

Priest Rapids Dam Adult Fishway PIT-Tag Detection Efficiency and Characterization of PIT-tagged Fish Passage in 2007

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January 2008

Executive Summary

A Passive Integrated Transponder-tag (PIT-tag) detection system was established in the Priest Rapids Dam fishways in spring 2003. The system consists of two detection weirs in the non-overflow section of each fishway. Each detection weir has two submerged orifices; each equipped with a PIT-tag antenna. The PIT-tag detection system was designed with the specification of achieving a detection efficiency of 0.95 (95%) for the Digital Angel model TX1400ST 134.2 kHz ISO PIT tag. A PIT-tag detection system in the Priest Rapids Dam Off-Ladder Adult Trap (OLAFT) was brought on-line in June 2007.

All PIT-tag detection data used in this report were obtained from queries of the Pacific States Marine Fisheries Commission PIT-tag Information Systems (PTAGIS). The PTAGIS database was queried to return detections of all fish detected at Priest Rapids Dam from 1 January to 31 December 2007. Additional queries were performed to return detections at Columbia River Basin observation sites of all Grant PUD survival study fish released since 2001.

Detection efficiency of both fishways and the OLAFT system exceeded 0.998 for all species. The high detection efficiency estimates are due to the majority of returning fish having been implanted with TX1400ST tags or better. This tag type, and more recent models, has a greater detection range and the orientation of the tag in the antenna field has less of an effect on detectability than the earlier TX1400BE tag.

The smolt-to-adult return rate (SAR) of fish released in 2001 is 0.88% with only one fish returning in 2007. The PIT-tag detection system at Priest Rapids Dam became operational in 2003. Therefore, the SAR of fish released in 2001 does not include any jacks that may have returned in 2002. There were no PIT-tagged fish released in 2002. The SAR of fish released in 2003 and returning in 2004 through 2007 is 1.14% and is higher than that observed for fish released in 2001 after four years (0.88%). The SAR of fish released in 2004 and returning in 2005 through 2007 is 0.79%. The SAR of fish released in 2005 and returning in 2006 and 2007 is 0.22%. Fish released in 2005 and returning in 2008 and 2009 should add substantially to the number of returning adults, thus increasing the SAR for this cohort. The SAR of fish released into the Priest Rapids Dam tailrace in 2001 is slightly higher than that for fish released into the other release sites. The highest SAR for fish released in 2003 (1.21%) is for fish released into the Wanapum Dam tailrace. The highest SAR for fish released in 2004 (0.82%) is the same for fish released into the Wanapum Dam tailrace and the Priest Rapids Dam tailrace.

Table of Contents

| | | |
|-----|---|----|
| 1.0 | Introduction..... | 1 |
| 1.1 | Objectives | 1 |
| 1.2 | Methods..... | 1 |
| 1.3 | Estimating Fishway Detection Efficiency | 1 |
| 1.4 | Estimating OLAFT Detection Efficiency | 3 |
| 1.5 | Estimating Smolt-to-Adult Return Rate..... | 4 |
| 2.0 | Study Area | 4 |
| 2.1 | Site Description..... | 4 |
| 3.0 | Results..... | 7 |
| 3.1 | Migration Characteristics..... | 7 |
| 3.2 | Migration Rate | 11 |
| 3.3 | Detection Efficiency | 11 |
| 3.4 | Smolt-to-Adult Return | 13 |
| 4.0 | Discussion..... | 15 |
| 4.1 | Detection Efficiency | 15 |
| 4.2 | Smolt-to-Adult Return | 15 |

List of Figures

| | | |
|----------|--|---|
| Figure 1 | Plan view of upper regions of the fishways at Priest Rapids Dam showing location of PIT-tag detection weirs the OLAFT system and coil identification numbers.... | 5 |
| Figure 2 | PIT-tag antennas mounted to the upstream face of Weir 3 in the Priest Rapids Dam east-bank adult fishway..... | 6 |
| Figure 3 | PIT-tag antennas mounted to the upstream side of the “video count box” of Weir 7 in the Priest Rapids Dam east-bank adult fishway..... | 6 |
| Figure 4 | Picture of the OLAFT PIT-tag detection pipe with three antenna coils, prior to installation..... | 7 |
| Figure 5 | Run-timing of adult salmonids at Priest Rapids Dam based on detection of PIT-tags from 1 January to 31 December 2007. | 8 |
| Figure 6 | Run-timing of Grant PUD and non-Grant PUD PIT-tagged Chinook salmon detected from 1 January to 31 December 2007. | 9 |

List of Tables

Table 1 Possible detection histories for the three coil OLAFT PIT-tag detection array.. ... 4

Table 2 Coil identification number, dimension, location, and water depth for the PIT-tag system at Priest Rapids Dam adult fishway..... 5

Table 3 Summary of PIT-tagged fish detected by the Priest Rapids Dam PIT-tag system from 1 January to 31 December 2007..... 7

Table 4 Summary of PIT-tagged subyearling and yearling Chinook salmon released by Grant PUD and detected at Priest Rapids Dam from 1 January to 31 December 2007..... 8

Table 5 Number of 2001, 2003, 2004 and 2005 Grant PUD study fish observed at Columbia River Basin observation sites between 1 January and 31 December 2007..... 9

Table 6 Release locations of PIT-tagged salmon and steelhead detected at Priest Rapids Dam between 1 January and 31 December 2006..... 10

Table 7 Sample size (n), median travel time in days (Med), and rate (km/d) from Bonneville Dam to McNary Dam (238 river kilometers) and from McNary Dam to Priest Rapids Dam (169 river kilometers) for summer Chinook salmon released in 2003, 2004, 2005 and detected between 1 January and 31 December 2007. ... 11

Table 8 Number of unique Priest Rapids Dam fishway and OLAFT detections between 1 January and 31 December 2007..... 12

Table 9 Estimated detection efficiency for the Priest Rapids Dam east-bank fishway PIT-tag array in 2007. 12

Table 10 Estimated detection efficiency for the Priest Rapids Dam west-bank fishway PIT-tag array in 2007. 12

Table 11 Estimated detection efficiency for the Off-Ladder Adult Fish Trap PIT-tag detection system in 2007..... 13

Table 12 Chinook salmon study fish released in 2001 and detected as juveniles at or downstream of McNary Dam, adults detected in 2003-2007, and SAR by release location..... 13

Table 13 Chinook salmon study fish released in 2003 and detected as juveniles at or downstream of McNary Dam, adults detected in 2004, 2005 and 2006, and SAR by release location..... 14

Table 14 Chinook salmon study fish released in 2004 and detected as juveniles at or downstream of McNary Dam, adults detected in 2005 through 2007, and SAR by release location..... 14

Table 15 Chinook salmon study fish released in 2005 and detected as juveniles at or downstream of McNary Dam, adults detected in 2006 and 2007, and SAR by release location..... 14

List of Appendices

Appendix A Number of Fish Detected by Species-Run-Rear Type..... A-1

1.0 Introduction

The Public Utility District No. 2 of Grant County (Grant PUD) installed a Passive Integrated Transponder-tag (PIT-tag) detection system in the Priest Rapids Dam fishways in spring 2003. PIT-tag detection weirs were established at two weirs in the non-overflow section of each of two fishways. A PIT-tag detection system was activated at the Off-Ladder Adult Fish Trap (OLAFT) in June 2007. Establishment of a PIT-tag detection system at Priest Rapids Dam has provided fisheries managers with an additional site to monitor survival and passage characteristics of PIT-tagged salmon and steelhead (*Oncorhynchus mykiss*) and any other PIT-tagged aquatic organism in the Columbia River Basin.

Survival of PIT-tagged juvenile summer Chinook salmon (*Oncorhynchus tshawytscha*) migrating through the Priest Rapids Project was evaluated in 2001, and 2003-2005 by Grant PUD. The number of PIT-tagged fish released on an annual basis ranged from 87,723 to 114,601. Downstream survival of these fish was evaluated in the year they were released and now their return provides an opportunity to describe migration histories and evaluate the adult PIT-tag detection system at Priest Rapids Dam.

1.1 Objectives

The objectives of this investigation were to:

- Estimate detection efficiency of the adult fishway system at Priest Rapids Dam using detections of PIT-tagged adult salmon and steelhead in 2007.
- Calculate the smolt-to-adult return rate for annual releases of Grant PUD study fish.
- Provide summary of adult migration timing, migration and detection histories at mainstem detection sites, including the dams and hatcheries, on the Columbia and Snake rivers for fish released as part of the Grant PUD Priest Rapids Project survival studies.
- Provide detail on release location and year for salmonids detected in 2007 at Priest Rapids Dam.

1.2 Methods

Detections of PIT-tagged fish were obtained from the PTAGIS database. For this report, the PTAGIS database was queried to return detections of salmonids at Priest Rapids Dam from 1 January to 31 December 2007. Using these criteria, datasets were constructed that contained tag and detection histories of all salmonids detected at Priest Rapids Dam in 2007. Additional queries were performed to return detections at all Columbia River Basin PIT-tag observation sites of yearling Chinook salmon released as part of Priest Rapids Project survival studies.

1.3 Estimating Fishway Detection Efficiency

Estimation of detection efficiency for the Priest Rapids Dam adult fishways followed the methods presented by Townsend et al. (2002) for the two-detection weir PIT-tag arrays at Wells Dam. Two weirs were equipped with PIT-tag detection systems in each adult fishway at Priest Rapids Dam. PIT-tag detection was established at weirs 3 and 5 in the west-bank fishway and weirs 3 and 7 in the east-bank fishway. Each weir has two submerged orifices and there are no overflow sections between detection weirs that would allow adult salmon to circumvent the

submerged orifices equipped with detection coils. The configuration of the detection arrays suggests that detection probabilities are independent between weirs. Two assumptions made in determining the detection history of each fish are: 1) fish are traveling in an upstream direction, and 2) fish detected on the downstream weir continue traveling upstream. The overall probability of detection (P) in a fishway can then be expressed as:

$$P = 1 - (1 - p_1)(1 - p_2) \quad (1)$$

where:

p_1 = probability of detection at first weir (i.e., Weir 5)

p_2 = probability of detection at second weir (i.e., Weir 3)

The detection histories of the adult PIT-tagged salmon at the two weirs can then be used to estimate the probabilities p_1 , and p_2 and subsequently, the overall detection probability (P).

Based on the Peterson/Lincoln single mark-recapture model, the detection probabilities at the individual weirs can be estimated as

$$p_1 = \frac{m}{n_2} \quad (2)$$

and

$$p_2 = \frac{m}{n_1} \quad (3)$$

where

n_1 = total number of PIT-tagged adult salmon detected at the first weir (i.e., 5);

n_2 = total number of PIT-tagged adult salmon detected at the second weir (i.e., 3);

m = number of PIT-tagged adult salmon detected at both weirs (i.e., 5 and 3).

Combining Equations 2 and 3 with Equation 1 yields an estimator for the overall detection probability of

$$\hat{P} = \frac{n_1 n_2 - (n_1 - m)(n_2 - m)}{n_1 n_2} \quad (4)$$

The likelihood model that describes the detection histories at the two weirs can be written as

$$L(p_1, p_2 | n_{11}, n_{10}, n_{01}) = \binom{r}{n_{11}, n_{10}, n_{01}} \left(\frac{p_1 p_2}{1 - (1 - p_1)(1 - p_2)} \right)^{n_{11}} \left(\frac{p_1(1 - p_2)}{1 - (1 - p_1)(1 - p_2)} \right)^{n_{10}} \left(\frac{(1 - p_1)p_2}{1 - (1 - p_1)(1 - p_2)} \right)^{n_{01}} \quad (5)$$

or equivalently

$$\binom{r}{n_1, n_2, m} \left(\frac{p_1 p_2}{1 - (1 - p_1)(1 - p_2)} \right)^m \left(\frac{p_1(1 - p_2)}{1 - (1 - p_1)(1 - p_2)} \right)^{n_1 - m} \left(\frac{(1 - p_1)p_2}{1 - (1 - p_1)(1 - p_2)} \right)^{n_2 - m}$$

where

n_{11} = number of PIT-tagged adults detected at both weirs (i.e., 3 and 5),

n_{10} = number of PIT-tagged adults detected at first weir but not the second (i.e., 5 but not 3),

n_{01} = number of PIT-tagged adults detected at the second weir but not the first (i.e., 3 but not 5),

$$r = n_{11} + n_{10} + n_{01} = n_1 + n_2 - m$$

A likelihood model (Equation 5) was used to calculate the variance of \hat{P} as well as construct a profile likelihood confidence interval for P . Profile likelihood 90% confidence intervals were generated via the User Specified Estimation Routine program (USER Version 3.1) developed by the University of Washington (<http://www.cbr.washington.edu/paramEst/USER/>).

Detection efficiency was calculated for each fishway, for each species-run-type combination, and for pooled detections of each species. Detections of individual fish greater than 12 hours apart were considered separate and legitimate passage events.

1.4 Estimating OLAFT Detection Efficiency

Detection efficiency estimates and 90% confidence intervals for the OLAFT were calculated with USER Version 3.1. Passage events for each fish were assigned to one of eight possible detection histories (Table 1). The overall probability of detection (P) in a fishway can then be expressed as:

$$P = 1 - (1 - p_1)(1 - p_2)(1 - p_3) \quad (1)$$

where:

p_1 = probability of detection at the first coil (i.e., Coil A1)

p_2 = probability of detection at the second coil (i.e., Coil A2)

p_3 = probability of detection at the third coil (i.e., Coil A3).

Table 1 Possible detection histories for the three coil OLAFT PIT-tag detection array. A value of “0” indicates the tag was not detected and “1” indicates the tag was detected on coil A1, A2, or A3, respectively.

| Detection Histories |
|---------------------|
| 000 |
| 010 |
| 111 |
| 101 |
| 100 |
| 001 |
| 110 |
| 011 |

1.5 Estimating Smolt-to-Adult Return Rate

Smolt-to-adult return rates (SAR) were calculated for each release location and overall for each release site used in 2001, 2003, 2004 and 2005. Differences in juvenile survival among release locations were controlled by constructing a database of study fish detected as juveniles at McNary, John Day, or Bonneville dams or the estuary towed array and detected as adults at Bonneville, McNary, Priest Rapids, Rock Island, Rocky Reach or Wells dams. PIT-tag detection was not established at Priest Rapids and Rock Island dams in 2002. SAR was calculated as: (number of adult fish detected)/(number of tagged fish detected at specified locations). The adult PIT-tag detection system at Priest Rapids Dam was operational beginning in spring 2003, requiring that detections at downstream observation sites (i.e., McNary and Bonneville dams) be queried for fish returning in 2002.

2.0 Study Area

2.1 Site Description

Priest Rapids Dam is located at Columbia River kilometer (Rkm) 643.3 and is the first dam upstream of the confluence of the Snake and Columbia rivers. The dam has two adult fishways, each with multiple non-overflow weirs in the uppermost sections. The adult PIT-tag detection system at Priest Rapids Dam is designed to detect upstream migrating fish bearing an ISO FDX-B PIT-tag (134.2 kHz). The PIT-tag detection system plans and specification document states the system is designed to be 95% efficient for the detection of Digital Angel’s PIT tag model TX1400ST or “supertag.” Each fishway has two detection weirs located within the non-overflow sections (Figure 1, Table 2). Each detection weir has two completely submerged orifices for fish passage equipped with PIT-tag antennas mounted to the upstream face of each orifice. Each antenna is controlled by a Digital Angel FS1001A Stationary Transceiver.

The east-bank fishway detection weirs are located at weirs 3 and 7. The antennas at Weir 3 are mounted directly to the upstream face of the weir wall and are 0.61 m wide and 1.4 m high (Figure 2). The Weir 7 antennas are mounted to the upstream side of a “video count box” that is attached to the upstream side of the weir wall (Figure 3). An aluminum transition piece was used to separate the antennas from the steel surface of the video count box. The inside dimensions of the antennas are 0.62 m wide and 1.14 m high.

The west-bank fishway detection weirs are located at weirs 3 and 5. Antennas at Weir 3 are mounted to a video count box and are 0.57 m wide and 1.09 m high. Weir 5 antennas are mounted to the upstream face of the weir wall and are 0.56 m wide and 1.27 m high.



Figure 1 Plan view of upper regions of the fishways at Priest Rapids Dam showing location of PIT-tag detection weirs the OLAFT system and coil identification numbers.

Table 2 Coil identification number, dimension, location, and water depth for the PIT-tag system at Priest Rapids Dam adult fishway.

| Antenna | Orifice dimensions | | Fishway | Weir | Water depth (m) |
|---------|--------------------|------|-----------|------|-----------------|
| | (m) | | | | |
| Coil 01 | 0.61 | 1.40 | East-bank | 03 | 3.7 |
| Coil 02 | 0.61 | 1.40 | East-bank | 03 | 3.7 |
| Coil 03 | 0.62 | 1.14 | East-bank | 07 | 2.7 |
| Coil 04 | 0.62 | 1.14 | East-bank | 07 | 2.7 |
| Coil 05 | 0.57 | 1.09 | West-bank | 03 | 4.6 |
| Coil 06 | 0.57 | 1.09 | West-bank | 03 | 4.6 |
| Coil 07 | 0.56 | 1.27 | West-bank | 05 | 3.7 |
| Coil 08 | 0.56 | 1.27 | West-bank | 05 | 3.7 |



Figure 2 PIT-tag antennas mounted to the upstream face of Weir 3 in the Priest Rapids Dam east-bank adult fishway.



Figure 3 PIT-tag antennas mounted to the upstream side of the “video count box” of Weir 7 in the Priest Rapids Dam east-bank adult fishway.

The Priest Rapid Dam OLAFT is located adjacent to east-bank fishway. Fish enter the facility via an entrance channel located at the uppermost turning pool in the east-bank. Fish ascend a steep pass ladder to enter the facility. Fish pass through the OLAFT PIT-tag detection system after ascending the ladder. The OLAFT PIT-tag detection system consists of three antenna coils (Figure 4). Each coil has an inner diameter of 50.8 cm. The three coils are identified as A1, A2, and A3 with coil A1 being the first coil that fish pass through.



Figure 4 Picture of the OLAFT PIT-tag detection pipe with three antenna coils, prior to installation.

3.0 Results

3.1 Migration Characteristics

A total of 4,409 PIT-tagged salmonids were detected at Priest Rapids Dam from 1 January to 31 December 2007 (Table 3; Figure 5, Appendix Table 1). Chinook salmon and steelhead constituted the majority of fish detected at Priest Rapids Dam followed by sockeye salmon (*Oncorhynchus nerka*). Approximately 41% of the Chinook salmon detected at Priest Rapids Dam during the reporting period were summer run Chinook released as part of Grant PUD research activities conducted from 2001 to 2005 (Table 4). Most PIT-tagged Chinook salmon released by Grant PUD were detected at Priest Rapids Dam during the middle of the summer Chinook salmon run, primarily in June and July (Figure 6). Grant PUD study fish were detected at adult facilities upstream of their release location in the Columbia River (Table 5). PIT-tagged fish released at locations throughout the Columbia River Basin were detected at Priest Rapids Dam in 2007 (Table 6).

Table 3 Summary of PIT-tagged fish detected by the Priest Rapids Dam PIT-tag system from 1 January to 31 December 2007.

| Species | Unique Tag Codes | Number of Observations |
|-----------|------------------|------------------------|
| Chinook | 1,537 | 5,949 |
| Steelhead | 2,266 | 8,262 |
| Sockeye | 372 | 2,372 |
| Coho | 234 | 1,410 |

Table 4 Summary of PIT-tagged subyearling and yearling Chinook salmon released by Grant PUD and detected at Priest Rapids Dam from 1 January to 31 December 2007.

| Run | Migration Year | Unique Tag Codes | Number of Observations |
|----------------------------|----------------|------------------|------------------------|
| subyearling Chinook salmon | 2001 | 0 | 0 |
| | 2002 | 0 | 0 |
| | 2003 | 3 | 13 |
| yearling Chinook salmon | 2001 | 0 | 0 |
| | 2003 | 51 | 141 |
| | 2004 | 506 | 2,136 |
| | 2005 | 113 | 650 |

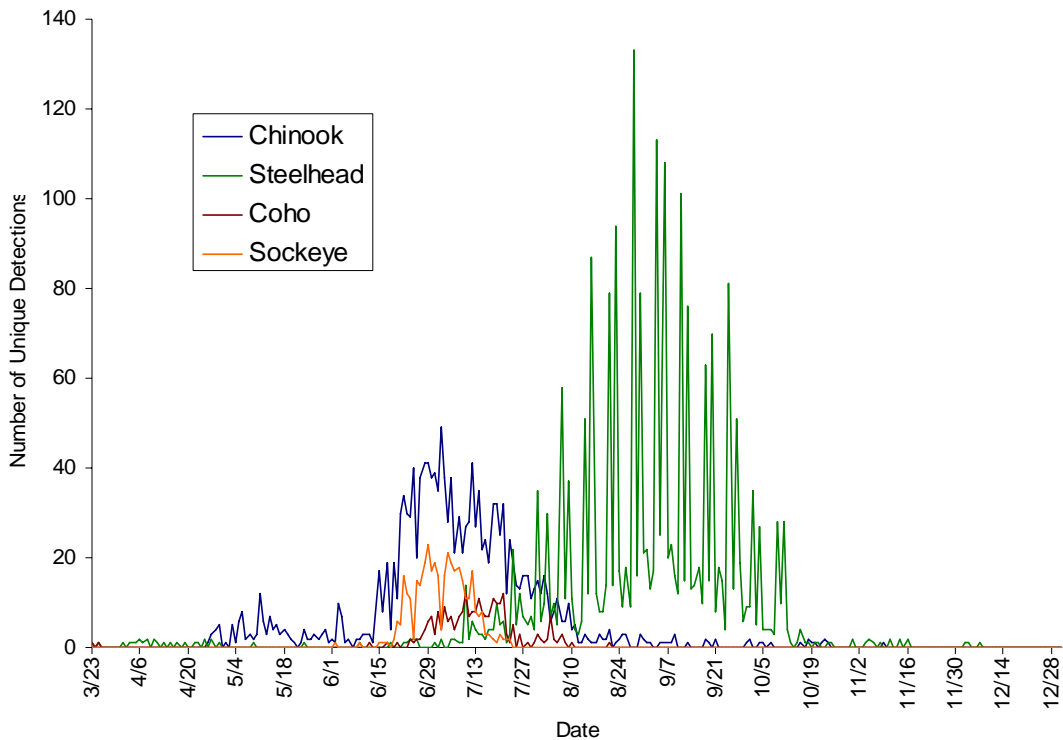


Figure 5 Run-timing of adult salmonids at Priest Rapids Dam based on detection of PIT-tags from 1 January to 31 December 2007.

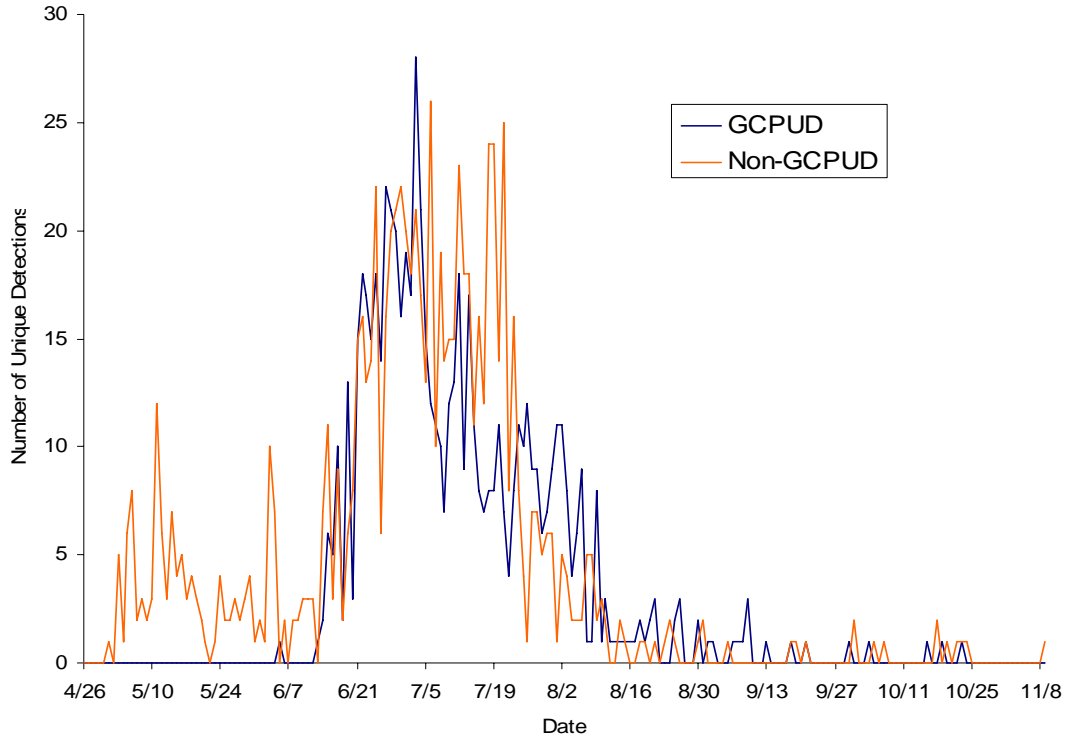


Figure 6 Run-timing of Grant PUD and non-Grant PUD PIT-tagged Chinook salmon detected from 1 January to 31 December 2007.

Table 5 Number of 2001, 2003, 2004 and 2005 Grant PUD study fish observed at Columbia River Basin observation sites between 1 January and 31 December 2007.

| Observation Site | Release Year | | | |
|------------------------------------|--------------|------|------|------|
| | 2001 | 2003 | 2004 | 2005 |
| Bonneville Dam (adult fishway) | | 71 | 641 | 157 |
| Bonneville Dam (juvenile facility) | | 1 | 1 | 1 |
| John Day Dam (juvenile facility) | | | 1 | |
| McNary Dam (adult fishway) | | 58 | 515 | 112 |
| McNary Dam (juvenile facility) | | | | |
| Priest Rapids Dam (adult fishway) | | 54 | 506 | 113 |
| Rock Island Dam (adult fishway) | 1 | 51 | 472 | 96 |
| Rocky Reach Dam (adult fishway) | | 53 | 445 | 84 |
| Wells Dam (adult fishway) | | 24 | 203 | 21 |

Table 6 Release locations of PIT-tagged salmon and steelhead detected at Priest Rapids Dam between 1 January and 31 December 2006.

| Release Location | Chinook | Coho | Sockeye | Steelhead |
|--|------------------|------|---------|-----------|
| Asotin Creek (km 522.234) | | | | 1 |
| Beaver Creek, Methow River | | | | 1 |
| Big Bear Creek, Potlatch River | | | | 1 |
| Bonneville Cascades Is. Ladder | 3 | | | |
| Bonneville Dam 2nd PH Corner Collector Outfall Channel | | | | 2 |
| Bonneville Dam Complex | 410 | | 370 | |
| Cedar Flats Acclimation Site | 1 | | | |
| Chewuch Acclimation Pond (WDFW) | 1 | | | |
| Chewuch River | | | | 113 |
| Chiwawa Rearing Pond | 5 | | | |
| Chiwawa River | | | | 37 |
| Chiwawa River Trap, 0.5 km below CHIP acclimation pond | 2 | | | |
| Cle Elum Dam | | 1 | | |
| Clearwater Trap | | | | 1 |
| Columbia River – mouth to Three Tree Point, WA (km 0-49) | 1 | | | |
| Columbia River – Lewis River to Bonneville Dam (km 140-243) | 25 | | | |
| Columbia River - Bonneville Dam to John Day Dam (km 234-347) | 48 | | | |
| Columbia River – Lower Crab Creek to Chelan Falls, WA (km 661-809) | 3 ^a | | | |
| Dworshak NFH, release into North Fork Clearwater River | 3 | | | |
| Entiat NFH | 16 | | | |
| Entiat River | 5 | | | 7 |
| Grande Ronde River - Wallowa River to headwaters (km 131-325) | | | | 1 |
| Hat Rock State Park (Oregon) | 1 | | | 1 |
| Imnaha River Weir | 2 | | | |
| John Day Dam | 1 | | | |
| Middle Fork John Day River | | | | 1 |
| Black Canyon Creek, South Fork John Day River | | | | 1 |
| Leavenworth NFH | 74 | 94 | | |
| Libby Creek, Methow River | | | | 1 |
| Lower Granite Dam | 3 | | | 23 |
| Maxwell Diversion Canal, Umatilla River | | | | 2 |
| McNary Dam | 7 | | | |
| Methow River | 1 | | | 165 |
| Methow River Trap (km 843.030) | 1 | | | 2 |
| Nason Creek (tributary to Wenatchee River) | | 64 | | 60 |
| Omak Creek (tributary to Okanogan River) | | | | 3 |
| Pahsimeroi Weir | | | | 1 |
| Peshastin River | 1 | | | |
| Pittsburg Landing Acclimation Facility | 1 | | | |
| Powell Rearing Pond | 1 | | | |
| Priest Rapids Dam | 287 ^b | | | 1435 |
| Ringold Hatchery | | | | 62 |
| Rock Island Dam | 276 ^c | | 1 | 15 |
| Rocky Reach Dam | 94 | | | 14 |
| Salmon Trap | | | | 1 |
| Similkameen River | | | | 48 |
| Stapaloop Creek, in Okanogan River basin | | | | 4 |
| Toppenish Creek | | | | 1 |
| Tucannon River | | | | 17 |
| Tumwater Dam | | | | 1 |
| Twisp Acclimation Pond (Methow Salmon Recovery Foundation) | | | | 9 |
| Twisp Acclimation Pond (WDFW) | 1 | | | |
| Twisp River | 2 | | | 50 |
| Umatilla River | | | | 1 |
| Walla Walla River | | | | 1 |
| Wanapum Dam | 200 ^d | | | |
| Wells Dam | 50 | | | 20 |
| Wells Hatchery | 3 | | | |
| Wenatchee Lake | | | 1 | |
| Wenatchee River | | 75 | | 141 |
| Wenatchee River Trap at West Monitor Bridge | | | | 2 |
| Winthrop NFH | 7 | | | 20 |

^a Includes 3 sub-yearling Chinook released by GCPUD in 2003.

^b Includes 18 yearling Chinook released by GCPUD in 2003 and 199 yearling Chinook released by GCPUD in 2004 and 70 yearling Chinook released by GCPUD in 2005.

^c Includes 12 yearling Chinook released by GCPUD in 2003 and 128 yearling Chinook released by GCPUD in 2004 and 43 yearling Chinook released by GCPUD in 2005.

^d Includes 21 yearling Chinook released by GCPUD in 2003 and 179 yearling Chinook released by GCPUD in 2004.

3.2 Migration Rate

Migration rates of study Chinook salmon released in 2003 through 2005 were highly variable between the Bonneville Dam-to-McNary Dam reach and the McNary Dam-to-Priest Rapids Dam reach. The study fish released in 2004 had the highest rate (35.0 km/d McNary Dam-to-Priest Rapids Dam reach) and lowest rate (22.8 km/d Bonneville Dam-to-McNary Dam reach) (Table 7). The 2004 study fish also had the greatest difference in migration rate between the two reaches at 12.2 km/d while the 2003 study fish had the least difference at 5.0 km/d. There are no detections of 2001 study fish that allow for the determination of migration rates for fish released in that year.

Table 7 Sample size (n), median travel time in days (Med), and rate (km/d) from Bonneville Dam to McNary Dam (238 river kilometers) and from McNary Dam to Priest Rapids Dam (169 river kilometers) for summer Chinook salmon released in 2003, 2004, 2005 and detected between 1 January and 31 December 2007.

| Release Year | Reach | n | Med (d) | km/d |
|--------------|---------------------------------|-----|---------|------|
| 2003 | Bonneville Dam-to-McNary Dam | 52 | 9.95 | 28.8 |
| 2003 | McNary Dam-to-Priest Rapids Dam | 50 | 5.48 | 33.8 |
| 2004 | Bonneville Dam-to-McNary Dam | 509 | 8.75 | 22.8 |
| 2004 | McNary Dam-to-Priest Rapids Dam | 495 | 5.78 | 35.0 |
| 2005 | Bonneville Dam-to-McNary Dam | 112 | 7.80 | 24.3 |
| 2005 | McNary Dam-to-Priest Rapids Dam | 108 | 5.77 | 34.4 |

3.3 Detection Efficiency

Fishway and OLAFT detection efficiency estimates were determined for steelhead and Chinook, coho (*Oncorhynchus kisutch*), and sockeye salmon. Detection efficiency estimates were not determined for northern pikeminnow (*Ptychocheilus oregonensis*) due to the small sample size (n=4). The number of unique detections, or passage events, was higher at the east-bank fishway for all species (Table 8). Detection efficiency exceeded 0.99 for both fishways. Detection efficiency of the east-bank system ranged from 0.9979 for Chinook salmon to 1.000 for coho and sockeye salmon (Table 9). West-bank fishway detection efficiency was 0.9994 for steelhead and 1.0000 for Chinook, coho, and sockeye salmon (Table 10). Detection efficiency in the each fishway was higher at the downstream weir for all species. Two-hundred-seven fish were detected by the OLAFT PIT-tag detection array. Detection efficiency was near 1.0 for all species (Table 11). Overall detection efficiency for the OLAFT system in 2007 was 0.9996 (90% CI; 0.9991, 1.0).

Table 8 Number of unique Priest Rapids Dam fishway and OLAF T detections between 1 January and 31 December 2007. (Note: individual fish can have more than one passage event.)

| Species | West-bank Fishway | East-bank Fishway | OLAF T |
|-----------|-------------------|-------------------|--------|
| Chinook | 158 | 1,564 | 105 |
| Steelhead | 355 | 1915 | 61 |
| Coho | 104 | 123 | 25 |
| Sockeye | 59 | 306 | 16 |

Table 9 Estimated detection efficiency for the Priest Rapids Dam east-bank fishway PIT-tag array in 2007.

| Parameter | Detection Estimates (standard error) on pooled | | | |
|---|--|-----------------|-----------------|-----------------|
| | Chinook | Steelhead | Coho | Sockeye |
| \hat{p}_1 (Weir 7) | 0.9910 (0.0024) | 0.9932 (0.0019) | 1.0000 (NA) | 0.9967 (0.0033) |
| \hat{p}_2 (Weir 3) | 0.9514 (0.0054) | 0.9848 (0.0028) | 0.9512 (0.0199) | 0.9575 (0.0153) |
| Overall \hat{P} | 0.9996 | 0.9999 | 1.0000 | 0.9999 |
| Profile likelihood 90% confidence interval on \hat{P} | (0.9993, 1.0) | NA | NA | (0.9995, 1.0) |

Table 10 Estimated detection efficiency for the Priest Rapids Dam west-bank fishway PIT-tag array in 2007.

| Parameter | Detection Estimates (standard error) on pooled | | | |
|---|--|-----------------|-----------------|-----------------|
| | Chinook | Steelhead | Coho | Sockeye |
| \hat{p}_1 (Weir 5) | 1.0000 (NA) | 0.9914 (0.0049) | 1.0000 (NA) | 1.0000 (NA) |
| \hat{p}_2 (Weir 3) | 0.8420 (0.0316) | 0.9171 (0.0147) | 0.9903 (0.0097) | 0.9492 (0.0294) |
| Overall \hat{P} | 1.0000 | 0.9993 | 1.0000 | 1.0000 |
| Profile likelihood 90% confidence interval on \hat{P} | NA | (0.9983, 1.0) | NA | NA |

Table 11 Estimated detection efficiency for the Off-Ladder Adult Fish Trap PIT-tag detection system in 2007.

| Parameter | Detection Estimates (standard error) on pooled | | | |
|---|--|-----------------|-----------------|---------|
| | Chinook | Steelhead | Coho | Sockeye |
| \hat{p}_1 (Coil A1) | 0.9238 (0.0259) | 0.9180 (0.0351) | 0.9200 (0.0543) | 1.0000 |
| \hat{p}_2 (Coil A2) | 0.9048 (0.0286) | 0.8689 (0.0432) | 0.8800 (0.0650) | 1.0000 |
| \hat{p}_3 (Coil A3) | 0.9714 (0.0162)) | 0.9508 (0.0277) | 0.8000 (0.0800) | 1.0000 |
| Overall \hat{P} | 0.9998 | 0.9995 | 0.9981 | 1.0000 |
| Profile likelihood 90% confidence interval on \hat{P} | (0.9994, 1.0) | (0.9983, 1.0) | (0.9922, 1.0) | NA |

3.4 Smolt-to-Adult Return

Smolt-to-adult return rates of fish released in 2001 were highest for fish released into the tailrace of Priest Rapids Dam. SAR estimates were standardized by including only adult detections of fish that were observed as juveniles at or below McNary Dam. An average of 28,312 yearling Chinook salmon was released at each location in 2001. Detections from each release location ranged between 14,390 and 18,296 fish at McNary Dam in 2001 (Table 12). The overall SAR estimate for yearling Chinook salmon released in 2001, detected at or below McNary Dam in 2001, and returning in 2003 through 2007 was 0.88%.

Table 12 Chinook salmon study fish released in 2001 and detected as juveniles at or downstream of McNary Dam, adults detected in 2003-2007, and SAR by release location.

| Release Location | Number Released | Juveniles Detected | Adults Detected | | | | | SAR (%) |
|----------------------------|-----------------|--------------------|-----------------|------------|-----------|----------|----------|-------------|
| | | | 2003 | 2004 | 2005 | 2006 | 2007 | |
| Wanapum Dam Pool | 28,353 | 14,390 | 51 | 63 | 12 | 0 | 0 | 0.88 |
| Wanapum Dam Tailrace | 28,297 | 16,161 | 68 | 62 | 12 | 0 | 0 | 0.88 |
| Priest Rapids Dam Pool | 28,300 | 16,346 | 55 | 70 | 13 | 1 | 0 | 0.85 |
| Priest Rapids Dam Tailrace | 28,297 | 18,296 | 56 | 81 | 28 | 1 | 1 | 0.91 |
| Total | 113,247 | 65,193 | 230 | 276 | 65 | 2 | 1 | 0.88 |

Based on fish returning in 2004 through 2007, smolt-to-adult return rates of fish released in 2003 were highest for fish released into the Wanapum Dam tailrace (Table 13). Similar to the methods used for fish released in 2001, SAR estimates were standardized by including only adult detections of fish that were observed as juveniles at or below McNary Dam in 2003. Detections from each release location ranged between 12,613 and 13,316 fish at or below McNary Dam in 2003. The overall SAR estimate for yearling Chinook salmon released in 2003, detected at or below McNary Dam in 2003 and returning in 2004 through 2007 was 1.14%.

Table 13 Chinook salmon study fish released in 2003 and detected as juveniles at or downstream of McNary Dam, adults detected in 2004, 2005 and 2006, and SAR by release location.

| Release Location | Number Released | Juveniles Detected | Adults Detected | | | | SAR (%) |
|----------------------------|-----------------|--------------------|-----------------|------|------|------|---------|
| | | | 2004 | 2005 | 2006 | 2007 | |
| Rock Island Dam Tailrace | 38,466 | 12,722 | 16 | 58 | 56 | 4 | 1.02 |
| Wanapum Dam Tailrace | 38,470 | 12,613 | 26 | 61 | 53 | 13 | 1.11 |
| Priest Rapids Dam Tailrace | 37,665 | 13,316 | 24 | 60 | 63 | 7 | 1.10 |
| Total | 114,601 | 38,651 | 66 | 179 | 172 | 24 | 1.08 |

The highest smolt-to-adult return rates of fish released in 2004 were for fish released into the Wanapum Dam tailrace or the Priest Rapids Dam tailrace (Table 14). SAR estimates included only adult detections of fish observed as juveniles at or below McNary Dam in 2004. Detections at or below McNary Dam in 2004 for each release location ranged between 8,947 and 10,670 fish. The overall SAR estimate for yearling Chinook salmon released in 2004, detected at or below McNary Dam in 2004 and returning in 2005 through 2007 was 0.79%.

Table 14 Chinook salmon study fish released in 2004 and detected as juveniles at or downstream of McNary Dam, adults detected in 2005 through 2007, and SAR by release location.

| Release Location | Number Released | Juveniles Detected | Adults Detected | | | SAR (%) |
|----------------------------|-----------------|--------------------|-----------------|------|------|---------|
| | | | 2005 | 2006 | 2007 | |
| Rock Island Dam Tailrace | 37,531 | 8,947 | 4 | 22 | 40 | 0.74 |
| Wanapum Dam Tailrace | 37,542 | 9,534 | 4 | 29 | 45 | 0.82 |
| Priest Rapids Dam Tailrace | 37,536 | 10,670 | 2 | 22 | 63 | 0.82 |
| Total | 112,609 | 29,151 | 10 | 73 | 148 | 0.79 |

The highest smolt-to-adult return rate of fish released in 2005 was for fish released into the Priest Rapids Dam tailrace (Table 15). SAR estimates included only adult detections of fish observed as juveniles at or below McNary Dam in 2005. Detections at or below McNary Dam in 2005 for each release location ranged between 13,479 and 15,485 fish. The overall SAR estimate for yearling Chinook salmon released in 2005, detected at or below McNary Dam in 2005 and returning in 2006 and 2007 was 0.22%. There were no fish released into the Wanapum Dam tailrace in 2005.

Table 15 Chinook salmon study fish released in 2005 and detected as juveniles at or downstream of McNary Dam, adults detected in 2006 and 2007, and SAR by release location.

| Release Location | Number Released | Juveniles Detected | Adults Detected | | SAR (%) |
|----------------------------|-----------------|--------------------|-----------------|------|---------|
| | | | 2006 | 2007 | |
| Rock Island Dam Tailrace | 43,417 | 13,479 | 4 | 16 | 0.15 |
| Priest Rapids Dam Tailrace | 44,306 | 15,485 | 12 | 32 | 0.28 |
| Total | 87,723 | 28,964 | 16 | 48 | 0.22 |

4.0 Discussion

4.1 Detection Efficiency

The Priest Rapids Dam PIT-tag detection array was designed to have a detection probability of 0.95 (95%) for TX1400ST PIT tags. Detection efficiency exceeded 0.998 for all species and location combinations in 2007. Detection efficiency estimates were similar to those reported for 2006 and should continue to remain high in the future. The majority of fish returning will have been implanted with TX1400ST PIT tags or better. The improved detectability of these tags is apparent when comparing detection efficiency estimates from 2004 when TX1400BE tags had been implanted in returning fish. Overall fishway detection efficiency estimates in 2004 ranged from 0.94 to 1.0 with individual weir detection efficiency estimates as low as 0.55.

Fishway usage continues to be strongly skewed toward the east-bank fishway. The difference in fishway usage is greatest for Chinook salmon, where there were approximately ten times the number of passage events in the east-bank fishway compared to the west-bank fishway times (1,564 vs. 158). The usage pattern is likely due to the east-bank fishway having two entrances; shoreline and mid-dam, compared to the west-bank fishway which has a single shoreline entrance. The number of coho passage events was higher in the east-bank fishway, but not by the same degree as other species.

The OLAFT facility increases the research capability at Priest Rapids Dam. The PIT-tag detection system replaces the manual scanning for PIT-tags employed with the in-ladder trap. The three coil design yielded high individual coil and overall detection efficiency estimates in 2007. Overall detection efficiency was 0.9999 with coil values ranging from 0.90 to 0.97. The difference among coils is due to the width or length of the fields of the individual coils. Coils A1 and A2 were constructed with relatively narrow fields to reduce the potential of collisions between tag signals. Coil A3 was constructed with a relatively wide or long field to enhance detection of fast moving fish.

4.2 Smolt-to-Adult Return

The SAR rate of fish released in 2001 remained constant at 0.88% in 2007. Only one fish returned in 2007 that was released in 2001. The SAR of fish released in the Priest Rapids Project in 2003 (1.14%) is higher than that observed for fish released in 2001 after four years (0.88%). Fish released in 2005 had a lower SAR after two years (0.22%) than fish released in 2001 (0.35%), 2003 (0.63%) and 2004 (0.28%).

The SAR of fish released in 2001 has remained unchanged from 2006 to 2007 with only one adult returning in 2007. The best overall SAR rate to date is for fish released in 2004 (1.14%). The lowest SAR rate is for fish released in 2005 into the Rock Island Dam tailrace (0.15%). The SAR rates for fish released in 2004 and 2005 should substantially increase with returning adults in 2008 and 2009.

List of Literature

- Anglea, S.M., R.J. Richmond, A.W. Carson, and A.T. Callagher. 2004. Priest Rapids Dam adult fishway PIT-tag detection efficiency probability and detection histories of 2001 Survival Study fish. Report to Grant County Public Utility District, Ephrata, Washington.
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- PTAGIS (Pacific States Marine Fisheries Commission PIT Tag Information Systems).
<http://www.psmfc.org/pittag/>
- Townsend, R.L., and J.R. Skalski. 2002. Estimation of detection efficiency at the adult PIT-tag interrogation systems at Wells Dam in 2002. Report to Douglas County Public Utility District, East Wenatchee, Washington.

Appendix A
Number of Fish Detected by Species-Run-Rear Type

Table A.1 Number of fish detected by Species-Run-Rear Type. Designations follow PITAGIS format. See Appendix A tables A.2 and A.3 for species and run codes.

| Species-Run-Type | Number Detected |
|------------------|-----------------|
| 11H | 173 |
| 11W | 22 |
| 11U | 2 |
| 12H | 858 |
| 12U | 3 |
| 13H | 5 |
| 13W | 1 |
| 13U | 9 |
| 15H | 218 |
| 15W | 0 |
| 15U | 246 |
| Pooled Chinook | 1,537 |
| 32H | 788 |
| 32W | 39 |
| 32U | 1435 |
| 35H | 3 |
| 35W | 1 |
| Pooled Steelhead | 2,266 |
| 25H | 233 |
| 25U | 1 |
| Pooled Coho | 234 |
| 45H | 6 |
| 45W | 1 |
| 45U | 353 |
| 40H | 3 |
| 40W | 8 |
| 42H | 1 |
| Pooled Sockeye | 372 |

Table A.2 Species codes used in the Columbia River Basin PIT Tag Information System.

| Code | Species |
|------|-----------|
| 1 | Chinook |
| 2 | Coho |
| 3 | Steelhead |
| 4 | Sockeye |

Table A.3 Run codes used in the Columbia River Basin PIT Tag Information System.

| <u>Code</u> | <u>Run</u> |
|-------------|------------|
| 1 | Spring |
| 2 | Summer |
| 3 | Fall |
| 4 | Winter |
| 5 | Unknown |