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Hydroacoustic Evaluation of Overwintering Summer Steelhead Fallback and Kelt Passage at The Dalles Dam, 2009–2010

DRAFT FINAL REPORT

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MA Weiland

July 2010

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Pacific Northwest National Laboratory
Richland, Washington 99352

Preface

This study was funded as part of the Anadromous Fish Evaluation Program (AFEP), which is managed by the U.S. Army Corps of Engineers (USACE) to support management decisions on operations of the eight federal dams on the lower Columbia and Snake rivers. This jurisdiction includes the sluiceway at The Dalles Dam. The AFEP study codes for the research reported herein are ADS-P-00-1 – Evaluation of Adult Salmon and Steelhead Delay and Fallback at Dams on Snake and Columbia Rivers, and ADS-P-00-6 – Evaluation of Steelhead Kelt Passage Through Columbia and Snake River Dams. The study was conducted by the Pacific Northwest National Laboratory (PNNL) for the USACE Portland District, whose technical lead was Sean Tackley (503 808 4751). The PNNL project manager was Fenton Khan (509 371 7230). The data are archived at PNNL offices in Richland, Washington. This draft of the final report is a project deliverable (PNNL Project No. 55449).

Summary

This report presents the results of an evaluation of overwintering summer steelhead (*Oncorhynchus mykiss*) fallback and early out-migrating steelhead kelts downstream passage at The Dalles Dam (TDA) sluiceway and turbines during fall/winter 2009 through early spring 2010. The study was conducted by the Pacific Northwest National Laboratory (PNNL) for the U.S. Army Corps of Engineers, Portland District (USACE). Operating the sluiceway reduces the potential for hydropower production. However, this surface flow outlet may be the optimal non-turbine route for overwintering summer steelhead fallbacks in late fall and winter after the sluiceway is typically closed for juvenile fish passage and for overwintering steelhead and kelt passage in early spring before the start of the voluntary spill season. The goal of this study was to characterize adult steelhead spatial and temporal distributions and passage rates at the sluiceway and turbines for fisheries managers and engineers to use in decision-making relative to sluiceway operations. This study is a follow-up to a similar study conducted in the fall/winter 2008 and early spring 2009, however in 2008-2009, the study was conducted with six operating sluice entrances (1-1, 1-2, 1-3, 5-2, 18-1, 18-2) and in 2009-2010, the study was conducted with four operating sluice entrances (1-2, 1-3, 18-1, 18-2). Based on the 2008-2009 results, the USACE and fisheries managers decided to have the study conducted with only four operating sluice entrances instead of six because very few fish passed through two of the six entrances (1-1 and 5-2).

The study was from November 1, 2009 to April 10, 2010 (161 days total). The study was divided into three study periods: Period 1, November 1 – December 15, 2009 (45 days) for a fall/winter sluiceway and turbine study; Period 2, December 16, 2009 – February 28, 2010 (75 days) for a turbine only study; Period 3, March 8 – April 10, 2010 (41 days) for a spring sluiceway and turbine study. Sluiceway operations were scheduled to begin on March 1 for this study; however, because of an oil spill cleanup near the sluice outfall, sluiceway operations were delayed until March 8, 2010 and so was the start of Period 3.

The study objectives were to 1) estimate the number and distribution of overwintering summer steelhead fallbacks and kelt-sized acoustic targets passing into the sluiceway and turbines at TDA between November 1 and December 15, 2009 and March 1 and April 10, 2010, and 2) estimate the numbers and distribution of adult steelhead and kelt-sized targets passing into turbine units between December 16, 2009 and February 28, 2010. We obtained fish passage data using fixed-location hydroacoustics.

For Period 1, overwintering summer steelhead fallback occurred throughout the 45-day study period. We estimated that a total of 879 ± 165 (95% CI) steelhead targets passed through the powerhouse intakes and operating sluice entrances during November 1 to December 15, 2009. Ninety two percent of these fish passed through the sluiceway. Therefore, without the sluiceway as a route through the dam, a number of steelhead may have fallen back through turbines. Run timing peaked in early December, but fish continued to pass the dam until the end of the study. Horizontal distribution data indicated that Sluice 1 is the preferred route for these fish during fallback through the dam. Diel distribution for overwintering steelhead fallbacks was variable with no apparent distinct patterns. Therefore, sluiceway operations should not be based on the diel distribution of passage.

For Period 2, adult steelhead passage occurred on January 14 and 31 and February 2, 22, and 24. We estimated that a total of 62 ± 40 (95% CI) adult steelhead targets passed through the powerhouse intakes

between December 16, 2009 and March 7, 2010. Horizontal distribution data indicated turbine unit 18 passed the majority of fish. Fish passage occurred during morning periods. Passage did not occur during afternoon or nighttime.

For Period 3, the early spring study period, overwintering summer steelhead and early out-migrating steelhead kelt downstream passage occurred throughout the 34-day study period. A total of 1,985 ± 234 (95% CI) kelt-size targets were estimated to have passed through the powerhouse intakes and operating sluices. Ninety-nine percent of these fish passed through the sluiceway. Therefore, as with steelhead fallback, not having the sluiceway as a route through the dam, a number of overwintering steelhead and kelts may use the turbines for downstream passage before the start of the spill season. Run timing peaked in late March and again in early April. Horizontal distribution indicated that Sluice 1 is the preferred route for these adult salmonids as they migrate downstream through the dam. Again, no clear pattern was seen for diel distribution of overwintering steelhead and early out-migrating kelt passage.

The results of this study strongly suggest that operating the TDA sluiceway for steelhead passage (fallbacks and kelts) during the late fall, winter, and early spring months will provide an optimal, non-turbine route for these fishes to pass the dam. Fallback of overwintering summer steelhead during late fall and winter and passage of early out-migrating steelhead kelt and overwintering steelhead during early spring are instances of the benefits of using surface flow outlets instead of turbines to pass salmonids. All 13 dams on the mainstem Columbia and Snake rivers have installed or are developing surface flow outlets to pass juvenile salmonids. Fisheries and hydrosystem managers are responsibly considering the use of these structures to protect adult salmonids from hydropower turbines.

Acknowledgments

The authors are grateful to the following people who contributed to this study:

- U.S. Army Corps of Engineers Personnel at The Dalles Dam: Robert Cordie, Miroslaw Zyndol, all of the project fish biologists, and the exceptional staff of the Operations, Electrical, and Structural and Maintenance crews.
- U.S. Army Corps of Engineers Personnel at Portland District Headquarters: Mike Langeslay, Natalie Richards, and Sean Tackley.
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- Precision Acoustic Systems: Alan Wirtz.
- Schlosser Machine Shop: Vincent Schlosser.

Acronyms and Abbreviations

AFEP	Anadromous Fish Evaluation Program
cfs	cubic feet per second
CI	confidence interval
d	day(s)
DART	Data Access in Real Time
dB	decibel(s)
ft	foot/feet
h	hour(s)
in.	inch(es)
kcfs	thousand cubic feet per second
kHz	kiloHertz
m	meter(s)
min	minute(s)
MSL	mean sea level
MU	Main Unit – turbine intake
NMFS	National Marine Fisheries Service
PAS	Precision Acoustic Systems
PNNL	Pacific Northwest National Laboratory
pps	pings per second
s	second(s)
TDA	The Dalles Dam
μPa	micro-Pascal
USACE	U.S. Army Corps of Engineers

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Tables

1.0 Introduction

This report presents the results of an evaluation of overwintering summer steelhead (*Oncorhynchus mykiss*) fallback and steelhead kelt downstream passage at The Dalles Dam (TDA) sluiceway and turbines during fall/winter 2009 through early spring 2010. The study was conducted by the Pacific Northwest National Laboratory (PNNL)[1] for the U.S. Army Corps of Engineers, Portland District (USACE). The goal of the study was to characterize adult steelhead spatial and temporal distributions and passage rates at the sluiceway and turbines at TDA for fisheries managers and engineers to use in decision-making for sluiceway operations.

1.1 Background

The upstream migration of summer steelhead, an anadromous Pacific salmonid (rainbow trout), begins in spring and goes through late fall (Keefer et al. 2008). The little information that exists about steelhead behavior during winter at or near hydroelectric dams on the Columbia River suggests that some summer steelhead overwinter within the hydrosystem before reaching spawning grounds (Keefer et al. 2008). Some of these fish may fall back at hydroelectric dams on the Columbia River, i.e., the fish pass back downstream through the dam after having migrated successfully upstream through the dam's fishway system (Boggs et al. 2004). Reischel and Bjornn (2003) and Boggs et al. (2004) describe fallback behavior as adult salmonids straying from their normal upstream migration to spawning grounds and moving back downstream through the dams by way of turbine intakes, bypass systems, spillways, navigation locks, or other available routes. Also, during upstream migration, some adult salmonids may travel upriver beyond their natal streams ("overshooting") and may fall back through dams to return to said streams (Boggs et al. 2004). In a letter report to the USACE Portland District, Keefer and Peery (2007) addressed the issue of steelhead falling back at TDA during late fall and winter months. In addition, Keefer et al. (2008) and Khan et al. (2009) recorded late fall and wintertime fallbacks at TDA. Keefer and Peery (2007) suggested overwintering adult summer steelheads are using the TDA turbines, sluiceways, and the navigation lock as fallback routes.

After overwintering and spawning in freshwater, steelhead can migrate back downstream to the ocean in the spring. These downstream migrants, commonly referred to as kelts, may eventually return to freshwater spawning grounds to spawn again. This life history pattern is termed iteroparity. Kelts have to navigate through hydroelectric dams on their outward migration. The dams may delay migration timing and negatively affect survival of fish (Wertheimer and Evans 2005; Wertheimer et al. 2003). As with the fallback of overwintering summer steelhead, kelts pass the dam through available routes, including turbines and sluiceways. Khan et al. (2009) found steelhead kelts are using the TDA sluiceway for downstream passage in early spring months before the start of the spill season for juvenile salmonids downstream passage.

The National Marine Fisheries Service (NMFS) stipulated in RPA 54 of the 2008 Biological Opinion on operation of the Federal Columbia River Power System (NMFS 2008) that "…*In addition to the current sluiceway operation (generally April 1–November 30), evaluate operation of The Dalles Dam sluiceway from March 1–March 31 and from December 1–December 15 as a potential means to provide*

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[1] Pacific Northwest National Laboratory is operated by Battelle for the U.S. Department of Energy under Contract DE-AC05-76RL01830.

a safer fallback passage route for overwintering steelhead and kelts, implement if warranted …Investigate surface-flow outlets during wintertime to provide safer fallback opportunity for over wintering steelhead (need will be determined by results of further research…Planning dates and voluntary operation of The Dalles Dam sluiceway may be adjusted (increased or decreased) through the adaptive management process or for research purposes."

Because steelhead are listed by the Endangered Species Act as endangered in the upper Columbia River and threatened in the Snake and mid Columbia rivers (NMFS 2004), the USACE is dedicated to providing safe and timely passage for overwintering summer steelhead fallbacks and kelts at TDA. Providing optimal, non-fatal downstream routes at dams should improve return rates of kelts (Wertheimer and Evans 2005). The USACE 2006 Fish Passage Plan included operating the TDA sluiceway until November 30 as a route for fallbacks because of concerns about these fish using the turbines as a route through the dam. Operating the sluiceway reduces the potential for hydropower production, but this surface flow outlet may be the optimal non-turbine route for overwintering fallbacks in late fall and winter and kelt passage in early spring before the start of the voluntary spill season.

1.2 Study Periods and Objectives

The study occurred from November 1, 2009 through April 10, 2010, with three specific periods of interest:

- Period 1: November 1 – December 15, 2009
- Period 2: December 16, 2009 – March 7, 2010
- Period 3: March 8 – April 10, 2010.

The study objectives were to estimate the passage rates, run timing, horizontal distribution, and diel distribution for the following:

- adult steelhead passing into the sluiceway and turbine units at TDA between November 1 and December 15, 2009 (Period 1).
- adult steelhead passing into turbine units between December 16, 2009 and February 28, 2010 (Period 2).
- steelhead kelt passing into the sluiceway and turbine units at TDA between March 1 and April 10, 2010 (Period 3).

1.3 Study Area

The Dalles Dam (Figure 1.1) is located at river mile 192 and is the second closest dam in the Federal Columbia River Power System to the Pacific Ocean. It has a 2,090-ft-long powerhouse with 22 turbine units (main units), a total generating capacity of 1,800 megawatts, and a total hydraulic capacity of 375 kcfs. Full pool elevation is rated at 160 ft above MSL (mean sea level is the reference level for all elevations in this report) and minimum operating pool elevation is 155 ft. The normal operating pool is at elevation 158 ft. The face of the powerhouse is 11.3° off vertical. The turbine intake ceiling intersects the trash racks at elevation 141 ft. The 1,380-ft-long spillway is comprised of 23 bays with 50-ft wide radial gates.

Figure 1.1. Aerial Photograph of The Dalles Dam. Flow is from right to left.

The ice-and-trash sluiceway is a rectangular channel that extends the entire length of the powerhouse. Sluice entrances are 20 ft wide. The sill at each sluice entrance is at elevation 151 ft. Water enters the sluiceway from the forebay when gates are moved off the sill. When any of the sluiceway gates are opened, water and migrating fish near the water surface may be skimmed from the forebay into the sluiceway, passing the fish to the tailrace. Overall, sluiceway discharge is a relatively small proportion of total project discharge (~2%). Flow into the sluiceway is dependent on forebay elevation and the number and location of open gates. For example, given a forebay elevation of 158 ft and six open sluice gates (MU 1-1, 1-2, 1-3, MU 5-2, and MU 18-1, 18-2), flows over the individual weir gates range from 564 cfs at MU 18-2 to 944 cfs at MU1-1, and total flow of 4,309 cfs (data provided by Stephen Schlenker, USACE, Portland District).

1.4 Report Contents

The ensuing sections of this report include the study methods (Section 2), results (Section 3), discussion and conclusions (Section 4), and literature cited (Section 5). There are no appendices.

2.0 Methods

The methods section includes descriptions of the general approach and the application of fixed-location hydroacoustics for this study.

2.1 General Approach

The fixed-location hydroacoustic technique was used to accomplish the objectives of this study. This technique, conceived by Carlson et al. (1981) for single-beam acoustic systems, is described by Thorne and Johnson (1993). In addition to single-beam technology, split-beam technology is now an important element of fixed-location hydroacoustics. The split-beam technique is explained by MacLennan and Simmonds (1992). The methods used in this study were similar to those used in the 2004, 2005, and 2008/2009 hydroacoustic studies at TDA (Johnson et al. 2005 and 2006 and Khan et al. 2009).

The general approach was to deploy a combination of single-beam and split-beam transducers to sample fish, and apply the acoustic screen model (Johnson 2000) to estimate fish passage rates and distributions. Split-beam transducers provided data to determine weighting factors, assess assumptions of the model, and determine the magnitude of any biases. Split-beam transducer deployments at each type of passage route were used to estimate the average backscattering cross section of fish for detectability modeling and the direction of fish travel through sampling volumes to assess the assumptions of the acoustic screen model. Single- and split-beam transducers were deployed to sample fish passage at the sluiceway and turbines. Transducer sampling volumes were positioned to minimize ambiguity in assigning fish passage routes and the potential for multiple detections of the same fish.

2.2 Fixed-Location Hydroacoustics

Details for the hydroacoustic systems, transducer locations and orientations, sampling design, and data processing and analysis are provided in the following sections.

2.2.1 Hydroacoustic Systems

Data collection involved three Precision Acoustic Systems (PAS) single-beam hydroacoustic systems and six PAS split-beam systems. All systems operated at 420 kHz. The data-collection systems consisted of either Harp-1B (Single-Beam) or Harp-SB (Split-Beam) Data Acquisition/Signal Processing Software installed on a personal computer controlling a PAS-103 Multi-Mode Scientific Sounder. The PAS-103 sounders controlled transducers deployed in main turbine units and sluice entrances. A total of 30 transducers (18 single-beam and 12 split-beam) were deployed at the powerhouse and sluiceway (Table 2.1). During data collection, all systems used a voltage output threshold range of -26 to -56 dB re: 1 μPa at 1 m.

Table 2.1. Sample Locations and Spatial Sampling Intensity at The Dalles Dam in 2009/2010

Unit	Intensity by Unit	Intensity by Intake	Number of Transducers	Sample Locations
Main Units 1-22	22 of 22	1 of 3	22	MU 1-1, 2-3, 3-1, 4-3, 5-1, 6-1, 7-2, 8-2, 9-2, 10-1, 11-3, 12-2, 13-3, 14-2, 15-3, 16-3, 17-2, 18-2, 19-1, 20-2, 21-2, 22-1
Sluice 1	1 of 1	2 of 3	4	Sluice 1-2, 1-3
Sluice 18	1 of 1	2 of 3	4	Sluice 18-1, 18-2

2.2.2 Transducer Locations and Orientations

Single-beam transducers (6°) were installed at all turbine unit sampling locations, except for Main Unit (MU) 2, MU 5, MU 16, and MU 18, each of which had a 6° split-beam transducer (Figure 2.1). The intakes sampled at a given turbine unit were randomly chosen. At all turbine intake sampling locations, divers installed transducers on the bottom of the second to the bottom trash rack at elevation 75 ft and aimed the transducers downstream and upward toward the intake ceiling at a 23° angle to the plane of the trash rack (Figure 2.2). The transducer mounts were designed to fit between the vertical bars of the trash rack. This design allowed divers to secure the mount to the trash rack of each intake from the forebay. A diver took a transducer/mount/cable assembly to the bottom of the trash rack located just above the deepest installed rack (Figure 2.2). The diver then installed the mount between two vertical bars of the trash rack at elevation 75 ft and secured the mount to the trash rack with “J” bolts.

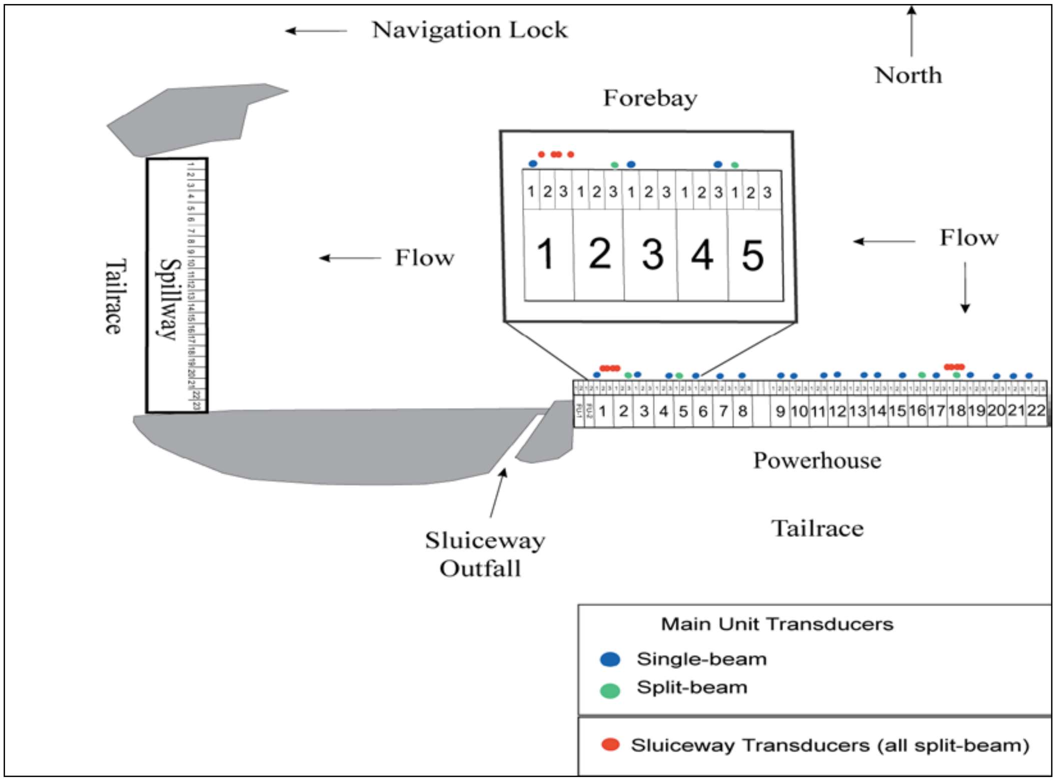

Figure 2.1. Plan View of The Dalles Dam Showing Transducer Locations. The spillway was not sampled.

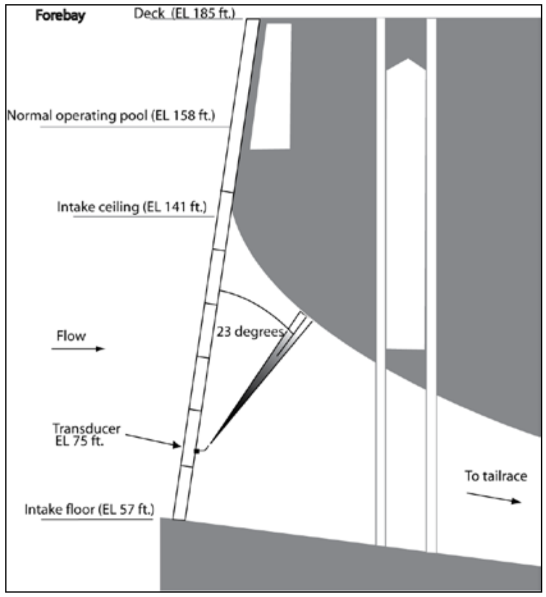

Figure 2.2. Cross-Sectional View of a Main Unit Intake Transducer Deployment

Sluiceway transducers (6° split-beam) were installed two of the three sluice entrances of MU 1 (1-2, 1-3) and two of the three sluice entrances at MU 18 (18-1, 18-2) at elevation 153 ft. These sluice entrances were agreed upon by USACE and fisheries managers because this configuration allows for passage opportunities at both the west and east ends of the powerhouse and four open gates provides a reasonable amount of flow. Transducers were attached to trolley mounts, which were then affixed to steel I-beams attached to the front of pier noses and lowered into the water (Figure 2.3). Each sluice entrance was monitored by a pair of transducers aimed horizontally and back at a 60° angle to the plane of the sill across the sluice entrance with a 6° up-looking angle (Figures 2.4 and 2.5).

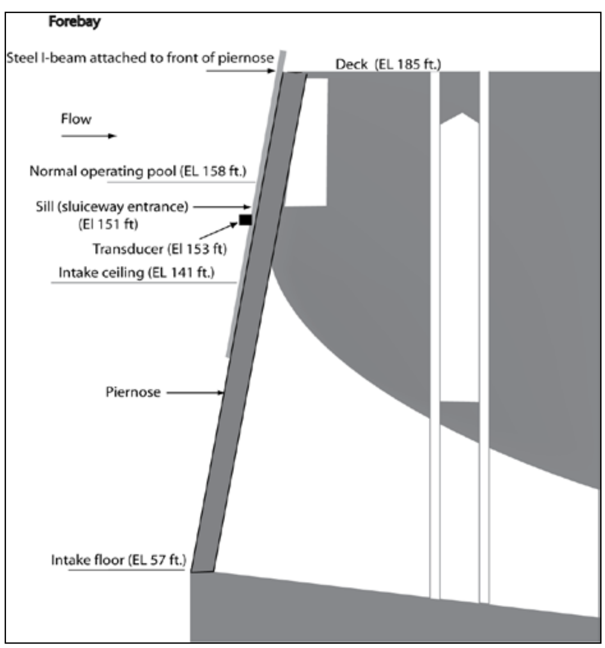

Figure 2.3. Deployment for a Side-Looking Sluiceway Transducer Mounted on a Steel I-Beam Attached to the Front of a Pier Nose

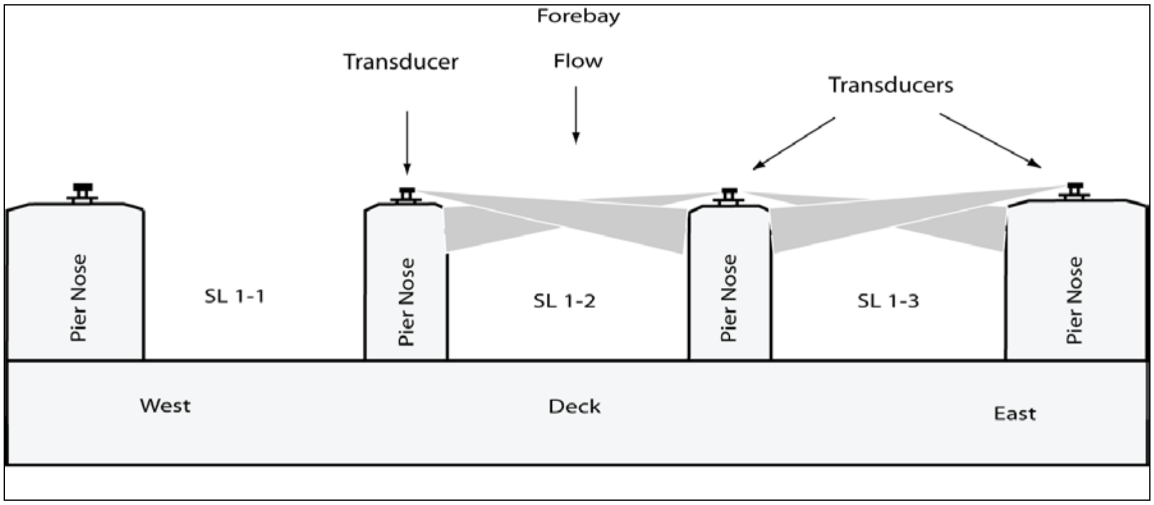

Figure 2.4. Top View of Transducer Deployment for Sluice 1

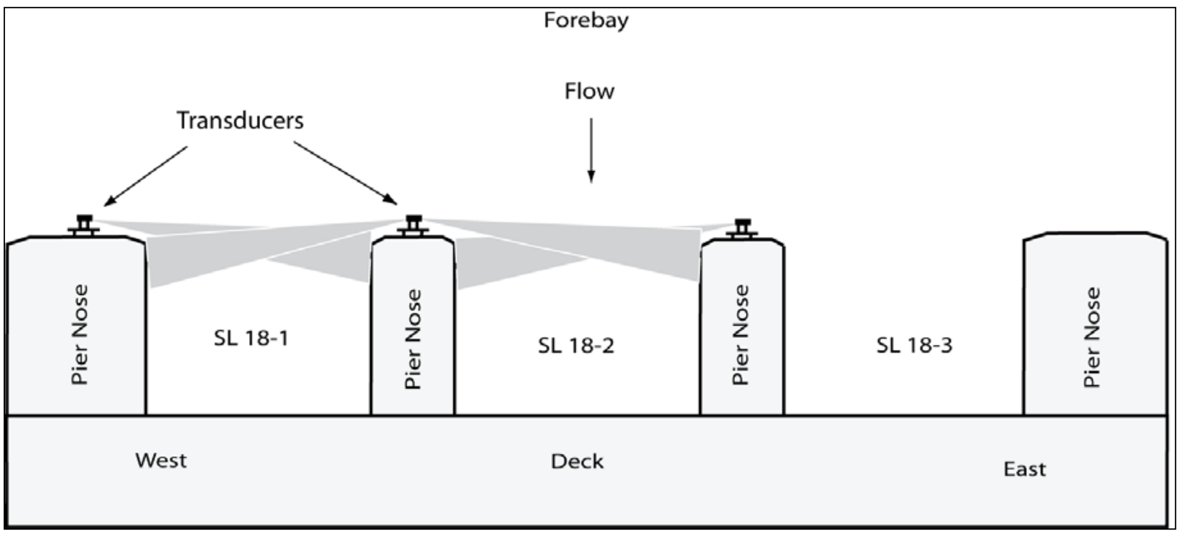

Figure 2.5. Top View of Transducer Deployment for Sluice 18

2.2.3 Sampling Design

Echo sounder transmission rates were 15 pps (pings per second) at the turbine intakes and 33 pps at the sluiceway. Systematic samples, i.e., same order among sampling locations each hour, were collected at 1-minute intervals 24 hours/day. Each location was sampled 10, 15, 20, or 30 times per hour depending on the number of transducers connected to the echo sounder.

2.2.4 Data Processing and Analysis

After the acoustic echo data were collected and archived, they were processed to extract fish tracks. At this stage in the analysis, we were careful to set the tracking parameters to include all fish at the expense of including spurious tracks. Next, to separate acceptable from unacceptable tracks, we filtered using fish tracks characteristics such as mean target strength, slope, speed, and pulse width. Subsamples of the data were manually checked to assure that valid fish tracks remained after filtering. Data processing and reduction methods were similar to those used by Khan et al. (2009) and Johnson et al. (2005). Mean target strength as an indicator of fish size was used to distinguish relatively large adult steelhead fallback and kelt passage from smaller targets such as juvenile shad. The maximum target strength was set at -26 dB re: 1 μPa at 1 m during data collection. In retrospect, this threshold may have excluded some of the larger steelhead (Nealson and Gregory 2000). During data processing, we filtered for large fish using mean target strengths (Table 2.2) based on the expected sizes of the smallest fish of interest of about 30 cm (personal communication from R. Wertheimer, USACE) and the relationship between fish length and target strength for adult salmon in side aspect described by Burwen and Fleischman (1998). The 3-dB difference between sluice and turbine target strengths accounted for the side and ventral aspects of insonification of fish by the respective deployments.

Table 2.2. Mean Target Strength Filters

	Late Fall and Winter 2009 Steelhead Fallback	Early Spring 2010 Steelhead Passage
Sluice	-29 dB	-31 dB
Turbine	-32 dB	-34 dB

The process used to estimate passage rates from filtered tracked fish involved spatial and temporal extrapolations. Briefly, each fish track that survived the filtering process was weighted spatially to account for the sample width of the acoustic beam at the target's mid-range relative to the width of the depth bin it sampled; i.e., fish passage at unsampled portions of a passage route was estimated by extrapolating from the sampled areas. Turbine estimates were multiplied by three because only one out of three intakes at a given unit was sampled. The sum of these weighted fish was then extrapolated temporally by the hourly sampling fraction (60/total hourly sample time per location).

The hourly passage rate data for each transducer were used to estimate various performance metrics. Equations for each estimator follow. Let x_{ijky} be the expanded fish passage count in the i^{th} transducer ($i = 1,\ldots,x$) during the j^{th} hour ($j = 1,\ldots,24$) of the k^{th} day ($k = 1,\ldots,d_y$) during y^{th} study period, where d_y is the number of study-days in the y^{th} study period (late fall 2008 or early spring 2009).

Total adult steelhead fallback (or kelt passage) for the y^{th} study period was estimated by the formula

$$\hat{TP}_y = \sum_{i=1}^{6} \sum_{j=1}^{24} \sum_{k=}^{d_y} x_{ijky} \quad (2.1)$$

Daily adult steelhead fallback (or kelt passage) for the k^{th} day in the y^{th} study period for analysis of run timing was estimated by the formula

$$\hat{DP}_{ky} = \sum_{i=1}^{6} \sum_{j=1}^{24} x_{ijky} \quad (2.2)$$

Hourly adult steelhead fallback (or kelt passage) for the j^{th} hour in the y^{th} study period for analysis of diel distribution was estimated by the formula

$$HP_{jy} = \sum_{i=1}^{6} \sum_{k=1}^{d_y} x_{ijky} \qquad (2.3)$$

Johnson et al. (2005) describe methods to estimate variances for the passage rate estimates. The variances associated with each passage rate estimate were likely underestimated because between-intake variability in passage within a given turbine unit could not be accounted for because of sampling limitations. Ninety-five percent confidence intervals (CIs) for total and daily passage rates were calculated as follows:

$$CI = \pm 1.96 * \sqrt{Variance} \qquad (2.4)$$

3.0 Results

The results from the study are organized into two main sections: environmental conditions and fish passage evaluation. The fish passage evaluation is organized into three sections, one for each study period.

3.1 Environmental Conditions

Daily outflow at TDA ranged from 85 to 149 kcfs during Period 1 (November 1 – December 15), with a mean daily outflow of 115 kcfs (Figure 3.1). For Period 2 (December 16 – March 7), daily outflow ranged from 91 to 140 kcfs, with a mean daily outflow of 111 kcfs (Figure 3.1). Daily outflow for Period 3 (March 8 – April 10) ranged from 76 to 124 kcfs, with a mean daily outflow of 102 kcfs (Figure 3.1). Discharge was around the 10-year average in November and December 2009, but decreased and was lower than the 10-year average in January, February, and March 2010 (Figure 3.1). Spill commenced on April 10 for the 2010 juvenile salmonid migration.

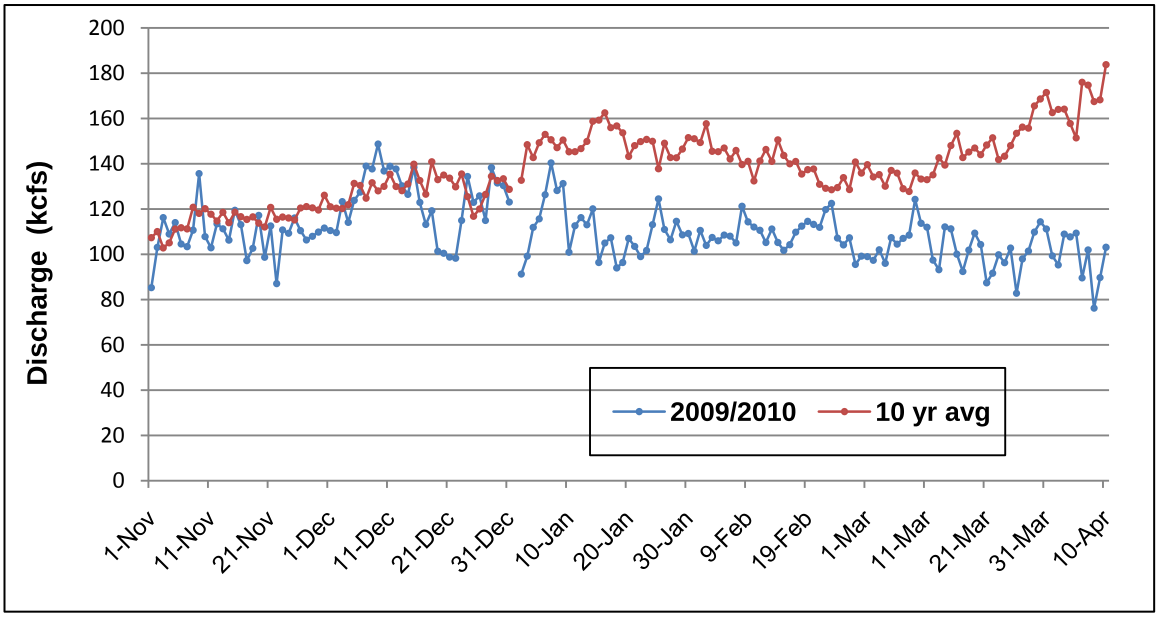

Figure 3.1. Total Outflow and 10-Year Average Outflow (kcfs) at TDA during the Entire Study Period (November 1, 2009 – April 10, 2010). Data were obtained from DART (http://www.cbr.washington.edu/dart/dart.html), accessed on July 10, 2010.

During Period 1, forebay elevation at TDA ranged from 158 to 159 ft, with an average elevation of 158.7 ft above MSL (Figure 3.2). During Period 2, forebay elevation at TDA ranged from 158 to 159 ft, with an average elevation of 158.8 ft (Figure 3.2). During Period 3, the forebay elevation at TDA ranged from 157 to 159 ft, with an average elevation of 159 ft (Figure 3.2).

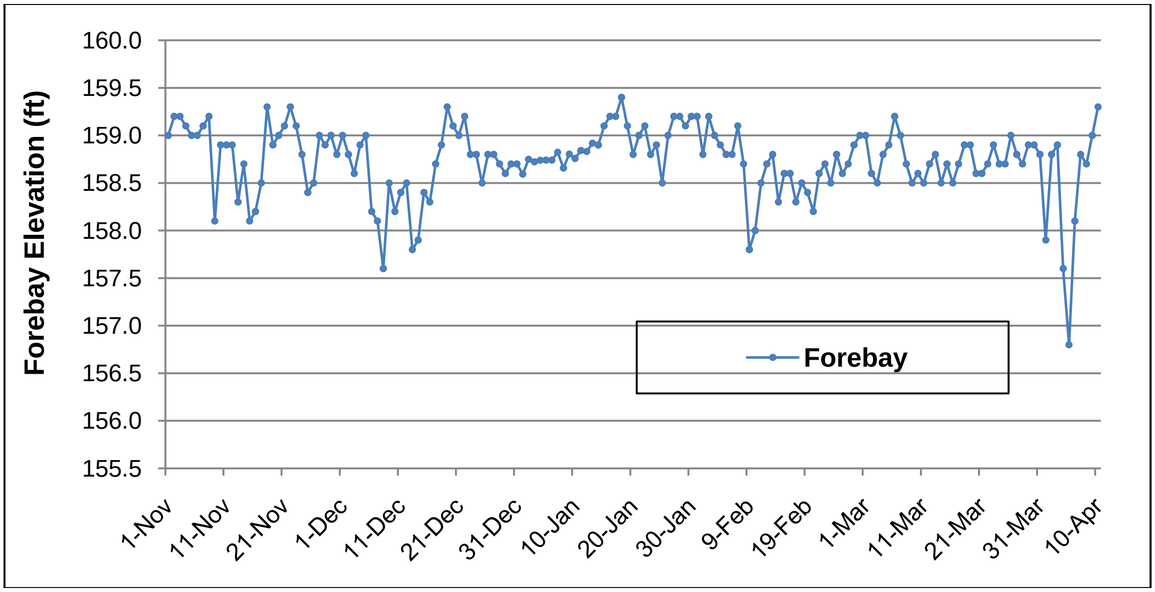

Figure 3.2. Forebay Elevation (ft above MSL) at TDA During the Entire Study Period (November 1, 2009 – April 10, 2010). Forebay data were obtained from DART (http://www.cbr.washington.edu/dart/dart.html), accessed on July 10, 2010 and from TDA Operations.

3.2 Fish Passage Evaluation

Fish passage results are organized into three sections: Period 1, sluiceway and turbine study of overwintering summer steelhead fallback in late fall/early winter; Period 2, turbine only study of overwintering summer steelhead fallback and kelt passage in winter; Period 3, sluiceway and turbine study of overwintering summer steelhead fallback and kelt passage in early spring. Under each of these topics, we present data on passage rates, run timing, horizontal distribution, and diel distribution.

3.2.1 Period 1, Sluiceway and Turbine Study (Fall/Winter 2009) – Overwintering Summer Steelhead Fallback

3.2.1.1 Passage Rates and Run Timing

During the 45-day fall/winter study period November 1 to December 15, 2009, a total of 879 ± 165 (95% CI) adult size steelhead targets passed through the powerhouse intakes and operating sluice entrances. A daily average of 20 steelhead targets passed (fall back) the dam during the study period. The sluiceway passed 804 (92%) of the 879 steelhead targets while the remaining 75 (8%) passed the powerhouse turbine units. Run timing peaked in early December (Figure 3.3). Fallback of adult size steelhead targets occurred throughout the study period, except for a few days when no targets passed the dam (November 1, 6, 21 and December 2, 15) (Figure 3.3).

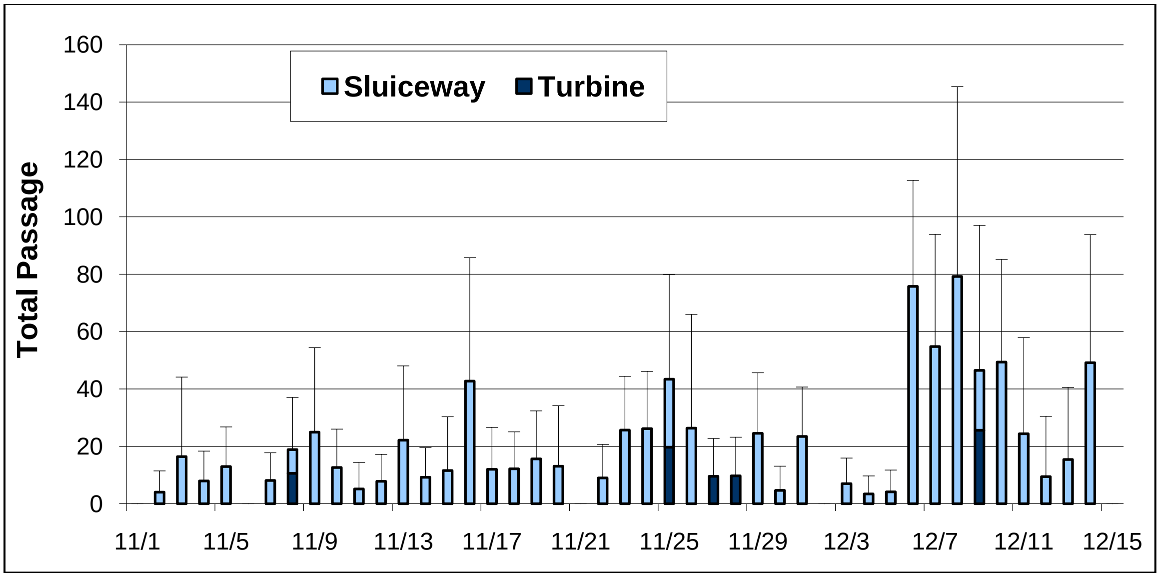

Figure 3.3. Number of Overwintering Summer Steelhead Targets Passing Daily at Each Route of the Powerhouse and Sluiceway from November 1 – December 15, 2009 (error bars depict the 95% CI)

3.2.1.2 Horizontal Distribution

Fallback of overwintering summer steelhead was highest at Sluice 1 (482 targets). Sluice 18 had the second highest number of fish passing (321) and a small number passed through the powerhouse MU 8, 16, and 18 (25, 38, and 12 fish, respectively) (Figure 3.4). For individual sluice entrances, Sluice 1-3 passed the highest number of fish (469 targets), followed by Sluice 18-2 (293). Fewer than 50 fish passed through Sluice 1-2, and 18-1 (Figure 3.5).

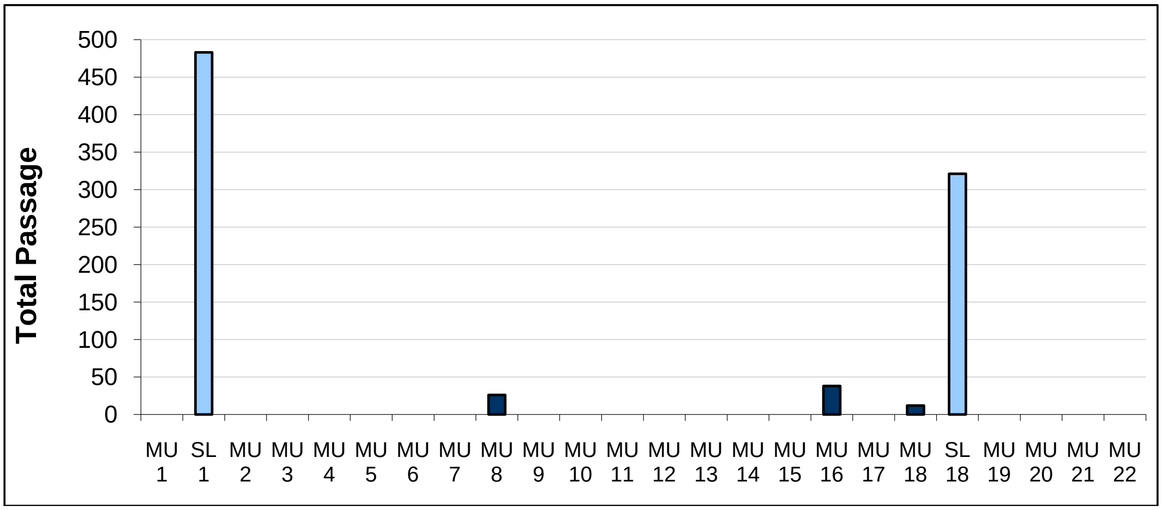

Figure 3.4. Horizontal Distribution of Overwintering Summer Steelhead Targets Passage at Each Route of the Powerhouse and Sluiceway from November 1 – December 15, 2009 (MU = main unit, SL = sluice)

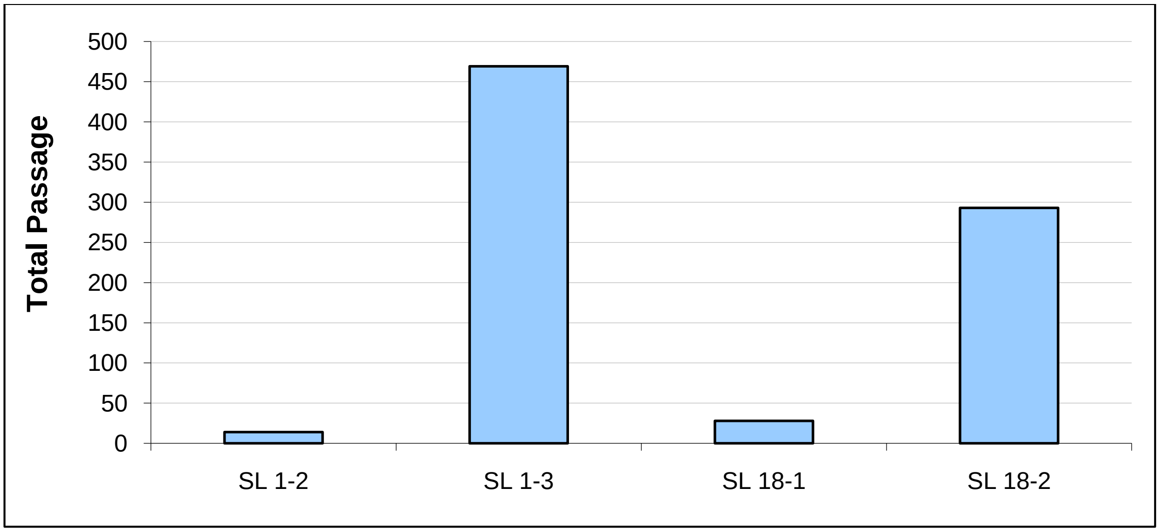

Figure 3.5. Horizontal Distribution of Total Passage of Overwintering Summer Steelhead Targets at Each Route of the Sluiceway from November 1 – December 15, 2009 (SL = sluice entrance)

3.2.1.3 Diel Distribution

Diel distribution of overwintering summer steelhead fallback was highly variable and indicates that steelhead targets were passing the dam at all times of the day (Figure 3.6).

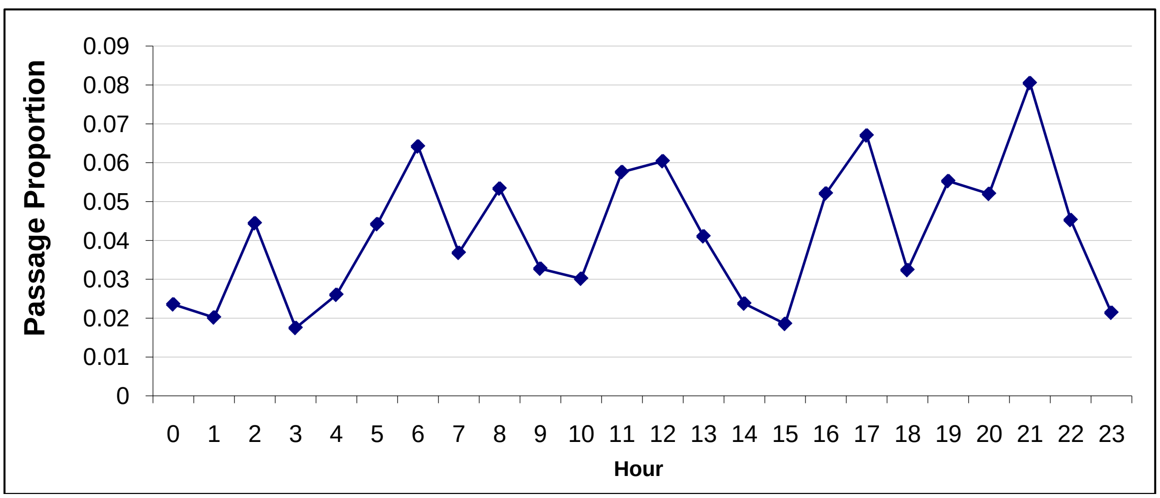

Figure 3.6. Diel Distribution of Overwintering Summer Steelhead Targets from November 1 – December 15, 2009. Data are the hourly proportions of total passage.

3.2.2 Period 2, Turbine Study (December 2009 – March 2010) Overwintering Summer Steelhead Fallback and Kelt Passage

3.2.2.1 Passage Rates and Run Timing

A total of 62 ± 40 (95% CI) adult size steelhead targets passed through the powerhouse intakes during the 82-day study period, from December 16, 2009 to March 7, 2010. Fish were detected passing the turbines on January 14 and 31 and February 2, 22, and 24 (Figure 3.7).

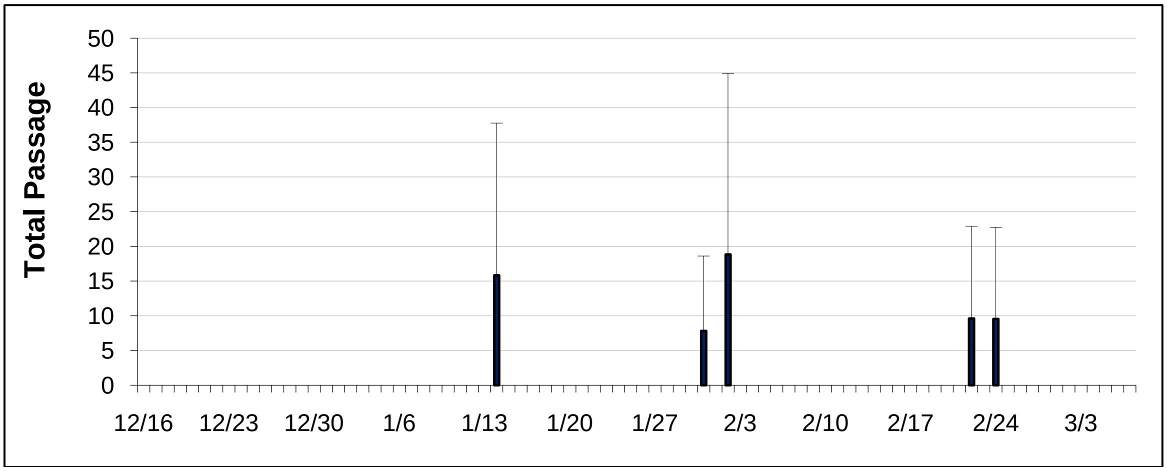

Figure 3.7. Number of Overwintering Summer Steelhead Targets Passing Daily at Each Route of the Powerhouse from December 16, 2009 to March, 7 2010 (95% CI).

3.2.2.2 Horizontal Distribution

Total fish passage was highest at Main Unit 18 (38 targets). Main Unit 5 passed the second highest number of fish (16) and Main Unit 1 passed 8 fish (Figure 3.8). Main Unit 8, which typically passes fish in the fall and spring (e.g., Khan et al. 2009), was offline for most of this study period.

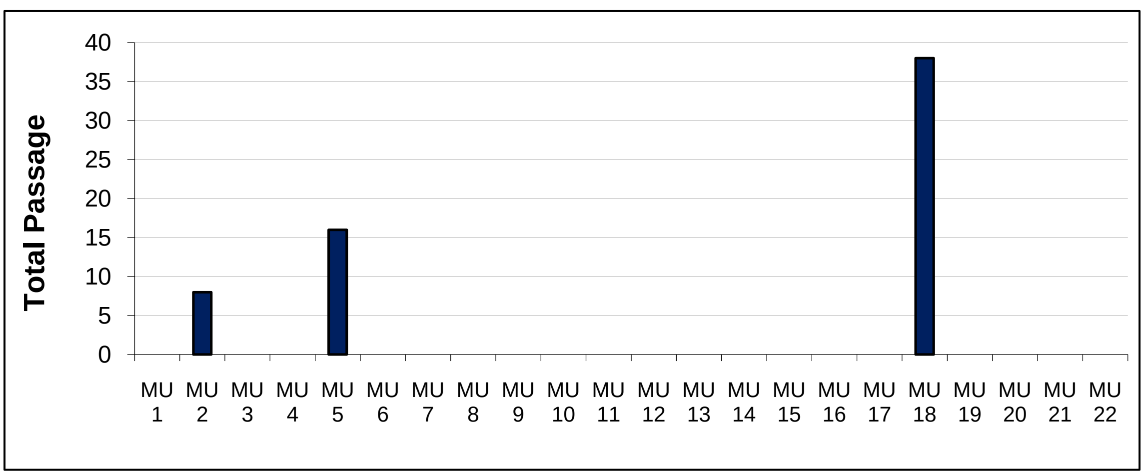

Figure 3.8. Horizontal Distribution of Overwintering Summer Steelhead Targets Passage at Each Route of the Powerhouse from December 16, 2009 to March 7, 2010 (MU = main unit)

3.2.2.3 Diel Distribution

Fish passage occurred during morning periods. Passage did not occur during the afternoon or nighttime (Figure 3.9).

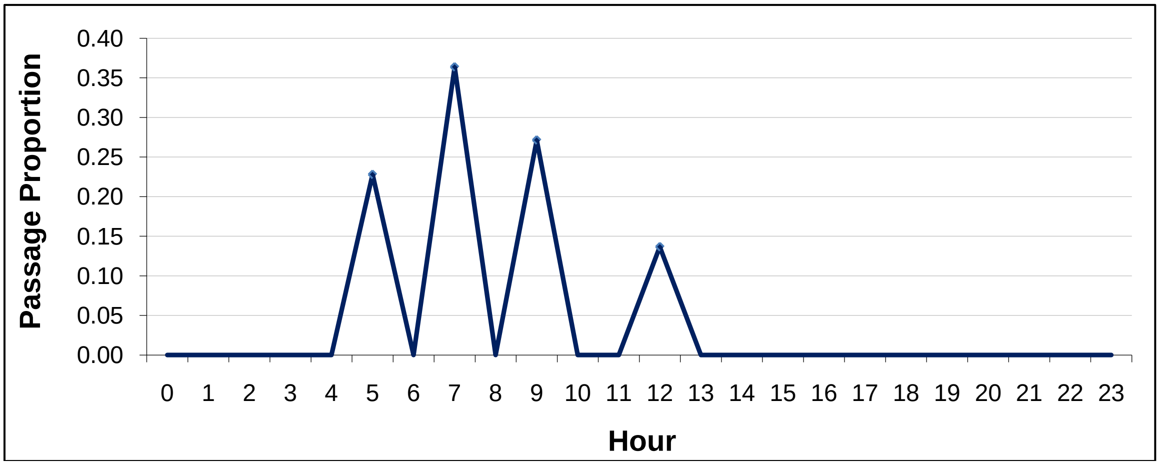

Figure 3.9. Diel Distribution of Overwintering Summer Steelhead Targets from December 16, 2009 to March 7, 2010. Data are the hourly proportions of total passage.

3.2.3 Period 3, Sluiceway and Turbine Study (Spring 2010) Overwintering Summer Steelhead and Early Out-Migrating Kelt Downstream Passage

3.2.3.1 Passage Rates and Run Timing

During the 34-day study period, from March 8 through April 10, 2010, a total of 1,985 ±234 (95% CI) adult size steelhead targets passed through the powerhouse intakes and operating sluice entrances. A daily average of 58 steelhead targets passed the dam during the study period. Of the 1,985 total steelhead targets, 1,958 passed through the sluiceway (99%) and 27 passed through the powerhouse intake units (1%). Run timing peaked twice, once on March 20/21 and again in early April. Passage of adult size steelhead targets occurred throughout the study period (Figure 3.10).

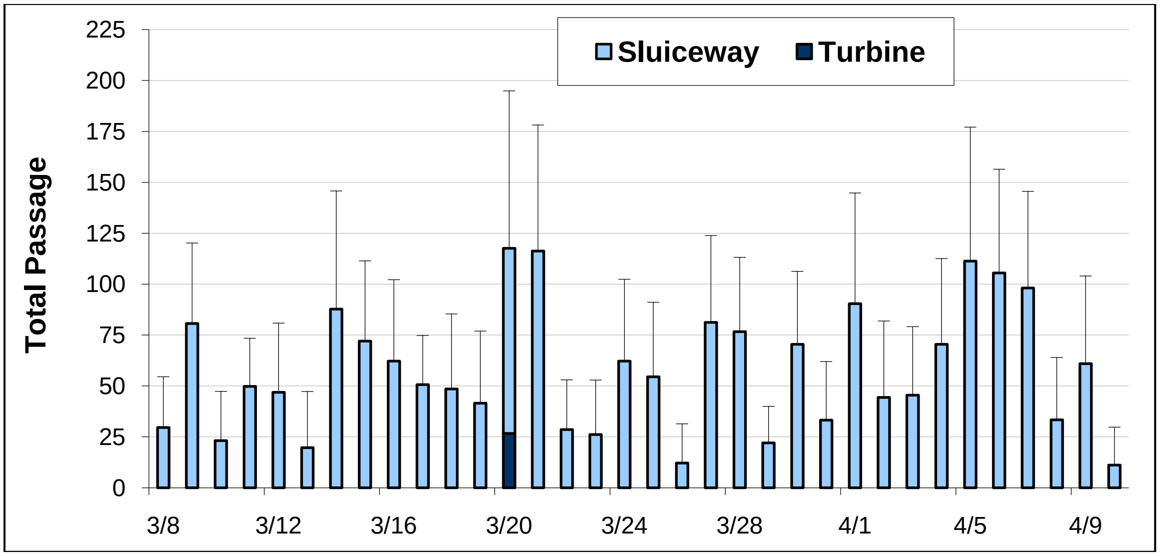

Figure 3.10. Number of Overwintering Summer Steelhead and Kelt-Sized Targets Passing Daily at Each Route of the Powerhouse and Sluiceway from March 8 Through April 10, 2010 (95% CI)

3.2.3.2 Horizontal Distribution

Total fish passage was highest at Sluice 1 (1,153 targets). Sluice 18 passed the second highest number of fish passing (805) and a small number passed through powerhouse intake unit 8 (27) (Figure 3.11). For individual sluice entrances, SL 1-3 passed the highest number of fish (579 targets), followed by SL 1-2 (574). SL 18-1 passed 430 fish and SL 18-2 passed 375 fish (Figure 3.12).

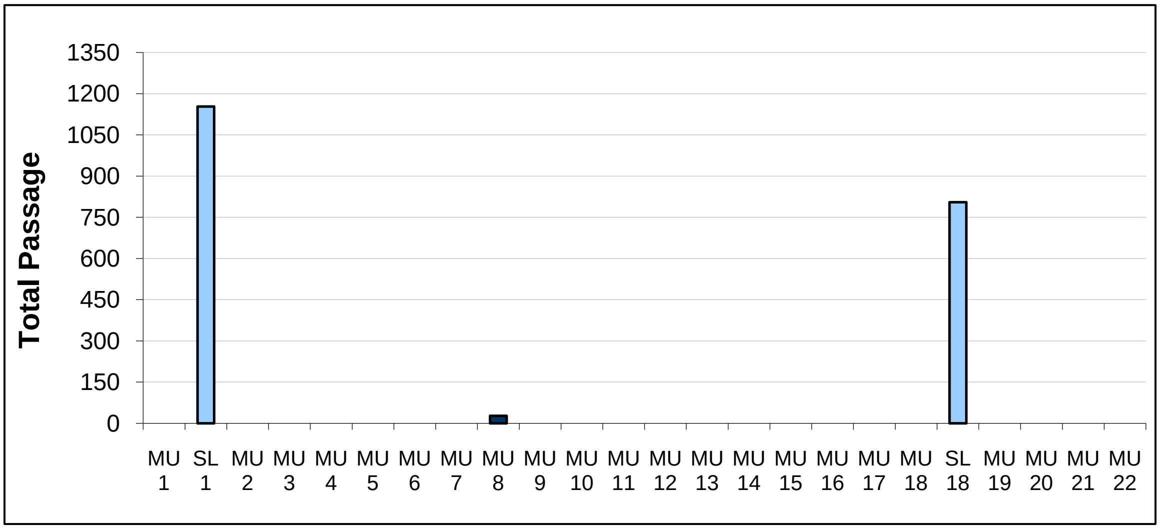

Figure 3.11. Horizontal Distribution of Overwintering Summer Steelhead and Kelt-Sized Targets Passage at Each Route of the Powerhouse and Sluiceway from March 8 Through April 10, 2010 (MU = main unit, SL = sluice)

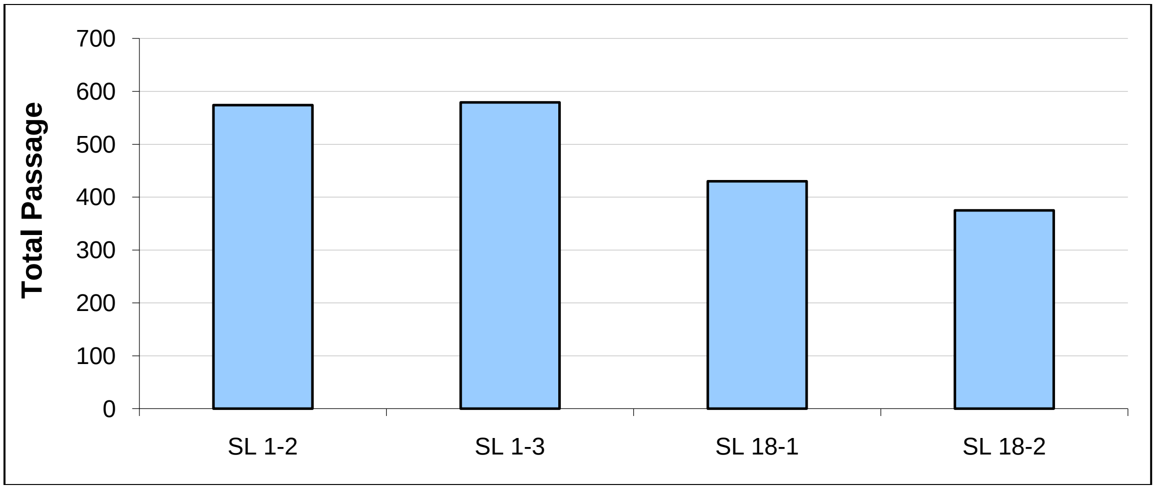

Figure 3.12. Horizontal Distribution of Total Passage of Overwintering Summer Steelhead and Kelt-Sized Targets at Each Route of the Sluiceway from March 8 Through April 10, 2010 (SL = sluice entrance)

3.2.3.3 Diel Distribution

Diel distribution was highly variable and indicate steelhead targets were passing the dam at all times of the day (Figure 3.13).

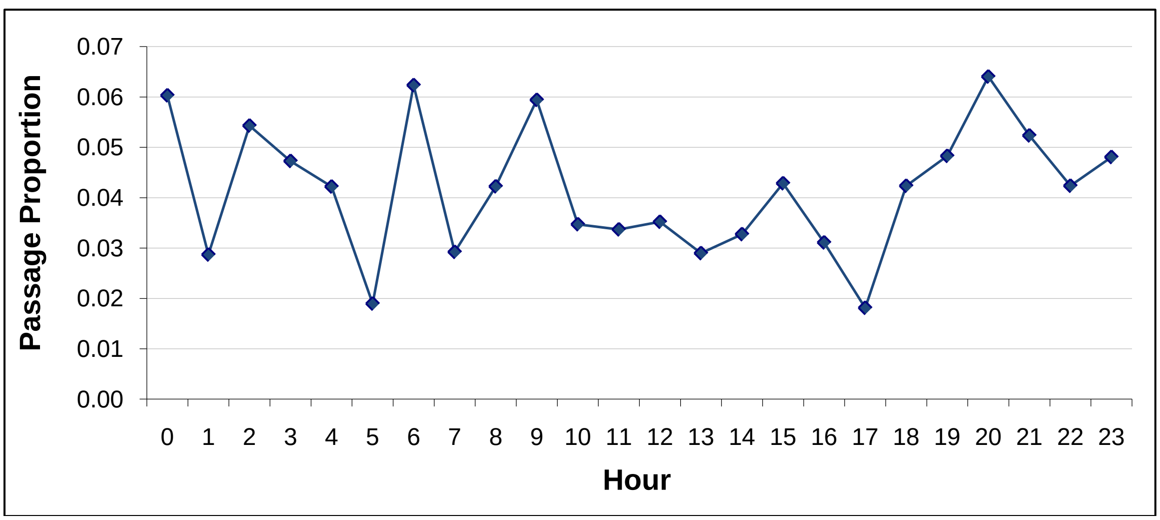

Figure 3.13. Diel Distribution of Overwintering Summer Steelhead and Kelt-Sized Targets from March 8 through April 10, 2010. Data are the hourly proportions of total passage.

3.2.4 Passage Summary 2008/2009 and 2009/2010

To summarize (Table 3.1), 2,926 adult steelhead targets passed the dam during all three study periods combined (from November 1, 2009 through April 10, 2010). For the 2008-2009 study (Khan et al. 2009), 3,556 adult steelhead targets passed the dam during the two study periods combined (November 1 through December 15, 2008 and March 1 through April 10, 2009). Thus, steelhead fallback and kelt passage rates were comparable between the 2008/2009 and 2009/2010 studies.

Table 3.1. Summary of Adult Steelhead Passage at The Dalles Dam 2008/2009 and 2009/2010

	Sluiceway		Turbine Units		Total	
Study Years	2008/2009	2009/2010	2008/2009	2009/2010	2008/2009	2009/2010
November 1 – December 15	1,704	804	86	75	1,790	879
March 1 – April 10	1,673	1,958	93	27	1,766	1,985
Total	3,377	2,762	179	102	3,556	2,864

4.0 Discussion and Conclusions

We conducted a hydroacoustic study at TDA from November 1, 2009 through April 10, 2010 to evaluate overwintering summer steelhead falling back through the dam in the fall and winter months and overwintering summer steelhead and early out-migrating steelhead kelt passage in winter and early spring. The overall goal of this study was to provide information about steelhead fallback and kelt passage at TDA to support decisions on the operations of the sluiceway in winter and early spring months to allow fish passage through that route, thus reducing turbine passage to improve steelhead survival as they pass the dam. In its 2006 Fish Passage Plan, the USACE Portland District included operating the TDA sluiceway until November 30 as a route for steelhead falling back because of concerns about these fish passing through turbines where mortality is presumably higher than at the sluiceway. Operating the sluiceway reduces the potential for hydropower production, but this surface flow outlet may be the optimal non-turbine route for fallbacks in the fall and winter months and kelt passage in early spring before the start of the spill season. Johnson and Dauble (2006) concluded that surface flow outlets are prime routes for passing downstream migrating juvenile salmonids at dams. The results of our study indicate that overwintering summer steelhead falling back during migration in the fall and winter months and kelts migrating downstream in winter and early spring used the sluiceway and some turbines as routes through the dam. Adult steelhead passage through the sluiceway far exceeded passage through turbines even though only a fraction of powerhouse flow went through the sluiceway.

From November 1 through December 15, fallback occurred throughout this 45-day study period, except for a few days (11/1, 11/6, 11/21, 12/2, and 12/15) when no steelhead targets were detected passing the dam. During this period, a total of 879 ± 165 (95% CI) summer steelhead targets passed through the powerhouse intakes and operating sluices. Ninety-two percent (804 targets) of the total fish passed though the sluiceway. Therefore, without the sluiceway as a route through the dam, a number of steelhead may have fallen back through turbines. Run timing peaked in early December, but fish continued to pass the dam until December 14 (~50 fish on 12/14) indicating that adult steelhead are still passing the dam in the middle of December. Horizontal distribution data indicated that Sluice 1 is the preferred route for these fish as they fall back through the dam. Diel distribution for overwintering steelhead fallbacks was variable with no apparent distinct patterns. The lack of a clear trend in diel passage suggests that fish are passing at all times of a day. Therefore, sluiceway operations should not be based on diel distribution in fall and winter.

During the winter study period between December 16, 2009 and March 7, 2010, the sluiceway was not in operation and a total of 62 ± 40 (95% CI) adult size steelhead targets passed through the powerhouse intakes. Steelhead targets were detected passing the turbines on January 14 and 31 and February 2, 22, and 24. Total fish passage was highest at Main Unit 18 (38 fish). Main Unit 5 passed the second highest number of fish (16) and Main Unit 1 passed eight fish. Main Unit 8, which typically passes fish in the fall and spring (e.g., Khan et al. 2009), was offline for most of this study period. Diel distribution indicated fish passage occurred only during morning periods; passage apparently did not occur during afternoon or nighttime.

From March 8 through April 10, 2010, downstream passage of overwintering summer steelhead and early out-migrating kelt occurred throughout this 34-day study period. The sluiceway operation was delayed from its usual start date of March 1 because of an oil spill cleanup near the sluice outfall. A total of 1,985 ± 234 (95% CI) adult-sized steelhead targets passed through the powerhouse intakes and operating sluices. Ninety-nine percent (1,958 targets) of the total fish passed though the sluiceway. Therefore, not having the sluiceway as a route through the dam, a number of overwintering steelhead and out-migrating kelts may use the turbines for downstream passage before the start of the voluntary spill season. Run timing peaked twice, in late March and again in early April. Horizontal distribution shows the highest passage occurred at Sluice 1 (58% of total fish), followed by Sluice 18 (40%), indicating that Sluice 1 is the preferred route for fish passage as they migrate downstream through the dam. As with the fall/winter study periods, we do not recommend changes to the sluiceway operations based on diel distribution, because diel passage distributions indicated steelhead were passing the sluiceway in variable numbers at all times of the day.

The results of this study strongly suggest that operating the TDA sluiceway for adult steelhead passage (fallbacks and kelts) during the late fall, winter, and early spring months will provide an optimal, non-turbine route for these fishes to pass the dam. Johnson et al. (2005, 2006) found the sluiceway to be an efficient and effective route for juvenile salmonids as they migrate downstream. Khan et al. (2009) found adult steelhead used the sluiceway for falling back and downstream passage during fall, winter, and early spring months. Results from a study conducted by Boggs et al. (2004) indicated that steelhead fallbacks “overshot” their natal streams or hatcheries during upstream migration and after falling back, these fishes were found in streams and hatcheries below the fallback site. Kelts migrating to the ocean are capable of returning to their freshwater spawning grounds to spawn again, which is an important factor for maintaining stable steelhead populations in their native rivers (Wertheimer and Evans 2005; Wertheimer 2007). Fallback of overwintering summer steelhead during late fall and winter and passage of out-migrating kelt and overwintering steelhead during early spring are instances of the benefits of using surface flow outlets instead of turbines to pass salmonids. All 13 dams on the mainstem Columbia and Snake rivers have installed or are developing surface flow outlets to pass juvenile salmonids. Fisheries and hydrosystem managers are responsibly considering the use of these structures to protect adult salmonids from hydropower turbines (NMFS 2008).

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