FISHWAY MONITORING AT THE CRAVEN DAM, QU'APPELLE RIVER, SASKATCHEWAN

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Introduction

Fish migrate within and between water bodies seasonally to carry out various life processes such as feeding, avoiding predators, and reproducing.[1] Fish spawning migrations are extensive, sometimes involving dramatic changes in habitat use. Spawning fish often require habitats different from those where they spend much of their time as adults. For example, walleye *(Sander vitreus)* and northern pike *(Esox lucius)* may migrate within lakes, or from lakes into rivers, seasonal streams, and wetlands to seek suitable spawning habitat.[2,3] The initiation of spawning in fish is governed by day length, water temperature,[2] and to some extent, stream flows.

In Saskatchewan, there are many dams, weirs, and poorly designed road crossings constructed within seasonal creeks, streams, and rivers used for spawning by various fish species. These structures alter water flow regimes by constricting flow and creating velocity barriers that may partially impede or completely block fish from reaching habitats critical to fulfill their life processes, especially reproduction.[1] Barriers to fish passage can have negative impacts on fish populations if they block migration routes to and from spawning habitats, especially for rare species and managed game fish populations. Accordingly, all new in-stream structures constructed in Saskatchewan where there are migratory fish species must be designed to appropriately facilitate fish passage as required by the federal *Fisheries Act*. However, it is also important to monitor the effectiveness of structures designed to accommodate fish passage and to ensure that they are functioning as intended.

The Qu'Appelle River system is one of the most important fish-bearing waterways in southern Saskatchewan, and has been subject to many human alterations and disturbances. In 2003, the water control structure in the Qu'Appelle River near the village of Craven was replaced. A fish bypass, or 'fishway,' was constructed in association with the structure to accommodate fish passage. The previous dam at Craven did not have a fishway. The focus of this study was to gain a better understanding of (1) how the new Craven Dam and associated fishway function, (2) the ability of the fish to migrate past the potential barrier, and (3) the behaviours of the fish when they encounter the fishway. This study was a cooperative project between the Saskatchewan Ministry of Environment

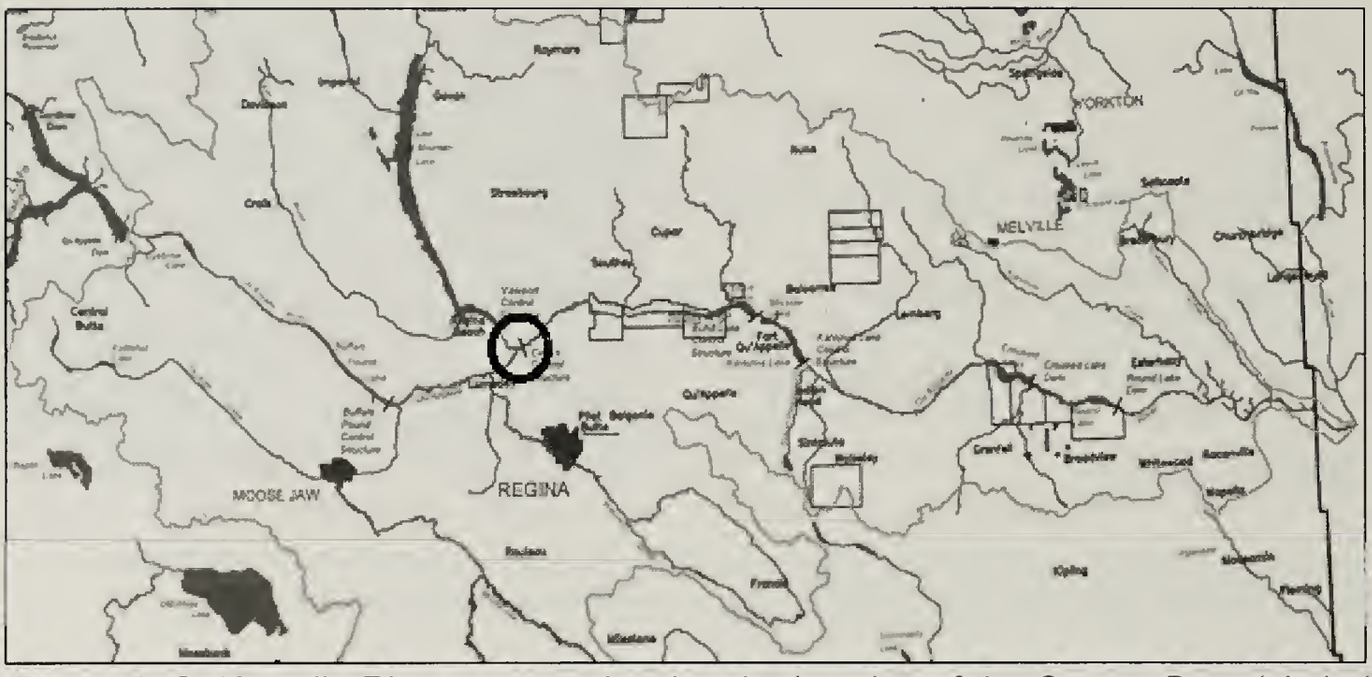

Figure 1. Qu'Appelle River system showing the location of the Craven Dam (circled in black). Map courtesy of the Saskatchewan Watershed Authority.

(MOE), the Department of Fisheries and Oceans (DFO), and the Saskatchewan Wildlife Federation (SWF).

Study Area

The Qu'Appelle River is a major drainage system encompassing approximately 52,000 km^2 in southern Saskatchewan.[4] It originates at Lake Diefenbaker in the west and flows eastward to its confluence with the Assiniboine River near St. Lazare, Manitoba. The watershed contains seven major lakes and two reservoirs and supports a variety of fish species.[5] There are several water control structures on the Qu'Appelle River designed to manage water levels within the watershed, including the dam near Craven, which was the focus of this study.

The present structure of the Craven Dam (currently operated by the Saskatchewan Watershed Authority [SWA]) was built on the Qu'Appelle River just east of the Village of Craven within SW 24-20-21 W2M by Agriculture and Agri-Food Canada (Fig. 1). Construction started in August of 2002 and was operational by the spring of 2003 (C. Lazurko, pers. comm.). The main structure is 28.4 m wide (including the fishway) and is comprised of four gated bays, each gate being 4.5 m wide and 2.15 m high.

An engineered vertical slot fishway was constructed on the north side of the structure adjacent to the river bank to facilitate fish passage around the dam. The fishway is 29.5 m long and 3.6 m wide. There are seven vertical baffles within the structure designed to reduce flow velocities and create refuges for migrating fish. At the upstream end of the fishway there is a gated bay. The gate measures 1.5 × 1.5 m and can be adjusted to regulate flows within the fishway. A steel fish trap can be lowered into the bay to sample fish that have successfully migrated through the fishway for scientific or monitoring purposes.

Manipulation of flows at the Craven Dam allows water managers to release water downstream to Pasqua Lake. It also allows water managers to constrict flow and backflood water into Last Mountain Lake via Last Mountain Creek to maintain lake levels or to use the lake as a reservoir for downstream flood protection. When the dam is open, water drains from Last Mountain Lake and the Qu'Appelle River watershed above the dam.

Methods

Fish Capture and Tagging

To assess fish passage, fish were first captured at the dam site. Fish were captured by two methods: the fish trap at the upstream end of the fishway and by gill nets set for short durations in the Qu'Appelle River on the downstream side of Craven Dam. The fish trap was typically set overnight for an 18- to 24-h period, approximately twice per week from April through June 2009 to capture fish that successfully migrated through the fishway. Trap sets became less frequent in July and August, averaging about one overnight set per week, as fish movement was expected to decrease after spawning was complete. Gill nets were set downstream of the dam for an average of about 2 h per day. Two gill nets were used: one with a 5 cm (2") stretched mesh and the other with a 7.5 cm (3") stretched mesh. Each net was 10 m long by 1.8 m deep. Gill nets were employed to increase the number of fish captured for tagging and to tag fish that may have congregated below the fishway and were unable to migrate past.

Passive Integrated Transponder (PIT) tags were used to assess fish movements through the fishway. These tags contain a microchip encased in glass and do not have an internal power source. A tag works by first using a scanner to send a low-frequency signal (via an antenna) to the microchip within the tag supplying the power needed to send its unique code back to the scanner, providing individual documentation for each fish. PIT tags were implanted into the abdominal cavity of fish. All tagged fish were released downstream of the dam. Prior to their release, the species, fork length, weight, and sex were recorded for each fish. Three antennae were installed at the vertical slot openings of the baffles in the fishway. The first antenna was installed at the baffle in the lower end of the fishway, the second antenna was installed approximately at the mid-point, and the third antenna was installed at the upper end of the fishway at the last baffle before the bay that contained the fish trap. By configuring the antennae in this manner, it could be determined when a fish entered the fishway, how far it moved through the fishway, and how long it remained in the

Table 1. Fish species (with four-letter abbreviation) captured by method.

Common name	Scientific name	Abbreviation	Number of fish captured	
			Trap	Gill Nets
Bigmouth buffalo	*Ictiobus cyprinellus*	BGBF	2	0
Common carp	*Cyprinus carpio*	CMCR	36	0
Lake whitefish	*Coregonus clupeaformis*	LKWH	1	0
Northern pike	*Esox lucius*	NRPK	1	53
Quillback	*Carpiodes cyprinus*	QUIL	2	0
Walleye	*Sander vitreus*	WALL	49	27
White sucker	*Catostomus commersonii*	WHSC	1807	44
Yellow perch	*Perca flavescens*	YLPR	2	0

Table 2. Fish trapped at the Craven Dam fishway. Abbreviations as in Table 1.

Date	Max. daily water temp (°C)	Turbidity (NTU)	Number of fish trapped								
			NRPK	WALL	WHSC	CMCR	BGBF	LKWH	QUIL	YLPR	Total
16-Apr-09	2.46	-									0
22-Apr-09	8.23	-									0
30-Apr-09	6.62	-									0
6-May-09	12.16	-			97						97
7-May-09	11.77	-			97						97
12-May-09	14.47	85		2	230						232
13-May-09	14.09	75		2	222						224
14-May-09	11.77	-		5	91						96
20-May-09	10.99	60		3	100						103
26-May-09	17.14	62		3	300	3	1		1		308
27-May-09	17.90	68	1	6	397	5	1				410
28-May-09	19.42	73			91	2					93
2-Jun-09	18.66	67			99	1		1	1		102
9-Jun-09	12.16	65		5	14						19
10-Jun-09	14.85	62		3	16						19
30-Jun-09	23.24	145		3	3	7					13
8-Jul-09	19.42	135		1	14	9					24
14-Jul-09	20.95	110		2	2						4
21-Jul-09	21.33	70			11	7					18
28-Jul-09	22.48	48		6	3	1					10
5-Aug-09	19.42	50		3	4						7
11-Aug-09	22.09	52		3	1	1					5
18-Aug-09	18.28	55		2	15					2	19
Total			**1**	**49**	**1807**	**36**	**2**	**1**	**2**	**2**	**1900**

Table 3. Number, sex, and size structure of tagged fish. F: female, M: male, U: unknown. Species abbreviations as in Table 1.

			Fork Length (mm)		Weight (g)	
Species	**Sex**	**n**	**Range**	**Mean**	**Range**	**Mean**
WHSC	F	5	370 - 450	412	700 - 1750	1072
	M	5	310 - 410	364	500 - 1100	790
	U	1	448	-	1400	-
WALL	F	22	545 - 740	622	1700 - 4700	2895
	M	5	565 - 730	638	2100 - 3900	2870
	U	31	348 - 745	554	500 - 4400	2050
NRPK	F	11	530 - 970	686	1200 - 6350	2527
	M	12	390 - 670	531	550 - 1900	1208
	U	25	474 - 850	576	900 - 4000	1498
LKWH	U	1	540	-	2800	-
BGBF	U	1	610	-	6000	-
QUIL	U	1	400	-	1200	-

fishway. Data recorded by the scanner were logged on site.

Water Flow and Quality

Flow data for the Qu'Appelle River were obtained from the Water Survey of Canada and SWA for the hydrometric station near Lumsden (05JF001) and the station below the Craven Dam (05JK002). Water temperature and turbidity were monitored throughout the study period. Water temperature was recorded in degrees Celsius using a temperature logger installed in the fishway. Readings were logged every hour from 16 April to 28 August 2009. Turbidity measurements were recorded weekly beginning 12 May 2009, using a visual clarity wedge and approximated in nephelometric turbidity units (NTUs, a proxy for clarity).

Results

Fish Capture and Tagging

Eight fish species were captured in the fish trap, and three species in gill nets (Table 1). In total, 1900 fish were captured in the trap on 23 sampling events between 16 April and 18 August 2009 (Table 2). An additional 124 fish were captured in gill nets downstream of the dam. Of the captured fish, 120 were marked with PIT tags. Walleye, northern pike, white sucker, lake whitefish, bigmouth buffalo, and quillback were PIT tagged. Table 3 shows the sex and size classes of each species tagged.

Water Flow and Quality

Water flows and temperature were expected to be the most significant triggers for fish movements in the Qu'Appelle River system, particularly at the Craven Dam. Figure 2 depicts the flow at the hydrometric stations at Lumsden (upstream of the dam) and below the Craven Dam. Flows rapidly increased at Lumsden starting on 1 April and peaked on 21 April 2009. The majority of the water was stored in Last Mountain Lake until 5 May, when releases were increased to 13 m^3/s below the Craven Dam.

The greatest numbers of fish were captured at the dam during the spring spawning season, primarily in May.

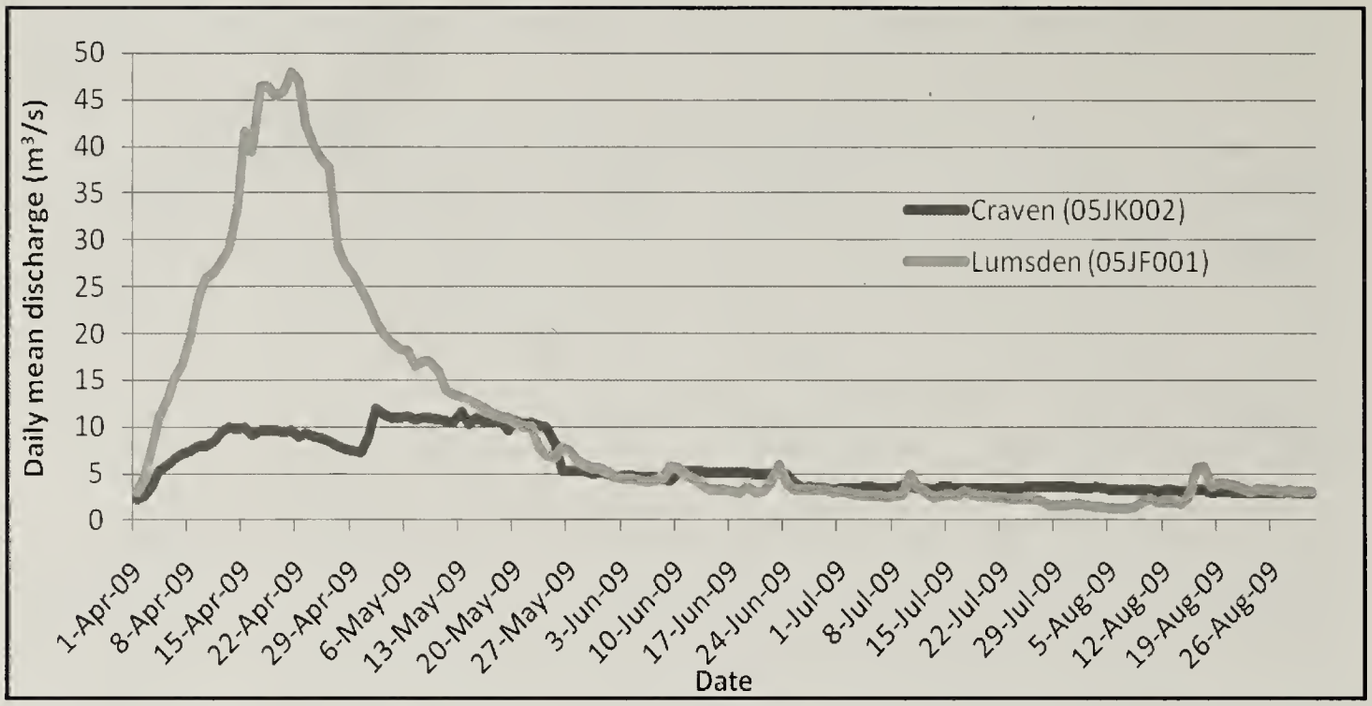

Figure 2. Qu'Appelle River daily mean discharge (m^3/sec) at Lumsden and below the Craven Dam, 1 April to 31 August 2009.

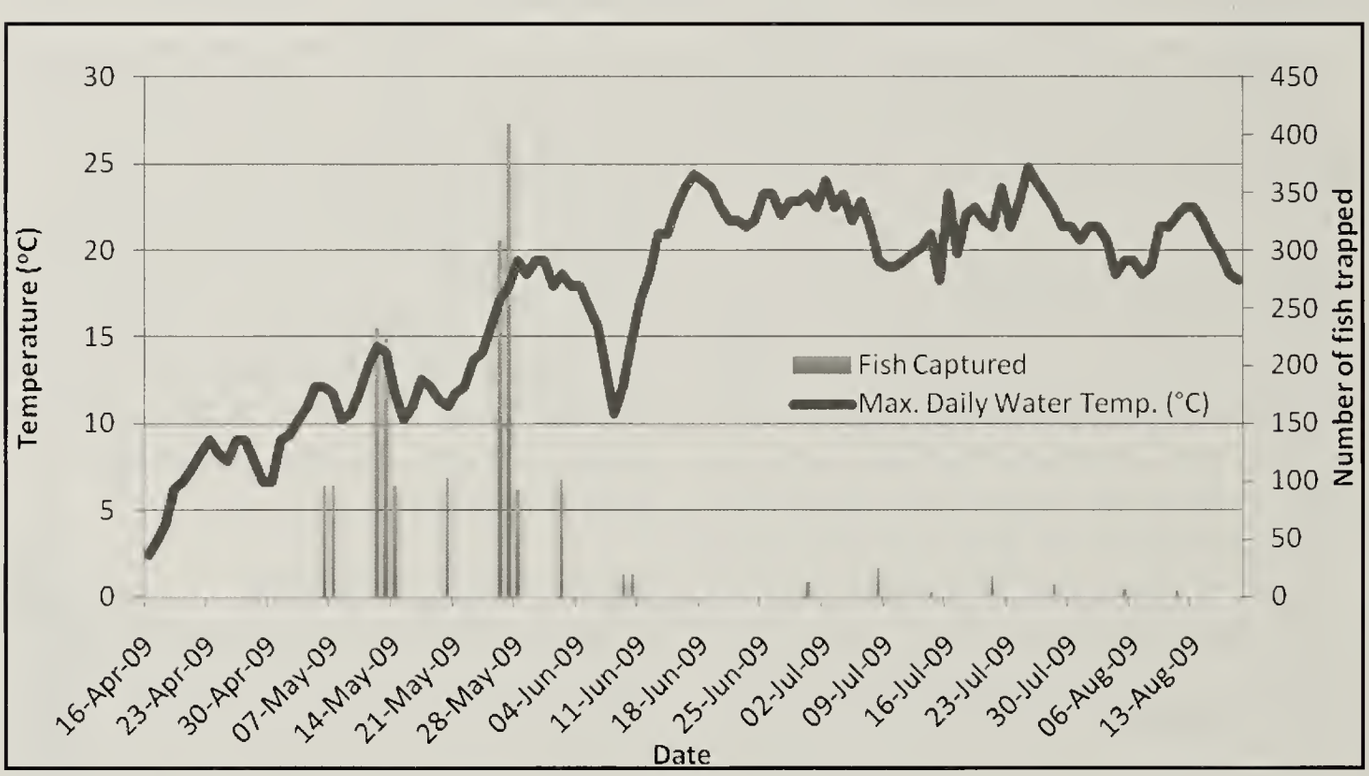

Figure 3. Maximum daily surface water temperatures (°C) and number of fish trapped at the Craven Dam, 16 April to 18 August 2009.

Capture rates in the fishway trap increased with water temperature and flow below the Craven Dam throughout May, but subsided by early June and remained lower for the rest of the summer. No fish were captured in the fish trap during the first three sampling events (16, 22, and 30 April 2009), and the first fish was caught in the trap on 6 May. Figure 3 relates the number of fish captured in the trap during the sampling period with the daily water temperatures. There was an increase in fish capture rates and water temperature during May and early June. High capture rates in May also correspond to the greatest discharge below the Craven Dam.

Fish movements through the fishway varied with respect to time of day. Twenty-

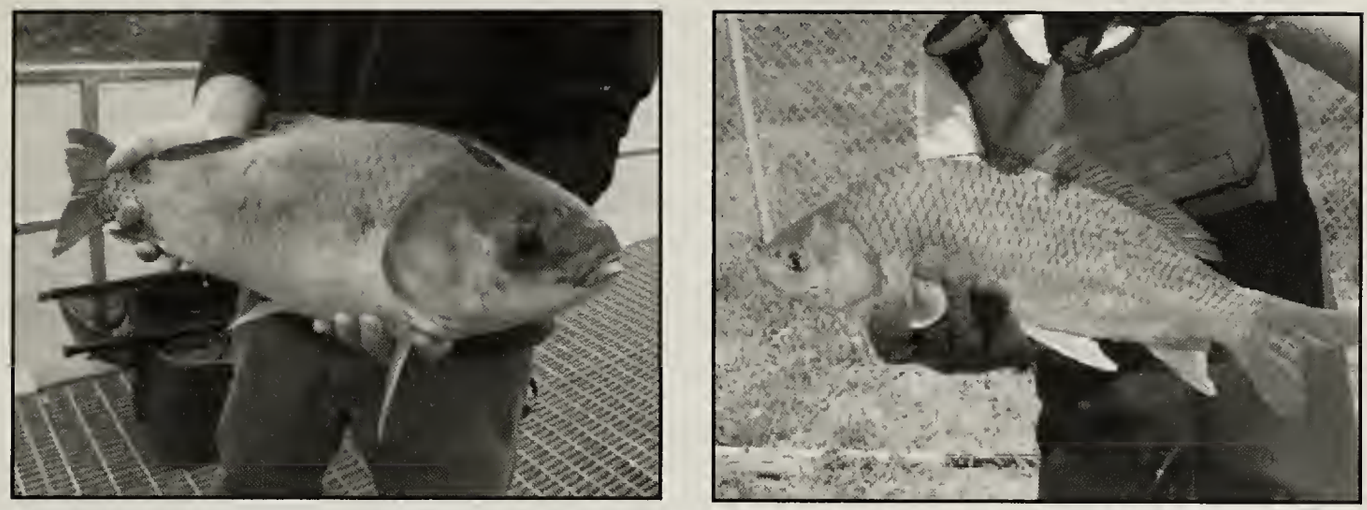

Figure 4. Bigmouth buffalo (Ictiobus cyprinellus*; left) and quillback* (Carpiodes cyprinus*; right).*

six PIT-tagged fish successfully migrated through the fishway during the study period: 15 walleye, four white sucker, six northern pike, and one quillback (see Fig. 4, which shows bigmouth buffalo and quillback, two of the rarer species captured). The majority of these fish (63%) moved during the evening hours (Fig. 5). Another 43 tagged fish were detected in the fishway by the antennae; however, these fish did not pass through the full length of the fishway.

Discussion

The results of this study indicate that the Craven Dam fishway was used by various fish species during the spring and summer conditions experienced in 2009. The results can likely be extrapolated to similar flow years, but not necessarily under all conditions. Field staff observed fish in the lower end of the fishway during April, yet no fish were captured in the trap during that time. The first fish caught in the trap that successfully migrated

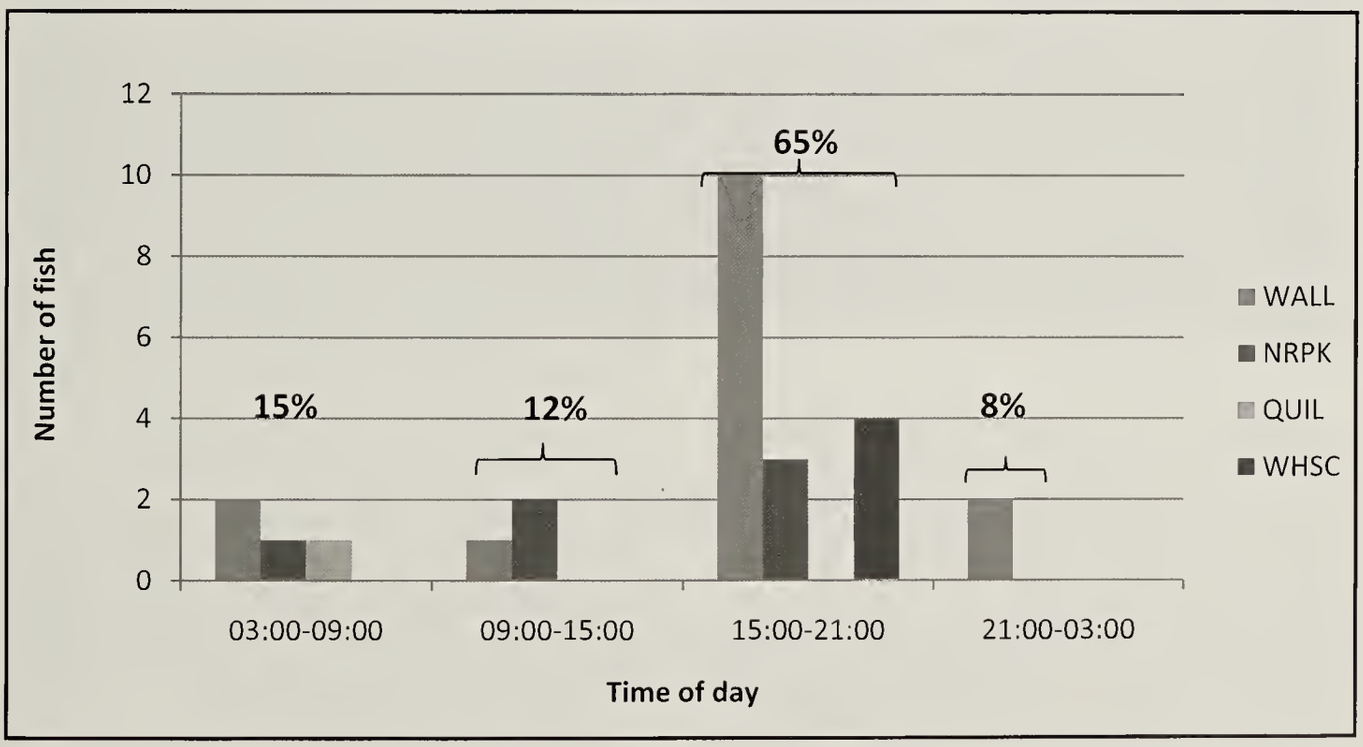

Figure 5. Time of day tagged fish successfully migrated through the fishway at the Craven Dam. Note that the percent value written above each group indicates the percentage of total fish that successfully migrated through the fishway during that time period. Abbreviations as in Table 1.

through the fishway occurred on 6 May, and the first successful migration by a PIT-tagged fish occurred on 11 May. This could correspond to an increased discharge below the Craven Dam (greater water release below the dam raises the tail water level below the dam) and an increase in water temperature (Figs. 2 and 3). On 5 May, SWA set the main gates at the dam to achieve a downstream release of approximately 13 m^3/s from approximately 7 m^3/s. Higher flows may have triggered upstream migration for fish downstream of the dam. Rising water temperatures could also have triggered fish migrations, especially for walleye and white sucker. Northern pike are reported to begin spawning when water temperatures are around 4°C, whereas walleye begin at 6°C, and white sucker around 10°C.[3] Water temperatures in April were more favourable for northern pike migration; however, flow velocities within the fishway may have been too high for pike to overcome, explaining why they were not captured in the trap (but many below it in gill nets). By the time flows in the fishway were lower, spawning conditions for northern pike had possibly diminished. Lower flow velocities in the fishway coupled with water temperatures in May that were more favourable for walleye and white sucker migration could explain the higher numbers of walleye and white sucker captured in the trap at that time.

Fish moved through the fishway at all times during the day and night. However, when considering only the fish that successfully migrated past the dam, there was a much greater tendency for fish to move during the evening hours (15:00 to 21:00 h), especially walleye (Fig. 5). Forty-three (36%) PIT-tagged fish were detected in the fishway, but did not migrate all the way through. Fifty-one percent of these fish were detected on more than one occasion. Most of the detections occurred in June to August, after the spawning season. In conjunction with field observations, these results suggest that these fish were likely moving in and out of the fishway to forage and were not necessarily attempting to move past the dam and migrate to upstream habitats.

Based on the results of this study, it can be concluded that various species of fish use the fishway at the Craven Dam throughout the open water season, but temporary restrictions to upstream fish passage may occur during certain flow conditions and critical life history stages (i.e., spawning periods). Information gathered in this study may be used by fisheries managers and fish habitat biologists to determine how to sustainably manage local fisheries and impacts from development and water management regimes within the Qu'Appelle River system.

Future monitoring is recommended to investigate flow velocities within the fishway during the spring freshet. It is also recommended that a fish movement study be conducted within the Qu'Appelle River watershed to obtain a better understanding of the origin of fish migrating upstream and downstream in the Qu'Appelle River system, and the importance of migrations to the fishery. Further, a water management operating plan should be developed in consultation with DFO, MOE, SWA, and other relevant stakeholders. The plan should be active and adaptive to ensure that water management activities have minimal impacts on upstream fish migrations in the Qu'Appelle River during the spring spawning period.

Acknowledgements

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Prairie falcon (Falco mexicanus). *Randy McCulloch*

Climb the mountains and get their good tidings.
Nature's peace will flow into you as sunshine flows into trees.
The winds will blow their own freshness into you...
while cares will drop off like autumn leaves.

- John Muir