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RE: Adult Chinook salmon and Pacific lamprey behavior in Bonneville's UMT channel

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Introduction

Upstream-migrating fish use the UMT channel at Bonneville Dam to pass from the Cascade Island fishway (adjacent to the north spillway), along the top of Powerhouse 2, and then into the upper section of the Washington-shore fishway (Figures 1 and 2). In 2010, research in the UMT channel will evaluate the effects of an electric field on fish passage through the channel. The study is part of a larger evaluation of whether electric fields can be used to deter pinnipeds in the Bonneville tailrace without affecting fish passage.

The UI and NMFS have used radiotelemetry to monitor adult salmon, steelhead and Pacific lamprey behavior in the UMT channel for many years. In this summary, we present some basic Chinook salmon and lamprey passage metrics that can be used to help evaluate if deploying the electric barrier in the UMT channel adversely affects fish behaviors in 2010.

Methods and Results

An underwater antenna has been used to monitor the upper end of the UMT channel since the start of large-scale radiotelemetry studies in 1996. This site is located inside the UMT channel near its junction with the Washington-shore fishway. The antenna is marked A1 at receiver OBO in Figure 1. In 2007, an underwater antenna was installed at the lower end of the UMT channel near its junction with the Cascade Island fishway. This antenna is marked A1 on receiver FBO in Figure 2. Prior to 2007, the only site other than OBO-1 that could be used to evaluate behavior in the UMT channel was the XBO receiver, which was used to monitor the lower portion of the Cascade Island fishway (Figure 2).

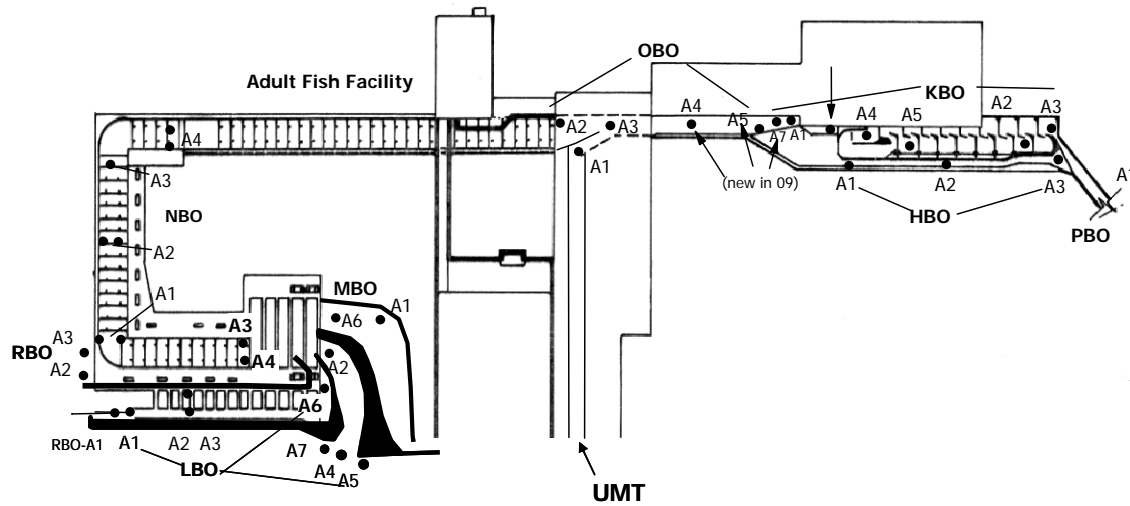


Figure 1. Map of the Washington-shore fishway at Bonneville Dam showing locations of underwater radiotelemetry antennas and receivers in 2009. The top of the UMT channel was primarily monitored using antenna A1 on receiver OBO (i.e., OBO-1). Note: antenna configurations changed slightly among years, but not at the OBO-1 site.

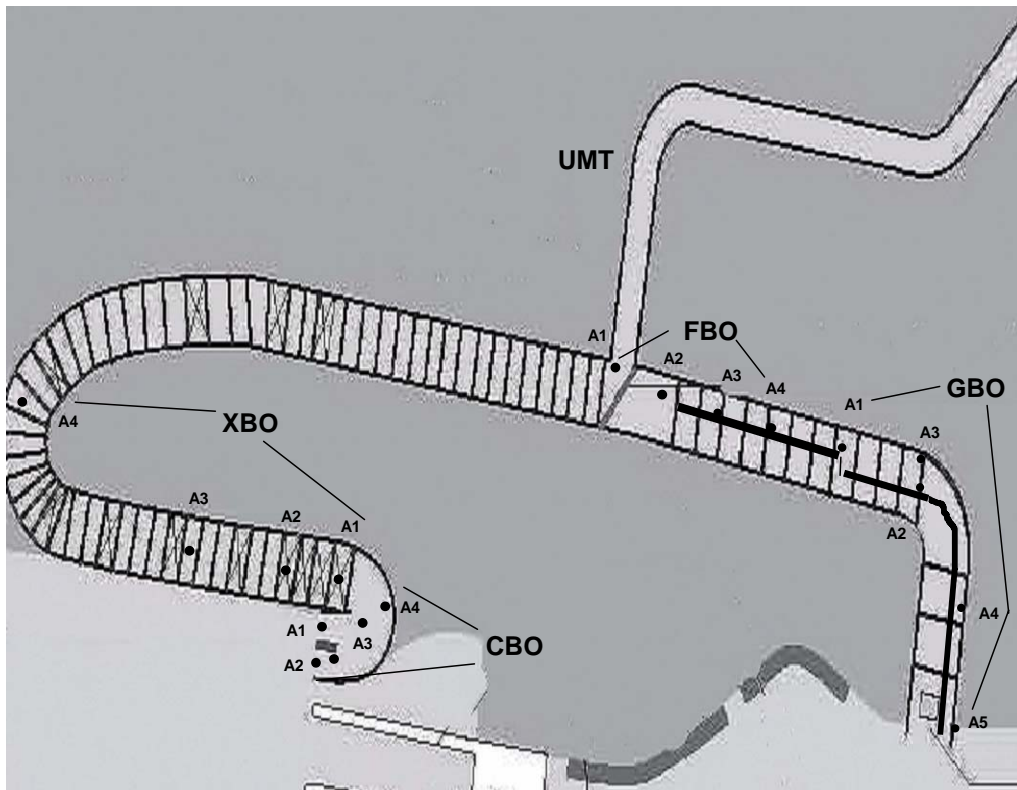


Figure 2. Map of the Cascade Island fishway at Bonneville Dam showing locations of underwater radiotelemetry antennas and receivers in 2009. The lower end of the UMT channel was monitored using antenna FBO-1 in 2007-2009; there was no monitoring at this site before 2007. Other FBO and GBO antennas were accessible only to lampreys. Antenna XBO-4 was present in all study years and was also used to calculate passage times to the top of the UMT channel.

For this summary, we used data for spring–summer Chinook salmon radio-tagged in 2003, 2004 and 2009. These were the three most recent years with reasonably large Chinook salmon sample sizes and detection rates in the UMT channel (Table 1). We used lamprey radiotelemetry data from 2007-2009. About 15% of the tagged Chinook salmon sample was recorded at XBO-4 in each year. The vast majority of these fish continued up the Cascade Island fishway and passed through the UMT channel (i.e., $\geq 97\%$ moved upstream, Table 1). More salmon were recorded at the OBO-1 antenna than the XBO-4 antenna in two years because some salmon were detected on this antenna after passing up the Washington-shore ladder – almost none of these salmon moved down the UMT channel to the FBO-1 antenna. Use of the UMT channel was proportionately lower for lampreys, with 3-9% of those released subsequently recorded at XBO-4. In part, this reflects lower dam passage efficiencies for lamprey. Lampreys were also less likely to move directly up the fishway, with 50-72% of those recorded at XBO-4 subsequently recorded at FBO-1 and OBO-1 (Table 1). Lampreys were also much more likely to move downstream in the UMT channel and Cascade Island fishway which is why numbers recorded at FBO-1 and OBO-1 were higher than at XBO-4 in some years (Table 1).

Table 1. Summary of the numbers and percentages of spring–summer Chinook salmon and Pacific lampreys detected at underwater antennas during the study years. The %Rel column shows the percentage of all fish released that were detected at each antenna and included fish moving both upstream and downstream in the fishway or UMT channel. The %XBO columns show the percentage of the fish recorded at XBO-4 that were subsequently recorded at FBO-1 and OBO-1 after moving upstream in the fishway. The %FBO column shows the percentage of fish recorded at FBO-1 that were subsequently recorded at OBO-1 after moving upstream in the UMT channel. The %XBO and %FBO data are for first passages only. Dashes indicate that no data were available.

Species	Year	Released	XBO-4		FBO-1			OBO-1			
			<i>n</i>	%Rel	<i>n</i>	%Rel	%XBO	<i>n</i>	%Rel	%XBO	%FBO
Chinook	2003	1183	190	16%	-	-	-	216	18%	97%	-
	2004	548	81	15%	-	-	-	33	11%	98%	-
	2009	599	78	13%	78	13%	97%	126	21%	97%	97%
Lamprey	2007	398	18	5%	19	5%	72%	20	5%	72%	68%
	2008	595	18	3%	38	6%	50%	43	7%	50%	53%
	2009	596	52	9%	57	10%	60%	60	10%	60%	56%

As would be expected, the majority of activity at the three antennas was during daylight for Chinook salmon and mostly at night for lampreys (Figure 3). Note that there was only one year of Chinook salmon data at the FBO-1 site.

Chinook salmon moved rapidly through the UMT channel (Figure 4). The median time from FBO-1 to OBO-1 was 0.7 h in 2009. Median times from XBO-4 to OBO-1 were also rapid at ~2.0 h in all three study years. The few Chinook salmon that took more than 8 hours to pass through the study area were almost all recorded at XBO-4 in the late afternoon or evening (Figure 5). This indicates that some salmon spent the night either in the Cascades Island fishway or the UMT channel. Increased passage time for adult salmon entering fishway sections late in

the day have been commonly observed at multiple locations and scales, and are due to the cessation of upstream movement at night.

Lamprey took considerably longer than salmon to pass through the combined UMT and Cascade Island fishway (XBO-4 to OBO-1), with median times from 5-11 h (Figure 4). However, most lampreys moved rapidly through the UMT channel itself, with median times < 1 h each year. The distribution of UMT channel passage times for lamprey was right-skewed, with some fish taking 12 h or more to pass. Many of these fish were first detected at the FBO-1 antenna during the day and others temporarily moved downstream in the Cascade Island fishway.

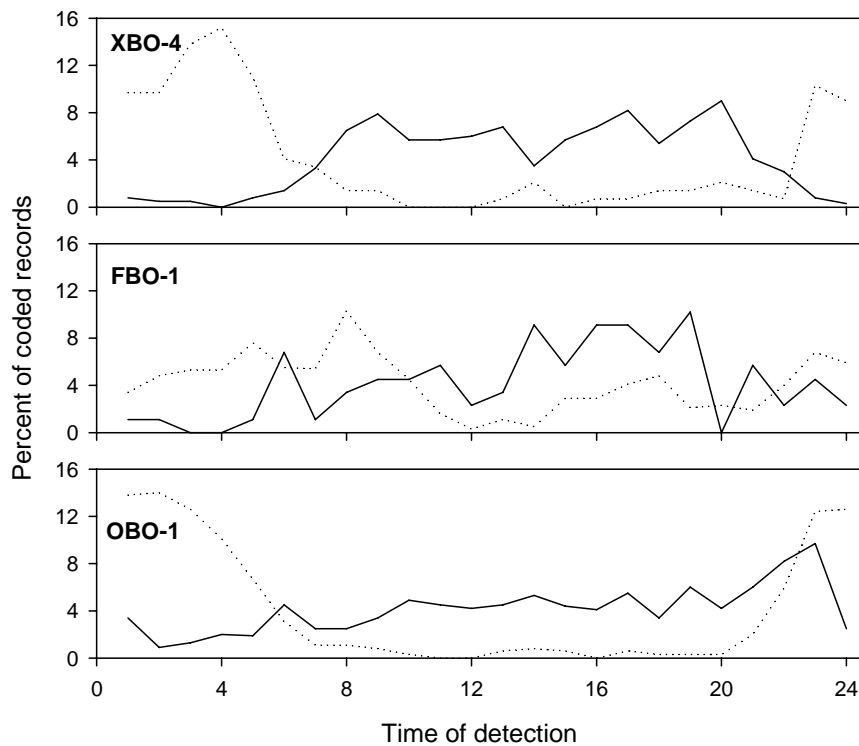


Figure 3. Distributions of all coded detection times for spring–summer Chinook salmon (solid lines) and Pacific lamprey (dotted lines) at antennas in the lower Cascade Island fishway (XBO-4), the lower end of the UMT channel (FBO-1) and the upper end of the UMT channel (OBO-1). All years combined.

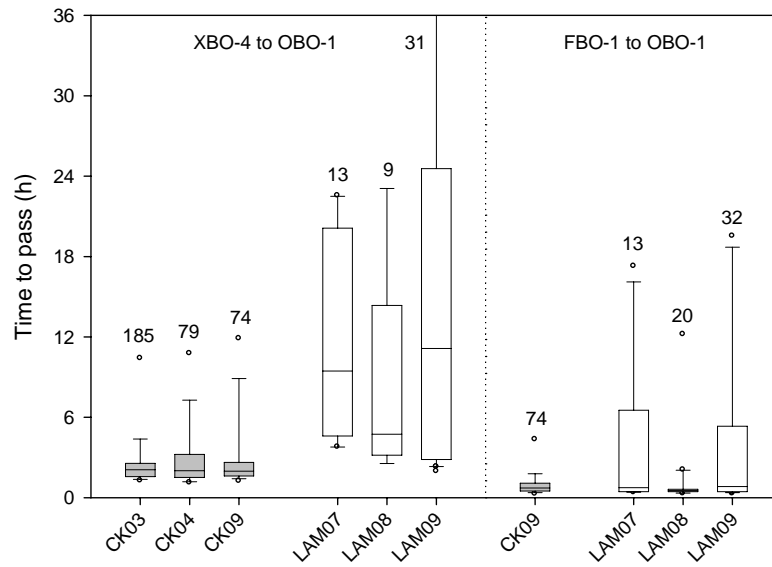


Figure 4. Box plots that show passage times calculated for spring–summer Chinook salmon (CK, gray boxes) and Pacific lamprey (LAM, white boxes) from the lower Cascade Island ladder (XBO-4) and from the bottom of the UMT channel (FBO-1) to the top of the UMT channel (OBO-1). Boxes show median, quartile, 5th, 10th, 90th and 95th percentiles for each year. Sample sizes above boxes.

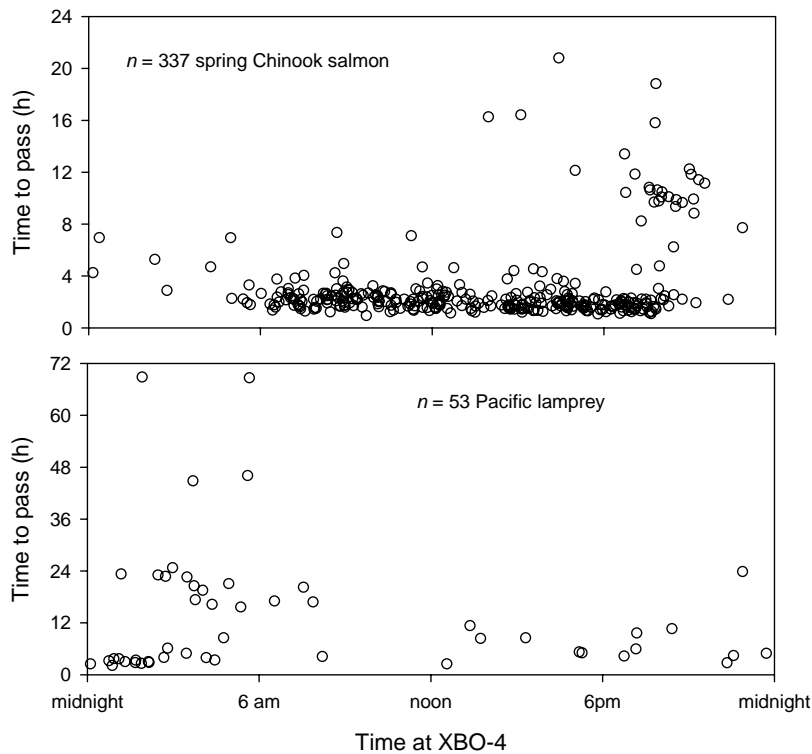


Figure 4. Scatterplots that show the total passage time from XBO-4 to OBO-1 based on time of first detection at XBO-4. All years combined within species. Note different y-axis scales. One outlier salmon and three outlier lampreys are not shown.

Unlike Chinook salmon, many lampreys were recorded moving downstream in the UMT channel after passing up either the Washington-shore fishway or the UMT channel. The ratio of upstream:downstream movements between OBO-1 and FBO-1 was approximately 1.5 across years. Almost all lampreys that moved down the UMT channel did so quickly, with most passing from OBO-1 to FBO-1 in less than 15 min. A few lampreys were recorded at OBO-1, then at antennas near the Washington-shore count window, then at OBO-1, then at FBO-1, suggesting there may have been repeated short-distance downstream movements into the UMT channel.

Discussion

In general, both adult Chinook salmon and adult lampreys moved efficiently upstream through the UMT channel. The few fish that resided in or near the channel for extended periods mostly entered the area near nightfall (salmon) or during the day (lamprey) when these species are less active in fishways. With antennas only at the upper and lower ends of the UMT channel (and further down the Cascade Island fishway), it was not possible to evaluate fish movement in the UMT channel on small spatial scales. However, given the rapid upstream passage times, it is likely that most fish moved steadily upstream through the UMT channel. While we saw very limited downstream movement by salmon, many lampreys did move down the UMT channel both after moving up the channel and after moving up the Washington-shore fishway.

Data from planned radiotelemetry studies of both spring Chinook salmon and lampreys in 2010 can potentially be used to test whether fish passage times or behaviors substantively change in response to the electric field. Adding UMT antennas closer to the deployment site may help with spatial and temporal resolution, but we expect the current radiotelemetry configuration would detect a large change in movement pattern or rate in either species (assuming the test is run when radio-tagged fish are passing through the channel). We expect that rejection behavior should also be relatively easy to detect using the planned DIDSON monitoring, at least for salmon. Frequent or sudden downstream movement by salmon in the UMT channel would be evidence of impeded passage due to the electric field effect given the rapid and directed upstream movements suggested by past radiotelemetry studies. Detecting effects on lampreys may be more difficult given their mixed up- and downstream behaviors in the channel, though large changes in upstream UMT passage times (e.g., passage times > 24 hrs) or a large increase in the frequency of downstream movements should be readily detected. Regardless, the radiotelemetry data could augment planned DIDSON evaluations post-season, once radiotelemetry data have been processed and analyzed.