1971).

At contact sites, nose velocity was significantly less ($p < 0.01$) in outside bends than middle or inside bends. This result can be attributed to fish utilizing velocity breaks in or near the thalweg. Other possible explanations of this behavior are that juvenile fish may be using velocity breaks for energy conservation and or feeding areas. The feeding ecology and diet of juvenile white sturgeon was described in two studies in the Columbia River (McCabe et al., 1993; Sprague et al., 1993); however, no literature was found to support or refute the use of velocity breaks as part of a feeding strategy. Energy conservation and feeding were not studied in this project, but should be investigated in future studies.

The results of this study contribute to the knowledge of the ecology of the endangered Kootenai River white sturgeon and support the findings of researchers in the Snake and Columbia rivers. Further detailed studies on feeding ecology and diet as well as accurate estimates of percentage of micro-habitats available for use, to permit electivity indices to be generated, would further the knowledge of the ecology of this endangered stock.

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