Seasonal Paddlefish (*Polyodon spathula*) Movements and Habitats in Upper Mississippi River Pool 5A

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INTRODUCTION

Certain Wisconsin and Minnesota rivers contain paddlefish (*Polyodon spathula*) populations that may represent the northern-most limit of this species distribution in North America. The paddlefish is an interjurisdictional species that is currently classified as threatened in both Minnesota and Wisconsin. Little is known of the movements or the characteristics of habitats utilized by paddlefish populations throughout its present range. Moreover, the construction of the upper Mississippi River (UMR) lock and dam system in the 1930s imposed a series of artificial barriers that may limit intrinsic movements of paddlefish.

A Habitat Rehabilitation and Enhancement Project (HREP) has been proposed for UMR Pool 5A that would include the construction of an island complex in the open waters of Polander Lake, an impounded backwater, to reduce wind-generated wave action and promote the development of rooted emergent vegetation. Paddlefish are known to utilize backwater habitats (Stockard 1907, Wagner 1908, Rosen et al. 1982, Southall and Hubert 1984) and sustained incidental catches of paddlefish have been reported by commercial fishermen working in portions of Polander Lake. A radio telemetry study of paddlefish movements and habitat use in Pool 5A was begun in late 1994 to aid in assessing the impact of proposed island construction and maintenance activities on resident paddlefish.

Initial findings from the first full year of the study (1995) suggested the proposed islands, with some minor design modifications, would not adversely impact paddlefish (U.S. Fish and Wildlife Service 1996). Moreover, island construction and maintenance operations in Polander Lake could perhaps be designed to increase the amount of a preferred type of paddlefish habitat (deep-water) provided that the pre-construction hydraulic circulation and flow patterns in the lake remain unchanged. To facilitate continued planning for the proposed project, we continued our netting and radio tracking operations in 1996 to expand the data base on seasonal movements and habitats (location and physical characteristics) of paddlefish in UMR Pool 5A. This report summarizes the cumulative data we have collected during more than 2 years of study (September 1994 - December 1996).

MATERIALS AND METHODS

Most of the 1996 effort to net paddlefish occurred in the lower reaches of Polander Lake (where we were most successful in 1995) during the open water season (April-October). This included one location adjacent to the Minnesota mainland shore and upstream of the spillway and another adjacent to the island shore separating the lake from the navigation channel (Fig. 1; Table 1). We also sampled the open waters of the lake (near the proposed HREP islands) in summer and Straight Slough, a backwater channel flowing into the lake, in summer and fall. Passive entanglement gear was used and typically consisted of a large mesh monofilament gill net (102-152 mm stretch measure) deployed in lengths of 30-100 m on the lake bed. A net 30.5 m in length set for 1 h was selected as the standard unit of fishing effort. Each paddlefish captured was weighed, measured (body length), and tagged with a uniquely numbered external Monel jaw band, as well as a subcutaneous binary coded microwire placed in the anterior dorsal tip of the rostrum, before it was released back into the lake (i.e., no radio transmitters were implanted in 1996).

The locations of five paddlefish (Table 2) that contained radio transmitters (49 mHz band) which we surgically implanted in 1994-95 were determined periodically (e.g., daily, weekly, or bimonthly) throughout the year by standardized radio telemetry procedures. The general location of each fish was typically determined from a boat using a frequency scanning receiver (Advanced Telemetry Systems, Isanti, MN) turned to full gain coupled with a yagi antenna. Once a strong audible signal was received with this initial array of equipment, a short strand of uninsulated metal wire (e.g., a paper clip) replaced the yagi antenna to aid in pin-pointing the location of the fish. Based on trials made with this second array of equipment, the location where an audible signal is received (at a volume setting < 50% of maximum) is generally within 10 m of the transmitter. Universal transverse mercator (UTM) coordinate data were collected at the location nearest each fish with a military-type global positioning system

(GPS) receiver (PLGR+96, Rockwell International, Cedar Rapids, IA) using wide area GPS enhancements (accuracy within 8 m). UTM positions of fish were subsequently transcribed into an electronic (ASCII) data format, proofed to assure transcription accuracy, and plotted on a geographical information system (GIS) land-water coverage map of Pool 5A using ArcView software (Environmental Systems Research Institute, Redlands, CA).

Flights over the UMR were also made on several occasions to more efficiently locate fish within large search areas. A one-quarter wavelength or wing-mounted loop antenna was used on these flights. Paddlefish locations were estimated by audible signal strength, marked on river navigation maps, and later plotted on GIS coverages to obtain approximated corresponding UTM coordinate data.

Several habitat characteristics were evaluated throughout the year at sites where paddlefish were located. These included water depth, dissolved oxygen concentration, temperature, and current velocity measured near the surface, the bottom, and at a mid-depth location in the water column. Dissolved oxygen and temperature were measured with a Yellow Springs Instrument model 57 meter (Yellow Springs, OH) following field calibration. Current velocity was measured with a Marsh-McBirney Flo-mate model 2000 meter (Frederick, MD). Probes for both meters were deployed from a cable with a diving weight attached to help maintain a vertical alignment in the water column. A bottom grab sample was also collected at each site with a ponar dredge to categorize the textural composition of the substrate. Field collected data were transcribed to an electronic (ASCII) format and proofed to assure transcription accuracy.

Results of the netting and radio telemetry operations were used to identify specific locations of different riverine habitats (Wilcox 1993) frequented by paddlefish in Pool 5A. All records (dating back to the inception of this study in fall 1994) of the occurrences of radio implanted paddlefish in each habitat type were identified to prepare seasonal summaries of mean physical habitat characteristics. Seasonal differences in characteristics between habitats were evaluated by a one-way analysis of variance (ANOVA; $p < 0.05$) and Tukey's method of multiple comparisons (∀ = 0.05) if there were ∃ 3 observations per habitat.

RESULTS AND DISCUSSION

Netting

A total of 223 units of fishing effort resulted in the capture of 9 paddlefish at two different netting sites during 1996 (Fig. 1; Table 1, 3). This represented about a 40% decrease in sampling effort with a 100% increase in catch per unit effort for the same sites sampled in 1995. Seasonal effort at most sample sites was greatest during the summer and cumulative effort for the year was greatest at shoreline sites around Polander Lake (mainland channel > island hole). Catch per unit effort (CPUE) was small (# 0.02) and remained nearly unchanged throughout the year at all sites except the mainland channel where it decreased incrementally from spring (0.18) through fall (0.00). The mean body length (front of eye to caudal fork) and weight of paddlefish captured in 1996 was 875 mm (range 700-1175) and 12.5 kg (range 6.6-20.7), respectively.

All 21 paddlefish we have tagged since 1994 in Pool 5A were initially captured in deep (> 2 m) locations along opposite shores of Polander Lake (15 in the mainland channel and 6 near the island hole) and all but four were captured during the spring and summer. Ten lake sturgeon (*Acipenser fulvescens*), a species of special concern in both Minnesota and Wisconsin, were also captured coincidentally during 1996 paddlefish netting operations, marked with a Monel self-piercing dorsal fin tag, and released (Table 4). Similar to the paddlefish, all but one of the 21 lake sturgeon caught to date in this study were taken at the shoreline sampling locations around Polander Lake during spring and summer. These netting results suggest the seasonal importance of deep (> 2 m) backwater holes and channels in Polander Lake, as well as other impounded UMR backwaters in Minnesota and Wisconsin, for spawning and growth of these state-listed threatened and special concern species.

Radio telemetry

Paddlefish implanted with radio transmitters in UMR Pool 5A have ranged throughout the length of this impoundment (12.2 km) and used a diverse range of seasonal habitats since 1994-95 (Fig. 2-6; Tables 5-8).

Cumulative telemetry observations indicate backwater habitats with channels and holes are preferred by most of these fish during the majority of each season and account for 53% of all our observations. The two primary backwater channels used by paddlefish were located in Polander Lake near (1) the mainland shore and (2) the passageway leading to the Minnesota City Boat Club harbor. These channels may serve as primary corridors for paddlefish movement within the lake. The two primary backwater holes used by paddlefish were located (1) near the island separating Polander Lake from the main channel and (2) in the Minnesota City Boat Club harbor. The consistent observations of one certain paddlefish in the Minnesota City Boat Club channel and harbor areas throughout most of the summer each year are quite striking given the far ranging movements of this individual in Pool 5A since 1994 (Fig. 6). Pool water levels generally recede during the summer and sustained periods of low water throughout much of this warm season may attract paddlefish to several deep locations near the perimeter of Polander Lake where hydrologic flow patterns may enhance the delivery of food items from throughout the large impoundment.

Observations of paddlefish in main channel and channel border habitats ranked second to that in backwater channels and holes from fall through spring and accounted for about 26% of our observations during these seasons. Successive observations of several paddlefish (including some radio tagged for similar studies in UMR tributaries up- and downstream of Pool 5A; Fig. 7, 8) at distant main channel and channel border locations during spring (Fig. 3-6) suggest that this contiguous anastomosed habitat complex is the primary corridor for rapid long range movements that may be associated with both inter- and intrapool spawning activities. Meanwhile, no fish were observed in main channel and channel border habitats during summer and only one individual frequented this habitat in winter (Fig. 6). Water levels in temperate regulated rivers like the UMR commonly approach an annual low during prolonged periods of temperature extremes in winter and summer and an annual high in spring when rainfall is accompanied by snowmelt runoff. These patterns of hydraulic flux may be a contributing environmental factor (along with intrinsic biological factors) that could limit the range of paddlefish movements in Pool 5A among fewer suitable habitats during winter and summer than in spring and fall.

The tailwater below Lock and Dam 5 was used by paddlefish throughout the year. The tailwater was a preferred habitat for one individual during much of the year (Fig. 4) while other radio tagged paddlefish were observed here during April and May (Fig. 5, 6). These observations were preceded by upstream movements from wintering sites in the lower reaches of the pool and may have been associated with spawning activities. Reception of radio signals emitted by fish in the tailwater habitat is relatively poor, compared to that in most other habitats, when tracking by boat. The attenuated signal is likely due to the depth of the fish and the random mixing of the highly turbulent water in this area. This combination of factors precludes our locating a fish precisely within the tailwaters area and limits our observations of habitat characteristics here as well. Despite this shortcoming, the upstream interpool movements of at least two radio tagged paddlefish in spring 1996 (49.720 and 49.190, Fig. 3 and 7, respectively) indicate the tailwaters may act in spring as a staging area for some fish until conditions (e.g., discharge, dam gate positioning, lock access) are suitable for continued upstream movement.

Sites in the shallow open waters of Polander Lake were used infrequently by most radio tagged paddlefish (Fig. 2-6). Most of these observations occurred in spring and summer and accounted for about 12% of seasonal totals. More than one-half of these sites were near the perimeter of the lake and in the vicinity of deeper habitats, including a closing dam (Fig. 4-6) that could provide suitable spawning substrate for paddlefish. The few remaining open water sites where paddlefish were observed in the lake occurred near the northern and eastern edges of the proposed island complex (Fig. 2, 5, 6). These data indicate that island placement in this location is not anticipated to displace resident adult paddlefish from a significant portion of its preferred habitats in Pool 5A.

Habitat characteristics

Seasonal comparisons of mean physical characteristics among habitats occupied by paddlefish indicated a high degree of similarity regarding water column temperatures and dissolved oxygen concentrations throughout the year for most sites (Tables 5-8). Mean seasonal water temperature and dissolved oxygen concentrations at these sites generally ranged 22.2-23.7EC and 6.8-8.7 mg/L in summer, 12.4-14.5EC and 9.7-10.5 mg/L in fall, 0.0-0.6EC and 11.7-14.8 mg/L in winter, and 7.7-14.5EC and 8.6-12.1 mg/L in spring, respectively. Water temperature and dissolved oxygen concentrations were both substantially reduced in the mid and lower portions of the water column at the Minnesota City Boat Club harbor during summer when stratification occurs in this deep, sheltered location. Mean seasonal depth was significantly different for several of the habitats and generally ranked in the following order (range in parentheses): main channel and channel border (8.8-10.7 m) ∃ tailwater (8.4-8.6 m) >> backwater channels and holes (2.7-3.7 m) ∃ closing dam (1.7-5.0 m) > impounded open water (1.4-1.6 m). Moreover, current velocities in the tailwater, main channel and channel border, and closing dam habitats appeared to be significantly greater (typically ranging 0.3-1.0 m/s) than that in all other habitats (range 0.03-0.20 m/s) throughout most of the year. Substrates in the relatively quiescent habitats where paddlefish were located during the year were judged as primarily composed of silt- and clay-sized particles (diameter < 63 µm) while substrates in the more turbulent habitats were composed of a mixture of sands and either gravel or rock (diameter ∃ 63 µm; Fig. 9).

CONCLUSIONS AND RECOMMENDATIONS

The results we have presented should be interpreted with some caution. Despite the considerable effort to net paddlefish in Pool 5A since 1994, the total numbers of fish captured (21), recaptured (2), and implanted with radio transmitters (5) to assess movements and habitat use are small. In addition, the apparent lack of movement of one fish since November 1995 suggests that this smaller individual may have died or voided the transmitter from its body (Fig. 2). Therefore we can express confidence in the reliability of recent telemetry signals for only four of the five fish originally tagged in Pool 5A. These findings would seem to suggest the size of the resident paddlefish population in Pool 5A may be small. However, the rapid long distance inter-pool movements (upstream and downstream) that we and other paddlefish researchers (Zigler 1996) observed in 1996 indicated paddlefish inhabiting Pool 5A are not isolated and may be closely related to paddlefish that typically reside in other portions of the Mississippi River, as well as the Black, Chippewa, and Wisconsin Rivers. Moreover, the size of the smallest individual we captured in 1996 indicated at least a limited degree of successful paddlefish recruitment from an unknown source that contributes to the Pool 5A population.

Despite the relatively small number of fish we have followed over the past 1-2 years, several general observations can be made regarding habitat use by paddlefish in Pool 5A. Netting and tracking data indicate that deep channels, holes, and submerged structures near the perimeter of Polander Lake provide important habitat for paddlefish throughout much of the year. Main channel and channel border habitat provide corridors for swift, long distance intra- and interpool movements (especially in spring) that may be associated with spawning activities. Navigation locks and dams may impede but do not entirely preclude interpool movements of paddlefish. The tailwaters consequently appear to represent an important habitat (by default) for paddlefish that do not continue to move upstream, particularly during spring spawning season.

The shallow open waters in the mid-region of Polander Lake do not appear to be a preferred habitat of paddlefish in Pool 5A. Therefore, the proposed placement of a ***stable*** island complex in this area is not anticipated to adversely impact paddlefish here. Given the wide ranging movements observed for certain paddlefish, we believe that the design, construction, and maintenance of artificial islands in Polander Lake should be executed in a manner that will insure the continuity of paddlefish passage between adjacent habitat areas. However, to perpetuate a terrestrial environment in the midst of the lake will require adequate consideration of site-specific variables (including but not limited to pedological, hydrological, meteorological, and biological factors) to prevent natural forces from eroding and transporting island fill materials to depositional sites such as the backwater channels and holes that are preferred habitats for paddlefish. Moreover, pre-existing hydrologic patterns, bathymetric profiles, and substrate composition in other portions of the lake that have been identified as paddlefish habitat should not be significantly altered as a consequence of island construction and maintenance activities. In addition, the protocol for evaluating and ranking proposed dredge sites for island fill materials should include an appraisal of opportunities to create deep (> 2 m) backwater holes to enhance paddlefish habitat in Pool 5A.

Given the anticipated 1-2 year remaining life expectancy for each of the radio transmitters in use, the small number of fish being monitored, and the wide ranging movements we have observed for these fish since 1994, we recommend continued tracking of these fish throughout the broadcast life of each transmitter to better describe and identify seasonal movements and habitats utilized by paddlefish in UMR Pool 5A and adjacent impoundments. For example, adult paddlefish do not reproduce every year. When a paddlefish is sexually mature, it still may not spawn if one of several environmental cues (e.g., increasing photoperiod, water temperature, flow) is lacking or insufficient. Therefore, tracking the same fish over several consecutive years will help to increase the probability of observing spring movements and habitat use that may correspond with actual spawning activity. This may require more frequent (e.g., daily or diel) monitoring of radio implanted fish in the upcoming field season. These additional data will also be useful in evaluating paddlefish movements and habitat use in Pool 5A following island construction in Polander Lake. Finally, continued netting efforts could also help to identify other preferred habitats of adult and juvenile paddlefish in Pool 5A.

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REFERENCES

Rosen, R.A., D.C. Hales, and D.G. Unkenholz. 1982. Biology and exploitation of paddlefish in the Missouri River below Gavins Point Dam. Trans. Am. Fish. Soc. 111:216-222.

Stockard, C.R. 1907. Observations on the natural history of *Polyodon spathula*. Am. Nat. 41(492):753-766.

Southall, P.D. and W.A. Hubert. 1984. Habitat use by adult paddlefish in the upper Mississippi River. Trans. Am. Fish. Soc. 113:125-131.

U.S. Fish and Wildlife Service. 1996. Identification and characterization of seasonal paddlefish (*Polyodon spathula*) habitats in Upper Mississippi River Pool 5A. La Crosse Fishery Resources Office, Onalaska, WI. 16 pp. + 11 figures.

Wagner, G. 1908. Notes of the fish fauna of Lake Pepin. Trans. Wis. Acad. Sci. Arts Lett. 16:23-37.

Wilcox, D.B. 1993. An aquatic habitat classification system for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, WI. EMTC 93-T003. 9 pp. + Appendix A.

Zigler, S. 1996. U.S. Geological Survey, La Crosse, WI.; unpublished data.

Table 1. Standard units of fishing effort‡ for paddlefish at sample sites in UMR Pool 5A during 1996 by season.

Season(s)	Sample site(s)				
	Polander Lake				
	Mainland channel	Island hole	Open water	Straight Slough	All
Spring†	27.5	41.0	0.0	0.0	68.5
Summer††	47.3	44.0	4.4	9.0	104.7
Fall†††	13.7	26.3	0.0	9.8	49.8
All	88.5	111.3	4.4	18.8	223.0

‡One unit of effort is equivalent to a net 30.5 m in length set for 1 h.

†April and May.

††June, July, and August.

†††September and October.

Table 2. Paddlefish captured in UMR Pool 5A and implanted with radio transmitters.

Capture		Paddlefish			Radio frequency (mHz)
Date	Location (river mile)	Body length (mm)	Weight (kg)	Sex	
26 May 95	728.7[†]	670	6.0	?	49.310
3 Aug 95	729.1[‡]	1105	21.6	%	49.720
9 May 95	728.7[†]	1000	16.8	?	49.730
19 May 95	728.7[†]	930	19.0	&	49.740
9 Sep 94	729.1[‡]	990	23.5	?	49.790

[†]Near channel along south (mainland) shoreline of Polander Lake

[‡]Near hole along south (mainland) shoreline of island separating Polander Lake and main channel.

Table 3. Paddlefish catch per unit effort[‡] at sample sites in UMR Pool 5A during 1996 by season (number of fish captured in parentheses).

Season(s)	Sample site(s)				
	Polander Lake				
	Mainland channel	Island hole	Open water	Straight Slough	All
Spring[†]	0.18 (5)	0.02 (1)	0	0	0.09 (6)
Summer[††]	0.04 (2)	0.02 (1)	0	0	0.03 (3)
Fall	0	0	0	0	0
All	0.08 (7)	0.02 (2)	0	0	0.04 (9)

[‡]One unit of effort is equivalent to a net 30.5 m in length set for 1 h.

[†]April and May.

[††]June, July, and August.

[†††]September and October.

Table 4. Lake sturgeon catch per unit effort[‡] at sample sites in UMR Pool 5A during 1996 by season (number of fish captured in parentheses).

Season(s)	Sample site(s)				
	Polander Lake				
	Mainland channel	Island hole	Open water	Straight Slough	All
Spring[†]	0.11 (3)	0.02 (1)	0	0	0.06 (4)
Summer[††]	0.06 (3)	0.05 (2)	0	0	0.05 (5)
Fall	0	0	0	0.10 (1)	0.02 (1)
All	0.07 (6)	0.03 (3)	0	0.05 (1)	0.04 (10)

[‡]One unit of effort is equivalent to a net 30.5 m in length set for 1 h.

[†]April and May.

[††]June, July, and August.

[†††]September and October.

Table 5. Mean physical characteristics of habitats frequented by radio implanted paddlefish in UMR Pool 5A during summer (June-August) 1995-96. Values followed by dissimilar letters indicate a significant difference (ANOVA, $p < 0.05$) among habitats.

			Mean									
				Temperature (EC)			Dissolved oxygen (mg/L)			Current velocity (m/s)		
Habitat	Number of fish*	Number of Occurrences*	Depth (m)	Surface	Mid	Bottom	Surface	Mid	Bottom	Surface	Mid	Bottom
Backwater holes & channels	5	63	3.7 a	23.7 a	23.5 a	22.2 a	8.7 a	7.9 a	6.8 a	0.13 a	0.12 a	0.10 a
Main channel	1	1	--	--	--	--	--	--	--	--	--	--
Tailwater	1	19	8.6 b	23.6 a	23.1 a	23.1 a	8.1 a	8.7 a	8.7 a	0.46 b	0.32 b	0.27 b
Impounded open water	4	10	1.4 c	23.5 a	23.2 a	23.3 a	8.6 a	8.5 a	8.0 a	0.09 a	0.06 a	0.06 a
Closing dam	1	1	1.7†	26.1†	26.1†	26.0†	8.2†	8.2†	8.2†	0.56†	0.49†	0.46†

*Includes telemetry observations from aircraft overflights.

†One observation.

Table 6. Mean physical characteristics of habitats frequented by radio implanted paddlefish in UMR Pool 5A during fall (September-November) 1994-96. Values followed by dissimilar letters indicate a significant difference (ANOVA, $p < 0.05$) among habitats.

Habitat	Number of fish*	Number of Occurrences*	Mean									
				Temperature (EC)			Dissolved oxygen (mg/L)			Current velocity (m/s)		
			Depth (m)	Surface	Mid	Bottom	Surface	Mid	Bottom	Surface	Mid	Bottom
Backwater holes & channels	4	28	3.6 a	14.5 a	13.8 a	13.8 a	10.5 a	10.2 a	10.0 a	0.12 a	0.15 a	0.14 a
Main channel & channel border	3	10	11.7 b	12.4 a	14.1 a	14.0 a	10.4 a	9.7 a	10.2 a	0.70 b,c	0.49 b	0.33 b
Tailwater	2	12	8.4 c	14.5 a	14.5†	14.5†	10.0 a	10.0†	9.8†	1.01 c	--	--
Closing dam	1	1	--	9.9†	9.7†	9.7†	11.0†	11.0†	11.0†	0.39†	--	--

*Includes telemetry observations from aircraft overflights.

†One observation.

Table 7. Mean physical characteristics of habitats frequented by radio implanted paddlefish in UMR Pool 5A during winter (December-February) 1994-96. Values followed by dissimilar letters indicate a significant difference (ANOVA, $p < 0.05$) among habitats.

			Mean									
				Temperature (EC)			Dissolved oxygen (mg/L)			Current velocity (m/s)		
Habitat	Number of fish*	Number of Occurrences*	Depth (m)	Surface	Mid	Bottom	Surface	Mid	Bottom	Surface	Mid	Bottom
Backwater holes & channels	3	10	3.2 a	0.0 a	0.0 a	0.0 a	11.7 a	11.8 a	11.9 a	0.08 a	0.11 a	0.10 a
Main channel & channel border	1	6	10.0 b	0.4 a	0.6 a	0.6 a	14.6 b	14.8 b	14.8 b	0.20 a	0.11 a	0.08 a
Tailwater	2	5	--	--	--	--	--	--	--	--	--	--

*Includes telemetry observations from aircraft overflights.

Table 8. Mean physical characteristics of habitats frequented by radio implanted paddlefish in UMR Pool 5A during spring (March-April) 1995-96. Values followed by dissimilar letters indicate a significant difference (ANOVA, $p < 0.05$) among habitats.

			Mean									
				Temperature (EC)			Dissolved oxygen (mg/L)			Current velocity (m/s)		
Habitat	Number of fish*	Number of Occurrences*	Depth (m)	Surface	Mid	Bottom	Surface	Mid	Bottom	Surface	Mid	Bottom
Backwater holes & channels	4	30	2.7 a	12.9 a	12.4 a	12.8 a	10.8 a	10.8 a	9.9 a	0.16 a	0.16 a	0.13 a
Main channel & channel border	6	23	8.8 b	8.1 a	7.7 a	8.0 a	12.1 a	11.9 a	12.0 a	0.95 b	0.86 b	0.90 b
Tailwater	5	13	--	2.0‡	--	--	12.6‡	--	--	--	--	--
Impounded open water	4	11	1.6 a	14.5 a	14.0‡	18.0†	8.6 a	7.2†	7.2†	0.15 a	0.14‡	0.12‡
Closing dam	2	4	5.0 a	8.0‡	8.2 a	8.0‡	11.4‡	11.7 a	11.0‡	0.04 a	0.03 a	0.03 a
Tertiary channels	1	1	1.5†	--	--	--	--	--	--	--	--	--

*Includes telemetry observations from aircraft overflights.

†One observation.

‡Two observations.