University of Idaho
College of Natural Resources

Department of Fish and Wildlife Sciences
875 Perimeter Drive MS 1136
Moscow, ID 83844-1136

Phone: 208-885-6434
Fax: 208-885-9080
fish_wildlife@uidaho.edu
www.uidaho.edu/cnr/fishwild

Adult salmon and steelhead behavior at the base of the John Day south ladder, 2013-2014 – Letter Report, 16 March 2015

To: Jon Rerecich and Sean Tackley (U.S. Army Corps of Engineers, Portland District)

From: Matthew Keefer and Christopher Caudill

Introduction

Fish managers are considering removing the three most downstream weirs at the John Day south fish ladder (Figure 1) to improve upstream passage of adult salmonids (*Oncorhynchus* spp) and adult Pacific lamprey (*Entosphenus tridentatus*). A similar removal of the lowermost two weirs at the John Day north fishway occurred in winter 2011-2012 and preliminary results from an ongoing salmon radiotelemetry study indicate that upstream fish passage improved there, with faster passage times and fewer turn-around behaviors compared to pre-removal conditions (Burke et al. 2014).

The lower three weirs in the John Day south fishway are in what is often referred to as the 'transition' area of the fishway, between the collection channel and the ladder. The configuration of this area at John Day south, and at most fishways as the lower Columbia and Snake River dams, includes diffuser grating on the fishway floor downstream from the first weir where makeup water is pumped into the fishway. The first several weirs at most transition areas also have submerged orifices and paired overflow segments (see Figure 1). Importantly, the lowermost weirs at most projects are fully submerged during normal operations (i.e., tailwater elevation is almost always higher than the elevation at the top of the weirs).

These transition areas have been associated with slowed passage and frequent turn-around behavior by adult salmonids and adult lamprey in many previous studies (e.g., Keefer et al. 2006, 2008, 2012; Naughton et al. 2007). We have hypothesized that the behaviors are associated with poor or confusing attraction cues. The experiment described by Naughton et al. (2007), where hydraulic head was increased at the lowermost Lower Granite weirs to increase attraction flow through the submerged orifices, supported this hypothesis. We also have evidence that some fish turn around near the actual transition from fully-submerged to overflow weirs in the ladders. This location is characterized by changing hydraulics and varies with tailwater elevation. At John Day Dam, for example, tailwater elevation varied by ~5 ft (1.5 m) during the spring and summer migration seasons in 2013 and 2014.

In this letter report we provide a brief summary of radio-tagged fish behavior at the base of the John Day Dam south ladder using data collected in 2013-2014. Ideally, we could use these data to directly assess whether weir removal would provide an upstream passage benefit. However, a direct assessment is not possible without an experimental approach akin to Naughton et al. (2007) or some similar modification that would simulate weir removal. Instead, our objectives here are to provide current information on fish behavior near the first three weirs by:

1) estimating passage efficiency (i.e., the percent of individuals that successfully passed upstream) through the transition area of the John Day south fishway;

2) calculating passage times through this area; and

3) assessing whether passage efficiency was associated with tailwater elevation given the likely effects on fish behavior.

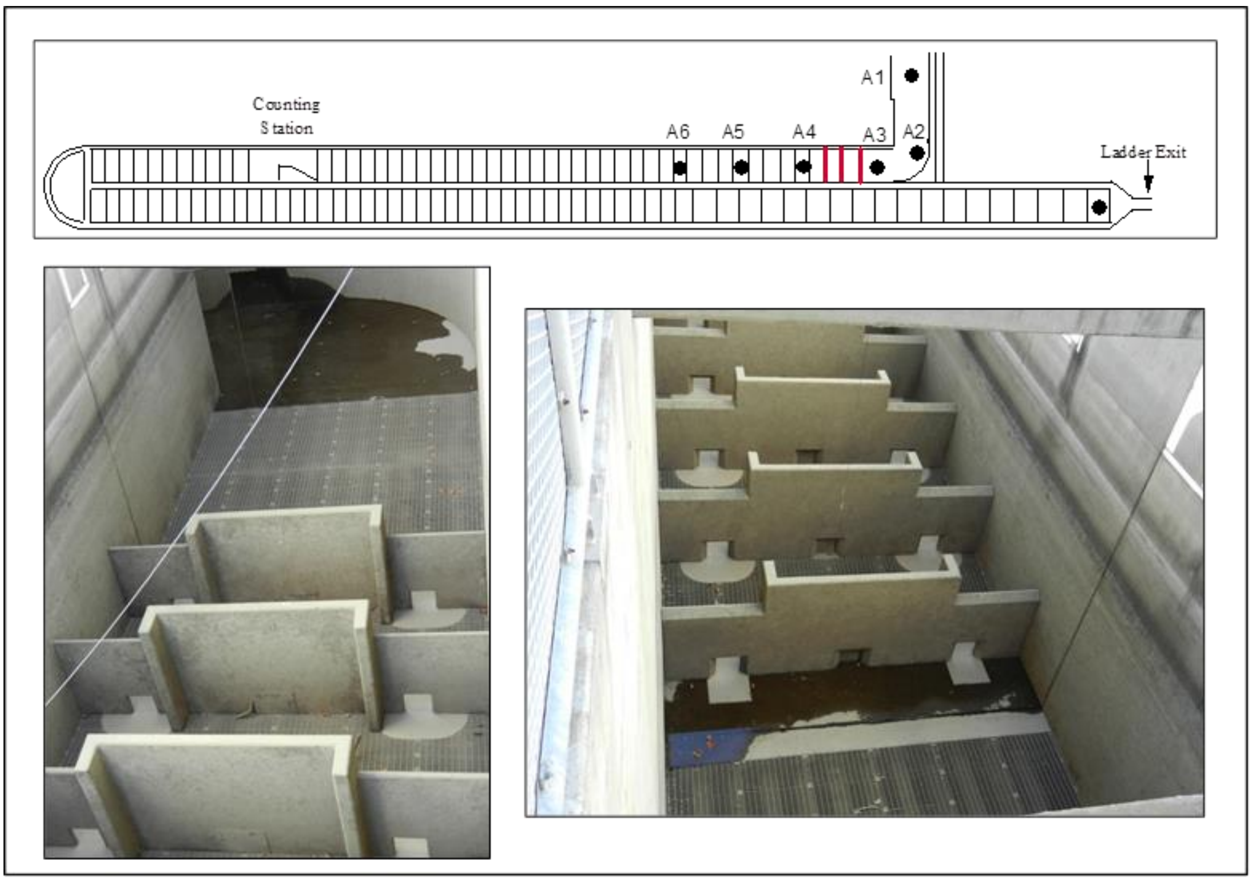

Figure 1. Schematic at top (not to scale) shows the locations (●) of underwater antennas used to monitor adult Chinook and sockeye salmon and steelhead at the John Day south ladder in 2013-2014. The lowermost three weirs, shown in red and in photos, may be removed in an effort to improve upstream fish passage. Photos courtesy of Miro Zyndol, USACE.

Radio-tagged samples and monitoring effort

Eight study groups were included in this data summary, including: adult and jack spring–summer Chinook salmon (2013 and 2014), adult sockeye salmon (2013 and 2014), adult summer steelhead (2013, selectively sampled late-run fish in September and October) and adult Pacific lamprey (2014). All fish were collected and radio-tagged at the adult fish facility (AFF) at Bonneville Dam using established protocols (see Clabough et al. 2011 and Keefer et al. 2014). The monitoring effort relevant to this evaluation included six underwater coaxial cable antennas in the lower fishway and transition area of the John Day south fishway and a single underwater antenna near the top-of-ladder exit (Figure 1). The typical detection range of underwater antennas is approximately 10 m, but there is considerable variation associated with fishway configuration (i.e., fishway turns, number and type of weirs, and other features that may block transmitter signals), with fish locations (i.e., detection may differ for shallow versus deep fish), and with transmitter signal strength. These caveats are relevant given the small spatial footprint of the study area of interest – it was not really possible to specifically identify fish location relative to the three lowermost weirs even with several nearby antennas because transmitters could be recorded nearly simultaneously at more than one antenna.

Analyses

Upstream passage efficiency through the transition area was calculated by dividing the numbers of radio-tagged fish detected at antennas 4, 5, and 6 by the numbers detected at antenna 3 downstream from the first weir. Efficiency was also estimated from A3 to the top of the south fishway. If a fish clearly passed an antenna without detection (based on compelling blocks of records further upstream) it was treated as being detected at the missed site. Such 'misses' can happen when there are signal collisions, when fish are moving rapidly, or during antenna power outages. The efficiency estimates reported here included all passage attempts by individual fish and therefore those that did not pass an antenna site above antenna 3 either exited the south fishway and passed the dam via the north fishway or did not pass the dam.

We used logistic regression to assess the relationship between passage efficiency and tailwater elevation because a seasonal effect was evident in preliminary analyses. In previous years, we have reported that fish increasingly exit the John Day fishways as fishway water temperature increases in summer (Keefer et al. 2003), and we note that tailwater elevation and water temperature were negatively correlated during the study period in both 2013 and 2014 (higher elevation ~ lower temperature). We used elevation in the logistic models because we think it was more relevant to the questions regarding the lowermost weirs.

Fish passage times were calculated for three nested sections of the transition area, from antenna 3 to antennas 4, 5, and 6. Start and end times were the first detection records at each of these sites and included time that fish moved downstream, including into the tailrace.

Results and Discussion

Several hundred radio-tagged fish from each of the tag groups (except lamprey; n =23) were detected at A3 in each year (Table 1). Detection at the A4 antenna was 92.8% for steelhead and was ≥ 97% for all other groups. Passage times from A3 to A4 were < 10 min for a large majority of the radio-tagged fish (Figure 2), with the 2013 steelhead being the only exception (*median time* ~ 15 minutes). These results indicate that most fish efficiently passed the three lowermost weirs. A caveat, however, is that some fish were likely detected at A4 without actually passing upstream from the site (i.e., they were detected while still downstream from the antenna – see comments in the monitoring section above). It is probable that some of these fish turned around near the first few weirs.

Many more fish turned around before reaching A5 or A6. Detection percentages at these sites were ~79-94% and ~68-87%, respectively (Table 1). It was not possible to determine why fish turned around and permanently exited the fishway, but the turn-around rates were consistent with previous radiotelemetry study results at this location (Keefer et al. 2008). The changing hydraulics through the transition area and variation in attraction cues likely played a role, as did temperature gradients associated with fish ladder water sources (e.g., Keefer et al. 2003; Caudill et al. 2013). Passage times from A3-A5 and especially from A3-A6 indicate that many fish moved more slowly through these sections, with ~18-28% of each study group taking 6 h or more to pass from A3-A6 (Figure 2). A portion of each sample took > 1 d to pass, and these extended passage times were often associated with temporary fish movement to the powerhouse collection channel or tailrace.

Most of the fish detected at A6 eventually passed the John Day south ladder, including 94-98% of Chinook salmon, 92-98% of sockeye salmon and > 99% of steelhead and lamprey (Table 1). This clearly suggests that the lower ladder presents a greater passage challenge than the mid- and upper ladder, particularly when viewed as attrition per weir.

Table 1. Numbers and percentages of radio-tagged fish detected at the base-of-ladder antenna (A3) that were subsequently detected at antennas upstream between weirs 4 and 5 (A4), 8 and 9 (A5), 12 and 13 (A6) and at the top of the south ladder in 2013 and 2014.

			Unique fish at A2 that subsequently were:							
		At A3	Detected A4		Detected A5		Detected A6		Passed ladder	
Run	Year	*n*	*n*	%	*n*	%	*n*	%	*n*	%
Chinook (A)	2013	384	375	97.7%	319	83.1%	305	79.4%	298	77.6%
	2014	303	300	99.0%	272	89.8%	223	73.6%	215	71.0%
Chinook (J)	2013	192	188	97.9%	152	79.2%	138	71.9%	132	68.8%
	2014	176	175	99.4%	165	93.8%	149	84.7%	140	79.5%
Sockeye	2013	202	199	98.5%	175	86.6%	168	83.2%	154	76.2%
	2014	203	201	99.0%	189	93.1%	176	86.7%	172	84.7%
Steelhead	2013	473	439	92.8%	412	87.1%	405	85.6%	403	85.2%
Lamprey	2014	23	23	100%	20	87.0%	20	87.0%	20	87.0%

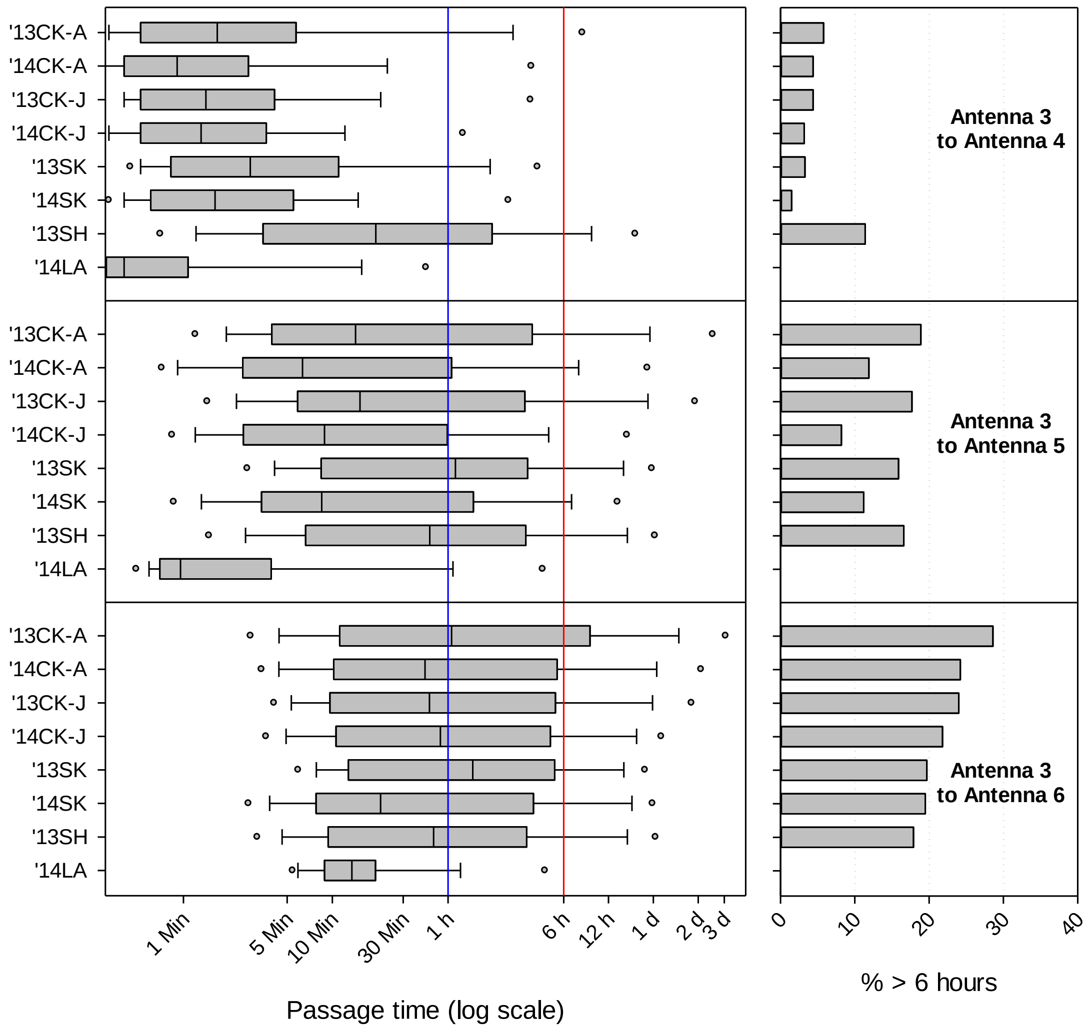

Figure 2. Left panel: boxplots showing distributions of radio-tagged fish passage times (log scale) from A3 to A4, A5, and A6. Boxes show median, quartile, 5th, 10th, 90th and 95th percentiles. Right panel: percent of each group that took >6 h to pass. CK-A = adult Chinook, CK-J = jack Chinook, SK = sockeye, SH = steelhead, LA = Pacific lamprey.

In both study years, tailwater elevation was mostly constrained between ~163-165 ft (49.7-50.3 m) during the Chinook and sockeye salmon migrations and between ~160-162 ft (48.8-49.4 m) during most of the steelhead and lamprey migrations (Figure 3). The logistic regression models indicated that Chinook salmon were more likely to pass through the transition area when tailwater elevation was relatively high (Figure 4). This effect was fairly strong, with predicted passage efficiencies between approximately 40-60% when tailwater was near 162 ft versus 70-90% when elevation was near 165 ft ($P < 0.05$ for adults and jacks in 2013 and adults in 2014). The logistic models were not statistically significant ($P > 0.05$) for sockeye salmon, steelhead, or lamprey. In part, this may have been because there was relatively little variability in tailwater elevation during the migrations of these species (Figure 3).

The tailwater elevation results can be interpreted several ways. At lower tailwater, fewer ladder weirs are submerged at John Day Dam and therefore the hydraulic transition to overflow weirs is closer to the ladder base. Lower fish passage efficiency under this condition (for Chinook salmon specifically, but also see relatively low steelhead efficiency from A3-A4) could reflect a negative response to the overflow transition. The behavior could also be associated with the warmer water temperatures that are typical during late summer and early fall, or with the combined temperature effects and varying hydraulic effects of water added through the diffuser gratings, which fluctuates with tailwater elevation. It is also possible that some fish simply swim over the first few weirs when tailwater is relatively high and are therefore less likely to move back downstream. The specific mechanisms remain unresolved and are likely multi-faceted.

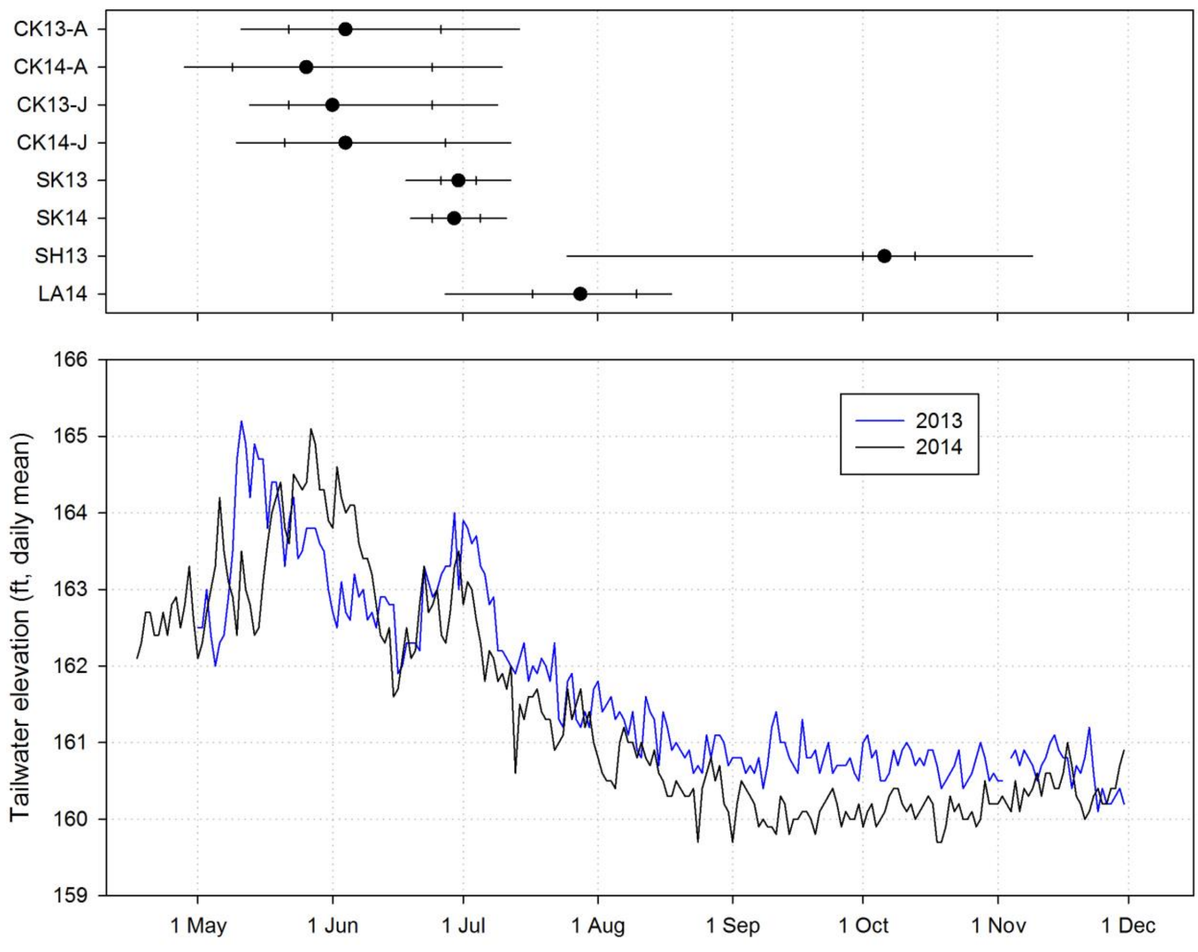

Figure 3. Top panel: distributions of first detection dates for radio-tagged fish at A3 showing median, quartile, 10^{th} and 90^{th} percentiles. Bottom panel: mean daily tailwater elevation (ft) at John Day Dam in 2013-2014. CK-A = adult Chinook, CK-J = jack Chinook, SK = sockeye, SH = steelhead, LA = Pacific lamprey.

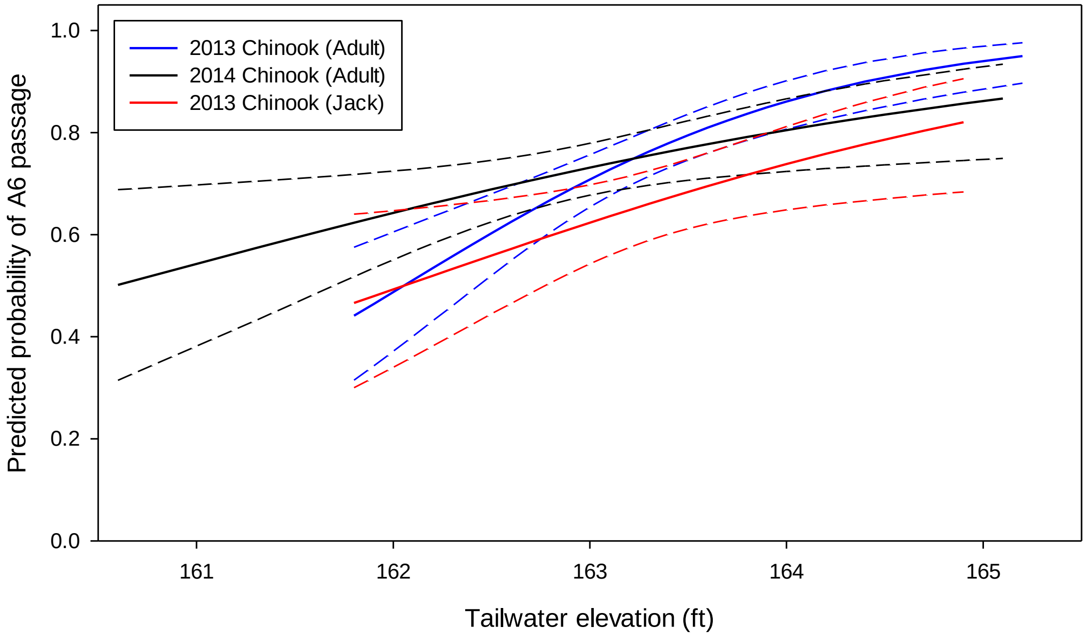

Figure 4. Estimated probabilities that radio-tagged adult Chinook salmon (blue and black lines) and jack Chinook salmon (red lines) would pass A6 in relation to tailwater elevation (ft) recorded on the date that each fish was first detected at A3. Dashed lines are 95% confidence intervals. Probabilities generated using logistic regression models.

Conclusions

These data suggest that the transition area of the John Day south fishway continues to present passage challenges for upstream migrants. Many radio-tagged fish turned around in this area and ultimately did not pass the dam via the south ladder. The passage 'delays' associated with the transition area were consistent with previous radiotelemetry results for salmonids (note: the 2014 lamprey passage efficiency estimates were somewhat higher than previous estimates, but the sample size was small). While the data indicate that the lowermost three weirs may be contributing to the observed behaviors, the spatial resolution of the data is insufficient to make unqualified recommendations. Removal of the weirs may provide some passage benefit, as suggested by the preliminary results at the John Day north ladder (Burke et al. 2014) and by the experimental results of Naughton et al. (2007). We also think that, intuitively, fewer weirs would be easier for fish to navigate past. Hydraulic models of the expected changes in the transition area and lower ladder may provide some insight regarding potential changes in attraction cues for upstream migrants.

References

Burke, B. J., K. E. Frick, M. L. Moser, T. J. Bohn, and T. C. Bjornn. 2005. Adult fall Chinook salmon passage through fishways at lower Columbia River dams in 1998, 2000, and 2001.

Research Report of National Marine Fisheries Service to U.S. Army Corps of Engineers, Portland District.

Burke, B. J., K. E. Frick, J. Garnett, M. A. Jepson, M. L. Keefer, and C. C. Caudill. 2014. Passage evaluation of radi0-tagged Chinook and sockeye salmon after modifications at The Dalles and John Day dams, 2013. Research Report of National Marine Fisheries Service to U.S. Army Corps of Engineers, Portland District.

Caudill, C. C., M. L. Keefer, T. S. Clabough, G. P. Naughton, B. J. Burke, and C. A. Peery. 2013. Indirect effects of impoundment on migrating fish: temperature gradients in fish ladders slow dam passage by adult Chinook salmon and steelhead. PLOS ONE:e85586.

Clabough, T. S., E. L. Johnson, M. L. Keefer, C. C. Caudill, and M. L. Moser. 2011. Evaluation of adult Pacific lamprey passage at the Cascades Island fishway after entrance modifications, 2010. Technical Report 2011-3, University of Idaho to U.S. Army Corps of Engineers, Portland District.

Keefer, M. L., C. A. Peery, R. Stansell, M. Jonas, and B. Burke. 2003. Passage of radio-tagged adult salmon and steelhead at John Day Dam with emphasis on fishway temperatures: 1997-1998. Technical Report 2003-1, University of Idaho to U.S. Army Corps of Engineers, Portland District.

Keefer, M. L., M. A. Jepson, and C. A. Peery. 2006. Adult Chinook salmon and steelhead passage times and behaviors in the south-shore ladder at John Day Dam, with special reference to ladder modifications: 1996-1998 and 2000-2004. Technical Report 2006-9, University of Idaho to U.S. Army Corps of Engineers, Portland District.

Keefer, M. L., C. A. Peery, T. C. Bjornn, M. A. Jepson, K. R. Tolotti, S. R. Lee, and L. C. Stuehrenberg. 2008. Adult salmon and steelhead passage through fishways and transition pools at John Day Dam, 2007-2001. Technical Report 2008-4, University of Idaho to U.S. Army Corps of Engineers, Portland District.

Keefer, M. L., T. C. Clabough, M. A. Jepson, E. L. Johnson, C. T. Boggs, and C. C. Caudill. 2012. Adult Pacific lamprey passage: data synthesis and fishway improvement prioritization tools. Technical Report 2012-8, University of Idaho to U.S. Army Corps of Engineers, Walla Walla District.

Keefer, M. L., M. A. Jepson, T. S. Clabough, E. L. Johnson, C. C. Caudill, B. J. Burke, and K. E. Frick. 2014. Reach conversion rates of radio-tagged Chinook and sockeye salmon in the lower Columbia River, 2013. Technical Report 2014-12, University of Idaho to U.S. Army Corps of Engineers, Portland District.

Naughton, G. P., C. C. Caudill, C. A. Peery, T. S. Clabough, M. A. Jepson, T. C. Bjornn, and L. C. Stuehrenberg. 2007. Experimental evaluation of fishway modifications on passage behaviour of adult Chinook salmon and steelhead at Lower Granite Dam, Snake River, USA. River Research and Applications 23:99-111.