First Year Fish Results from a Newly-Constructed Top-Spill Bypass at Wanapum Dam, Washington, USA

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ABSTRACT

The Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates two hydroelectric projects on the Columbia River in Washington State: Wanapum Dam and Priest Rapids Dam - Priest Rapids Hydroelectric Project FERC License No. 2114. On May 3, 2004, the National Marine Fisheries Service (NMFS - then referred to as NOAA Fisheries) issued its Biological Opinion of the effects of the proposed action on listed species, in accordance with Section 7 of the Endangered Species Act of 1973 as amended (16 USC 1531 et seq.), regarding the Federal Energy Regulatory Commission’s (FERC’s) proposed action amending Grant PUD’s existing license for the Priest Rapids Hydroelectric Project (Project) to authorize implementation of an Interim Protection Plan for listed anadromous salmonids. Subsequent to NOAA Fisheries’ issuance of the Biological Opinion and consistent with the requirements of the Biological Opinion and within the scope of its own agency jurisdiction under the Federal Power Act, on December 16, 2004, FERC issued an Order requiring Grant PUD to “implement NOAA Fisheries’ Reasonable and Prudent Alternative (Actions 1 through 25) and sections 12.2 and 12.3 of NOAA Fisheries’ Biological Opinion filed with the Commission on May 6, 2004.”

In response to these requirements for downstream fish passage facilities, Grant PUD engaged in an extensive review of fish bypass concept designs to evaluate options available to increase the survival of smolts passing Wanapum Dam. Using a set of guiding principles related to the capture effectiveness, transport survival, construction costs, and construction feasibility of fish bypass options, the selection process resulted in the construction of the Wanapum Future Unit Fish Bypass (WFUFB) in early 2008. To evaluate fish responses to this newly-constructed fish bypass, in 2008 acoustically-tagged salmonid smolts were tracked as they approached and passed Wanapum Dam. The fish passage efficiency (FPE) and passage survival rate of three species of salmonid smolts that passed via the WFUFB were estimated.

Data analysis of the acoustically-tagged smolts showed a FPE of 57%, 34% and 31% for steelhead, sockeye and yearling Chinook (respectfully) and a passage survival estimate of 100%, 95% and 96% for steelhead, sockeye and yearling Chinook (respectfully).
Introduction
The Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates two hydroelectric projects on the Columbia River in Washington State: Wanapum Dam and Priest Rapids Dam - Priest Rapids Hydroelectric Project FERC License No. 2114. (Figure 1). On May 3, 2004, the National Marine Fisheries Service (NMFS - then referred to as NOAA Fisheries) issued its Biological Opinion of the effects of the proposed action on listed species, in accordance with Section 7 of the Endangered Species Act of 1973 as amended (16 USC 1531 et seq.), regarding the Federal Energy Regulatory Commission’s (FERC’s) proposed action amending Grant PUD’s existing license for the Priest Rapids Hydroelectric Project (Project) to authorize implementation of an Interim Protection Plan for listed anadromous salmonids.

Subsequent to NOAA Fisheries’ issuance of the Biological Opinion and consistent with the requirements of the Biological Opinion and within the scope of its own agency jurisdiction under the Federal Power Act, on December 16, 2004, FERC issued an Order requiring Grant PUD to “implement NOAA Fisheries’ Reasonable and Prudent Alternative (Actions 1 through 25) and sections 12.2 and 12.3 of NOAA Fisheries’ Biological Opinion filed with the Commission on May 6, 2004....”. On April 17, 2008 FERC issued a new License Order for the Priest Rapids Project (Project), which incorporated the 2008 NMFS Biological Opinion Terms and Conditions, which are adapted from the 2004 NMFS’s Reasonable and Prudent Alternatives.

Figure 1. Wanapum and Priest Rapids Dams

Within its Biological Opinion, NOAA Fisheries identified specific actions it expected to result in Project operations meeting or exceeding Project survival standards for listed...
species by 2013. Some of these actions required the development of new downstream fish passage facilities to improve downstream juvenile salmon and steelhead passage survival rates. In response to these requirements for non-turbine downstream fish passage facilities, Grant PUD engaged in an extensive review of fish bypass concept designs to evaluate options available to achieve at least 95% survival of anadromous salmonid smolts passing Wanapum Dam. One proposed location for the Wanapum Dam fish bypass was in the “future units” area, adjacent to the powerhouse, where bulk flow hydrodynamic patterns had the potential to bring a substantial proportion of fish into the vicinity of the fish bypass. Before advancing a final design of a Wanapum Dam fish bypass (WDFB), several questions regarding its design and location needed to be answered. Using a set of guiding principles related to the capture effectiveness, transport survival, construction costs, and construction feasibility of fish bypass options, the selection process resulted in two conceptual designs that were expected to meet the various objectives of this initiative for Wanapum Dam.

With respect to identifying a preferred concept design, a decision needed to be made between these two WDFB entrance designs (“concepts”) that had substantially different physical and hydraulic characteristics. The first concept (Concept 10) was structured to fit within the confines of a single turbine intake slot, with a simple straight chute entrance. The second concept (Concept 11) was structured to fit within two intake slots, with a more complex curvilinear chute entrance, see Figure 2.

![Figure 2. Concept 10 and Concept 11](image)

The primary hydraulic difference between these concepts was that the former had uncontrolled flow acceleration occurring upstream of the entrance, whereas the latter had controlled flow acceleration occurring within the entrance. To evaluate fish responses to these different physical and hydraulic characteristics, and determine which entrance design would best benefit fish passage, a study was designed to monitor and
evaluate fish behavior as they approached one of these WDFB entrance concept designs – “Concept 10”.

“Concept 10” Study
To evaluate fish responses to these two different WDFB entrance concepts and determine which entrance design would best benefit fish passage, a study was designed to monitor and evaluate the fishes' behavior as they approached one of two entrance designs – “Concept 10”, which exhibited uncontrolled flow acceleration upstream of the bypass entrance.

A modified bulkhead gate incorporating a 20 kcfs surface opening ("top-spill gate" with similar flow characteristics as the WDFB – Concept 10) was installed at Wanapum Dam Spill Gate 12 (Figure 3). The study was designed to see if the Concept 10 hydraulic conditions would result in fish rejecting this as a passage route. As part of this study, 1,000 hatchery-produced Chinook salmon smolts were surgically implanted with a small acoustic transmitter, released upstream of Wanapum Dam and electronically tracked over their migration in the Wanapum Dam forebay and passed the dam (Figures 4 & 5).

Figure 3. Top-Spill Bulkhead at Gate 12 Wanapum Dam
Results from the study showed that “rejection” of the top-spill entrance was not a common event of the fish at the WDFB (Concept 10) prototype. This demonstrated that the uncontrolled acceleration of water in front of a top-spill opening was not a factor to fish for rejecting this design of passage route.

In addition to evaluating if fish would reject a top-spill passage route that had an uncontrolled acceleration of water in the dam’s forebay, the location (in regards to placement at the development) for building such a fish bypass facility was also evaluated via the tracks produced by the acoustic tagged salmon smolts. At Wanapum Dam, it was determined that Powerhouse Future Unit 11 would be an adequate location for the Wanapum Dam future fish bypass (WFUFB – Wanapum Future Unite Fish Bypass), based on the high concentration of fish in that area of the dam as they followed the bulk flow toward the powerhouse (Figure 6).
Figure 6. Concentrations (depicted by color) of tagged fish in front of Wanapum Dam

Along with questions concerning entrance conditions (i.e. uncontrolled acceleration of water in the dam’s forebay) for a Wanapum fish bypass, concerns regarding the WFUFB’s exiting flow conditions upon fish health had to evaluated. For this evaluation, the Wanapum ice/trash sluice way was modified to model the exit conditions that fish would see upon exiting the proposed WFUFB. The exit conditions that were modeled were an exit flow of 225 cfs/linear ft. at a velocity of 65 ft./sec (Figure 7).
A balloon-tag study was conducted at this modified ice/trash sluice way to evaluate the WFUFB exit flow conditions upon Chinook salmon smolts (Figure 8). Test results from this study showed 100% survival of the smolts and indicated less than 1% had injuries due to minor abrasions.

Figure 8. Balloon-tag testing at modified ice/trash sluice way.

It was with this type of “fish validation” that the production design and location for the WFUFB was finalized and construction started at Wanapum Dam in fall of 2005 (Figures 9, 10, and 11).
Figure 9. Location of the Future Fish Bypass at Wanapum Dam

Figure 10. Conceptual drawing of the WFUFB: A) upstream side and B) downstream side

Figure 11. Construction of the WFUFB
Biological Evaluation of the WFUFB
Construct of the WFUFB was competed in early 2008 (Figure 12) and biological evaluation of its performance as a fish bypass facility at Wanapum Dam was conducted in May, 2008. Through conducting acoustic tag studies in the Priest Rapids Project, Grant PUD looked at steelhead, yearling Chinook and sockeye salmonid smolts as they passed Wanapum Dam, and particularly their use and survival rate through the WFUFB. 1,054 Chinook, 562 steelhead and 373 sockeye (all acoustically tagged) were tracked in 3-Dimensional as they approached and passed Wanapum Dam.

Results
Results from the 2008 studies showed that turbine passage was reduced for all species, with the greatest reduction seen in steelhead. Turbine passage of out-migrating steelhead smolts in 2007 was 67% as compared to 34% turbine passage in 2008. The fish passage efficiency (FPE) of the WFUFB for the three species of salmonids looked at were: 57% for steelhead, 34% for sockeye and 31% for yearling Chinook. Survival estimates for salmonid smolts using the WFUFB in 2008 were: 100% for steelhead, 95%* for sockeye and 96%* for yearling Chinook. In the calculation of survival estimates for the different passage routes (i.e. the WFUFB), steelhead were the only species of acoustically-tagged smolt that used a “paired-release” study design to account for tagging and handling effects that may be present in tagging study, such as an acoustic tag study. The route-specific survival estimates seen for sockeye and yearling Chinook in 2008 at the WFUFB were calculated based on a “single-point” release.

Figure 12. The WFUFB was completed for operations in spring, 2008.
Authors

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