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: Tom Rien, ODFW

From: Michele DeHart

Date: December 18, 2014

Re: Review of Adams et al. (2014), *Performance of a surface bypass structure to enhance juvenile steelhead passage and survival at Lower Granite Dam, Washington*

In response to your request to update the FPC Memo "Review of RSW and TSW Studies" from January 15, 2010, we provided a memorandum response on October 31, 2014. Subsequent to the completion of that response, we became aware of a recent journal article published in the North American Journal of Fisheries Management, entitled *Performance of a Surface Bypass Structure to Enhance Juvenile Steelhead Passage and Survival at Lower Granite Dam, Washington* by Adams et al. (2014). Because the subject of this article was the performance of surface bypass structures, and the article is based upon the same research reports and results the FPC reviewed in both 2010 and October 2014, it was determined that a review of Adams et al. (2014) should be included in the response to your original request.

The Adams et al. (2014) journal article uses data from radio-tagged steelhead from studies in 2002, 2003, 2005, and 2006 at Lower Granite Dam, the same reports summarized in previous FPC memos. The four years of studies conducted are not replicates of one study design. Each annual study was conducted with a different design, different objectives, and different operational conditions. Most importantly, the flow and spill operations under which these data were collected do not resemble the present operations experienced by migrating smolts. In addition, Adams et al. (2014) limit their evaluation to steelhead passage via surface passage and ignore Chinook passage. Also, the conclusions of Adams et al. (2014) infer a comparison of fish passage with surface structures versus spill without a surface structure. However, a review of Lower Granite project operations during these tests shows that they do not provide an adequate data set for this comparison.

The summary of our review is listed below for your consideration, followed by detailed discussions of each point.

- There is nothing in the Adams et al. (2014) article that supports modification of the conclusions of the October 31, 2014, memorandum provided to ODFW. We agree that surface passage structures may provide some benefits for spill passage efficiency of steelhead, however, the authors fail to address the limited benefit for Chinook.
- The effectiveness of surface passage structures is highly dependent on river flows and spill proportion.
- Reducing spill volumes with the operation of surface passage structures will reduce overall spill passage efficiency.
- Adams et al. (2014) conclusions regarding the effectiveness of surface passage structures are overly optimistic and not supportable from the available data. This is likely the result of the assumptions required to combine annual data from disparate studies of varying operating conditions.

Combining data from annual tests with disparate objectives and designs

It is important to recognize immediately that this paper attempts to combine data from four independent studies, each of which was conducted with different objectives and under varying dam operations and river conditions. The differences among years results in an assortment of data that cannot be forced into a single analysis of the impacts of surface passage (Table 1). Studies in 2002 and 2003 have the stated objective of comparing surface spill passage to spill without a surface passage structure in place. However, the study carried out in these years does not provide this comparison. Because spill efficiency is highly dependent on flow and spill operations, using different spill levels for RSW and traditional spill make true comparisons in efficiency impossible. In 2005, periods of RSW use alternated with periods of no spill, providing no potential comparisons between spill types. The RSW was in constant use in 2006, again providing no potential comparisons between RSW use and limiting spill to traditional passage routes. However, the object of the 2006 study was to determine the effects of the location of the Behavioral Guidance System (BGS), which was moved between the "stored" and "deployed" locations, providing a further confounding factor to spill metrics.

As outlined in Table 1 and the FPC memo from October 31st, the study years at Lower Granite Dam reflect operations that are no longer implemented. Spill for fish passage is currently provided on a 24-hour basis and is no longer provided only during nighttime hours at any project. One of the four study years had abnormally high flows (2002) and one of the four years had abnormally low flows (2005). Any potential benefits of surface passage are highly dependent both on flow and spill operations, so results from past operations do not necessarily extrapolate to the current passage conditions. Additionally, it is important to note that a "true" comparison of passage with and without surface structures is impossible. No studies were conducted to estimate spill passage efficiency under current spill levels prior to the installation of the RSW. Spillbay passage is known to vary across the spillway and the RSW was installed in the spillbay with the highest passage proportion (Adams et al. 1998). Consequently, it is impossible to show how much of the higher passage through spillbay 1 is due to the RSW, rather than natural passage patterns. The authors discuss the implications of their findings to extrapolate potential RSW benefits from this study to other sites, years, and operations, but given the unique operations and the spillbay configuration, this conclusion is certainly questionable.

Table 1: Comparisons of surface passage studies at Lower Granite Dam

Year	Objective (length of study)	Were Conditions Met?	Tag Size	Operation	Days at Operation	Average Spill (Kcfs)
2002[A]	Compare non-equivalent spill levels of RSW and traditional spill (21 days)	High flows made planned operations impossible.	1.75 g	Gas Cap, no RSW, 12-hour spill	2	42
				No RSW, 24-hour spill	5	38
				RSW + 8 Kcfs	3	15
				RSW + 16 Kcfs	4	23
				RSW + >29 Kcfs	7	>= 36 (actual average not reported)
2003[B]	Compare non-equivalent spill levels of RSW and traditional spill (41 days)	Yes Turbine 1 was offline during study.	1.75 g	Gas Cap nighttime, 0 daytime spill, no RSW	20	48.8 when excluding no spill periods, 33.4 including daytime
				RSW	21	21.5
2005[C]	Compare passage conditions with different BGS positions (58 days)	Low flows made planned operations impossible. Turbine 1 was offline during study.	1.03 g	No Spill	39.5	0
				RSW Spill	18.5	18.3
2006[D]	Compare passage conditions with different BGS positions (41 days)	Yes	0.71 g	RSW Spill	41	48
2007–2014	Current Operations (no study)			RSW Spill		20 Kcfs (planned)

[A] Plumb et al. 2003A
[B] Plumb et al. 2004
[C] Perry et al. 2007
[D] Beeman et al. 2008

For a more detailed review of the reports from those years, please see FPC memos from October 31, 2014, and January 15, 2010. Our conclusions on Adams et al. (2014) are summarized below, followed by more detailed explanations.

- The effectiveness of spill operations is heavily dependent on both total river flow and the percentage of flow that is spilled. This paper presents widely varied passage conditions, and there are no tests directly comparing spill, flow, and operations with and without the RSW at Lower Granite Dam. Overall conclusions about RSW effectiveness that can be compared to other years are impossible to extract from this paper.
- Different spillbays across the dam will pass smolts at different rates, depending on the site and on turbine operations (Plumb et al. 2003B). In 1995, prior to the installation of the RSW, passage studies at Lower Granite Dam showed the highest passage proportion through spillbay 1, the location of the RSW. The location, rather than the surface passage itself, may be providing benefits to migrating smolts (Adams et al. 1998).
- Adams et al. (2014) considers only the data on juvenile Steelhead passage at Lower Granite Dam, and does not present any of the available data on yearling and subyearling Chinook salmon. During the RSW test for subyearling Chinook at Lower Granite in 2005, fewer smolts passed via spill during the RSW treatment than the traditional spill treatment. Data from Lower Monumental and Ice Harbor show decreased Spill Passage Efficiency (SPE) for yearling Chinook after the installation of the RSW.
- Adams et al. (2014) states that "The relationships between physiology and fish passage are generally poorly understood… and how this relates to passage through surface flow bypasses such as the RSW is no exception." We would add to this that the radio tags used in this study create a substantial tag burden ranging from 0.53% to 6.4%, when the recommended standard is less than 4%. Additionally, radio tags require antennae which protrude from the smolt. The potential effects of handling and tagging were not adequately addressed in Adams et al. (2014). These factors may significantly affect smolt behavior when passing a dam, making study results less applicable to the general run-at-large.
- Neither the original Corps of Engineers funded research reports for these studies, nor Adams et al. (2014) address the issue of representation of the run-at-large by these radio-tagged steelhead. There is no available information on how steelhead smolts were selected for this study from the Lower Granite bypass facility. Due to the large size of the tags, it is clear that rejection rates due to size, injury, and fish condition were likely very high. The results from these years at Lower Granite will not represent migration conditions for the majority of migrating smolts.
- In 2005, RSW spill was compared to a no-spill operation. In 2002 and 2003, the gas cap operation was conducted only for 12 nighttime hours, leaving 12 daytime hours with no spill. A lack of spill will severely delay smolts in the forebay, potentially resulting in skewed fish passage conditions when spill is reopened.
- Only spring conditions are considered in this study. Temperature stratification, as can occur at Lower Granite Dam in the summer months, may significantly affect the vertical distribution of smolts within the forebay. This will impact the efficiency of surface passage.
- It is clear from surface passage studies throughout the Columbia Basin that while surface passage may have provided limited benefits to passage efficiency, they cannot make up for reductions in spill, and so pass fewer overall fish through the spillway than higher spill

levels. For a more thorough review of surface passage in the Snake and Lower Columbia, see FPC Memos from January 15, 2010, and October 31, 2014.

Spill, Flow, and Operations are Not Designed to Compare RSW and non-RSW Operations

Spill Passage Efficiency (SPE) is highly sensitive to river flow. This means that SPE measured in one year can only be compared to other years if flows are similar, and equivalent operations are used at the dam. Adams et al. (2014) does not provide any of these comparisons, nor does it outline the range of benefits that may occur under a range of flow conditions. Consequently, the conclusions of this paper, which state that the benefits of the RSW will be experienced across years, are questionable.

Comparisons of Passage Between Spillbays Cannot Be Made

The density of passing smolts through each spillbay is dependent on the location of the spillbay and the operations of turbines, which draw smolts to certain passage routes. Lower Granite has eight spillbays, seven of which provide traditional spill and one which became the RSW in 2001. There are no data provided on the SPE of spillbay one *prior* to the installation of the RSW. It is entirely possible that the passage efficiencies of the RSW are largely due to its location, as indicated by Adams et al. (1998), rather than the function of surface passage. The location of the RSW is a confounding factor to this study which is not addressed.

Adams et al. (2014) Presents Data Only for Steelhead Passage

While steelhead passage is presented in this paper, yearling and subyearling Chinook also use passage structures. While direct comparisons of Chinook passage with and without an RSW are impossible at Lower Granite, the benefits of surface passage at other sites are not clear. Comparisons of SPE at Lower Monumental between 2007 and 2008, years with similar flows and operations, show that yearling Chinook SPE was lower after the introduction of the RSW. At Ice Harbor Dam in 2005, operations were tested with and without use of the RSW. During these tests, yearling and subyearling Chinook showed decreased SPE under the RSW operations.

Data from a complete study design is lacking on the benefits of surface passage. However, there are clear indications that any benefits are not equal between different species and at different sites. The data presented in Adams et al. (2014) cannot be extrapolated to other species and other dams within the hydrosystem.

Radio Tags May Affect Smolt Behavior

The tag burden from radio tags can be significant for smolts and may affect behavior such as choice of passage due to the impairment of swimming ability. A tag burden, defined as the ratio of tag weight to body weight, is some indication of the potential effects on fish behavior and mortality. Tag burdens from 2% to 4% have been used and recommended in the Columbia Basin for smolts of the size found at Lower Granite (Winter 1983, 1996, 2000, and Zale 2005). Larger tag burdens, through impairing swimming ability, may have an impact on the selection of passage routes and therefore do not fully represent dam passage for the run-at-large.

The radio tags used in Adam et al. (2014) create a tag burden of 0.45% – 4.2% for hatchery steelhead and 0.79% – 6.4% for wild steelhead. No information is provided on the distribution of those tag burdens across years, or if smolts with higher tag burdens were more or less likely to use certain passage routes, so it is not possible to determine the potential magnitude of impact from exceedingly high tag burdens. For more detail on tag burdens, please see previous FPC Memos (June 24, 2009; March 24, 2011; February 15, 2012; and March 19, 2013).

High-Grading of Samples

Smolts are rejected from tagging for passage experiments due to size, disease, deformities, and injuries. The rejection rates of smolts for each of these reasons are provided for all performance testing in the hydrosystem since 2010, and clear rejection criteria are used throughout the region. This information allows managers to evaluate how applicable study results are to the juvenile run at large.

The rejection rates are not included for this study, nor are the criteria for rejection provided. However, it is clear that radio tags are larger and create a larger tag burden than the JSATS tags currently used for performance testing. Rejection rates for steelhead with JSATS tags have ranged from 6.4% – 12.6%, depending on the site and year. Rejection rates for radio tags can be expected to far exceed these rates.

Larger fish without deformities, disease, or injury may have significantly better swimming ability than those that do not qualify for tagging. Swimming ability may affect the route of passage, so excluding such a large portion of the run-at-large from the data means that this report cannot accurately reflect the passage distribution of untagged fish. For further detail on the effects of rejection rates, please see previous FPC Memos (June 24, 2009; March 24, 2011; February 15, 2012; March 23, 2012; January 4, 2013; February 11, 2013; March 19, 2013; March 22, 2013; December 3, 2013; January 14, 2014).

Alternating Operations with No Spill May Affect Passage Efficiency

In 2002, 2003, and 2005, use of the RSW was alternated with periods of no spill. During the periods of no spill, forebay delay will be increased while smolts search for suitable passage. When spill is then turned on, passage may increase for a time. The routes of passage during this initial period may not represent the distribution of fish that do not experience the same forebay delay, making the SPE of this operation not directly comparable to regular, continuous passage. Additionally, these operations often alternated between day and night, further confounding passage rates with natural diel passage patterns.

Under the current Fish Operations Plan and Biological Opinion, there is always spill during the fish passage season at Lower Granite Dam. This means that the results from tests in 2002, 2003, and 2005 cannot be extrapolated to compare to spill operations used in the present day. Additionally, due to the large effects of flow levels on fish passage, these data cannot be used to compare to years outside of the flows experienced in those years.

Spring and Summer Passage Conditions Differ

Adams et al. (2014) considers only the spring migration season, when river water is cool and relatively well mixed. In contrast, thermal stratification of the forebay is a persistent problem during the summer months at Lower Granite Dam. The effectiveness of surface passage is dependent on the vertical distribution of smolts through the forebay that favors the upper four meters of water. When temperatures are high in surface waters, the vertical distribution of smolts may be skewed to deeper water, reducing the effectiveness of surface passage (Deng et al. 2014). The results from this study cannot be extrapolated to potential benefits for summer migrants.

Surface Passage Cannot Make Up For Reductions in Spill

While there are no direct comparisons of RSW and conventional spill with similar flows, operations, and spillbays, it is clear that surface passage does not improve overall SPE enough to justify reductions in spill volume. At Ice Harbor, McNary, and John Day Dams, high spill levels without surface passage were compared to lower spill levels with surface passage. In each instance, the lower spill resulted in lower overall SPE for yearling Chinook, steelhead, and subyearling Chinook (FPC Memo January 15, 2010). These data call into question the overall benefits of surface passage that are discussed in Adams et al. (2014). For a detailed discussion of surface passage studies at other sites in the Columbia Basin, including models by the Comparative Survival Study, please see FPC Memos from October 31, 2014, and January 15, 2010.

In summary, it is clear that the study design used in Adams et al. (2014) cannot provide the data necessary to accurately assess any potential benefits of surface passage. To determine those benefits, a study involving current spill operations, multiple species, and representative flow years would be required. Furthermore, critical information such as fish rejection rates is omitted, so the quality of the representation of the run-at-large is impossible to determine. This paper should not be used to justify high expectations of the benefits of surface passage throughout the system.

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