FISH PASSAGE CENTER

847 NE 19th Avenue, #250, Portland, OR 97232
Phone: (503) 833-3900 Fax: (503) 232-1259
www.fpc.org/
e-mail us at fpcstaff@fpc.org

MEMORANDUM

TO: Bill Tweit, WDFW
Mark Bagdovitch and Howard Schaller, USFWS
Bob Rose, The Confederated Tribes and Bands of the Yakama Nation
Tom Skiles, CRITFC
Ritchie Graves, NOAA
Sheri Sears, Confederated Tribes of the Colville Reservation
FPAC

FROM: Michele DeHart

DATE: July 22, 2015

RE: Upper Columbia study design and analyses reviews

The purpose of this memorandum is to focus attention on the process of review and approval of studies being conducted in the upper Columbia River under the auspices of the Priest Rapids Coordinating Committee and the Upper Columbia Coordinating Committee. These studies are important because they form the basis for long-term decisions on fish passage operations at the Upper Columbia hydroelectric projects, therefore having long-term implications for the success of mitigation measures upstream, as well as recovery of listed stocks of salmon and steelhead.

The Fish Passage Center has received requests to review various studies that have been conducted in the Upper Columbia. Many times these requests are to provide review comments on study reports. These requests to review study results and analyses arise when study results are proposed for application in a fish passage management framework. Issues that arise from these reviews are often issues that could have been addressed during the development of the study design. Specific study design elements, such as mark group size, marking and handling effects, expected magnitude of effect being tested, power of statistical tests, and representativeness of the test group, can affect the application of study results to fish passage management decisions. The weaknesses in study designs can result in erroneous fish passage management decisions that decrease fish survival and decrease the effectiveness of other

mitigation measures. Attention to the intended management application of study results at the time of the study design development can decrease disagreement regarding the application of study results, therefore increasing the cost effectiveness of study implementation.

The following discussion focuses on a recent example of implementation of a study design in the Upper Columbia that could affect long-term fish passage decisions for the Upper Columbia. The Fish Passage Center responded to a request to provide technical review comments on performance standard testing. The FPC reviewed the available study design document and prepared the attached memorandum (memo dated June 22, 2015). There was apparent confusion among agencies' representatives regarding study design documents. On Monday, July 13th, NOAA Fisheries provided further description of the statistical analyses to be used. This additional documentation had not previously been made available to all members of the Priest Rapids Coordinating Committee or to the FPC for technical review. The FPC reviewed the additional study design elements. After reviewing all of the documentation currently available, the FPC concludes that many aspects of the 2015 Grant County study plan will limit the fish passage management application of the data collected. These concerns are outlined in the FPC Memo from June 22 but are included here in summary:

- The study plan lacks basic information on study objectives and data analysis, which limits a full review of the proposal. Without stated management objectives, it is not possible to assess if the proposed study will provide the information required for management decisions.
- The comparison of fish guidance efficiency (FGE) under two levels of spill does not account for other operations, such as turbine flow, that directly affect FGE. The comparisons will not be applicable to management decisions in future years. Additionally, the study does not include an analysis of appropriate sample size, so it is likely the comparison will utilize data from which no statistically meaningful conclusions can be drawn.
- The study plan does not mention Chinook, lamprey, or other species that may be impacted by the changing operations required by the study design. Although these species are not part of the study plan, their passage and survival should not be ignored in years they are not the subject of performance testing.
- The proposed comparison of survival at different turbine efficiencies at Priest Rapids Dam does not include an analysis of the appropriate sample sizes to detect a biologically significant difference between operations. Although this comparison was not included in the final study design carried out in 2015, the same concerns about the Wanapum FGE testing in 2014, particularly in regard to effect and sample size, also apply here if this operation is to be tested in the future.

In addition to the technical problems present in the study plan, difficulty was encountered in obtaining the documents pertinent to a full review. Study plans and amending documents are not made available online, or widely distributed for technical review beyond the PRCC. This has hindered the provision of timely study and monitoring design technical support for the agencies and tribal representatives in the Upper Columbia and Priest Rapids Committees processes. Technical support for the agencies and tribes representatives is consistent with established FPC goals and objectives.

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MEMORANDUM

TO: FPAC

FROM: Michele DeHart

DATE: June 22, 2015

RE: Grant County performance testing in 2015

At your request, we have reviewed the Grant County proposal *Study plan for the estimation of juvenile steelhead and sockeye salmon survival through the Priest Rapids Project in 2015*. This document was originally released in December of 2014, and amended on March 25, 2015. The study plan is designed to test survival of juvenile steelhead and sockeye through Wanapum and Priest Rapids dams using acoustic tags. The March 25 addendum included an additional comparison of the Wanapum Fish Bypass (WFB) at different levels of flow, and a comparison of dam passage at Priest Rapids during varying turbine efficiency operations. The latter comparison was removed before the start of the study.

In our review, we found numerous aspects of the study plan that lead us to recommend that these studies not be accepted without serious reservations. Below is a summary of our comments, followed by a more detailed discussion of each point.

- The comparison of fish guidance efficiency (FGE) at the WFB was not fully described in the proposal and did not include information critical for review.
    - No management objective, such as a target FGE, was provided for the comparison of FGE.
    - Flow volume and dam operations, such as turbine operations and flow through other spill routes, can affect the FGE at the WFB. These factors are not included in the analysis, and it is unclear what applicability the comparison will have.

    - Other passage metrics such as survival, forebay delay, and tailrace egress are not included in the comparison of flow through the WFB.
    - The comparison of spill volumes through the WFB includes no evaluation of the potential effect size the study will be able to detect. The statistical methodology of comparing the FGE between the two operations is not included, nor is there an analysis of appropriate sample sizes for the comparison. If sample sizes are insufficient to detect an existing difference, the study may incorrectly conclude that the two operations are equivalent for fish passage.

- The study plan does not address passage of juvenile Chinook salmon through Wanapum and Priest Rapids. Performance standards for yearling Chinook were met in 2003, 2004, and 2005, but numerous changes in spill level and operations have occurred since then and Chinook have not been re-tested, with the exception of 2014. However, tests in 2014 were under extreme conditions due to the Wanapum reservoir drawdown, and do not reflect current or future operations.
    - The study plan includes varying levels of spill through the WFB, but there is no analysis on what effect this may have on yearling Chinook passage.
    - Subyearling Chinook passage has never been tested in Grant County, so there is no available data on how changing operations may impact subyearling Chinook migration.
- The proposed comparison of survival at different turbine efficiencies at Priest Rapids Dam does not include an analysis of the appropriate sample sizes to detect a biologically significant difference between operations. Although this comparison was not included in the final study design carried out in 2015, the following should be considered before this comparison is considered for future study plans.
    - Under the expected sample sizes for each turbine treatment operation, the statistical power to detect a difference in survival ranging from 0.01 to 0.09 is less than 50%. For small differences in survival from 0.01 to 0.04, the statistical power is less than 25%.
    - Researchers often design their studies in order to have at least 80% statistical power as a commonly chosen goal. According to our power analysis, 80% statistical power will be achieved only for very large sample sizes or very large differences in turbine survival that are unlikely to be observed in this study.

Overview of 2015 Proposal and Study

The 2015 performance test follows much of the same protocol as 2014 testing of yearling Chinook and steelhead smolts. Acoustically tagged smolts are released upstream of the project and in the tailrace. Adjusted survival estimates are presented as a ratio of the survivals of S_1 (dam passage) and S_2 (control). Mortality in the control group due to handling, predation, or other factors not experienced by the dam passage group can inflate the value of the adjusted survival estimate (Skalski et al. 2010).

Acoustic tagging of smolts has limitations for both size and condition for tagged fish. If a considerable portion of the run is rejected due to small size, disease, injury, or other conditions, the results will reflect the survival only of the healthiest portion of the run-at-large and will not be representative of true dam survival. Previous performance testing in Grant County (from 2008, 2009, 2010, and 2014) have not included rejection rates, so the potential representation of testing in 2015 is impossible to estimate from past studies. Any evaluation using acoustic tags should include tag size criteria and rejection rates.

With the inclusion of a comparison of FGE through the WFB under 15 and 20 Kcfs of flow through the WFB, the 2015 study plan differs from what was conducted in 2014 at Wanapum Dam. In 2015, flows were planned to alternate in 3-day blocks during the month of May. The study plan does not specify where, during days of 15 Kcfs flow through the WFB, the additional 5 Kcfs will be passed (i.e., turbines or other spill routes) or whether this will be consistent for all 15 Kcfs days.

The 2015 study plan also differs from the 2014 plan at Priest Rapids Dam because of the inclusion of a comparison of survival at different turbine efficiencies. Although not actually carried out in 2015, the study plan calls for alternating 3-day blocks of 'fish mode' on and 'fish mode' off. 'Fish mode' is a project operation that refers to the allowable flow through turbine units. While 'fish mode' is on, as usual during the passage season, turbine flows cannot exceed 15.7 Kcfs. While 'fish mode' is off, turbine flows can be as high as 17.5 Kcfs, although turbine flows are determined by power needs and flow volumes. The minimum flow through the turbines does not change with 'fish mode.' High flows through the turbines would be used opportunistically depending on flows and power demands, and might not actually differ during the two test conditions.

Evaluation of Fish Passage Efficiency at Wanapum Dam Bypass

The 2015 study plan for the Priest Rapids Project calls for additional evaluations beyond the questions that the study was designed to answer. This study was designed to estimate dam survival and ascertain whether this survival estimate meets survival performance standards. However, in addition to testing survival performance standard metrics, additional evaluations in the 2015 study plan called for evaluating fish passage efficiency of the WFB during periods of reduced flow. The study design, particularly in regard to sample sizes, did not attempt to account for comparisons between operations and flow levels.

Additional evaluations beyond the questions that the study was designed to answer often lack large enough sample sizes to reliably test statistical hypotheses. In this case, statistically insignificant results from comparisons of operations do not imply a lack of effect, but instead may result from an insufficient amount of data relative to the effect size that is being tested (i.e., lack of statistical power). For this reason, the results of the additional evaluations conducted at the Priest Rapids Project need to be interpreted with caution. If the study fails to find a statistical difference between two operations, it does not necessarily imply that one does not exist. In order to test for a statistical difference between project operations at the WFB, Grant County PUD should specifically design a study, separate from their survival performance evaluation study, to

answer these questions. The lack of detail about the analysis of data collected in the WFB evaluation precludes a detailed exploration of sample size similar to the one completed below regarding the evaluation of 'fish mode.'

It is unclear from the study plan how the evaluation of flow through the WFB will inform management decisions. The performance standards require project survival of 93% for smolts, and the differences in WFB flow will not be evaluated for survival differences, nor other metrics which may affect dam passage such as forebay delay and tailrace egress. Additionally, FGE is influenced not only by flow through a particular passage route, but also overall dam operations, turbine flow, flow through other spillways, and total river flow. Finally, the results of this evaluation, which was conducted in an extremely low flow year, will not be applicable to other flow conditions.

Changing Spill Operations May Impact Other Species

The comparison of FGE under two operations was proposed only for steelhead and sockeye smolts. However, other species migrate through Wanapum Dam, and these operations may affect their passage experience. Yearling Chinook passed performance tests in 2003, 2004 and 2005. In 2008, spill levels at Priest Rapids and Wanapum Dam were significantly reduced, but yearling Chinook were not retested under the new operations until 2014. Tests in 2014 at Wanapum Dam have severely limited applicability to other years due to the drawdown of the reservoir, which impacted all aspects of dam passage. Tests conducted in 2014 should not be used to draw conclusions about survival with the current operations, and additionally provide no information on the potential impact of the 2015 WFB test on Chinook migration.

Changing dam operations without testing the impacts on juvenile survival and adult returns should not be an appropriate management strategy. In particular, reductions in spill may increase turbine passage, which has increased delayed mortality and reduced smolt-to-adult returns (Schaller and Petrosky 2007; Petrosky and Schaller 2010; Haeseker et. al. 2012; Schaller et al. 2013).

Evaluation of 'Fish Mode' Does Not Utilize Appropriate Study Design

Statistical power of the proposed 'fish mode' on and off experiment

Below we investigate the expected statistical power to detect a difference in steelhead turbine survival between the proposed 'fish mode' on and off operations at Priest Rapids Dam. This comparison was not conducted in 2015, but it may be proposed again in future years, so we have provided this exploration of the proposed study.

As a reminder, statistical power is defined as the probability of correctly rejecting the null hypothesis (i.e., 'fish mode' on survival equals 'fish mode' off survival) when in fact it is not true. More generally, statistical power can loosely be thought of the as the probability of correctly finding effects that are genuinely true. Thus, studies with low power produce more false negatives (e.g., erroneously conclude that there isn't a difference between two turbine

treatment operations) than high-powered studies. In order to avoid making erroneous conclusions, studies typically make sure that there is sufficient statistical power to detect the hypothesized effects or safeguard against wrongly concluding that there isn't one. We evaluate the statistical power under a range of sample sizes assumed to be equal for each treatment group and also a range of effect sizes (i.e., the difference in survival between the two treatments).

As described in the study plan, the Priest Rapids Dam powerhouse turbines will be operated in alternating 3-day blocks of 'fish mode' on and off. Five blocks of each operation will be tested. When 'fish mode' is on, turbine operation at Priest Rapids Dam is set not to exceed 17.5 kfcs per turbine unit, and when fish mode is off, turbine operation is set not to exceed 18.2 kfcs per unit. For the purpose of our power analysis, we assumed that the data would be collapsed across all five operation blocks.

In the proposed study plan, 650 and 550 juvenile steelhead will be released at Rock Island and Wanapum dams respectively. We used estimates of survival and fish guidance efficiency from 2014 testing at Priest Rapids for steelhead, reported in Skalski et al. (2014) to inform the expected sample size of the power analysis. In 2014, survival from Rock Island Dam tailrace to the forebay of Priest Rapids was estimated at 0.88. Survival from Wanapum Dam tailrace to the Priest Rapids forebay was estimated at 0.97. Therefore, based on the release numbers this year we would expect around $650 \times 0.88 + 550 \times 0.97 \approx 1{,}105$ individuals to be alive at the forebay of Priest Rapids Dam. If we assume 100% detection probability within turbine routes, and use the reported estimate of steelhead fish passage efficiency (the proportion of fish that pass through the dam by non-turbine routes) at Priest Rapids Dam of 0.6920, then we would expect around $1{,}105 \times (1\text{-}0.6920) \approx 340$ individuals to pass through the Priest Rapids powerhouse over the course of the study. Since two turbine operations are being tested, we would then expect around $340 \div 2 = 170$ individuals to form each turbine treatment group (i.e., virtual release group).

We also assume estimates of survival and detection downstream of Priest Rapids and reported in Skalski et al. (2014) for our power analysis. Detection probability at Vernita Bridge, the first array location downstream of Priest Rapids was estimated at 0.99, and the joint probability of surviving and being detected from Priest Rapids to White Bluffs (the next downstream array) was estimated at 0.93. Finally, we assumed a turbine survival during the 'fish mode' on operation of 0.95 (Dresser 2015) and varied the survival in the 'fish mode' off operation.

In order to simplify the power analysis, we assumed that a single release-recapture model composed of two virtual release groups under the two different 'fish mode' operations would be used to compare survival. A more sophisticated approach might be taken (e.g., multi-state route-specific model with a downstream paired release), but the methodology was not specified in the proposal. Therefore, we also mention that the results of this power analysis are dependent on the choice of the mark-recapture model assumed for the analysis.

Figure 1 shows the results of the power analysis over a range of sample sizes for each 'fish mode' off treatment operation. Different curves are drawn for the assumed difference in powerhouse survival between the 'fish mode' on and off operations. Several conclusions can be drawn from this figure:

- Under the expected sample size of 170 individuals per 'fish mode' on and off treatment, the power to detect a statistical difference in survival rates ranged from < 1% to 62%. Statistical power was greater than 50% only when the difference in treatments was 0.1 (i.e., 0.85 'fish mode' off turbine survival). All other differences in survival at these sample sizes resulted in statistical power less than 50%. For small differences in turbine survival, 0.01 – 0.04 (i.e., 0.91 to 0.94 'fish mode' off survival), statistical power was less than 25%.
- Although the choice is arbitrary, a target of 80% statistical power is a commonly chosen target. Under the assumptions of our power analysis, 80% or greater statistical power is achieved only for very large differences in turbine treatment survivals, 0.07 – 0.1 (i.e., 0.85 – 0.88 'fish mode' off survival). Additionally, 80% or greater statistical power is only achieved when the sample size is at least 250 fish under any assumed difference in turbine treatment operations.
- For more reasonable effect sizes, 0.01 – 0.04 (i.e., 0.91 to 0.94 'fish mode' off survival), statistical power is always less than 50% even at the largest sample size of 600 individuals per turbine treatment operation.

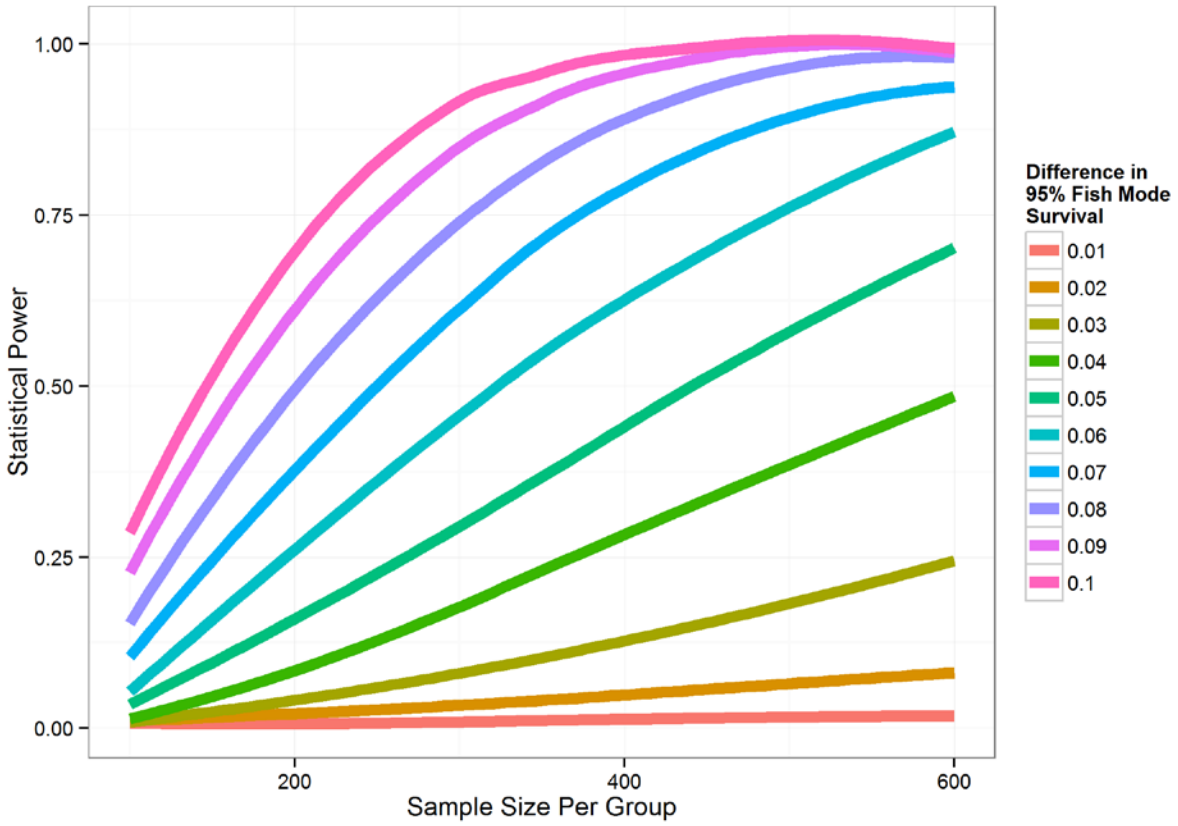

Figure 1. Statistical power to detect a difference between 'fish mode' on and off survival as a function of sample size. An equal sample size for each group is assumed. Each colored curve represents the difference between 95% 'fish mode' on and 'fish mode' off survival.

Conclusions

The study conducted in 2015 at Priest Rapids and Wanapum dams does not provide fisheries managers the data required to make informed decisions regarding dam operations. The current study design used for performance testing has a number of weaknesses that limits their applicability to actual dam passage conditions. Additionally, comparisons of operations were appended to the initial proposal that were inappropriate for the original plan. We do not recommend accepting the results of these tests, and we recommend a more rigorous evaluation of proposals from Grant County PUD in the future.

References

Dresser, T. 2015. Hydro Seminar Impacts and Solutions. Presentation February 11, 2015. http://www.ucsrb.org/Assets/Documents/Workshops/Hydro%20Seminar_2_11-2015_Final.pdf

Haeseker, S.L., J.A. McCann, J. Tuomikoski, and B. Chockley. 2012. Assessing freshwater and marine environmental influences on life-stage-specific survival rates of Snake River spring-summer Chinook salmon and steelhead. Transactions of the American Fisheries Society, 141(1), 121–138.

Johnson, D. H. 1999. The Insignificance of Statistical Significance Testing. Journal of Wildlife Management: 63(3):763–772.

Petrosky, C.E. and H.A. Schaller. 2010. Influence of river conditions during seaward migration and ocean conditions on survival rates of Snake River Chinook salmon and steelhead. Ecology of Freshwater Fish, 19(4), 520–536.

Schaller, H.A. and C.E. Petrosky. 2007. Assessing hydrosystem influence on delayed mortality of Snake River stream-type Chinook salmon. North American Journal of Fisheries Management, 27(3), 810–824.

Schaller, H.A., C.E. Petrosky, and E.S. Tinus. 2013. Evaluating river management during seaward migration to recover Columbia River stream-type Chinook salmon considering the variation in marine conditions. Can. J. Fish. Aquat. Sci. 71(2) 259–271.

Skalski, J.R., Townsend, R.L., Steig, T.W., Hemstrom, S. 2010. Comparison of two alternative approaches for estimating dam passage survival using acoustic-tagged sockeye salmon smolts. N. Am. J. Fish. Mgmt. 30:831–839

Skalski, J.R., Townsend, R.L., Lady, J.M., Timko, M.A., Sullivan, L.S. and Hatch, K. 2014. Survival of acoustic-tagged steelhead and yearling Chinook Salmon Smolts through the Wanapum-Priest Rapids Project in 2014. Prepared for Curt Dotson, Public Utility District No. 2 of Grant County.