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MEMORANDUM

TO: Tom Lorz (CRITFC), chair of FPOM Task Group on BON Unit Operating Range

Michele DeHart

FROM: Michele DeHart

DATE: December 17, 2012

RE: Re-ascension rates at Bonneville Dam in response to Operations in 2012

In response to your request, the Fish Passage Center analyzed the effects of operations at Bonneville Dam during the Spring of 2012 on adult salmon re-ascensions using PIT-tags. In particular, the focus of this investigation was on the trade-off between operating Bonneville Powerhouse One (PH1) at high discharge levels indicative of using the open geometry, versus spilling that volume of water. This analysis focused primarily on spring/summer Chinook and steelhead as these were species that passed during the spring when open geometry was used and these species had the largest number of PIT-tagged adults available for analysis. The results of the analysis were conclusive for steelhead and showed an increase in fall back/re-ascension rate when PH1 discharge increased. Although modeling results for Chinook were weaker, relationships between the operations at the dam and the re-ascensions showed similar patterns to those for steelhead adults. Modeling results showed that at a Bonneville Dam total discharge in the 320 to 350 Kcfs range (range during which open geometry was typically used), increases in PH1 discharge resulted in a higher proportion of re-ascending adults, than would have occurred had the same volume of water been spilled. The findings are summarized below:

- Based on multi-variate regression modeling of re-ascension rates versus spill and PH1 discharge, at flows in the range of 320 to 350 Kcfs, it appeared that decreasing spill and increasing PH1 discharge led to higher re-ascension rates in 2012 for both steelhead and spring/summer Chinook adults.

- Re-ascension rates were highest for all species of PIT-tagged adult salmon exiting the ladder into Bonneville PH1 forebay at 11.2%, while re-ascensions for adults exiting into PH 2 forebay were only 1.5%.

- Adult steelhead had the highest re-ascension rate at Bonneville Dam from April 1 to July 1, at 9%, while 6% adult spring/summer Chinook re-ascended, followed by only 0.5% of sockeye adults.

- Between 40% and 46% of PIT-tagged adult salmon exited ladders into the forebay of PH1 compared to 54% to 60% exiting into the forebay of PH2.

- Patterns of discharge in PH1 and spill were not significant in explaining the variability in proportion of adults entering the ladder entrances that exit into the PH1 forebay (BO1 exit).

Introduction

The Fish Passage Operations and Maintenance (FPOM) Coordination Team assigned a task group to evaluate unit operating ranges at Bonneville Dam. As part of this task group, the Fish Passage Center was requested to analyze PIT-tag data at Bonneville Dam to determine if operating the spillway above 100 kcfs or increasing discharge out of PH1 to the "open geometry" level would have an impact on adult salmon re-ascensions. During 2012, turbines at Bonneville PH1 were operated at high discharge in the "open geometry" configuration during parts of the spring migration. The intent of this exercise was to determine if extra discharge through PH1 by operations to "open geometry" or additional spilled water would impact adult re-ascensions at Bonneville Dam.

PIT-tag detection data from April 1 through July 1, 2012 were used to analyze rates of adult salmon ladder re-ascensions at Bonneville Dam. Unlike telemetry data, PIT-tags cannot be used to directly measure fallback rates, as adult fish falling back at the dam are not directly detected with PIT-tag systems. Instead, PIT-tag analysis relies on fish that ascend and exit a ladder, fallback, and subsequently re-enter and exit a ladder in order to measure fallback events. The data presented and analyzed for this task were based on ladder re-entry after fish fell back and are termed "re-ascensions". Re-ascension rates were used as a surrogate for fallback rates to utilize existing PIT-tag data to determine what portion of fish might have fallen back and how that fallback rate might be related to operations at the dam. Based on telemetry studies in 2001 and 2002 (Boggs et. al. 2004) about 93% spring/summer Chinook fallbacks re-ascend the ladders at Bonneville Dam. Thus re-ascension rates underestimate fallbacks and therefore may be less able to detect relationships between operations and fallback rates.

However, assuming that those fish that did not re-ascend were random with relation to dam operations, route of fall back and other environmental conditions considered, PIT-tag data may be useful to determine effects of operations on fallbacks if relatively strong covariance exists between conditions and fallback rates. PIT-tagged adult salmon represent a large crosssection of the returning adult population and provide an opportunistic source of data since there was no need to mark fish as they enter the ladders in order to obtain data.

PIT-tag data were also used to determine ladder entrance events. First ladder detection in a PIT-tag array was used to determine ladder choice by upstream migrating adults. The proportions of adults entering ladders that exited into PH1 and PH2 forebays were analyzed in relation to environmental factors to determine if dam operations affected the distribution of adult entrance preferences. Because a higher proportion of fish fell back when exiting into the forebay of PH1, if operations caused fish to enter PH1 at higher rates, then that operation could be indirectly responsible for increased fallbacks.

Methods

Detections of PIT-tagged adult steelhead and spring/summer Chinook salmon were analyzed to determine fish that fell back and subsequently re-ascended the ladders at Bonneville Dam. There are five fishway entrances with PIT-tag detectors at Bonneville Dam (see PTAGIS maps at www.ptoccentral.org), and two exits that were operating in 2012. The ladder exit at Bradford Island (BO1) discharges into the PH1 forebay and is fed by fish entering either on the south side of the spillway or at PH1 The ladder exit at PH2 (BO4) provides egress for fish entering either on the north side of the spillway or at PH2.

PIT-tag coils in the lower sections of the ladders were used to determine location and timing of first entry while coils at the upper end of the exit ladders were used to determine date and time of exit as well as location of exit.

PIT-tagged adult fish were determined to have re-ascended ladders if they were detected at exit coils (at the upper end of ladders near forebay) and then subsequently detected at entrance coils (in the tailrace) more than 6 hours later-without having been detected passing downstream (within the ladder). Six hours appeared to be a long enough time period for fall back and re-ascension to occur. While shorter time periods were consistent with fish falling back within the ladder. Occasionally, adults were determined to have descended within the ladders but those fish were not considered fallbacks for this analysis. Only fish that successfully exited the ladders and were subsequently detected at entry coils were considered to have fallen back and thus were part of the re-ascension analysis.

Logistic Regression of Adult Fallback/Re-ascension

For logistic regression analysis, exit times and locations were assigned to fish based on the time and location of last detection at an exit coil. Operational conditions at the time of ladder exit were recorded for each fish using 24-hour averaged flow and spill data following ladder exit. Operational conditions considered in analysis included total discharge, spill discharge, PH1 discharge, and Julian date. Information about fish were also considered in analysis; including ocean age, whether fish were transported or passed Bonneville in-river and also the total distance above Bonneville Dam (in kilometers) that the fish were released as a juveniles. Because some fish re-ascended and exited more than one time, each exit was considered a separate event in the analysis.

Concerning the logistic regression modeling, the response variable was binary. Fish that exited the ladder and were not detected re-ascending within two days of exit were assigned a zero (0). These fish were assumed to have exited the forebay successfully. Fish that re-entered the ladder within two days of exiting in the forebay were assigned a one (1). The assignment of fish to the "re-ascension" group was limited to those fish re-entering the ladder within a two day period of forebay exit in order to better match fall back with conditions in the immediate forebay of the dam. Boggs et al (2004) conducted a similar analysis of radio-tagged adult fish, limiting their analysis of fallbacks to fish that fell back within 24-hours of exiting the ladders. Boggs et al (2004) also limited the time period to match exit/fall back with environmental variables and project operations that were occurring at the time of exiting the ladder. The researchers in this study found that a portion of fallbacks occurred several days after fish had exited the forebay and some fallbacks migrated considerable distances upstream of the dam before being detected falling back. Fallbacks such as these were not likely caused by project or other environmental conditions. For this analysis of PIT-tagged fish, a longer window of time was allowed for fish to fall back and then begin re-ascent as fall back and re-ascent to a PIT-tag detector was assumed to take longer than the time required to only fall back. Fish that fell back and re-ascended more than two days after exit were assumed to have successfully exited into the forebay upstream and then subsequently fell back close to the time when they were detected as re-ascending. In those cases of longer times to re-ascent detection, the ladder exit was considered successful relative to project and environmental factors and the event was coded a zero (0).

Logistic regression models were run using generalized linear models with a logit link function. The full model included all environmental and biotic variables described above. All possible model subsets were run and models were evaluated using AICc to determine their relative weight of evidence (Burnham and Anderson 2002). Model averaging and multi-model inference were used to develop a predictive model (Burnham and Anderson 2005). Model predictions and model-averaged coefficients were estimated using the R packages "MuMin" (Barton 2011) and "glmulti" (Calcagno and de Mazancourt 2010).

Model fit was assessed by estimating Somers D statistic (Newson 2006) on the predicted re-ascension rates versus observed re-ascensions using R package "Hmisc" (Harrell 2012) available at http://biostat.mc.vanderbilt.edu/trac/Hmisc. Also goodness of fit was assessed using the Hosmer-Lemeshow test. Both tests compare predictions to observed re-ascension rates.

Logistic Regression of Adult Ladder Entrance

Logistic regression was also used to determine the probability of fish entering ladders that exited in the forebay of PH1 exit (BO1) or ladders that exited in forebay of PH2 (BO4). Those fish that entered PH1 ladders were assigned a value of one (1) in the response variable while those entering PH2 ladders were assigned a value of zero (0). The logistic model assessed the probability that fish would enter ladders that ultimately lead to them exiting into the PH1 forebay (BO1), where fallback rates were shown to be higher. The response variable was regressed against 24-hour averaged operational conditions, such as spill, total discharge, PH1 discharge, proportion spill and proportion PH1 discharge on the day of entry. Similar to the re-ascension analysis, logistic regression models were run and fit was assessed using AICc. Model coefficients were averaged based on model weights and predictions of re-ascension were compared to observed daily proportions of re-ascensions.

Results

Logistic Regression of Adult Fallback/Re-ascension

Table 1 shows a summary of the total number of PIT-tagged adult salmon that exited ladders at Bonneville Dam during the period April 1 to June 30, 2012. Re-ascension rates were higher for PIT-tagged adults of all species that exited BO1 into the forebay of PH1 compared to the PH2 exit (BO4). Spring/summer Chinook showed the highest number of fallback/re-ascensions of the species that were detected, with 319 total re-ascents out of 5,192 ladder exits. However, steelhead showed a higher re-ascension rate at 9%. A large majority of steelhead re-ascensions occurred from fish exiting PH1 (BO1 in the table) with 32 of 178 fish detected re-ascending. Sockeye had the lowest number of re-ascensions as well as the lowest rate of re-ascensions with only 3 adults re-ascending after exiting into the forebay of PH1. Between 82% and 100% of adult re-ascensions, depending on species, were of fish that exited the ladder at PH1 (BO1). Between 41% and 45% of total adult exits were into the PH1 forebay using the BO1 ladder exit.

Table 1. Ladder detections and re-ascension rates of PIT-tagged adult salmon at Bonneville Dam from April 1 to June 30 2012 broken down by exit ladder location (BO1-forebay of powerhouse 1, B04-forebay of powerhouse 2).

Ladder Exit Location		Spring/Summer Chinook	Steelhead	Sockeye	Total Adults
BO1	Re-ascents	275	32	3	310
	Total exits	2377	178	225	2780
	Pct. Re-ascent	11.6%	18.0%	1.3%	11.2%
BO4	Re-ascents	44	7	0	51
	Total exits	2815	253	313	3381
	Pct. Re-ascent	1.6%	2.8%	0.0%	1.5%
Combined	Re-ascents	319	39	3	361
	Total exits	5192	431	538	6161
	Pct. Re-ascent	6%	9%	1%	6%
Pct. B01	Re-ascents	86.2%	82.1%	100.0%	85.9%
	Exits	45.8%	41.3%	41.8%	45.1%

Because Chinook and steelhead PIT-tags were most prevalent during the spring period, when PH1 at Bonneville Dam was operated at open geometry, and the majority of the re-ascensions were observed in spring/summer Chinook, this analysis focused on the re-ascension of Chinook adults and steelhead. Because re-ascensions were much higher from PH1, where the operational change under consideration was occurring, we focused our analysis on those PIT-tagged adult salmonids that exited the BO1 ladder. There were 2,377 ladder exits of adult spring/summer Chinook from BO1 which we were able to analyze while 178 PIT-tagged adult steelhead exits were available. Those fish exiting BO1 were most likely to be affected by operations at the first powerhouse or the spillway in terms of the affect on fallback and subsequent re-ascension.

Figure 1 shows a frequency distribution of all adult Chinook re-ascension times (in days) from forebay exit to first re-entry detection at the beginning of re-ascension. The figure includes all 275 adult Chinook re-ascents and shows that 195 of those occurred within two days of exit. Those 195 re-ascents were designated as “unsuccessful exits” and assigned a “1” in the logistic regression analysis as described in the methods section. Fish with longer times to re-ascend were assumed to have spent time migrating upstream and then fallen back as observed by Boggs et. al. (2004) in their radio-telemetry study so that the conditions at ladder exit did not lead to the fish fall back. For steelhead 29 of the 32 steelhead fallbacks re-ascended within 2 days of exiting the forebay and so were coded “1”

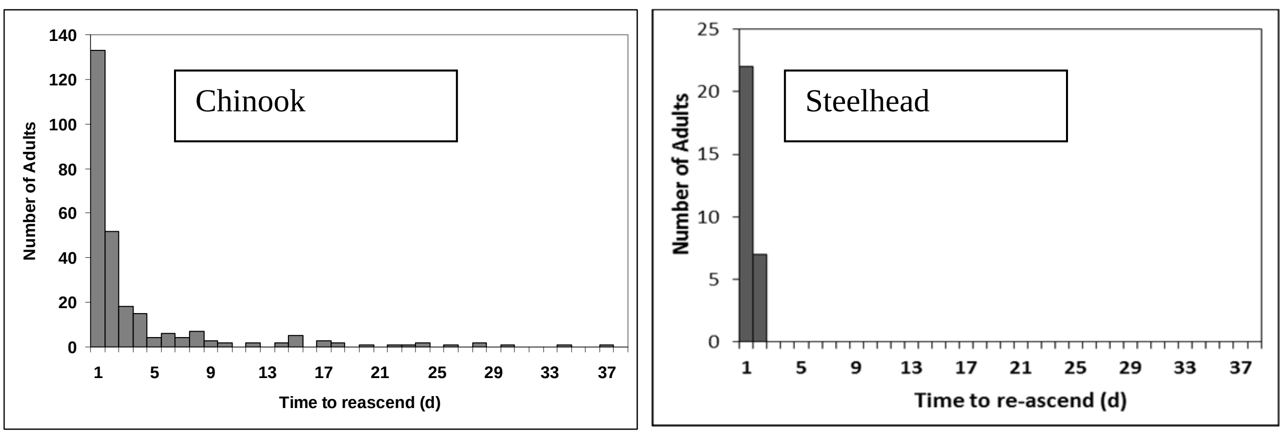

Figure 1. Histograms of the time (in days) between ladder exit into the forebay of Bonneville Dam PH1and next detection re-ascending in the ladder entrance.

Table 2 shows the top models from the multi-model logistic regression analysis of re-ascension versus environmental and biotic variables. The models are arranged from highest weight of evidence to lowest based on AICc values (Burnham and Anderson 2005). The model with the highest weight had a 0.084 weight, and other models had similar low weights which indicated that no single model was uniquely better than others for explaining the variability in re-ascension rates. Overall the model was relatively poor at predicting re-ascension rates with the Somer’s D statistic of 0.167 (Table 4). However, there was some indication that the model did fit the data based on the Hosmer-Lemeshow test result of 0.249, suggesting there was no indication of a lack of fit. Concerning the Hosmer-Lemeshow test, there was fairly good agreement in 9 out of the 10 deciles which suggests the fit was better that indicated based on the test. The poor model fit indicated by the Somer’s D statistic is likely due to the low incidence of re-ascensions in adult Chinook.

In contrast, steelhead showed a much higher re-ascension rate and model averaged predictions showed a much better fit with a Somer's D statistic of 0.618 showing a good correspondence between predicted and observed re-ascension rates. The Hosmer-Lemeshow test value of 0.113 showed no indication of lack of fit. Again, there was one decile that showed a poor correspondence between prediction and observed re-ascension rates which made the test statistic closer to a significant value than other decile fits would have indicated. Removing that decile the chi-square test statistic was not significant at 0.75.

Table 2. Top models from multi-model logistic regression of PIT-tagged adult Chinook re-ascension rate with weights above 0.100. The predictor variables were "sp"-spill; "b1"-discharge powerhouse 1; "tq"-total discharge; "jd"-julian day; "tr"-transport; "rkm"- river kilometers released above Bonneville dam; and "ag"-ocean age of returning adult.

Model	Weights
sp + b1 + tq + jd + ag	0.084
sp + b1 + tq + jd + rkm + ag	0.063
sp + b1 + tq + jd	0.041
sp + b1 + ag	0.039
sp + b1 + tq + jd + tr + ag	0.031
sp + b1 + tq + jd + rkm	0.030
sp + b1 + jd + ag	0.027
sp + b1 + rkm + ag	0.027
sp + b1 + tq + jd + tr + rkm + ag	0.025
sp + b1	0.024
sp + b1 + jd + rkm + ag	0.022
b1 + ag	0.021
sp + b1 + tq + ag	0.021
b1 + tq + ag	0.020
sp + b1 + rkm	0.017
b1 + rkm + ag	0.016
sp + b1 + tq + jd + tr	0.015
b1 + tq + rkm + ag	0.015
sp + b1 + tr + ag	0.014
sp + b1 + tq	0.014
b1	0.014
sp + b1 + jd	0.014
sp + b1 + tq + rkm + ag	0.013
sp + b1 + tq + jd + tr + rkm	0.013
b1 + tq	0.012
b1 + jd + ag	0.012
sp + b1 + jd + rkm	0.011
sp + b1 + tr + rkm + ag	0.010
b1 + jd + rkm + ag	0.010
b1 + rkm	0.010

Table 3. Top models from multi-model logistic regression of PIT-tagged adult steelhead re-ascension rate with weights above 0.100. The predictor variables were "sp"-spill; "b1"-discharge powerhouse 1; "tq"-total discharge; "jd"-julian day; "tr"-transport.

Model	Weights
b1+tr+rkm+ag	0.078
b1+tr+rkm	0.072
sp+b1+tr+rkm+ag	0.062
sp+b1+tq+tr+rkm	0.060
sp+b1+tq+tr+rkm+ag	0.057
sp+b1+tr+rkm	0.052
sp+b1+tq+rkm	0.050
b1+rkm+ag	0.046
sp+b1+tq+rkm+ag	0.045
b1+rkm	0.043
b1+tq+tr+rkm+ag	0.032
b1+jd+tr+rkm+ag	0.031
sp+b1+rkm+ag	0.030
b1+tq+tr+rkm	0.028
b1+jd+tr+rkm	0.027
sp+b1+rkm	0.026
b1+jd+rkm+ag	0.025
sp+b1+jd+tr+rkm+ag	0.022
sp+b1+tq+jd+tr+rkm	0.021
b1+jd+rkm	0.020
sp+b1+tq+jd+tr+rkm+ag	0.019
sp+b1+jd+tr+rkm	0.018
sp+b1+tq+jd+rkm	0.017
b1+tq+rkm+ag	0.017
sp+b1+tq+jd+rkm+ag	0.016
b1+tq+rkm	0.015
sp+b1+jd+rkm+ag	0.013
b1+tq+jd+tr+rkm+ag	0.012
sp+b1+jd+rkm	0.010
b1+tq+jd+tr+rkm	0.010

Table 4. Results of goodness-of-fit tests/measures for model prediction versus observed re-ascension rates for model averaged equations.

	Chinook	Steelhead
Somer's D	0.167	0.618
Hosmer-Lemeshow	0.249	0.113

Figure 2 shows the relative variable importance for both Chinook and steelhead multi-model analyses of re-ascension rates. The relative variable importance indicates the weight of evidence that a particular variable is important in explaining variability in the response variable. A relative variable importance of 1 indicates that the variable was present in all models that had any weight. For adult Chinook discharge at Bonneville PH1 (b1) had the highest relative weight at 0.82, followed by ocean age (ag) in years with a weight of 0.63 and spill discharge (sp) at

0.62. The model average coefficients for b1 and sp were positive coefficients, meaning re-ascension rates at PH1 increased with increases in discharge through either structure (Table 5). The coefficient for b1 was larger than that for sp indicating that re-ascension rates increased more rapidly for a given increase in discharge at PH1 compared to a similar increase in spillway discharge. Figure 3 shows a comparison of the slopes of predicted increases in re-ascension rates with increasing discharge through PH1 or the spillway. This figure shows the relative slope of the increase in re-ascension rates when discharge through each route was increased and all other conditions were held constant (at average values). As can be seen from Figure 3 the slope of the prediction line plotted against discharge PH1 1 was steeper than that for spill discharge, although confidence intervals around those prediction lines indicate that the predictions were not significantly different and there was very low precision so that the slope was not significant either.

Realistically, as discharge through PH1 increased, discharge through the spillway typically decreased, such that the two would act synergistically to change re-ascension rates. Figure 3 shows what that relationship would look like if the flows through PH1 and the spillway were allowed to change in a realistic manner (i.e. as flow through PH1 increased spill discharge would decrease and vice versa).

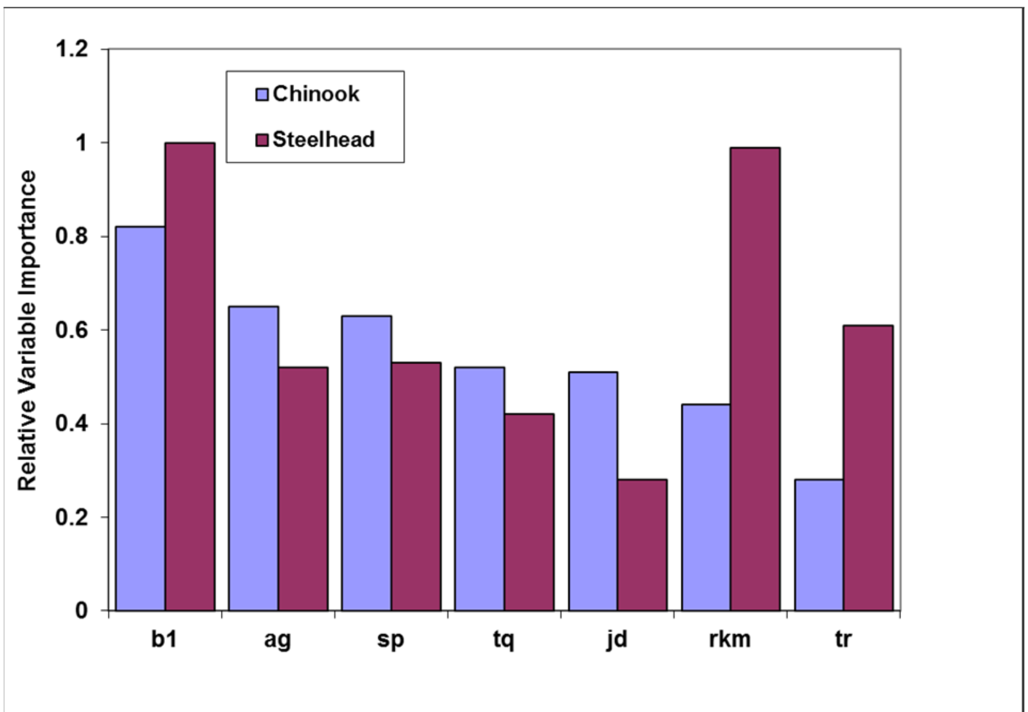

Figure 2. Relative variable importance or evidence weights (from AICc) of variables from multi-model logistic regression of re-ascension rates. The variables were “sp”-spill; “b1”-discharge powerhouse 1; “tq”-total discharge; “jd”-julian day; “tr”-transport; “rkm”- river kilometers released above Bonneville dam; and “ag”-ocean age of returning adult.

For steelhead, the relative variable importance of discharge at Bonneville PH1 (b1) was the highest at 1.00, with spill (sp) having a value of 0.53. The model average coefficients for b1 and sp were again positive, meaning re-ascension rates at PH1 increased with increases in discharge through either structure (see Table 6). The coefficient for b1 was much larger than that for sp in the case of the steelhead model average estimates indicating that re-ascension rates increased more rapidly for a given increase in discharge at PH1 compared to a similar increase in spillway discharge. Figure 3 shows a comparison of the slopes of predicted increases in re-ascension rates for steelhead adults as discharge increased through PH1 or the spillway. Figure 3 also displays the relative slope of the increase in re-ascension rates when discharge through each route was increased and all other conditions were held constant (at average values). As can be seen from the figure the slope of the prediction line plotted against discharge for PH1 was much steeper than that for spill discharge, and in contrast to Chinook prediction lines, confidence intervals around steelhead prediction lines were relatively narrow indicating the better fit of the model and that the slope of the predictive line was significant. Based on Figure 3 it would appear that increasing discharge into PH1 at flows in the range of 320 to 350 Kcfs greatly increased steelhead re-ascension rates. And as shown for adult Chinook, when the trade-off with spill discharge is considered, as shown in Figure 4, increasing discharge through PH1 increases the number of steelhead re-ascensions.

Table 5. List of variables in multi-model regression analysis of re-ascension rates for adult spring/summer Chinook at Bonneville Dam, showing the weighted average coefficients, and associated confidence intervals around those coefficients, as well as their relative variable importance. The variables were "sp"-spill; "b1"-discharge powerhouse 1; "tq"-total discharge; "jd"-julian day; "tr"-transport; "rkm"- river kilometers released above Bonneville dam; and "ag"-ocean age of returning adult.

Variable	Coefficient	Lower 95% CI	Upper 95% CI	Relative Variable Importance
ag	-0.2073	-0.1948	-0.2198	0.65
b1	0.0124	0.0130	0.0117	0.82
jd	-0.0039	-0.0036	-0.0043	0.51
rkm	0.0002	0.0002	0.0002	0.44
sp	0.0078	0.0085	0.0072	0.63
tq	-0.0042	-0.0036	-0.0048	0.52
tr	-0.0185	-0.0047	-0.0324	0.28

Table 6. List of variables in multi-model regression analysis of re-ascension rates for adult steelhead at Bonneville Dam, showing the weighted average coefficients, and associated confidence intervals around those coefficients, as well as their relative variable importance. The variables were "sp"-spill; "b1"-discharge powerhouse 1; "tq"-total discharge; "jd"-julian day; "tr"-transport; "rkm"- river kilometers released above Bonneville dam; and "ag"-ocean age of returning adult.

Variable	Coefficient	Lower 95% CI	Upper 95% CI	Relative Variable Importance
ag	8.1423	-2717	2749	0.52
b1	0.0678	0.0303	0.1055	1.00
jd	0.0012	-0.0173	0.0259	0.28
rkm	0.0033	0.0014	0.0054	0.99
sp	0.0122	-0.0153	0.0616	0.53
tq	-0.0075	-0.0577	0.0221	0.42
tr	-10.0267	-3780	3747	0.61

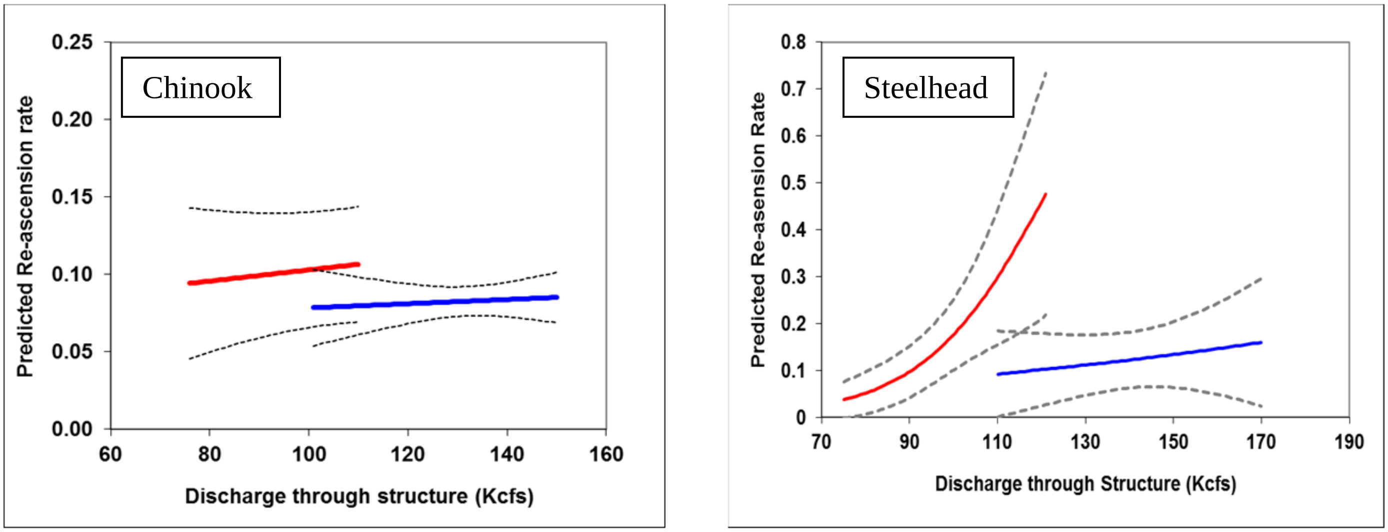

Figure 3. Predicted re-ascension rate at Powerhouse 1 plotted against powerhouse 1 discharge (red) and spillway discharge (blue) for Chinook and steelhead adults when all other variables were held at averages.

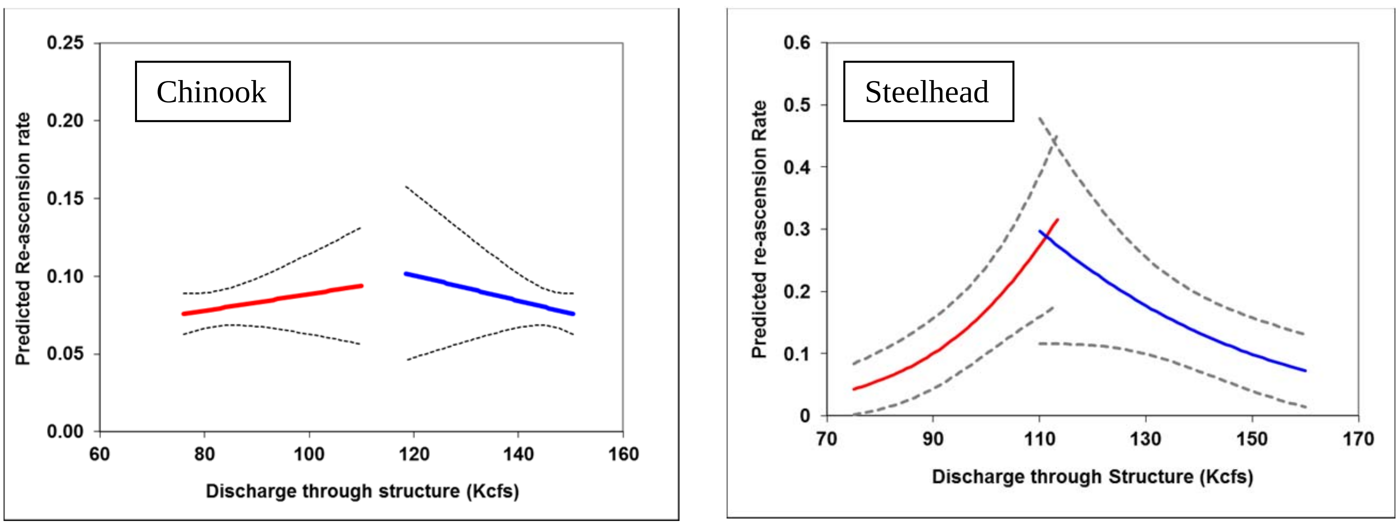

Figure 4. Predicted re-ascension rates at Powerhouse 1 plotted against powerhouse 1 discharge (red) and spillway discharge (blue) for Chinook and steelhead adults when spill and powerhouse 1 discharge vary in opposite directions (i.e when spill decreases as powerhouse 1 discharge increases).

Logistic Regression of Adult Ladder entrance

For adult Chinook, the logistic regression for ladder entrance preference showed no relation between project operations and adult fish probability of entering ladders that exit into the PH1 forebay (BO1) versus PH2 (BO4). From Table 1 it appears that just over half the adults enter into ladders leading to the BO4 exit. But for PIT-tagged adult Chinook it did not appear that choice of entrance was affected by operations. The Somer's D statistic for the predictive model that included operational and biological variables was 0.02 indicating very poor predictive accuracy. For steelhead the Somer's D statistic of 0.206 indicating a better fit between predicted preference for BO1 versus observed entrance choice. The only variable in the model that had a relative variable importance greater than 0.5, was total discharge at the dam (tq), which had an RVI of 0.88. Predictive modeling showed that as discharge increased the proportion of adult steelhead using PH1 decreased across the range of flows seen in 2012. But when plotted against spill and PH1 discharge that occurred when flows were in the 320 to 350 Kcfs range, there was not a significant slope to the line for either predictive lines. There was a slight downward trend in the predicted proportion choosing PH1 as spill discharge increased, but that trend was not significant and the confidence intervals around the prediction were wide. It appeared that in terms of the trade-off between spill and PH1 operations, at least in the 320 to 350 Kcfs range, there was no discernible effect on adult choice of entrances.

Conclusions

Based on our analysis, fallback/re-ascension rates of PIT-tagged Chinook salmon in 2012 were not closely related to Bonneville Dam operations at the time scale 24 hours after exit, using the fish that exited and re-entered within two days. However, for steelhead the re-ascension rates in 2012 were more closely related to operations and particularly to the operation of PH1. As discharge increased at PH1, adult steelhead re-ascension rates were predicted to increase rapidly. While the relation between re-ascension rates and spill was also positive for steelhead (the model predicted only small increases in re-ascension rates as spill increases), increasing spill volume while at the same time decreasing discharge through PH1, had the effect of decreasing overall re-ascension rates. A similar effect was predicted for adult Chinook although not as strong an effect as seen with steelhead due to poorer performance of the predictive model.

Based on our modeling it appears that the trade-off of increasing discharge at PH1 in the range of 85 to 125 Kcfs, indicative of discharge levels during open geometry, and decreasing spill, resulted in higher adult fallback/re-ascensions particularly for steelhead.

There appeared to be no effect on first ladder entrance (either entering a ladder leading to PH1 exit or PH2 exit) with changes in spill proportion versus PH1 operation.

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DATA REQUEST FORM

Request Taken By: David Benner **Date:** 7/18/2012

Data Requested By:
Name: FPOM - Unit Ops Task Group **Phone:**
Address: **Fax:**
Email:

Data Requested:
Analysis looking at if operating BON PH1 to open geometry would impact adult Fallback, or is it best to spill the additional water. Also look at BON operations as they may impact entrance approach.

Data Format: Hardcopy ☐ Text ☑ Excel ☐

Delivery: Mail ☐ Email ☑ Fax ☐ Phone ☐

Comments:

Data Compiled By: D. Benner J. McCann **Date:** 12/17/2012

Request # 74

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