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To: Derek Fryer, USACE Walla Walla District

From: M.A. Jepson, C.C. Caudill, M.L Keefer (U. Idaho), and B.J. Burke (NOAA Fisheries)

Re: Preliminary Evaluation of Radio-telemetry Data for Chinook Salmon at McNary Dam - 2010

Introduction

Modifications to the upper portion of the Oregon-shore fishway at McNary Dam were made in winter 2010 to improve passage rates and efficiencies of adult Pacific lampreys. Specific alterations included cutting 7.5 cm (h) × 45.0 cm (w) openings into the bases of adjustable-overflow weirs (Figure 1). These openings provide an alternate upstream passage route for lampreys, which are substrate-oriented inside fishways (Keefer et al. 2010 and *in review*).

A radiotelemetry study of adult Chinook salmon was conducted at McNary Dam because the structural modifications designed to aid lampreys may affect behavior and passage success of adult salmon. This report summarizes data on passage times of radio-tagged spring-summer Chinook salmon through the upper portions of both the Oregon- and Washington-shore fishways at McNary Dam from 19 April through 12 July 2010. It also compares passage times from 2010 with passage times from Chinook salmon data collected in 2002-2007 and 2009.

Figure 1. Photograph depicting openings cut into the bases of adjustable-overflow weirs in the Oregon-shore fishway at McNary Dam, 2010.

Methods

From 10 April through 30 June 2010, we collected and intra-gastrically radio-tagged 600 Spring-summer Chinook salmon at the Adult Fish Facility of Bonneville Dam and released them approximately nine kilometers downstream from the dam (Figure 2). A description of the tagging methods used is presented in Keefer et al. (2004). A total of 313,142 adult Chinook salmon were counted passing the dam during the tagging interval. Radio-tagged salmon represented ~0.2 % of the salmon counted at the dam during the tagging period.

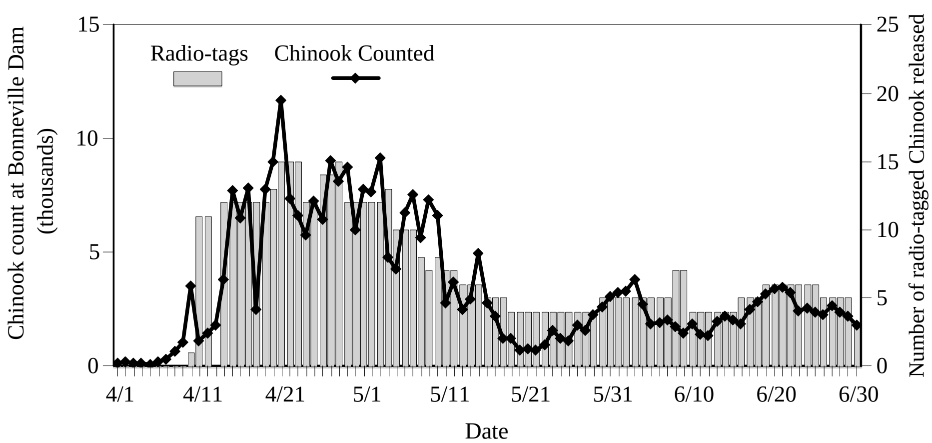

Figure 2. The number of Chinook salmon radio-tagged and released downstream from Bonneville Dam and the count of adult Chinook salmon passing the dam from 1 April through 30 June 2010.

All main fishway openings, the transition pool, and the upper portions of both the Oregon- and Washington-shore fishways of McNary dam were monitored with underwater radio antennas connected to radio receivers (Figure 3). Radiotelemetry data from fixed receivers were reviewed to remove obvious errors and noise records. Processed data were then coded using automated software to identify salmon behaviors within fishways. The coded records from the automated processing were reviewed for appropriateness by a trained technician and were used to calculate passage times for statistical analyses. We defined Oregon-shore weir passage times as the difference in time between the first detection on antenna EMN-2 and the last detection on antenna EMN-3 and similarly defined this metric for the Washington-shore adjustable overflow weirs using antennas FMN-2 and FMN-3, respectively (Figure 3). We added antenna EMN-5 in 2010 as part of this evaluation. Preliminary data from EMN-5 suggest the antenna will provide little useful additional information because of the limits of radio telemetry to resolve fish locations at this spatial scale.

We $\log^e$-transformed weir passage times and compared differences among years (within months) using an analysis of variance (ANOVA) (Zar 1999). If significant differences were found among years, we conducted a Student-Neuman-Keuls Test (SNK) to determine which years were significantly different from each other.

Finally, we evaluated the degree of association between monthly median Oregon-shore weir passage times and monthly median Washington-shore weir passage times using Spearman correlations. We also tested for associations between monthly median passage time and mean monthly water temperatures using Spearman correlations.

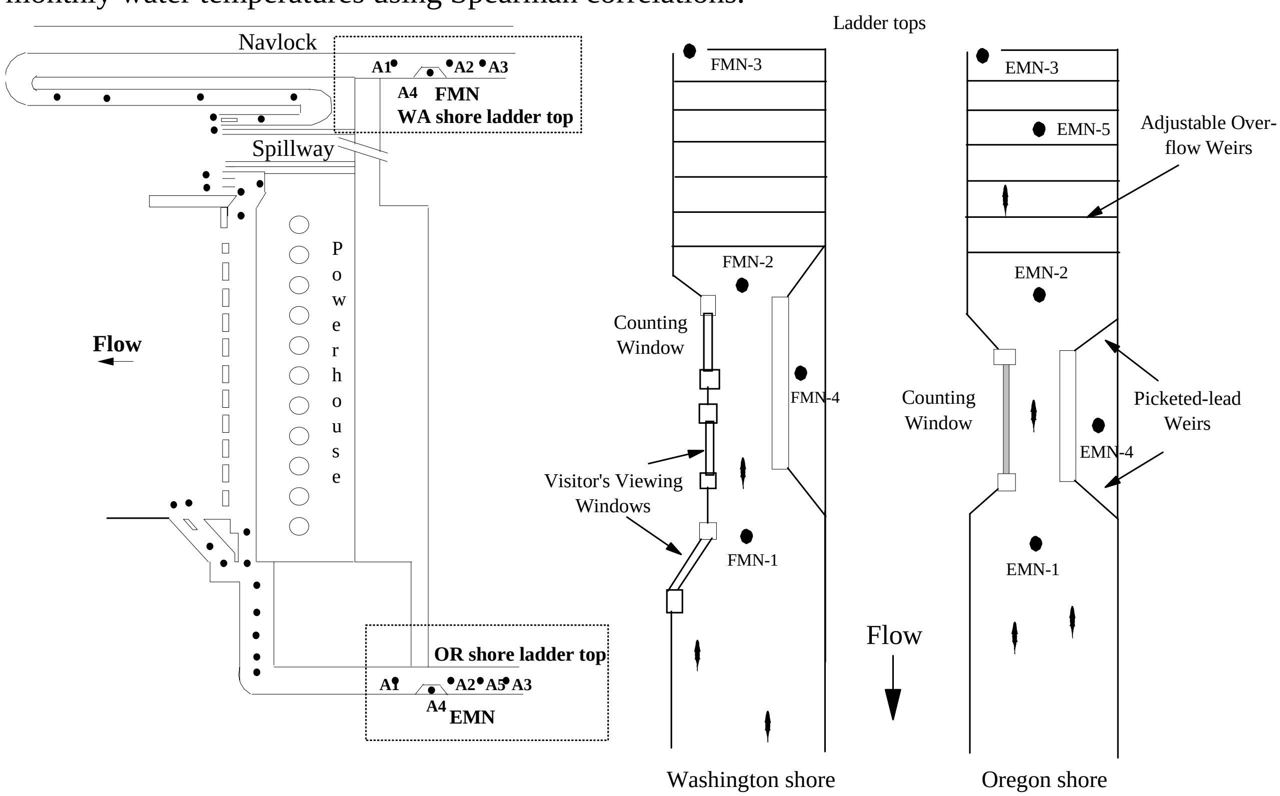

Figure 3. Aerial view of underwater antennas (solid circles) deployed at McNary Dam in 2010 (left panel) and detailed views of the upper portions of the Washington- and Oregon-shore fishways (right panel).

Results & Discussion

Within the month of April, significant differences in log^e-transformed mean Oregon-shore weir passage times among years were found ($P < 0.001$, ANOVA). Based on the ensuing multiple range comparison test (i.e., the SNK test), the April 2010 values were found to be significantly higher than April values from the three previous study years with April data (Figure 4). The median April 2010 value (32.6 min) was approximately two times higher than the median April values from the three previous study years with April data (11.8-15.3 min) (Table 1).

The median Oregon-shore weir passage time from May 2010 were relatively long, though not significantly longer than the two most recent years with observations (Figure 4). Significant differences in log^e-transformed mean Oregon-shore weir passage times were found among years when we examined May values exclusively ($P < 0.001$, ANOVA). The SNK test results indicated that means from May 2007, 2009, and 2010 belonged to a single, similar group that had significantly higher mean passage times than another group that included values from 2002-2006 (Figure 4).

In June, significant differences ($P < 0.001$, ANOVA) in log^e-transformed mean Oregon-shore weir passage times were found among years. In multiple comparisons, Oregon-shore weir passage times in 2010 were not significantly different from 2002-2004. However, 2005 and 2009 weir passage times were significantly different than other years with lower mean passage times in 2005 and higher mean passage times in 2009.

Although significant differences ($P < 0.001$, ANOVA) in log^e-transformed mean Oregon-shore weir passage times were found among years in July, multiple comparison tests were not significantly different. This may be due to small sample sizes in several years and/or the high variability within years.

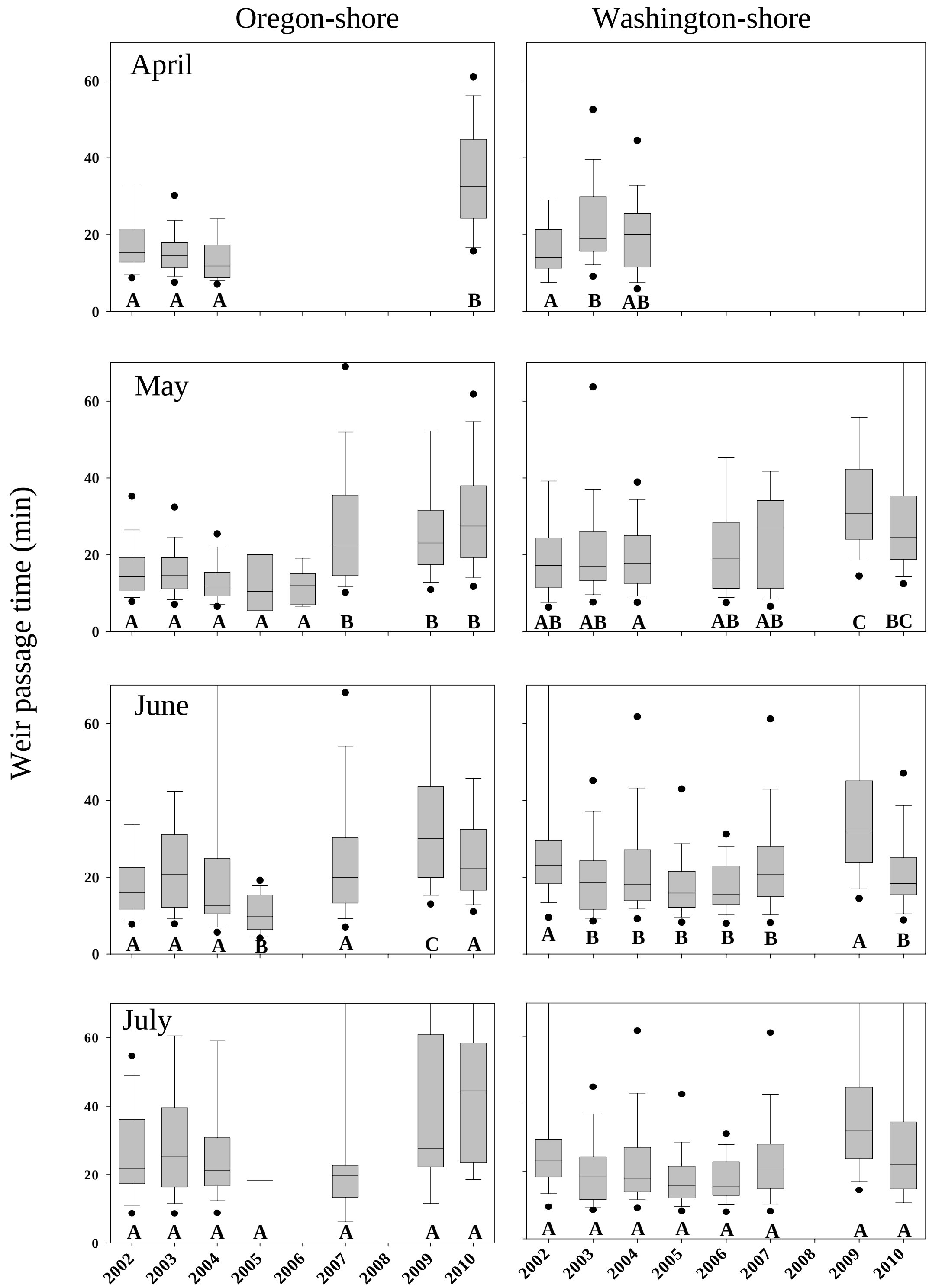

Figure 4. Median (line), quartile (box), 5th and 95th (dots), and 10th and 90th (whiskers) percentile passage times (min) for radio-tagged adult Chinook salmon to swim through the upper, Oregon-shore (left panels) and Washington-shore (right panels) fishways at McNary Dam, 2002-2007 and 2009-2010. Sample sizes are presented in Tables 1 and 2. Letters beneath boxes indicate homogenous groupings based in SNK test results.

Overall, the data suggest some potential for slowed passage in April 2010 compared to previous study years (2002-2004). However, the April result is also consistent with the relatively slow passage in observed recent years during May. Whether the relatively long observed times were related to the lamprey orifice modification during winter 2009-2010 or some other change (e.g., some common factor causing the longer 2007, 2009, and 2010 times in May such as river conditions) remains unknown. Results suggest passage rates in May 2010 were similar to the two most recent monitored years, 2007 and 2009 but longer than in 2002-2006. Potential mechanisms for slowed salmon passage in 2010 are unclear, but could include alteration to hydraulic cues used for orientation or changes in olfactory cues related to the construction of the orifices and installation of video systems, or other factors (e.g., river environment). Mean weir passage times in June of 2010 were similar to earlier years and no differences were found between years in July. Any olfactory effects related to construction are expected to decline through time as the modifications "cure" by leaching and formation of biofilms. The magnitude of the increased passage times in April compared to previous years was relatively small (tens of minutes).

Table 1. Monthly median passage times (min) and sample sizes for radio-tagged adult Chinook salmon to swim from downstream from the adjustable-overflow weirs (first detection at EMN-2) to the Oregon-shore ladder top (last detection at EMN-3) of McNary Dam, 2002-2007 and 2009-2010.

Year	April		May		June		July		August		Total	
	Med.	n	Med.	n	Med.	n	Med.	n	Med.	n	Med.	n
2002	15.3	29	14.5	220	16.0	87	21.9	47	31.2	8	16.0	391
2003	14.6	62	14.6	116	20.7	73	25.3	40	12.8	8	15.8	299
2004	11.8	29	11.9	45	12.6	39	21.2	32	18.0	4	14.5	149
2005	-	-	10.5	6	9.9	25	18.3	2	-	-	9.9	33
2006[1]	-	-	12.1	16	-	-	-	-	-	-	12.1	16
2007	-	-	22.8	67	20.0	72	19.6	12	-	-	20.6	151
2009	-	-	23.1	133	30.0	99	27.6	18	-	-	25.6	250
2010	32.6	31	27.5	113	22.2	73	44.5	11	-	-	25.9	228

[1] EMN-2 had no detections after 16 May 2006

Results from the Washington-shore ladder indicated relatively long passage times in May 2010 compared to some, but not all, prior study years. No weir passage times were recorded in the upper Washington-shore fishway in April because a receiver to monitor that section of the fishway was not available until 30 April 2010. Within the month of May, significant differences in Washington-shore weir passage times were found among years ($P < 0.001$, ANOVA). Based on SNK test results, $\log^e$-transformed values from May 2010 were significantly different from those from May 2004, but were not significantly different from those from any other previous year (Figure 4). On median, the May 2010 value (24.5 min) was 5–7 min slower than 2002-2004 and 2006 and 2–5 min faster than in 2007 and 2009 (Table 2). In June, mean weir passage times were not significantly different from previous years (except 2002 and 2009) and July passage times in 2010 were not significantly different than any prior years.

Table 2. Monthly median passage times (min) and sample sizes for radio-tagged adult Chinook salmon to swim from downstream from the adjustable-overflow weirs (first detection at FMN-2) to the Washington-shore ladder top (last detection at FMN-3) of McNary Dam, 2002-2007 and 2009-2010.

Year	April		May		June		July		August		Total	
	Med.	n	Med.	n	Med.	n	Med.	n	Med.	n	Med.	n
2002	14.1	18	17.3	163	23.1	66	18.9	86	13.2	13	18.9	346
2003	19.0	67	17.0	59	18.6	81	18.2	102	14.4	24	17.8	333
2004	20.1	30	17.8	59	18.1	67	18.2	24	6.7	2	18.3	182
2005	-	-	-	-	15.9	71	11.0	5	-	-	15.7	76
2006	-	-	19.0	35	15.5	23	25.8	2	-	-	16.8	60
2007	-	-	27.0	19	20.8	69	22.8	17	-	-	21.5	105
2009	-	-	30.8	32	32.0	56	21.3	27	-	-	29.5	115
2010[1]	-	-	24.5	57	18.4	42	20.7	18	-	-	22.1	117

[1] FMN was deployed on 30 April 2010.

When we examined the degree to which monthly median Oregon-shore and Washington-shore passage times co-varied, we found a significant, but weak correlation between the two (P = 0.033) (Figure 5). We found no significant correlation between median monthly Oregon-shore weir passage times and mean monthly water temperatures (P = 0.271). In combination, these analyses suggest fairly weak environmental control of passage time through the upper ladder section. A more comprehensive analysis of passage times in the upper section compared to lower ladder sections for the Oregon-shore Fishway will be presented in the final report in an effort to determine if the observed increase in passage time in April was related to dam- or river-wide conditions (e.g., April passage times were slow at all locations) or if the slow times were restricted to the Oregon-shore upper ladder section.

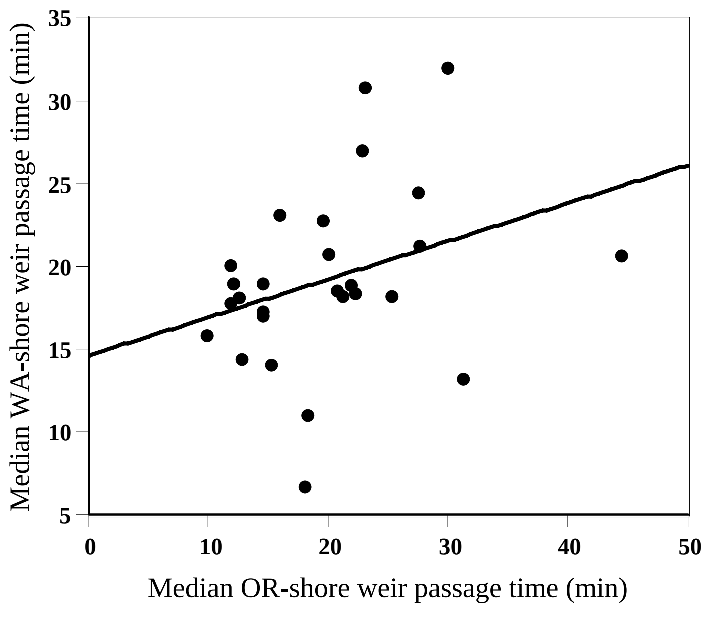

Figure 5. Scatterplot of median monthly weir passage times from the upper, Washington-shore fishway versus those from the upper, Oregon-shore fishway at McNary Dam, 2002- 2010.

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