Confederated Tribes of the Warm Springs Reservation of Oregon

P. O. Box 960 • Warm Springs, OR 97761

Portland General Electric Company

121 S.W. Salmon Street • Portland, OR 97204

June 26, 2017

ELECTRONICALLY FILED

Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: Project No. 2030 – Pelton Round Butte Hydroelectric Project
Appendices C and D – Condition 13 - Test and Verification Study: Juvenile Migration 2016 Annual Report

Dear Secretary Bose:

Portland General Electric Company and the Confederated Tribes of the Warm Springs Reservation of Oregon are the Joint Licensees for the Pelton Round Butte Hydroelectric Project (Project No. 2030). On June 21, 2005, the Commission issued an Order Approving Settlement and Issuing New License, *Portland General Electric Company & Confederated Tribes of the Warm Springs Reservation of Oregon*, 111 FERC ¶ 61,450 (2005); *order on rehearing,* 117 FERC ¶ 61,112 (2006).

As required by Condition 13 of Appendices C and D of the license, on April 22, 2008, the Joint Licensees filed a Test & Verification Study: Juvenile Migration Plan, which the Commission modified and approved on September 2, 2008. *Portland General Electric Company & Confederated Tribes of the Warm Springs Reservation of Oregon*, 124 FERC ¶ 62,161 (2008). The Study Plan requires the Joint Licensees to file by July 1 of each year, after consultation with the Fish Committee, an annual report of the previous calendar year's activities.

Accordingly, pursuant to Condition 13 of Appendices C and D of the license, attached for filing with the Commission is the Joint Licensees' *Test & Verification Study: Juvenile Migration 2016 Annual Report*. This report has been prepared in consultation with the Fish Committee.

If you have questions about this filing, please contact me at 503-464-8133.

Very truly yours,

Jessica Graeber
Environmental Compliance and Licensing
cc. Fish Committee

2016 Juvenile Migration Test and Verification Study Annual Report

Prepared by:

Gonzalo Mendez and Megan Hill

Portland General Electric

On Behalf of

Portland General Electric Company

And

The Confederated Tribes of the Warm Springs Reservation of Oregon

June 2017

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Executive Summary

We captured and PIT-tagged 383 steelhead naturally-reared smolts in upper tributary screw traps in 2016. No Chinook fry were released into the upper basin tributaries in 2015; therefore, insufficient numbers of naturally-reared Chinook were encountered to allow for analysis in this report. Therefore all Chinook data reported are for hatchery-reared Chinook. We PIT-tagged 1,200 hatchery Chinook smolts and 800 hatchery steelhead smolts released at the head of the arms in Lake Billy Chinook. ODFW also PIT-tagged and released 1,194 hatchery Chinook and 795 hatchery steelhead smolts into the upper tributaries. Chinook migration in the tributaries peaked in late-March. Steelhead migration peaked in mid-May. Migration peaks at the SWW occurred several weeks after the migration peak in the tributaries.

Hatchery-reared steelhead spent 21 days (median) in Lake Billy Chinook (LBC), and median Chinook travel time through LBC differed by arm, ranging from 31-35 days. Travel times through the reservoir for naturally-reared smolts are confounded by their travel from their release points in the tributaries to LBC. Of the hatchery-reared Chinook and steelhead smolts PIT-tagged in the tributaries, 47.7% and 11.5% respectively, were captured at the SWW. Eight percent of the naturally-reared steelhead smolts PIT-tagged in the tributaries were captured at the SWW. Based upon the number of hatchery-reared Chinook and steelhead smolts captured at screw traps, the majority of hatchery smolts appear to have left Whychus and the Metolius and entered LBC. We estimate between 3,828 and 11,462 naturally-reared steelhead were produced by Whychus Creek in 2016.

In 2016 we tested survival of day-released versus night-released fish throughout the lower Deschutes and to Bonneville Dam. This revealed that night-released Chinook and steelhead have a significant survival advantage over day-released fish that were present at the mouth of the Deschutes and persisted to Bonneville Dam. In 2015, Chinook survival estimates were 51%, similar to the day-released smolts in 2016, 59.5% (36.8-75.7). Night-released Chinook smolts survival estimate was 96.0% (79.3-100%). In 2015, steelhead survival estimates were 55%, similar to 2016 day-released smolts of 49.8% (29-69.4%). Night-released steelhead smolt survival estimate was 77.4% (43.1-91.1%). We were not able to derive separate day versus night

survival estimates for sockeye. In 2017, we will release smolts from the SWW at night to maximize lower river survival and improve adult return rates.

Introduction

Specific objectives of the Juvenile Migration Test and Verification Study are to: 1) determine the number of salmon smolts and steelhead smolts entering Lake Billy Chinook (LBC) from each tributary, 2) determine the timing and numbers of salmon and steelhead emigrating from LBC, 3) determine the percentage of fish entering LBC that are successfully captured at the Selective Water Withdrawal (SWW) at Round Butte Dam, and 4) determine travel times and relative survival of each species to Bonneville Dam (Portland General Electric 2007a).

Data for this report are presented in two sections. The first section summarizes the data collected from the upper basin tributaries to the SWW in 2016. The second section summarizes the data collected in 2016 from the SWW to the mouth of the Deschutes (radio telemetry) and the Columbia River (PIT tags).

Upper Deschutes Basin Tributaries to the SWW

Methods

Smolt Trap Operations and Tagging

Trapping locations and dates are summarized in Figure 1 and Table 1. Trap operations were conducted similar to previous years with the Whychus Creek and Crooked River traps checked 7 days/week throughout the migratory season. However, no Chinook fry were outplanted in 2015 due to broodstock shortages. Therefore, the screwtrap at Monty Camp was only operated for 5-d per week during the peak of the hatchery-reared smolt outmigration (March 21, 2017 to April 15, 2017). Smolt traps were operated until smolt catch was fewer than 10 smolts per week. Fish less than 200 mm were anaesthetized with MS-222. Naturally-reared steelhead were measured (TL mm, weight g) and checked for the presence of a passive integrated transponder (PIT) tag. If the smolt was greater than 60 mm and weighed more than 2.0 g, and did not have a PIT tag, a 12-mm full duplex PIT tag was inserted into the peritoneal cavity of the fish via an incision.

PIT-tagged fish were released upstream of the fish traps to allow calculation of trap efficiencies. Release sites were located at least two riffle/pool sequences upstream. Release sites were no more than 300 m upstream of the trap to avoid substantial losses to marked fish due to predation (Volkhardt et al. 2007).

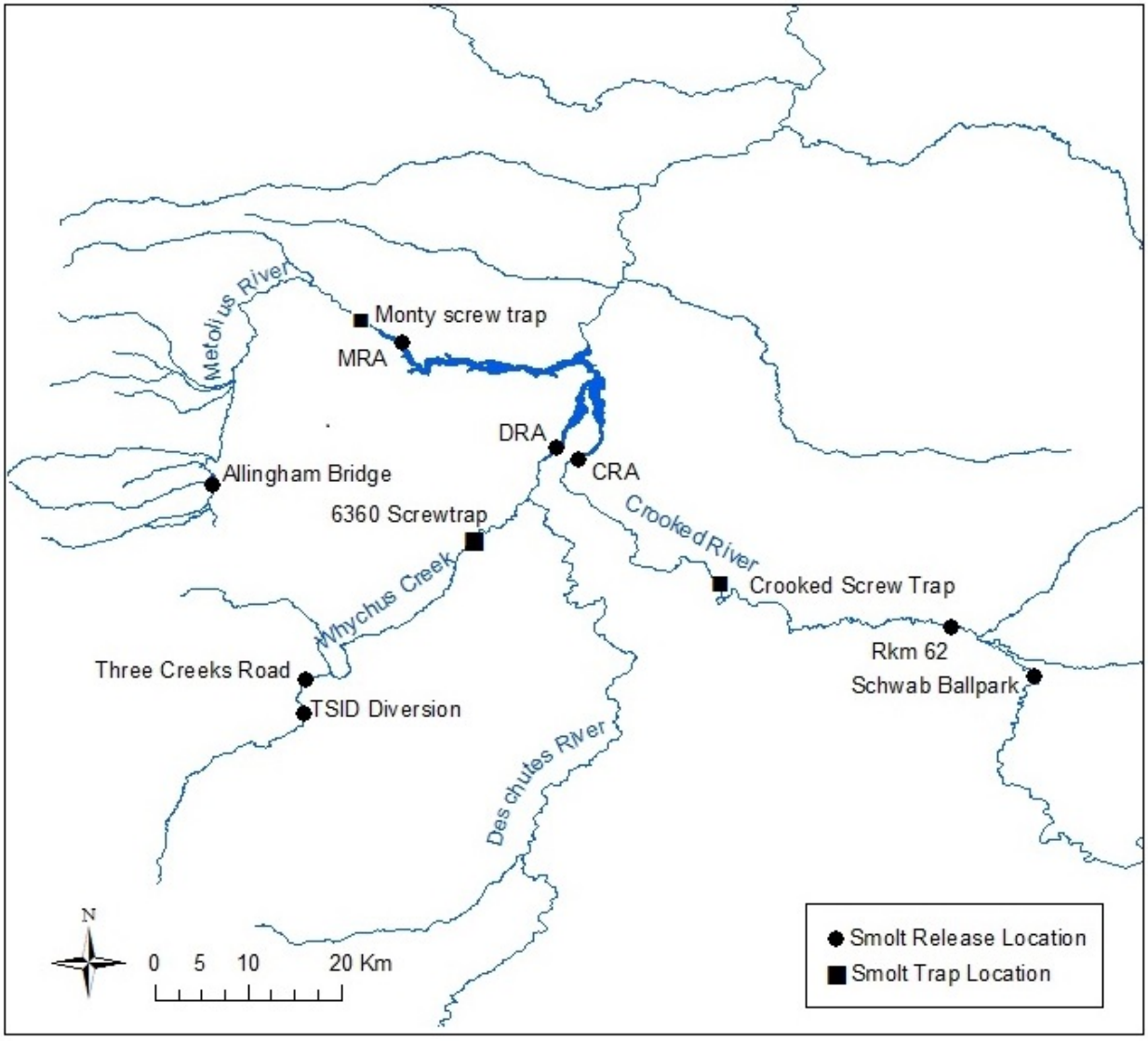

Figure 1. 2016 Smolt release and trapping locations

Table 1. Summary of screw trap operations. Whychus and Crooked River screwtraps were operated 7-d per week. The Metolius trap was operated 5-d per week.

Trap Site	Trap Type Size	Start Date	End Date
Metolius River at Monty Camp	Screw trap (2.5m)	3/21/2016	4/15/2016
Whychus Creek at 6360 crossing	Screw trap (1.5m)	3/23/2016	6/9/2016
Crooked River near Smith Rock	Screw trap (1.5m)	3/24/2016	6/10/2016

All PIT tag data were uploaded to the regional PIT tag database, PTAGIS (Columbia River Basin PIT Tag Information System), administered by Pacific States Marine Fisheries Commission (PSMFC). We are notified when any of the PIT-tagged study fish are detected at Bonneville Dam. In addition, NOAA Fisheries operates a PIT tag trawl in the Columbia River estuary (rkm 70). This trawl boat is outfitted with swim-through PIT tag detectors. PSMFC conducts PIT tag surveys for shed tags at several avian colonies on the Columbia River which provides us with some mortality data. In addition, other researchers encountering our fish can upload the recapture data or contact us directly.

To assess survival of fish in Whychus Creek and the Deschutes River to LBC, a subset of naturally-reared steelhead smolts were radio-tagged. Forty-nine steelhead were implanted with radio tags at the Whychus screw trap and 52 steelhead were tagged at the Crooked River screwtrap as described in Mendez and Hill (2016). The proportion of fish that did not enter LBC from the tagging site was used to identify mortality rates for tributary migration and reservoir passage.

Hatchery Smolt Releases

Spring Chinook and steelhead smolts were raised at the ODFW Wizard Falls Hatchery for release into the Metolius River, Whychus Creek, and the Crooked River in March and April of 2016. Spring Chinook were released in late-March and early-April at 19.4/lb and 17.5/lb respectively, while summer steelhead were released in late-April and early-May at 8.13/lb and 4.75/lb respectively. The smaller sizes were used to more closely match the size at migration of naturally-reared smolts, while the larger release size reflects the size typically used in past smolt releases above Pelton Round Butte Project. All hatchery fish were marked with a left maxillary

(LM) clip; a subset of fish were PIT-tagged to allow us to calculate survival and travel times of individual fish in the tributaries and LBC arms. Release numbers, dates, and marks are shown in Table 2. Release locations are shown in Figure 1.

Table 2. Hatchery steelhead and Chinook smolt releases, 2016. LM = left maxillary clipped, PIT = PIT-tagged.

	Site	Agency	Mark	Number Released*
Steelhead				
	Whychus Creek at TSID Diversion	ODFW	LM, PIT	394
	Deschutes River Arm of LBC, confluence	PGE	LM, PIT	400
	Crooked River at Schwab Ballpark	ODFW	LM, PIT	399
	Crooked River Arm of LBC, confluence	PGE	LM, PIT	400
	Whychus Creek at TSID Diversion	ODFW	LM	11,382
	Crooked River at Schwab Ballpark	ODFW	LM	5,644
	Crooked River at Opal Springs	ODFW	LM	1,500
Chinook				
	Metolius River at Allingham Bridge	ODFW	LM, PIT	399
	Metolius River Arm of LBC, confluence	PGE	LM, PIT	400
	Whychus Creek at Three Creeks Bridge	ODFW	LM, PIT	398
	Deschutes River Arm of LBC, confluence	PGE	LM, PIT	400
	Crooked River at Schwab Ballpark	ODFW	LM, PIT	400
	Crooked River Arm of LBC, confluence	PGE	LM, PIT	400
	Whychus Creek at Three Creeks Bridge	ODFW	LM	13,360
	Metolius River at Allingham Bridge	ODFW	LM	19.062
	Crooked River at Schwab Ballpark	ODFW	LM	11,848

*Total released at the site (number of PIT-tagged individuals + non PIT-tagged individuals)

Results

The number of smolts captured and PIT-tagged at each screwtrap site are displayed in Table 3. Unmarked Chinook were captured at each screwtrap site. The majority of these fish were captured during the pulse following the hatchery Chinook releases and are believed to be unmarked hatchery-origin Chinook. However, a few were captured outside of these pulses and were smaller in size. These fish could be the result of natural spawning occurring in the upper basin, but aren't designated as such for analysis due to the uncertainty.

Table 3. Number of smolts captured and PIT-tagged at each site in 2016. HR = hatchery-reared, UNK = unknown origin, NR = naturally-reared.

	Origin	#Caught	#PIT-tagged
Chinook			
Whychus	HR	4,100	0
Whychus	UNK	56	0
Crooked	HR	96	0
Crooked	UNK	6	0
Metolius	HR	890	0
Metolius	UNK	276	0
Steelhead			
Whychus	HR	3,379	0
Whychus	NR	318	308
Crooked	HR	123	0
Crooked	NR	75	74

Migration Timing

Steelhead

A total of 74 and 308 naturally-reared steelhead were captured in the Crooked River and Whychus Creek screw traps respectively in 2016. In the Crooked, the first fish was captured on April 21 and the last fish was captured on June 10. In Whychus, the first fish was captured March 23 and the last was captured on June 9. The steelhead smolt migration timing in the Crooked River and Whychus Creek are shown in Figure 2 and Figure 3. Capture of naturally-reared steelhead peaked in May in both tributaries. Hatchery-reared steelhead were released into both tributaries on April 27 and May 5. Capture of hatchery steelhead peaked immediately following release in Whychus Creek, whereas capture in the Crooked was more protracted. Hatchery-reared steelhead continued to be captured at both traps through late-May (Figure 2, Figure 3).

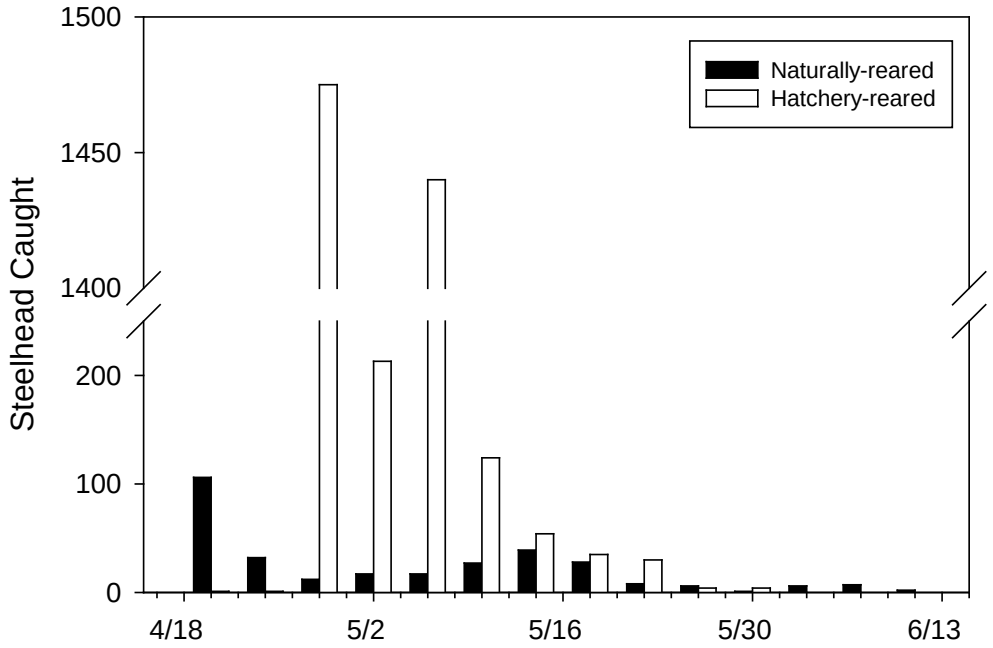

Figure 2. Steelhead captured by date at the Whychus Creek screw trap in 2016. Hatchery fish were released on April 27 and May 5.

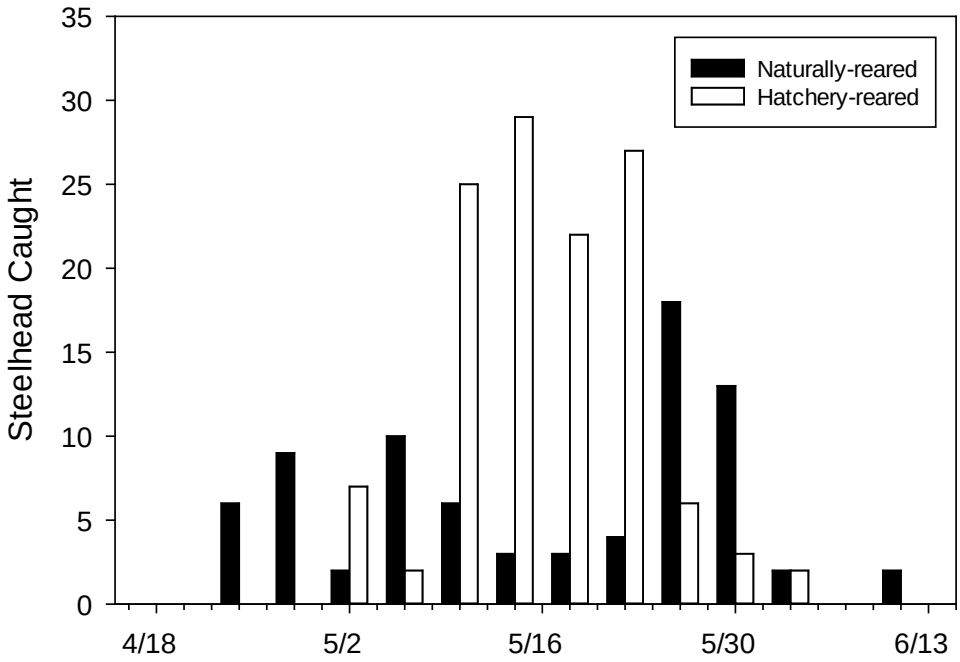

Figure 3. Steelhead captured by date at the Crooked River screw trap in 2016. Hatchery fish were released on April 27 and May 5.

Chinook

Hatchery-reared Chinook were released into Whychus Creek in two release groups on March 24 and April 5. Chinook quickly migrated out of Whychus Creek. It took two to four days for the smolts to migrate from the release site at the Three Sisters irrigation diversion (TSID), approximately 29 km upstream of the 6360 screw trap. Over 99% of hatchery-reared Chinook caught at the Whychus screw trap were captured within a week of release.

Following the two release events on the Metolius River, Chinook migration to the Monty Camp screw trap was slightly more protracted. It took one to six days for the hatchery-reared smolts to migrate from the release site at Allingham Bridge, approximately 37 km upstream of the Monty screw trap. The majority of these out-migrated immediately— 93% to 97% of the hatchery-reared smolts captured at Monty camp were captured within 4 days of release.

Following the two release events on the Crooked River, Chinook migration to the screw trap near Smith Rock State Park was faster compared to Whychus and Metolius. It took one to two days for the hatchery-reared smolts to migrate from the release site at Les Schwab Fields in Prineville, approximately 44.5 km upstream of the Smith Rock screw trap. A total of 96 hatchery-reared Chinook were captured over the course of both releases with 72% of fish captured 2 days after the first release (Figure 4).

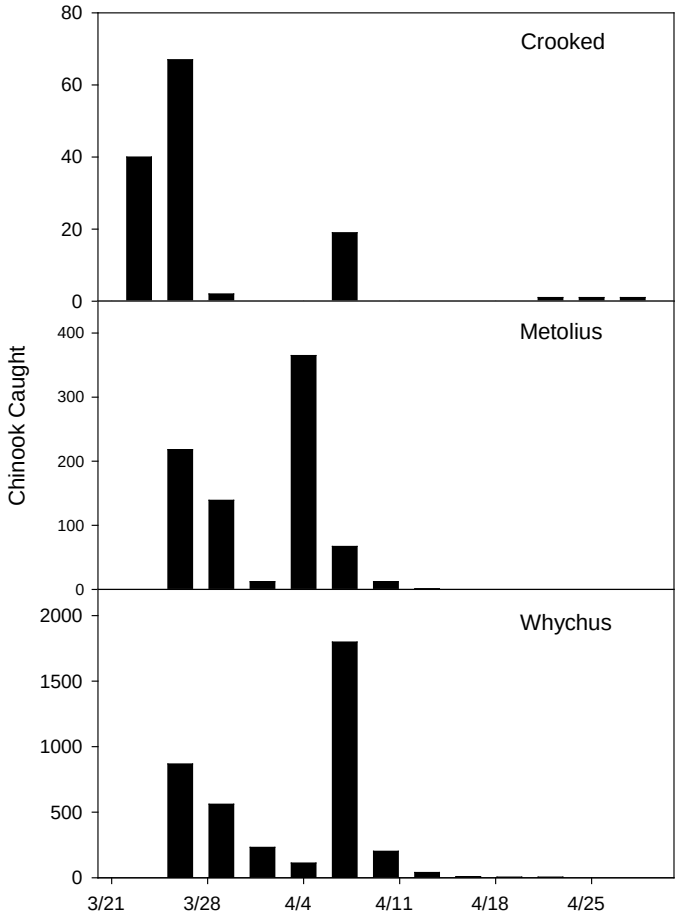

Figure 4. Hatchery-reared Chinook captured by date at screwtraps located in the Crooked River, Whychus Creek, and Metolius River. An additional 2 Chinook were captured after May 1 in Whychus Creek.

Timing of Entry into the SWW

Chinook catch at the SWW began increasing in late-March 2016. Chinook capture remained relatively high from March to May, peaking in late April (Figure 5). The 2016 Chinook run timing was similar to previous years (2010-2015), except that relatively more Chinook were captured in April compared to previous years (Figure 6). Steelhead catch at the SWW started to increase in mid-April and was the highest in mid-May. Seventy-two percent of steelhead were captured in the month of May. The sockeye (1+ yearling kokanee) migration occurred primarily between late-March and early-May, with the highest numbers caught during April (Figure 5). Similar to Chinook, a higher percentage of sockeye were captured in April compared to previous years (Figure 6).

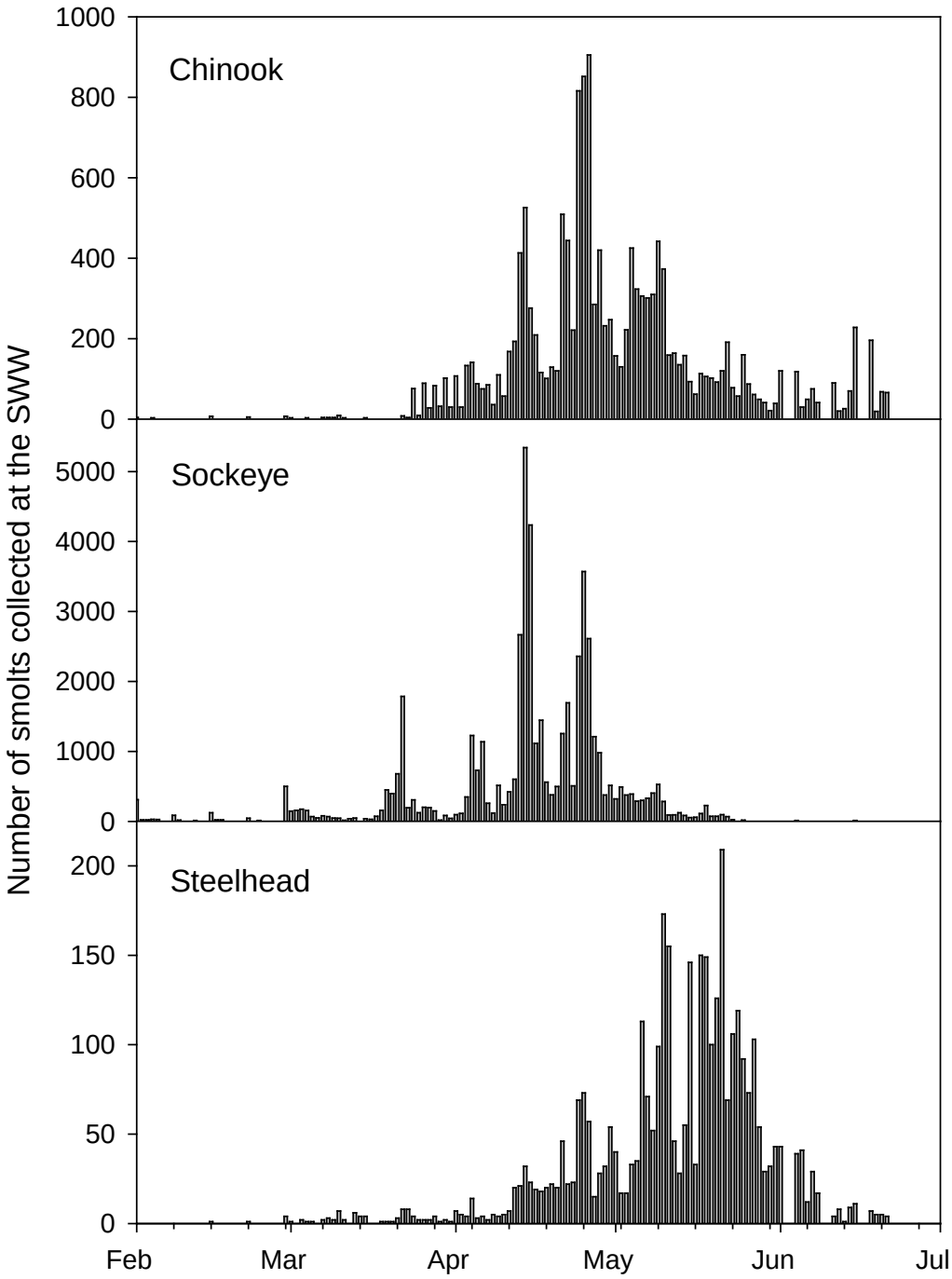

Figure 5. Migration timing of Chinook, steelhead, and sockeye smolts into the SWW in 2016.

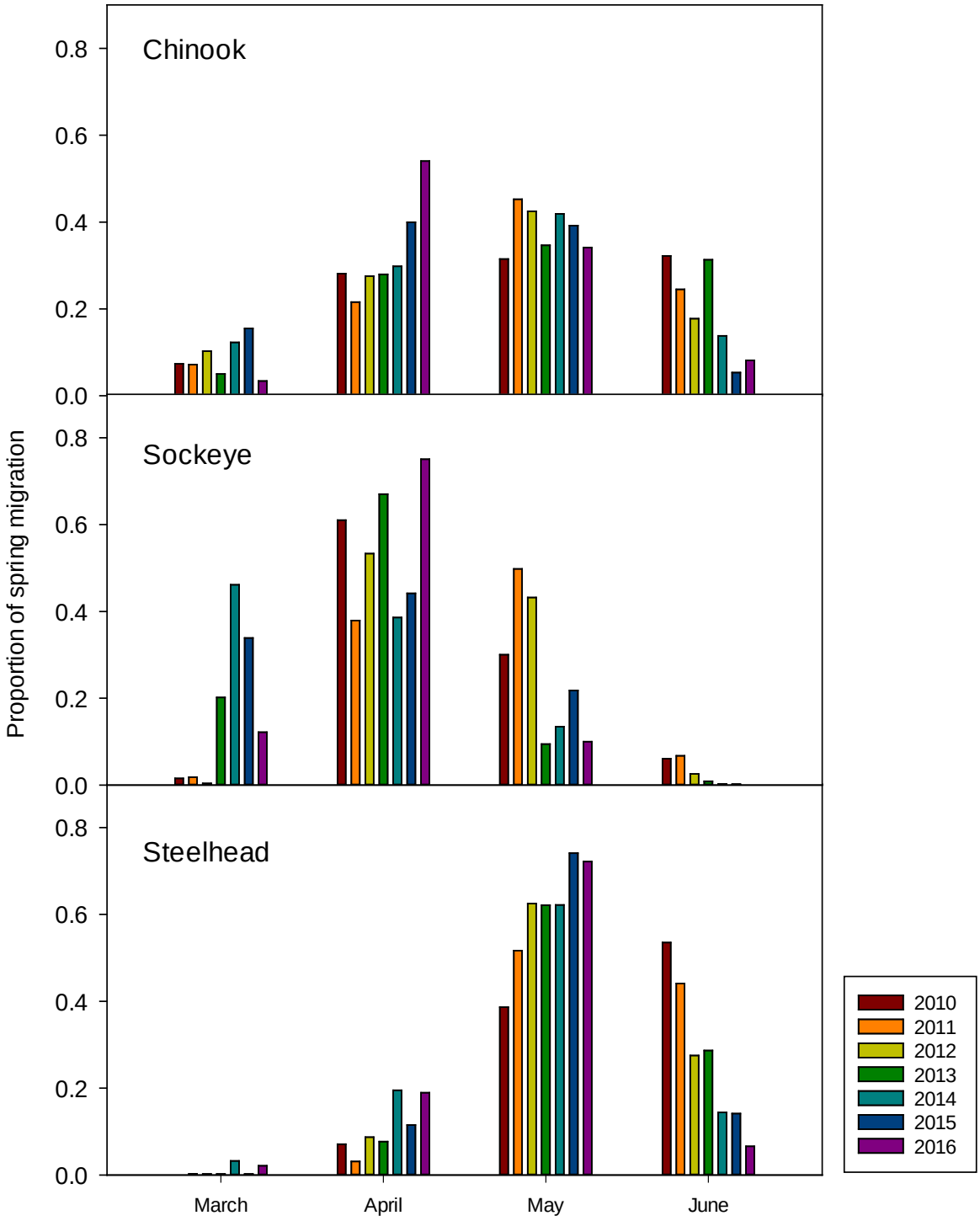

Figure 6. **Proportion of spring run captured by month at the SWW for Chinook, steelhead, and sockeye, 2010-2016.**

Travel Time

Hatchery Chinook smolts released at the upper ends of the Crooked, Metolius, and Deschutes arms of LBC had similar average travel times through LBC in 2016 (Table 4). Steelhead, especially naturally-reared smolts, tended to move through the reservoir more quickly than Chinook (Table 4). On average, hatchery Chinook and steelhead spent 9 fewer days in LBC in 2016 compared to 2015.

Table 4. Median travel time of PIT-tagged Chinook and steelhead smolts through LBC. NR = naturally-reared, HR = hatchery-reared.

Release Site	Fish Origin	n	Median Travel Time (d)	Range (d)
Chinook				
UCRA	HR	234	35	2 - 106
UDRA	HR	201	34	1 - 106
UMRA	HR	136	31	3 - 79
Steelhead				
Crooked screwtrap	NR	4	14	13 - 37
UCRA	HR	44	21	9 - 43
Whychus screwtrap @6360	NR	28	21	7 - 35
UDRA	HR	48	21	5 - 59

Size and Growth

Naturally-reared steelhead grew an average of 17.6 mm in the time it took them to reach the SWW from trapping locations in the Crooked River and Whychus Creek (Figure 7).

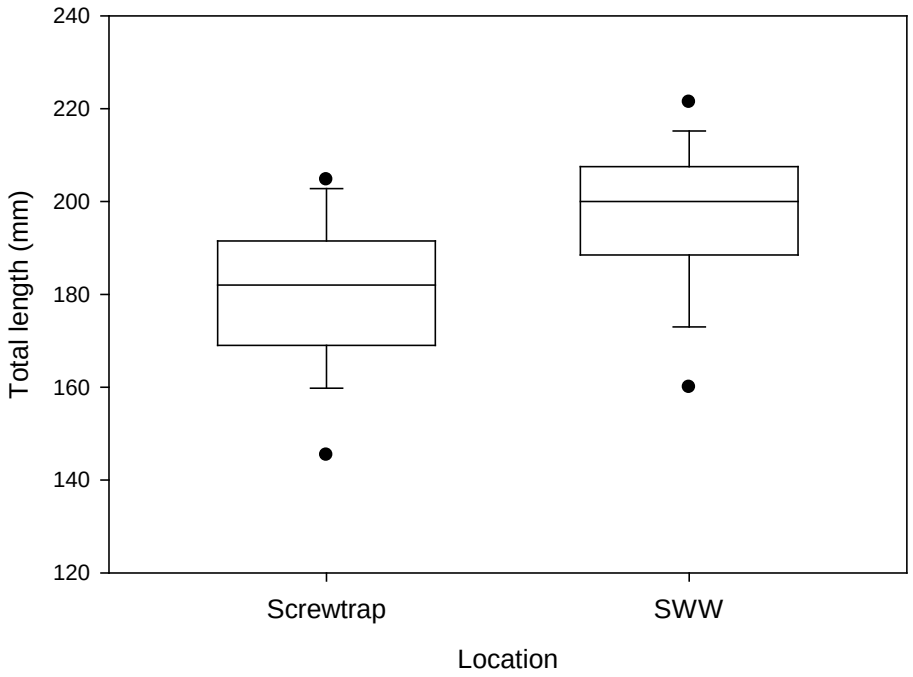

Figure 7. Total length of naturally-reared steelhead measured at the screw traps and recaptured at the SWW in 2016. The line within the box is the median value; the upper and lower boundaries of the box are the 25th and 75th percentiles. The whiskers indicate the 10th and 90th percentiles and the dots show the 5th and 95th percentiles.

Tributary Population Estimates

Whychus Creek Chinook and Steelhead

We captured 4,151 hatchery-reared Chinook smolts. Based on recapture of marked fish, we estimate trap efficiency for hatchery-reared Chinook to be 33%. We estimate that 16,038 ± 1,562 hatchery Chinook migrated out of Whychus Creek in 2016. As in 2015, this estimate is slightly higher than the total number of Chinook released into Whychus, indicating that nearly all hatchery-reared Chinook left the creek. We captured 408 naturally-reared steelhead at the trap. The screw trap efficiency was much lower for naturally-reared steelhead, estimated at 4.4%. This yields a population estimate of 7,645 ± 3,817 steelhead migrating out of Whychus Creek in 2016. This is similar to the 2015 estimate of 6,223 naturally-reared steelhead. In addition, we captured 3,299 hatchery-reared steelhead at the Whychus screw trap. The screwtrap efficiency for hatchery-reared steelhead was estimated at 2.8%. This is likely an underestimate of trap efficiency; when a population estimate is calculated and it indicates a population exceeding the

number of steelhead released into Whychus Creek. Based on this, we think that the majority of the hatchery-reared steelhead moved past the screw trap similar to 2015.

Crooked River Steelhead and Chinook

We captured 71 hatchery-reared Chinook smolts at the Crooked River screwtrap. Based on recaptured fish, trap efficiency was estimated to be 1.4% for Chinook smolts. This yields a population estimate of 2,608 ± 2,402 Chinook. A total of 527 hatchery-reared steelhead smolts were captured in the trap, which operated with an average efficiency of 4.9%. An estimated 2,502 ± 1, 091 steelhead passed by the Crooked River screwtrap.

Metolius Chinook

The Monty screwtrap was operated for 3 weeks during the peak of the hatchery smolt out-migration. During this period we captured 1,025 hatchery-reared Chinook smolts. Trap efficiency was estimated at 7.8%. Based on this efficiency, we estimate 11,279 ± 3,837 hatchery Chinook moved into Lake Billy Chinook during this period.

SWW Collection Efficiency

The SWW captured 16,997 Chinook, 4,024 steelhead, and 49,497 sockeye smolts in spring 2016. Total catch of all three species was higher in 2016 than 2015. The Chinook catch was comprised almost entirely of fish released as hatchery smolts, as no fry were released into the upper basin in 2015 (compared to 256,404 fry outplants in 2014) (Figure 8).

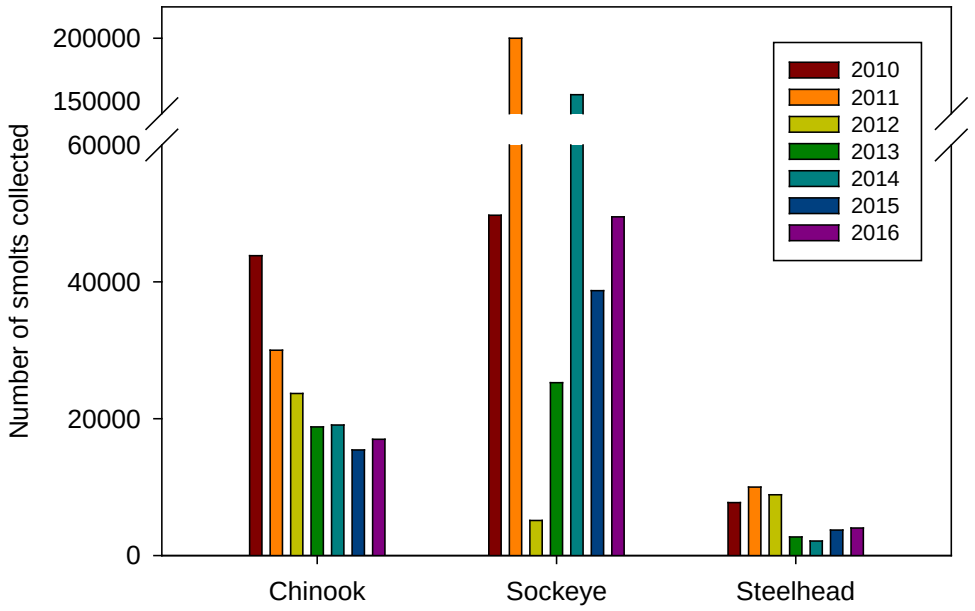

Figure 8. Number of smolts captured at the SWW during the smolt migration season (February 1 to June 30) from 2010 to 2016.

Collection efficiency was estimated by the ratio of the number of PIT-tagged fish that were captured at the SWW to the number of PIT-tagged fish released for each arm of LBC and tributaries. Confidence intervals for mean capture efficiency for each release group were calculated, at α=0.05, for the binomial population parameter per Zar (1999). Results are summarized in Table 5.

Because the total number of hatchery smolts released is known, we can also estimate reservoir and tributary passage for them as a group (all release locations combined). The SWW captured 13,946 of the approximately 47,125 (29.6%) hatchery Chinook released, and 2,328 of the approximately 45,939 (5.0%) hatchery steelhead smolts released. Hatchery Chinook passage efficiency was 10% higher in 2016 compared to the previous year. Hatchery steelhead passage efficiency was similar between the years. The passage efficiencies for Chinook are lower than the reservoir passage efficiencies reported for PIT-tagged hatchery-reared smolts released into

LBC in Table 5. This likely reflects the different release locations (as shown in Table 2); un-PIT-tagged hatchery-reared smolts were released into the tributaries upstream of LBC.

Table 5. Number of fish PIT-tagged and recaptured at the SWW for each release location.

Chinook

Release Site	Fish Origin	# Tagged	# Detected at SWW	Percent Collected	95% CI
MRA	HR	400	136	34.0%	30% - 39%
DRA	HR	399	202	50.6%	47% - 54%
CRA	HR	400	234	58.5%	55% - 62%

Steelhead

Release Site	Fish Origin	# Tagged	# Detected at SWW	Percent Collected	95% CI
Crooked screwtrap	NR	74	4	5.4%	1% - 13%
Whychus screwtrap	NR	308	28	9.1%	6% 13%
DRA	HR	400	48	12.0%	9% - 15%
CRA	HR	400	44	11.0%	8% - 14%

The 2016 reservoir passage survival estimates for naturally-reared steelhead are likely slightly underestimated. Forty-one of the 49 (84%) radio-tagged steelhead were detected in LBC after release at the Whychus screw trap. If the SWW collection percentages are corrected for in-river loss, estimated reservoir passage efficiency for Whychus naturally-reared steelhead through the Deschutes River Arm is increased to 10.5%. For Crooked River steelhead, accounting for the percentage of radio-tagged steelhead that entered LBC (46%), increases the reservoir passage survival estimate to 8.3%. Collection of hatchery-reared PIT-tagged Chinook was higher in 2016 compared to the previous years (Figure 9). Whereas results for individual arms varied, overall collection for all arms combined was the highest since the SWW went into operation. Hatchery-reared steelhead performed slightly better in 2016 compared to 2015. In contrast, a smaller percentage of naturally-reared steelhead were collected in 2016 compared to the previous year (Figure 10).

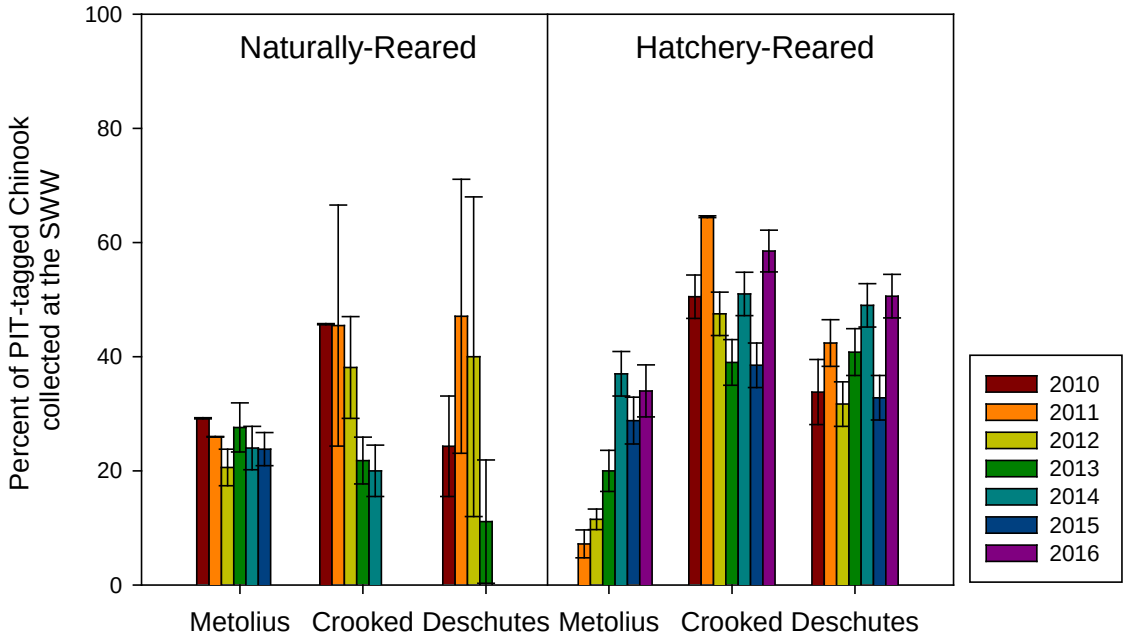

Figure 9. Percent of PIT-tagged Chinook collected at the SWW from 2010-2016. Note- **no Chinook fry were outplanted in 2015 due to broodstock shortages.**

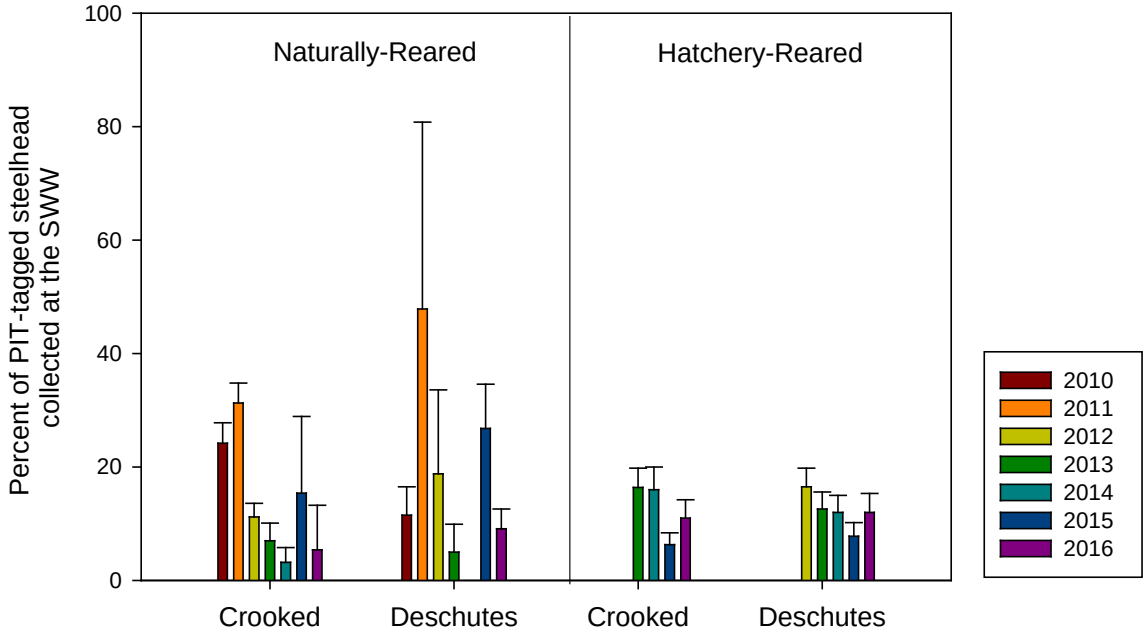

Figure 10. Percent of PIT-tagged steelhead collected at the SWW from 2010-2016.

Discussion

Migration of naturally-reared steelhead smolts varied in 2016. Steelhead were captured approximately a month earlier in Whychus Creek (late March) compared to the Crooked River (late April). Capture of hatchery-reared steelhead differed as well with Whychus Creek captures closely associated with release timing whereas Crooked River captures were protracted throughout the migration season. Travel times through LBC were similar with median travel times being 21 days for both groups of planted smolts. Entry into the SWW of both naturally-reared and hatchery-reared steelhead peaked in mid-May.

Migration of hatchery-reared Chinook smolts also varied in 2016. Chinook released into Whychus Creek and Metolius River had similar behavior with the capture of the majority of out-migrating smolts lasting only two to four days. In contrast, Chinook smolts released into the Crooked River, of which there were few, were captured quickly two days after release. Travel times through LBC were similar among tributaries with median travel times being 31-35 days for all three groups of planted Chinook smolts. Entry into the SWW was similar to previous years, lasting from late-March until May, peaking in late-April. Naturally-reared sockeye (1+ yearling kokanee) migration was similar to Chinook with the capture of out-migrating sockeye at the SWW beginning in late-March and ending in late-May, with the peak being in mid-April to early-May.

Based on efficiency estimates of the screw traps, smolt estimates for 2016 are similar to 2015. Whychus Creek hatchery-reared Chinook and steelhead estimates were higher than what was actually released. Therefore, we believe nearly all outplanted smolts left Whychus Creek. Naturally-reared steelhead smolt population estimate was 7,645 ±3,817 migrating out of Whychus Creek. The placement of a screw trap near Smith Rock on the Crooked River improved the capture of out migrating smolts in 2016. Population estimate of hatchery-reared Chinook and steelhead was 2,608 ± 2,402 and 2,502 ± 1,091 respectively. The Monty screw trap on the Metolius River was in operation for 3 weeks allowing us to calculate a population estimate of 11,279 ± 3,837 hatchery-reared Chinook.

We will adjust our previous year's survival estimates to account for capture of smolts that may have remained in the tributaries or reservoir for a season or more before out-migrating. In 2016, 11 PIT-tagged Chinook from the Metolius screw trap that were tagged in 2015 were captured at the SWW. One hatchery-reared Chinook, one hatchery-reared steelhead, and one naturally-reared steelhead tagged in 2015 were also captured at the SWW in 2016. Inclusion of these post-spring migrants does not significantly change the estimated passage efficiencies. We will continue to monitor recapture of 2016 fish at the SWW and generate a 2-year smolt estimate if this pattern continues.

SWW to the Columbia River

In previous years we have relied on PIT tags to measure survival of smolts to Bonneville. However, PIT tag detections have not been able to provide us all the data that we need to understand survival of smolts after they are released from the SWW. In 2016 we continued to improve on the previous two years' of radio-tagging and monitoring smolts in the lower Deschutes River to Bonneville Dam. We tagged 150 smolts of each species and divided them into two release groups to test post-release survival. All fish were captured in the SWW, tagged and released along with the day's catch at the facility. In the first section, we describe the results of the 2016 PIT-tagging study. We then describe the use of radio-tags to assess two objectives: 1) estimate travel timing and survival of Chinook, sockeye, and steelhead smolts released from the juvenile release pipe at rkm 161 below the Re-regulating Dam to near the mouth of the Deschutes River (rkm 5); and 2) identify reaches in the lower Deschutes River where mortality might be occurring.

Methods

PIT tags

Hatchery-reared Chinook (n=783), naturally-reared sockeye (n=600), and both naturally and hatchery-reared steelhead (n=760) were PIT-tagged at the SWW and released into the lower Deschutes River. The Cormack Jolly-Seber model in Program MARK (White and Burnham 1999) was used to estimate survival from the SWW to Bonneville Dam. Due to the low number of PIT-tagged fish detections at downstream PIT detectors in 2016, we applied detection efficiency values for Warm Springs National Fish Hatchery Chinook supplied by David Hand

(USFWS pers. comm.) for Bonneville (42%) and for the estuary trawl (3%). Because the confidence intervals do not include error in the fixed detection efficiencies, estimates are biased low.

Radio tags

Radio Tag Specifications

Model NTQ-2 Nano tags (Lotek Wireless, Inc.) with a minimum tag life of 25 days (4.5 - 5.0 second burst rate) were used in this study. Tag size was 5 x 3 x 10 mm with an antenna length of 18 cm and a weight of 0.31 g in air. In addition, fish received a 12.5 x 2.1 mm PIT tag, weighing 0.10 g in air. To keep tag-to-body weight ratios less than 5% per Liedtke et al. (2012), fish less than 8.2 g were excluded from tagging.

Fish Selection and Tagging

In 2016 no naturally-reared Chinook were available for use as study fish since no fry were out planted in the spring of 2015. Additionally, we decided not to use naturally-reared steelhead in this study given the low numbers that out-migrated in 2015. During routine SWW fish processing operations, fish of each species were randomly selected and transferred from the holding raceways to an experimental tank inside the fish sorting building. Fish selected for radio-tagging versus the entire SWW catch are displayed in Figure 11, Figure 12, and Figure 13. Fish were held in the covered experimental tank for approximately 24 hours to evacuate stomach contents and monitor behavior prior to surgery. Fish were then netted out of the experimental tank and anaesthetized with tricaine methanosulfanate (MS-222), and examined for fin-clips, PIT tags, and major external injuries. We did not “high grade” the fish used for the study as it would have biased our results. Therefore, fish that had parasitic copepods, *Salmincola californiensis,* (copepods) present in their gills and fins were not excluded from the study. We did exclude some fish that had clear signs of *Renibacterium salmoninarum* (BKD) or *Ceratonova shasta* (*C. shasta*) infections. Despite this, some infected fish were included in our study.

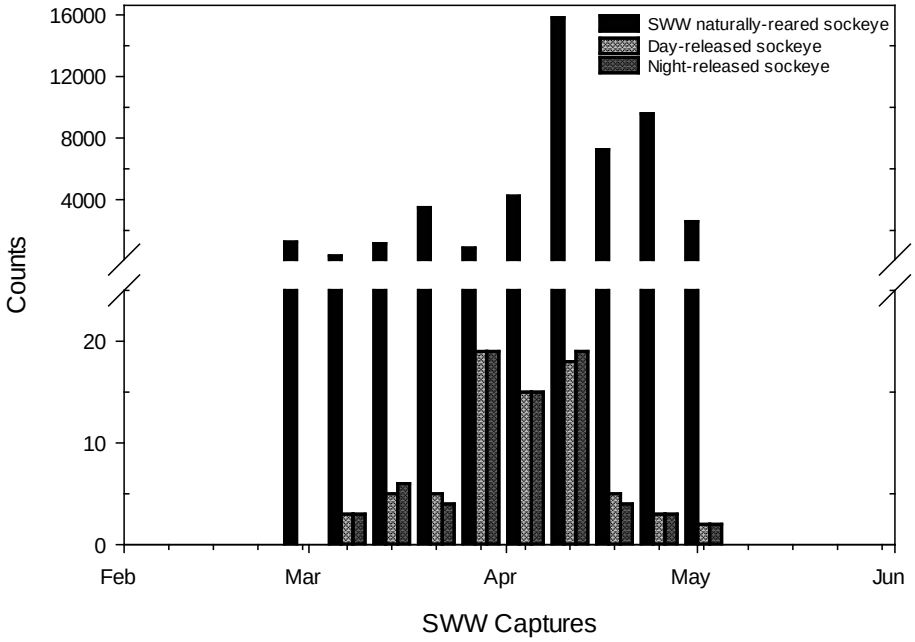

Figure 11. Number of naturally-reared sockeye smolts captured at the SWW (black bar), radio-tagged (day treatment = grey bar) and radio-tagged (night treatment = medium bar) at the SWW February 21 - July 2, 2016.

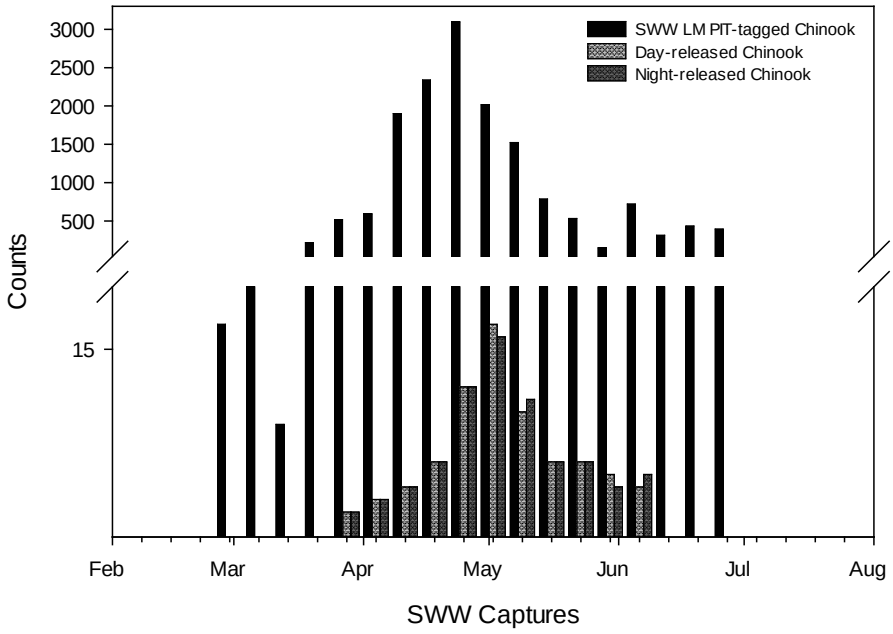

Figure 12. Number of LM Chinook smolts captured and PIT-tagged (black bar), radio-tagged (day treatment = grey bar) and radio-tagged (night treatment = medium bar) at the SWW February 4 - July 8, 2016.

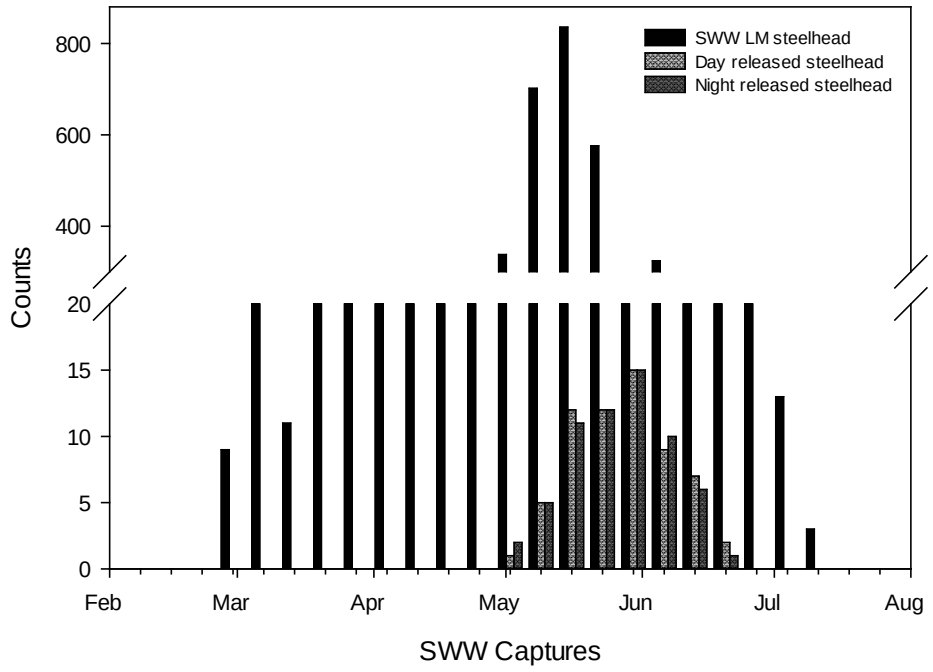

Figure 13. Number of LM steelhead smolts captured at the SWW (black bar), radio-tagged (day treatment = grey bar) and radio-tagged (night treatment = medium bar) at the SWW May 1 – June 30, 2016.

Smolts were tagged using methods similar to Liedtke et al. et al. (2012). Once sedated in a MS-222 solution of 100 mg/L, smolts were measured to the nearest mm (total length), weighed to the nearest 0.1 g, and placed ventral side up on a foam pad containing a v-notched groove securing the fish. Gills were continuously bathed with a dilute MS-222 solution (~50 mg/L) during the procedure. A 6-8 mm incision was made deep enough to penetrate the peritoneum slightly anterior to the pelvic girdle and parallel to the mid-ventral line. The radio tag was inserted into the body using the shielded needle technique (described by Ross and Kleiner 1982) along with a PIT tag, then the incision was closed using two simple interrupted sutures (2x3 knot). Fish were placed in an oxygenated bucket after tagging. The buckets had holes drilled through the upper two-thirds of their sides. After initial recovery, buckets were kept in the experimental indoor tanks where the holes allowed water to flow through. Each bucket held 1-4 smolts (depending on fish size) for 20-24 hours prior to release. Before transport we performed a visual inspection of the fish, looked for shed tags and confirmed radio tags were properly functioning. Fish were

released from the buckets directly into a fish transport truck. The remainder of the SWW catch was loaded into the fish transport truck(s) with the radio-tagged smolts. Fish were transported 32 km to release into the Deschutes River through the Juvenile Release Pipe located at rkm 161.

Delayed Mortality and Tag Retention

To evaluate potential effects of surgically implanting fish with radio tags, we selected and tagged additional control fish that were "dummy" radio-tagged at the same time as the study fish. Thirteen sockeye, 21 Chinook, and 13 steelhead smolts were tagged during normal tagging activities. These "dummy" radio-tagged fish were transferred to the Round Butte Hatchery Isolation Facility. The fish were fed and monitored throughout the course of the study to evaluate tag retention and survival.

Radio Telemetry Fixed Stations

Radio telemetry stations consisted of a Lotek SRX-800 receiver/data logger, a charge regulator, 80-90 Ah SLA battery, a 5-element directional Yagi antenna, and a 50-watt solar panel mounted to a 3-meter mast supported by a 1-meter tripod. Stations were tested for detection range and efficiencies. After set-up we tested each station to evaluate detection range and relative efficiencies and assure full coverage of the river. Using activated "test" tags we floated through the site using a kayak or pontoon boat at far, mid, and near-channel transects. Based on the number and power of detections, adjustments were made to antenna orientation and receiver gain settings. Fixed radio telemetry stations were positioned at five locations between the release site, at rkm 161, and near the mouth of the Deschutes River (rkm 5), (Figure 14). Stations were operated from February 11 to July 5. The stations were located at Dizney Riffle (rkm159), Trout Creek Campground (rkm 140), the mouth of Buck Hollow Creek (rkm 69), and two stations at the Mouth (rkm 5 & 4.8). Two stations were setup at the mouth to assure reliable data collection.

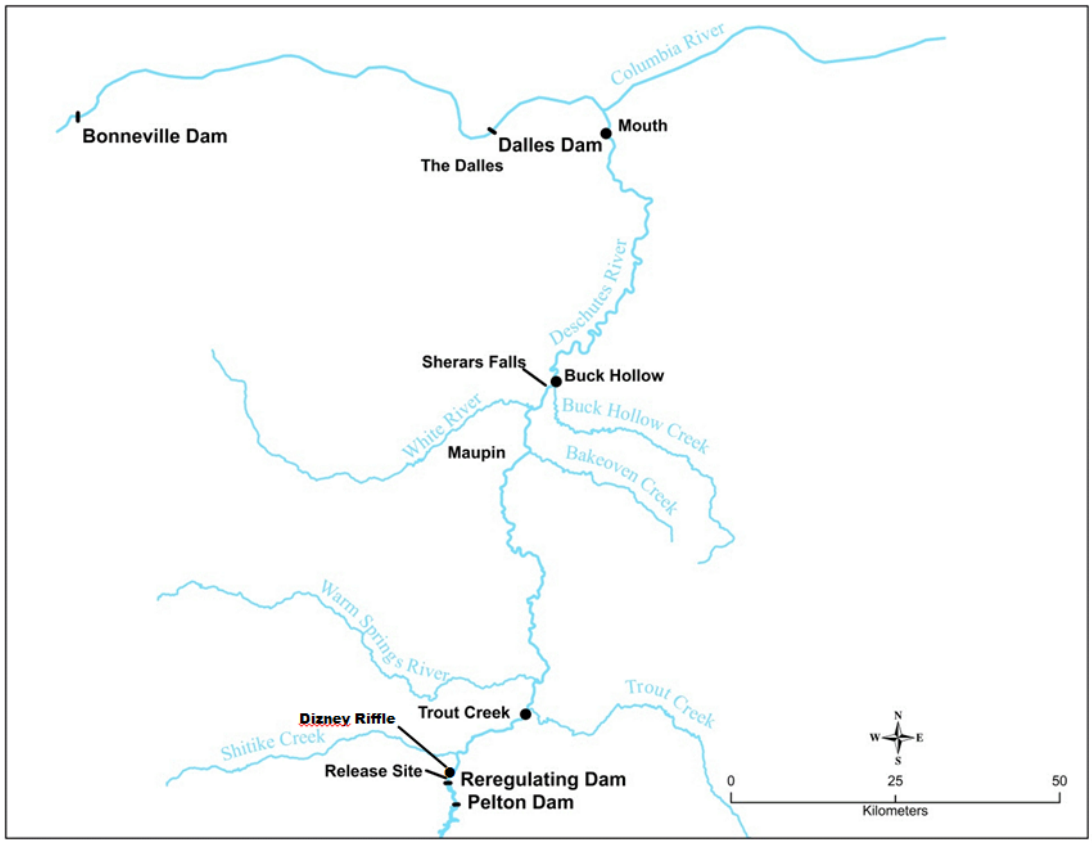

Figure 14. Map of study area and the four radio telemetry fixed stations on the Deschutes River. Two stations were operated at the Mouth site.

Results

PIT Tag 2016 Survival Estimates

Survival estimates as measured by PIT tag detections are shown in Table 6. Survival from the SWW to Bonneville Dam was lowest for sockeye. Chinook survival in 2016 was similar to 2015. Survival for sockeye and steelhead was significantly lower than the 2015 survival estimates (Hill and Quesada 2015).

Table 6. Survival from the SWW to Bonneville based on PIT tag recaptures in 2016

Species	Rearing Type	Survival Estimate	95% Confidence Interval
Sockeye	naturally-reared	5.70%	3.4%- 9.4%
Chinook	hatchery-reared	18.80%	16.3%- 21.6%
Steelhead	hatchery-reared	33.50%	21.4%-48.3%
Steelhead	naturally-reared	14.00%	10.1%19.0%

PIT Tag Detections of Radio-Tagged Smolts

All radio-tagged smolts also received a PIT tag allowing detection after release at various interrogation sites located in mainstem Columbia and lower Deschutes tributaries. No study fish were detected in any of the tributary PIT arrays or the mouth of the Deschutes River. Multiple PIT tag antennas are operated at Bonneville Dam to detect downstream migrating juvenile salmonids. A combined total of 16 sockeye and Chinook smolts were detected, 9 from the day-released group and 7 from the night-released group. A total of 12 steelhead; 9 day-released and 3 night-released smolts were detected at Bonneville Dam. Median travel times from release site to Bonneville Dam by species and treatment groups were not significantly different (Table 7, Mann-Whitney Rank Sum: sockeye U = 15.0, p = 0.09, Chinook U = 23.0, p = 0.397 and steelhead U = 13.0, p = 1.00). Radio-tagged sockeye, Chinook, and steelhead had similar travel times with a median range of 3 to 6 days. One sockeye was detected in the Columbia River by the estuary towed array (near rkm 70) eleven days after release. Three Chinook smolts were also detected in the towed array 6 to 9 days after release and 2 steelhead smolts were detected 6 and 21 days after release.

Table 7. Travel times by species from release to the Bonneville Dam.

			Travel Times (d)			
Species	Treatment	N	Mean	Median	Range	St Dev.
Sockeye	Day	9	3.82	3.0	3-6	1.43
	Night	7	7.17	6.0	3-12	4.05
Chinook	Day	9	5.39	4.0	3-13	3.15
	Night	7	6.33	4.5	4-16	4.47
Steelhead	Day	9	7.54	5.0	4-26	7.14
	Night	3	5.36	5.0	4-7	1.42

Radio Tag 2016 Survival Estimates

Fish Selection and Tagging

We attempted to tag a representative subsample of smolts captured at the SWW throughout the course of the spring migration. Fish were randomly selected from the day's daily SWW captures. As much as possible, tagging and release timing coincided with regular capture and trasport

operations at the SWW for each species. Tagging activities were conducted from mid-March to late May. Fish less than 130 mm (TL) were considered too small and were not radio-tagged. We maintained a 5% or smaller tag-to-body weight ratio and did not exceed a 2% tag burden on our study fish. As a result, there was a significant difference between the median lengths of PIT-tagged and radio-tagged sockeye and Chinook smolts captured at the SWW (Figure 15 and Figure 16; Mann-Whitney Rank Sum: sockeye U=34,196.0, p=0.001, Chinook U = 42,112.0, p = 0.001). However, there was no significant difference between the median lengths of radio-tagged and non-radio-tagged steelhead smolts captured at the SWW (Figure 17; Mann-Whitney Rank Sum: steelhead, U = 7924.0, p = 0.150).

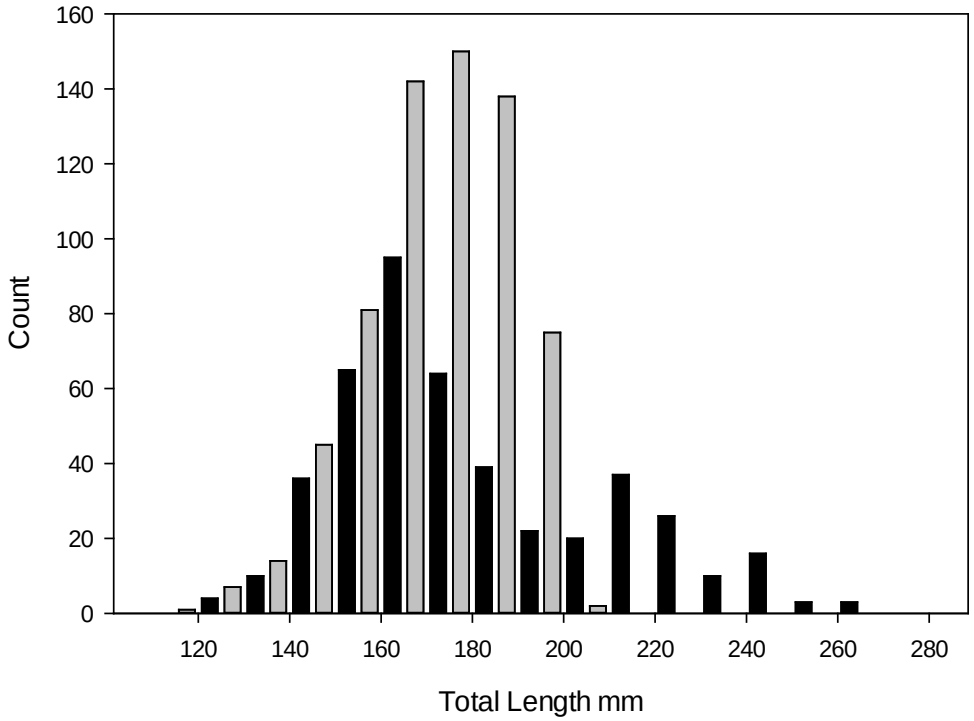

Figure 15. Size distribution of all naturally-reared PIT-tagged sockeye smolts (grey bars), and radio-tagged smolts (black bars) captured at the SWW March 3 - June 6, 2016.

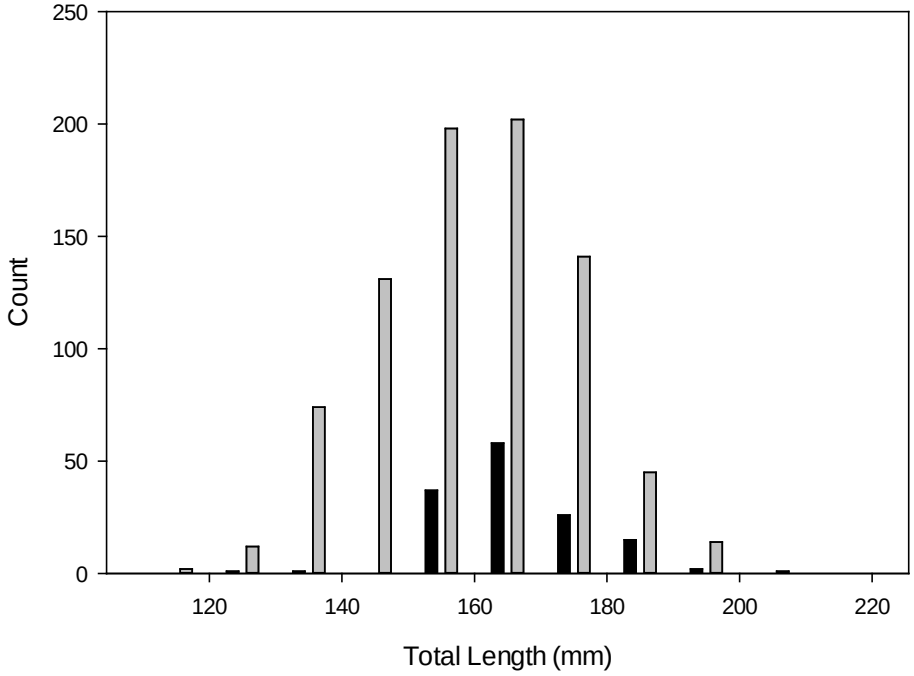

Figure 16. Size distribution of all PIT-tagged LM Chinook smolts (grey bars), and radio-tagged smolts (black bars) captured at the SWW February 4 – July 8, 2016.

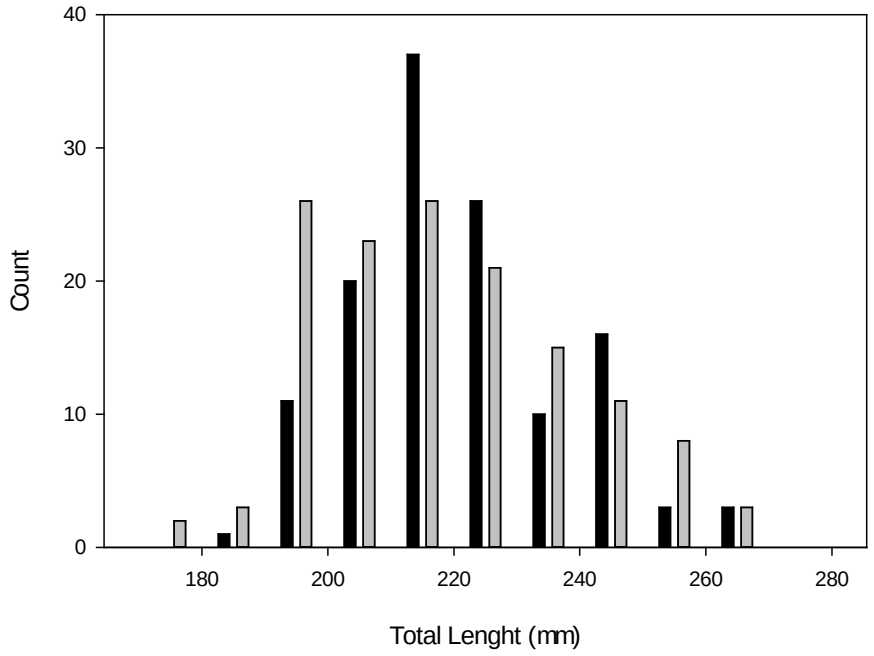

Figure 17. Size distribution of all PIT-tagged LM steelhead smolts (grey bars), and radio-tagged smolts (black bars) captured at the SWW May 1 - June 30, 2016.

Delayed Mortality and Tag Retention

Of the 426 smolts radio-tagged, four Chinook and three steelhead smolts were found dead or moribund in recovery buckets the day after surgery. All mortalities were taken to the on-site ODFW pathologist for examination. Tagging was ruled out as cause of death (no internal bleeding, organs looked healthy, good tag and suture placement). Pre-existing infection, BKD or *C. shasta* was the predominant cause of death in these fish. During tagging we gained experience identifying steelhead that were infected with *C. shasta,* and discontinued with tagging activities on those fish.

Two of the 47 smolts implanted with 'dummy' radio tags held at Round Butte Hatchery died 24 and 27 days after tagging (radio tags are guaranteed for 25 days). Both of those Chinook exhibited poor condition and copepod infections. One steelhead also exhibited poor condition and was found dead 35 days after tagging. Eleven of the 44 control fish or 25% were confirmed to be infected with BKD or *C. shasta*: 5 sockeye (BKD), 3 Chinook (BKD), and 3 steelhead (*C. shasta*). These control fish lived between 41 to 69 days past their respective tag insertion. Eighteen of the remaining 33 control fish exhibited normal behavior and died between 50 and 83 days post-surgery: 6 sockeye, 7 Chinook, and 5 steelhead. The last 14 control fish were euthanized 84 to 148 days post-surgery.

Radio Telemetry at Fixed Stations

Radio telemetry fixed stations were downloaded weekly and all four stations operated with minor interruptions. Detection efficiencies for each radio telemetry station were calculated using the Cormack Jolly-Seber (CJS) model in Program MARK. Overall, radio-tagged sockeye smolts had lower detection efficiencies than Chinook, ranging from 76.7% (95% CI: 67.6-83.9%) at Dizney Riffle to 100% (95% CI: 100-100%) at the mouth (Table 8). Similar to 2015, Chinook smolt detection efficiency was lowest at the Trout Creek station 82.7% (95% CI: 74.5-88.5%). Using Akaike's Information Criteria (AIC), Program MARK was not able to provide an estimate of detection rates by telemetry station for radio-tagged steelhead. The overall detection rate of

radio-tagged steelhead smolts was 89.0% (95% CI: 82.1-93.3%). Program MARK was not able to provide detection rates by treatment group for any of our study fish.

Table 8. Detection efficiencies of radio-tagged sockeye and Chinook smolts calculated for each radio telemetry station using CJS in Program MARK. Selected models explain 56.3% and 64.0% of the variation in the data respectively.

	2016 Detection Efficiencies by Telemetry stations (95% CI)			
Species	Dizney Riffle	Trout Creek	Buck Hollow	Mouth Rkm 5.0
Sockeye	82.3 % (74.1-88.3%)	76.7% (67.6-83.9%)	77.1% (67.6-84.4%)	100% (100-100%)
Chinook	93.3 % (87.2-96.6%)	82.67% (74.6-88.5%)	93.0% (86.7-96.5%)	99.1% (94.0-99.9%)

Survival through the Lower Deschutes River

Sockeye

We tested 12 models with various combinations of parameter estimates (survival and detection efficiency) for radio-tagged sockeye smolts. Models were ranked using AIC. The top two models explained 87.3% of the data with an estimated 56.3% of the variation explained by the top model (AIC value 766.4). Overall, the top ranked model was not the most parsimonious model, the model that best explains the variation in the data with the fewest parameters. The top model derived 8 parameters, four survival estimates, one for each telemetry station with no group effect. Overall cumulative survival to the mouth of the Deschutes was estimated at 64.4% (95% CI: 43.1-79.1%). Estimated survival rates between telemetry stations are shown in Table 9.

Table 9. Survival estimates for radio-tagged sockeye smolts calculated for each radio telemetry station using CJS in Program MARK

2016 Survival estimates of sockeye (95% CI)			
Dizney Riffle	Trout Creek	Buck Hollow	Mouth Rkm 5.0
83.2 % (75.8-88.6%)	93.6% (84.4-97.5%)	90.6% (81.1-95.5%)	91.4% (83.0-95.8%)

Chinook

We tested 12 models with various combinations of parameter estimates for radio-tagged Chinook smolts. Using AIC, Program MARK ranked all models and provided results with the top two models explaining 99.6% of the data with an estimated 64.0% of the variation explained by the

top model (AIC value 559.4). The top model was not the most parsimonious model but it did estimate 12 parameters which provided parameter estimates with a group effect for both survival and detection efficiencies. Survival of radio-tagged Chinook smolts to the mouth of the Deschutes was estimated at 59.5% (95% CI: 36.8-75.7%) for day-released smolts and 96.0% (95% CI: 79.3-99.2%) for night-released smolts (Table 10). Estimated survival rates by telemetry station and treatment group ranged from a low of 75.3% at the Trout Creek station to a high of 100% at the mouth of the Deschutes River in day-released smolts. In contrast, survival ranged from 97.6% to 100% for night-released smolts at the same stations (Table 11).

Steelhead

We tested 12 models with various combinations of parameter estimates for radio-tagged steelhead. Using AIC, Program MARK ranked all models and provided results with the top two models explaining 85.7% of the data with an estimated 52.8% of the variation explained by the top model (AIC value 518.3). The top model was not the most parsimonious model. The model estimated 10 parameters which provided survival estimates with a group effect by telemetry station and detection efficiency with no group effect. Estimated survival of radio-tagged steelhead smolts to the mouth of the Deschutes River was 49.8% (95% CI: 0.2-69.4%) for day-released smolts and 77.4% (95% CI: 43.1-91.1%) for night-released smolts (Table 10). Estimated survival rates by telemetry station and treatment group ranged from a low of 73.5% at the Trout Creek station to a high of 99.2% at the mouth of the Deschutes River for day-released smolts and a low and high of 88.7% to 98.9% at Buck Hollow and Dizney Riffle respectively for night-released smolts (Table 11).

Table 10. Overall survival estimates by species and treatment to the mouth of Deschutes River (rkm) in 2016. Estimates calculated using CJS in Program MARK.

2016 Overall Survival (95% CI) to Mouth Rkm 5		
Species	Treatment	Survival (95% CI)
Sockeye	None	64.4% (43.1-79.1%)
Chinook	Day	59.5% (36.8-75.7%)
	Night	96.0% (79.3-100%)
Steelhead	Day	49.8% (29.0-69.4%)
	Night	77.4% (43.1-91.1%)

Table 11. Survival estimates for radio-tagged Chinook and steelhead smolts by treatment group calculated for each radio telemetry station using CJS in Program MARK

		2016 Survival estimates by Telemetry Station (95% CI)			
Species	Treatment	Dizney Riffle	Trout Creek	Buck Hollow	Mouth Rkm 5.0
Chinook	Day	85.3%(74.4-92.1%)	73.5%(60.7-83.3%)	94.8%(81.5-98.7%)	100.0%(100-100%)
	Night	100.0%(100-100%)	97.6%(89.2-99.8%)	98.3%(89.0-99.8%)	100.0%(100-100%)
steelhead	Day	75.0%(62.2-84.5%)	73.5%(58.5-84.5%)	91.1%(74.9-97.2%)	99.2%(1.1-100%)
	Night	98.9%(83.1-100%)	91.8%(80.7-96.8%)	88.7%(76.8-94.9%)	96.2%(83.5-99.2%)

Survival to Bonneville Dam on the Columbia River

Sockeye

We tested 12 models with various combinations of parameter estimates (survival and detection efficiency) for radio-tagged sockeye smolts. Using AIC, Program MARK ranked all models. The top three models explained 96.9% of the data with an estimated 52.5% of the variation explained by the top model (AIC value 941.5). Overall, the top model was the most parsimonious model. The top model derived 7 parameters, with no group effect (one survival estimate for all radio-tagged sockeye combined) and six recapture probabilities (detection efficiencies) for each station. Estimated survival of radio-tagged sockeye smolts to Bonneville Dam was 88.9% (95% CI: 84.0-92.2%, Table 13.).

Chinook

We tested 12 models with various combinations of parameter estimates for radio-tagged steelhead. Using AIC, Program MARK ranked all models and provided results with the top two models explaining 97.4% of the data with an estimated 60.9% of the variation explained by the top model (AIC value 689.41). The top model was not the most parsimonious model, estimating 26 parameters which provided parameter estimates with a group effect for both survival and detection efficiencies. Estimated survival of radio-tagged Chinook smolts to Bonneville Dam was estimated at 13.4% (95% CI: 2.0-41.3%) for day-released smolts and 18.8% (95% CI: 4.5-45.8%) for night-released smolts (Table 13).

Steelhead

We tested 12 models with various combinations of parameter estimates for radio-tagged steelhead. Using AIC, Program MARK ranked all models and provided results with the top two models explaining 94.8% of the data with an estimated 54.8% of the variation explained by the top model (AIC value 614.5). The top model was not the most parsimonious model but it did estimate 16 parameters which provided survival estimates with a group effect by telemetry station and an overall detection efficiency. Estimated survival of radio-tagged steelhead smolts to Bonneville Dam was 8.2% (95% CI: 0-26.3%) for day-released smolts and 15.7% (95% CI: 2.3-32.3%) for night-released smolts (Table 13).

Table 12. Survival estimates by species and treatment to Bonneville Dam on the Columbia River, 2016. Estimates calculated using CJS in Program MARK.

2016 Overall Survival (95% CI) to Bonneville Dam		
Species	Treatment	Survival (95% CI)
sockeye	None	88.8% (84.0 – 92.2)
Chinook	Day	9.5% (0 - 24.0)
	Night	24.3% (3.4 - 67.7)
steelhead	Day	8.2% (0 – 26.3)
	Night	15.7% (2.3 – 32.3)

Factors Affecting Survival in the Lower Deschutes River

We attempted to control for extraneous factors that could affect survival in the lower Deschutes River by limiting the number of taggers (1 used during entire study), and monitoring fish size and copepod rates. Unlike in 2015, we did have significant difference in mean length of radio-tagged sockeye and Chinook compared to PIT-tagged smolts in 2016. However, there was no significant difference in mean length of radio-tagged steelhead compared to PIT-tagged smolts. Differences in survival and detection efficiencies were detected in groups with and without differences in length, indicating that length did not play a significant role in survival or detection efficiencies.

In 2016, parasite loads varied among species with Chinook having the greatest infection rates of 32% (night-released) and 36% (day-released). Sockeye had the second highest parasite loads with 13% of day-released and 5% of night-released fish being infected. Steelhead had the lowest rate with 7% of day-released fish and 8% of night-released fish being infected. Infection rates

were similar to those found in control fish. Survival of copepod-infested control Chinook held at Round Butte Hatchery were significantly different than non-infested Chinook (Student's $t = 4.1$, $df = 19$, $p = 0.0006$). However, the average number of days that infested Chinook lived at Round Butte Hatchery was 52.3 days (Std = 17.1). Average travel time for radio-tagged Chinook to the mouth of the Deschutes was 3.35 days for day-released and 3.58 days for night-released. Average travel time for radio-tagged Chinook to the Bonneville Dam was 5.39 days for day-released and 6.33 days for night-released. Given the number of days that infested control Chinook survived and the number of days that study Chinook took to reach Bonneville Dam, we do not believe copepod infection was a major factor in survival estimates or detection efficiencies.

Travel Times in the Lower Deschutes River

Travel times (days) were converted to travel rates (km/d) to standardize travel between telemetry stations due to the difference in distances: Release site to Dizney Riffle is 1.09 rkm, Dizney to Trout Creek is 18.4 rkm, Trout Creek to Buck Hollow is 73.6 rkm, and Buck Hollow to Deschutes mouth is 63.9 rkm. Travel rates (km/d) for radio-tagged smolts were calculated between radio telemetry stations (Table 13). Median travel times for each leg of the downstream migration from the release site to the mouth of the Deschutes River (rkm5) varied by species and treatment group. Overall, median travel rates for day-released smolts were similar compared to night-released smolts for all three species, but there were distinct travel rate patterns between stations. Travel rates between segments and treatment groups were highly variable.

Table 13. Travel times by species from release to the mouth of the Deschutes (rkm 5).

	Travel Times (d)				
Species	Mean	Median	Range	St Dev.	km/day
Chinook	3.3	2.7	1.6-11.6	1.7	58.5
Sockeye	4.8	2.5	1.0-34.0	6.7	63.5
Steelhead	6.9	4.0	1.9-27.0	6.1	38.5

Sockeye

Radio-tagged sockeye moved through the first leg from the release site to Dizney Riffle slowly compared to the other three legs with night-released smolts moving twice as fast (day: 11.9 km/d, night: 25.0 km/d) (Table 14). On the second leg, Dizney to Trout creek (18.4 km), both groups of radio-tagged smolts picked up speed and traveled faster with night-released smolts sustaining almost twice the rate of day-released smolts (day: 105.8 km/day, night: 182.7 km/d). On the third leg, Trout Creek to Buck Hollow (73.6 rkm), travel rates flipped: day-released fish traveled at 117.0 km/d, night-released smolts traveled at 93.3 km/d. On the fourth leg, Buck Hollow to the Deschutes mouth (63.9 rkm), smolts reached their fastest combined rates at 153.1 km/d for day-released and 160.1 km/d for night-released smolts.

Table 14. Travel rates (km/d) of radio- tagged sockeye smolts between radio telemetry stations by treatments in 2016.

Travel Rates (km/d) by Detection Site and Treatment					
	Treatment	Release to Dizney	Dizney to Trout Ck.	Trout Ck. to Buck Hollow	Buck Hollow to Mouth (rkm5)
Avg.	Day	11.9	105.8	117.0	153.1
	Night	25.0	182.7	93.3	160.1
Median	Day	13.4	70.0	86.8	162.4
	Night	20.8	216.9	84.1	177.6
Range	Day	0.15-26.2	5.1-326.6	39.4-182.5	64.3-204.0
	Night	0.18-174.4	26.3-278.6	10.3-178.5	61.8-201.4
St. Dev	Day	8.03	77.6	45.2	40.1
	Night	33.4	79.8	34.03	38.2

Chinook

Travel patterns for radio-tagged Chinook were similar compared to sockeye relative to day- versus night-released smolts. Chinook smolts moved through leg one, Release site to Dizney faster than sockeye, at 24.8 and 78.5 km/d day- and night-released respectively. In the second leg, Dizney to Trout creek, travel rates tripled and doubled with day-released smolts reaching 73.9 km/d and night-released smolts reaching 146.3 km/d. Again, similar to sockeye, night-released smolts slowed down and matched the rates of day-released smolts 51.6 km/d and 61.4

km/d respectively. In the fourth leg, day-released smolts increase their rates to 82.1 km/d compared to 75.0 km/d for night-released smolts (Table 15).

Table 15. Travel rates (km/d) of radio- tagged Chinook smolts between radio telemetry stations by treatments in 2016.

Travel Rates (km/d) by Detection Site and Treatment					
	Treatment	Release to Dizney	Dizney to Trout Ck.	Trout Ck. to Buck Hollow	Buck Hollow to Mouth (rkm5)
Avg.	Day	24.8	73.9	61.4	82.1
	Night	78.5	146.3	51.6	75.0
Median	Day	13.4	42.1	64.5	73.1
	Night	20.8	146.23	62.5	67.7
Range	Day	0.09-82.6	2.3-257.0	25.0-97.5	4.0-168.0
	Night	6.4-392.4	6.3-297.4	7.4-129.6	13.0-178.0
St. Dev	Day	20.7	62.0	15,7	33.4
	Night	72.3	52.2	23.4	31.2

Steelhead

Travel patterns for steelhead followed a similar pattern compared to both sockeye and Chinook smolts. The first leg was the slowest with day-released smolts averaging 8.9 km/d and night-released smolts averaging 70.4 km/d. From there steelhead smolts also increased their travel rates from Dizney to Trout Creek, with 89.6 km/d and 133.6 km/d day and night respectively. In the third leg, Trout Creek to Buck Hollow, steelhead smolts also slowed down and flipped rates with night-released smolts averaging 38.0 km/d and day-released smolts averaging 50.1 km/d. In the last leg, Buck Hollow to the Deschutes mouth, day-released smolts increased their travel rate up to 93.4 km/d and night-released smolts also sped up 89.5 km/d (Table 16).

Table 16. Travel rates (km/d) of radio- tagged steelhead smolts between radio telemetry stations by treatments in 2016.

Travel Rates (km/d) by Detection Site and Treatment					
	Treatment	Release to Dizney	Dizney to Trout Ck.	Trout Ck to Buck Hollow	Buck Hollow to Mouth (rkm5)
Avg.	Day	24.8	89.6	50.1	93.4
	Night	78.5	133.6	38.0	89.5
Median	Day	2.5	133.7	42.8	87.2
	Night	68.2	147.0	35.1	82.2
Range	Day	0.07-78.5	1.36-177.6	4.39-148.7	10.8-177.3
	Night	0.13-196.2	3.98-205.2	3.1-116.5	14.2-162.0
St. Dev	Day	15.1	66.7	32.1	38.4
	Night	51.7	42.1	26.3	34.3

Discussion

PIT Tags

The 2016 estimates for survival to Bonneville were lower than previous years. This could be due to real differences in survival or the efficiency estimate developed for Warm Springs Chinook may not be a good surrogate for SWW-released fish. Applying an efficiency estimate developed for Chinook to sockeye and steelhead is especially problematic. The efficiency estimate developed for 2016, was 42%, this is significantly higher than previous years' estimates. If this efficiency estimate was too high, this would bias survival estimates low. When Bonneville releases species specific efficiency estimates for 2016, these survival estimates can be re-calculated.

Radio Tags

In 2016, we radio-tagged 150 (75 per release treatment) sockeye, and Chinook and 125 (63 day- and 62 night-released) steelhead smolts to estimate migration survival and timing through the lower Deschutes River and subsequently to Bonneville Dam. The study was initiated to collect additional information on smolt migration patterns and survival of SWW-collected smolts that

are released below the Pelton-Round Butte Project. Smolt to adult return rates (SAR) for all three introduction species have been low. SAR for smolts captured at the SWW have been consistently lower than for Round Butte Hatchery smolts released into the Deschutes River at approximately the same location below the Re-regulation Dam.

Similar to 2015, detection rates were lowest at Trout Creek station, 76.7%, for radio-tagged sockeye. However, Buck Hollow station was also low at 77.1% compared to Dizney Riffle (82.3%) and the mouth of the Deschutes (100%) stations. There are several possible reasons for the low estimated detection rates at Trout Creek station: 1) delayed mortality due to handling/transport, 2) delayed mortality due to surgical implantation, 3) delayed mortality due to copepod infestation, and 4) predation by avian and aquatic species.

To minimize the impact of handling and surgery, crews attended a hands-on course to refine the procedures and protocols recommended by Liedke et al. (2012). We used only one tagger in the study that showed proficiency in surgically implanting telemetry transmitters following the course. Additionally, we also tagged and held an additional 47 control smolts (13 sockeye, 21 Chinook and 13 steelhead) for the duration of the study. Control fish we exposed to the same surgical procedures and similar handling activities as study fish released with daily SWW catches. Survival of control fish was relatively high immediately following surgery, 100% survival 72 hours immediately following implantation, and 98.0% survival 24 days after tag implantation (tags have a guaranteed life span of 25 days). We tagged smolts that exhibited similar infestation rates of parasitic copepods and only 2 Chinook smolts died 24 and 27 days following the implantation. Therefore, we do not believe that post release mortalities were due to surgical implantation, handling, or copepod infestation.

The placement of a telemetry station close to the release site allowed us to geographically isolate the area of release where previously our understanding was limited to the lower 21 km below the release site. Survival and detection rates by telemetry stations indicate that smolts released below the Re-regulation dam experience rapid losses. For example, sockeye survival estimates for all released smolts combined were lowest at Dizney Riffle, a distance of 1.09 rkm.

Avian and fish predation may provide some explanation for loses directly below the release site. There are 4 active osprey nests near the release site and an additional 11 nests between Dizney Riffle and Trout Creek. PGE fish crews have observed osprey congregating near the release location. Cormorants are another source avian predation. We did not formally survey the average number of cormorants that congregate near the Re-regulation Dam. Informally we observe at least a dozen cormorants near the release location on a daily basis. We suspect the area below the Re-regulation Dam provides a consistent source of prey otherwise the numbers of cormorants would not be so consistent. Additionally, there are a number of large redband and bull trout in the Re-regulation tailrace, though their numbers are unknown, catch data from the Pelton Trap indicate a constant presence during most months. Crews have also observed large fish actively pursuing smolts after they were released into the Deschutes River. Predation may be a likely source of mortality for released smolts below the Re-regulation Dam.

Overall, survival estimates were generally lower for radio-tagged sockeye compared to Chinook and steelhead. Survival estimates through the Deschutes River for sockeye were 64.4% (43.1-79.1) similar to 2015 (67%). We did not detect a treatment effect for radio-tagged sockeye. It's likely that detection rates played a role in not finding a treatment effect in radio-tagged sockeye. However, Chinook and steelhead smolts have different survival estimates by treatment groups. Both Chinook and steelhead provided evidence to suggest that night-released smolts have a significant survival advantage that was present at the mouth of the Deschutes and persisted to Bonneville Dam. In 2015, Chinook survival estimates were 51%, similar to the day-released smolts in 2016, 59.5% (36.8-75.7). Night-released Chinook smolts survival estimate was 96.0% (79.3-100%). In 2015, steelhead survival estimates were 55%, similar to 2016 day-released smolts of 49.8% (29-69.4%). Night-released steelhead smolt survival estimate was 77.4% (43.1-91.1%). These results provide evidence to suggest that predation may be playing a role in mortality below the Re-regulation Dam. Both osprey and cormorants are most active during daylight hours. The higher survival rates for night-released Chinook and steelhead provide evidence that the lack of visual cues may play a role in decreased mortality, particularly where predators are known to congregate.

Acknowledgments

Thanks to the PGE technicians who were responsible for the daily operation of the screw traps, SWW, radio tag implantation and downloading radio telemetry stations: Micah Bennett, Renny Schmidt, Juan Leach Orozco, Kat Smith, Elayne Barclay, Cheryl Miller, Todd Vanek, Jaym'e Shricker, and Leah Hough. Thanks to the PGE mechanical crew for installation and maintenance of the screw traps and to the landowners who allowed us to operate traps on their property. Thank you to the crew who operated the SWW: Rich Madden, Renny Schmidt, and to Brad Wymore for GIS and radio telemetry station support.

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Attachment A

Consultation with the Fish Committee

Ordering Paragraph B of FERC's September 2, 2008, *Order Modifying and Approving Test and Verification Study Plan, Departments of the Interior and Commerce Section 18 Fishway Prescription Condition 13 (b) (v)* requires the filing of an Annual Juvenile Migration Test and Verification Study Report annual by July 1.st. The report is to be filed pursuant to Article 402 of the license following consultation with the Fish Committee and Fish Agencies.

The Licensees initiated consultation on May 16, 2017 with the following message:

From: Jessica Graeber
Sent: Tuesday, May 16, 2017 9:12 AM
To: 'Robert.Dach@BIA.gov'; 'Jeisner@blm.gov'; 'brad.houslet@ctwsbnr.org'; 'scott.carlon@noaa.gov'; 'LAMB.Bonnie@deq.state.or.us'; 'mriehle@fs.fed.us'; 'Peter_Lickwar@fws.gov'; 'CFerrari@tu.org'; 'terry.m.shrader@state.or.us'; 'J_Manion@wspower.com'
Cc: 'jennifer.graham@ctwsbnr.org'; 'robert.brunoe@ctwsbnr.org'; 'ted.g.wise@state.or.us'; 'DStaab@tu.org'; 'jonathan.treasure@ctwsbnr.org'; 'brett.l.hodgson@state.or.us'; 'rod.a.french@state.or.us'; 'stacy.a.strickland@state.or.us'; 'dmoryc@americanrivers.org'; 'conrad@nativefishsociety.org'; 'mark@nativefishsociety.org'; 'brian@waterwatch.org'; 'rhsims@hra-nw.com'; 'bmbakke@gmail.com'; 'mtmetz@outlook.com'; 'peter@nativefishsociety.org'; Tom Nilan; Megan Hill; Robert Spateholts; Rebekah Burchell; James Bartlett; Rich Madden; Cory Quesada; Lori Campbell; Erica Amt; Gonzalo Mendez; Katherine Smith; Arya Behbehani; Chad Croft; John Esler
Subject: PRB: T&V study Juvenile Migration for FC 30-day review

Greetings FC,
Uploaded to the SharePoint site you will find the Draft 2016 T&V Juvenile Migration Report for review and comment. The report is located in the folder labeled 2016 Draft fish passage report and appendices. Please provide comments to me by June 16 and contact me for any questions.

https://sp.portlandgeneral.com/ECL/SitePages/Home.aspx

Thanks,

Jessy Graeber
Portland General Electric Co., Environmental Compliance & Licensing Services
121 SW Salmon St, 3WTCBR05 | Portland, Oregon 97204 | 360-481-4672

On June 16, 2017 ODFW provided comments via the following email.

From: Stacy A Strickland <stacy.a.strickland@state.or.us>
Sent: Friday, June 16, 2017 1:45 PM
To: Jessica Graeber
Subject: RE: T&V study Juvenile Migration for FC 30-day review
Attachments: DRAFT 2016 Juvenile Migration_TV study FC 30 day review_SAS.docx

Hi Jessy,

My comments and edits are attached.
Thanks,
Stacy

All comments were incorporated into the report by the author.

No other comments were received from the Fish Committee.

Document Content(s)