The Dalles Watershed Fish Monitoring Report

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Oregon Department of Fish and Wildlife

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The Dalles, OR

In partnership with Wasco County Soil and Water Conservation District

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ABSTRACT

We assessed outmigrant juvenile abundance and life-history characteristics of summer steelhead, Coho salmon, and Coastal Cutthroat trout in Mill Creek, a tributary to the Columbia River within The Dalles Watershed. Fish were sampled using a rotary screw trap and tagged with a passive integrated transponder (PIT) tag from 2013 to 2024. Population monitoring efforts were initiated on Threemile Creek and Chenoweth Creek in 2021 and 2022, but low sample size prevented baseline estimates and sampling was discontinued. In Mill Creek, annual smolt outmigrant estimates were variable across years. Smolt to adult return rates (SAR) were generally below 2% for steelhead and Coho, but Coho SAR rates demonstrated some improvement to 3% for the 2023 outmigrant cohort. SAR rates were not estimated for Coastal Cutthroat due to insufficient adult returns. PIT tag detection histories for Mill Creek-origin steelhead and Coho demonstrate that overshoot beyond the mouth of Mill Creek is reducing annual spawner abundance. This monitoring provides a baseline for managers to gauge population status and inform potential restoration opportunities in the watershed.

INTRODUCTION

Mill Creek, a tributary to the Columbia River near The Dalles, Oregon, supports a variety of native migratory fish species including summer steelhead *Oncorhynchus mykiss*, Coho salmon *Oncorhynchus kisutch*, Coastal Cutthroat trout *Oncorhynchus clarki,* Pacific lamprey *Entosphenus tridentatu*, and a limited return of fall Chinook salmon *Oncorhynchus tschawytscha*. Steelhead are listed under the Federal Endangered Species Act (ESA) as threatened while Coho salmon, Coastal Cutthroat trout, Pacific lamprey, and fall Chinook salmon are listed by the state of Oregon as sensitive (ODFW 2021; NMFS 2009). Mill Creek steelhead are included in the Middle Columbia Steelhead Distinct Population Segment and grouped into the Fifteenmile Steelhead Major Population Group (MPG) (Poxon et al. 2014).

Monitoring and research of Mill Creek steelhead was initiated from 2012 to 2019 and continued from 2021 to 2024 with a grant from the Oregon Watershed Enhancement Board (OWEB) in cooperation with the Wasco County Soil and Water Conservation District (Wasco SWCD). Prior to this monitoring, information on abundance and life history of these species in Mill Creek, Chenoweth Creek, and Threemile Creek was limited. For this grant, primary metrics that were proposed for evaluation were (1) establish a four-year baseline for juvenile outmigrant abundance for steelhead, Coho, and Coastal Cutthroat, (2) evaluate duration and peak of juvenile outmigration from streams and migration timing to Bonneville Dam, (3) describe run timing of adult returns to Bonneville Dam and to natal streams, and (4) establish a four-year baseline of SAR's by species for each stream.

This report uses several terms that require definition to clarify their connection to fish and their behavior. *Return year* refers to the calendar year when fish migrate from the ocean back into freshwater, while *spawn year* denotes the calendar year in which fish spawn. For summer steelhead, the return year precedes the spawn year because these fish overwinter in the Columbia River or its tributaries before spawning. We also define *overshoot* as a behavior in salmon and steelhead in which adults migrate upstream beyond the confluence of their natal stream, and *fallback* as the subsequent behavior of some overshoot fish that later migrate downstream to their natal stream (Murdoch et al., 2022). These behaviors were identified through detections at *Passive Integrated Transponder (PIT) tag interrogation sites,* which are permanent or temporary monitoring stations that record the movements of juvenile and adult fish previously implanted with a PIT tag.

STUDY AREA

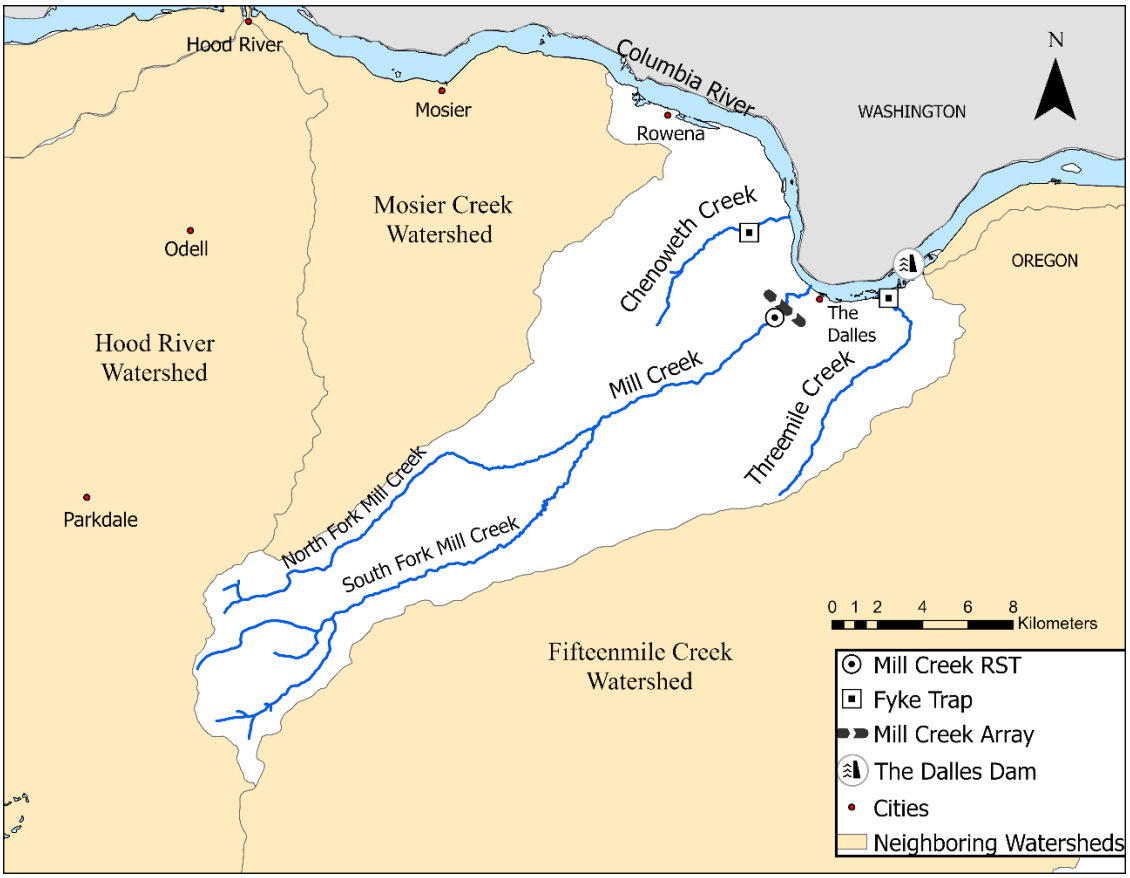

Figure 1: The Dalles Watershed Study Area

Anadromous fish that occupy streams in the area commonly referred to The Dalles Watershed, must travel upstream in the Columbia River about 305 river kilometers (rkm) before reaching their natal area (Figure 1). These fish must pass through fish ladders at Bonneville Dam on the Columbia River, located at rkm 235. Just upstream of The Dalles Watershed is The Dalles Dam on the Columbia River, at rkm 307.

Mill Creek

Mill Creek is a 40,550-acre watershed located on the east slope of Mount Hood, flowing through Hood River and Wasco Counties before entering the Columbia River at The Dalles, Oregon. Elevations range from 1,497 meters at Mill Creek Butte to 29 meters at the mouth. The creek is a critical municipal water source for the City of The Dalles. The South Fork of Mill Creek is supplemented by the City of The Dalles by diverted flows from Dog River, a tributary of the East Fork Hood River. Hydrologically, Mill Creek experiences high spring flows from snowmelt and low summer flows. It traverses diverse riparian zones, including forested, agricultural, and urban landscapes. Mill Creek's confluence with the Columbia River is unique, flowing underground through a 300-meter concrete box culvert into the Columbia River; the creek joins the Columbia River less than 1 rkm downstream of The Dalles Dam. Mill Creek has an assemblage of anadromous fish species, including summer steelhead, Coho salmon, fall Chinook Salmon, Coastal Cutthroat trout, and pacific lamprey. The rotary screw trap (RST), which was the primary sampling site for this study, was located at rkm 2.

Chenoweth Creek

Chenoweth Creek is a small stream that originates in the hills near the unincorporated community of Chenoweth in Wasco County and flows through the northwestern portion of The Dalles. Main tributaries include Badger and Brown Creeks. The creek experiences high spring flows from snowmelt and surface runoff, followed by low summer flows with intermittent dry reaches. The creek enters the Columbia River just southeast of Crates Point. Fish species assemblage in Chenoweth Creek is summer steelhead, Coho Salmon, and Coastal Cutthroat trout. The juvenile sampling site was located at rkm 1.9.

Threemile Creek

Threemile Creek flows northeast from headwaters southwest of The Dalles and enters the Columbia River east of The Dalles, upstream of Mill Creek and Chenoweth Creek. The creek spans 26 kilometers and drops approximately 400 meters in elevation from source to mouth. It maintains perennial flow, while its main tributary, Dry Creek, is intermittent. Seasonal flow variability includes higher springtime discharge and low summer flows. Fish species assemblage in Threemile is summer steelhead and Coastal Cutthroat trout. The juvenile sampling site was located at rkm 0.8.

METHODS

Fish Trapping

Mill Creek Screw Trap

A 1.5 meter rotary screw trap was installed on Mill Creek across project years. The trap was installed at rkm 2.7 during March and fished through early June, or when flows subsided (Table 1). The trap was checked seven days per week when ambient air temperatures were lowest. To prolong trap operations in low flows, the rotary screw trap was retrofitted with a small motor to spin the cleaning drum. This retrofit was necessary to ensure efficient debris removal from the trap box when a non-motorized cone-wheel-gear box cleaning drum systems would not work.

Fyke Trap

Modified fyke traps were installed on Chenoweth Creek and Threemile Creek. Insufficient flow and water depth did not allow for a rotary screw trap to be installed in these locations. Fyke traps were installed and operational from March – June and were checked seven days per week (Table 2). Fyke traps were fitted with an aluminum fyke on the upstream side with a 12" pipe connecting the fyke and a large livestock feeding trough. Fish would enter through the fyke, travel downstream through the pipe, and then hold in the trough, which served as a live well. The troughs were retrofitted with small, motorized cleaning drums to manage debris and powered by 12V batteries on site.

Biological Sampling

Juvenile salmon, steelhead, and trout were netted from trap live boxes, held in aerated buckets or coolers prior to sampling, and anesthetized with tricaine methanesulfonate (MS-222). Each fish species was identified, measured to fork length (mm), and weighed (g). Scale samples were collected for age analysis, while fin clips were taken for future genetic analysis from juvenile steelhead and Coastal Cutthroat Trout. Scale samples were placed directly onto labeled gum cards while genetic samples were placed in labeled scale envelope or on labeled Whatman blotting paper.

Juvenile salmonid migrants were marked with either a passive integrated transponder tag (PIT tag) or an upper caudal fin clip. Full duplex 12.5 millimeter (mm) PIT tags were inserted in the peritoneal cavity of fish greater than 80 mm fork length. Captured smolts and emigrant juvenile Coastal Cutthroat trout were marked with a PIT tag. Steelhead and Coho migrants and juvenile Coastal Cutthroat trout under 80 mm fork length were marked with upper caudal fin tip clips. Biological measurements, PIT tag numbers, genetic sample numbers, and scale sample numbers were entered into P4 software, stored in P4 tag files, and uploaded to the Columbia Basin PIT Tag Information System

PIT Antenna

A PIT tag array was deployed at Mill Creek approximately 100 meters below the rotary screw trap site in 2015.Within the Columbia Basin PIT tag Information System (PTAGIS), the Mill Creek array was queried as MTD (Mill Creek, The Dalles).

Trap Efficiency

Trap efficiencies trials were completed continuously during operation of the Mill Creek rotary screw trap across project years. All marked (PIT tag or caudal clip) fish were released 0.2 rkm upstream of the trap site at the 25th Street bridge in The Dalles. Fish that were subsequently recaptured were released downstream of the trap site.

Some fish that were marked at the fyke traps during project years 2021 and 2022 were released approximately 100 yards upstream from the fyke trap location.

Models

Outmigrant Estimates

We used the following Chapman's modification of the Lincoln Peterson Mark Recapture Estimate to find smolt abundance (Guy and Brown 2007). This estimator, and associated variance equation, estimates outmigrant abundance for a single time stratum (one trapping season):

$$\widehat{N} = \frac{(M+1)(C+1)}{(R+1)} - 1$$

Where:

N= Population Estimate

M= number marked and released upstream

C= number of fish captured both marked and unmarked

R= number of recaptures

Variance was determined by:

$$\widehat{Var}(\widehat{N}) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}$$

Rotary Screw Trap Efficiency

Trap efficiency for the Mill Creek rotary screw trap was estimated using the Chapman 1951 form of the Lincoln-Peterson method (Guy and Brown, 2007). Trap efficiency was calculated weekly to account for seasonal variation in efficiency:

$$TE_i = \frac{(R+1)R_i}{(M+1)M_i}$$

Where:

TE = Estimate trap efficiency
M = The number of marked fish released upstream
R = The number of marked fish recaptured

Mill Creek Array Detection Efficiency

The detection efficiency was calculated for the Mill Creek array using adult PIT tag returns in years following installation in 2015 with methods described in Connolly et al. (2008) where:

S_1 = fish detected on antenna 1 only

S_{12} = fish detected on antenna 1 and 2

S_2 = fish detected on antenna 2 only

To calculate the probability of detection we found the following four values for each antenna, the following was for antenna 1:

N_1 = All fish detected on antenna 1 (S_1+S_{12})

N_{12} = Fish detected on antenna 1 and antenna 2

N_2 = Fish detected on antennas 2 only

M_1 = Fish estimated to missed by antenna 1 ((N_1xN_2)/N_{12})

Detection efficiency (P_1) was then calculated as:

$$P_1 = \frac{N_1}{N_1+M_1}$$

After this formula was adapted to the other antenna, overall detection efficiency was calculated as:

$$P = 1-[(1-P_1)(1-P_2)]$$

Smolt to Adult Return Rates

Smolt to adult (SAR) returns were calculated by:

To Bonneville:

$$SAR = \frac{n\_to\_BON_i}{n_i}$$

Where:

$n\_to\_BON_i$ is the number fish PIT-tagged as smolts in cohort year i returning to Bonneville as adults

n_i is the number of PIT-tagged smolts released in cohort year i

To Mill Creek:

$$SAR = \frac{n\_to\_MILL_i}{n_i}$$

Where:

$n\_to\_MILL_i$ is the number fish PIT-tagged as smolts in cohort year i returning to the Mill Creek array as adults

n_i is the number of PIT-tagged smolts released in cohort year i

95 percent confidence intervals were generated through bootstrapping, using 1000 iterations of measured annually detection efficiency for a given interrogation site (Faber 2025).

Age Determination

Age determinations were made by estimating annual growth from annuli on scales. Scale preparation was conducted by the standard operating procedures of the ODFW Fish Life History Analysis Project (FLHAP) in Corvallis (Clemens et al. 2014). Fish ages were determined by protocols established by the FLHAP (Borgerson et al. 2014). Scale samples were read by two individuals, independent of each other. The biological data (i.e., length, weight, etc.) associated with each fish was not initially provided to the scale readers. However, background information along with the species, date, and location were given to scale readers to provide an idea of the life history considerations. Some scale samples were not aged because scales were regenerated or mounted upside down.

Data Storage

Tagging data were uploaded to the regional PTAGIS database. The PTAGIS mark sites fish were tagged at: MILL3C (Mill Creek), 3MIL2C (Threemile Creek), CHENC (Chenoweth Creek). Interrogation data from the Mill Creek site was MTD (Mill Creek, The Dalles). Genetic clips collected from steelhead smolts were stored in the genetic library at the ODFW District office in The Dalles, 3561 Klindt Drive. Raw age analysis results were stored on the ODFW District office shared drive.

RESULTS

Juvenile Outmigrants

Sample sizes for juvenile fish captured at Chenoweth Creek and Threemile Creek during the first two years of the project were low (Table 3). Due to low sample sizes, baseline productivity estimates for Chenoweth and Threemile Creeks could not be reliably calculated. We proposed to conclude Mill Creek trapping in 2021, but sampling was extended to complete intended analysis. Pacific lamprey was not a target species for this study but sample sizes were recorded (Table 3).

Steelhead outmigrant estimates for Mill Creek across years ranged from 3,178 – 9,228 smolts annually (Table 4). Cohorts were summarized by migration year generally comprising age 1, age 2, and age 3 smolts.

Coho outmigrant estimates for Mill Creek demonstrated substantial annual variability where estimates ranged from 245 – 16,178 Coho smolts (Table 5). Coho outmigrants are summarized by both brood year and migration year, since Coho have a consistent age structure for juvenile outmigration (Groot and Margolis 1991).

Low sample size limited the ability to estimate Coastal Cutthroat trout outmigrants. For 6 out of 12 monitoring years, estimates were not possible (Table 6). Coastal Cutthroat outmigrant estimates were below 1,000 outmigrants for all study years.

Overall, annual variability was observed in both steelhead and Coho outmigrants (Figure 2). The range of variability was higher for Coho, while steelhead was more stable.

Age Structure

Freshwater age composition for juvenile steelhead in Mill Creek for outmigrant years were summarized in Table 7. An average of 61% of Mill Creek steelhead were age-2 smolts and an average of 31% were age-1. Age-3 smolts were less common, comprising an average of 8% of outmigrant classes. Juvenile Coho scales were not analyzed, as age-1 smolt is the dominant strategy. Coastal Cutthroat Trout sample size was not sufficient to complete age analysis.

Smolt Travel Time

Median arrival time at the Mill Creek screw trap site ranged from May 3 – May 16 for steelhead, followed by Coho (May 10 – May 17) and Coastal Cutthroat Trout (May 15- May 25)(Figures 3 and 4). Arrival timing at Bonneville Dam interrogation facilities followed a similar pattern, with steelhead arriving first (median dates: May 7 – May 10), followed by Coho (May 12 to May 25), and Coastal Cutthroat Trout (May 18 to May 28). Coastal Cutthroat Trout detections at Bonneville interrogation facilities included 8 individuals detected. Migration time from Mill Creek to Bonneville Dam averaged 5.6 days for steelhead, Coho 10.0 days, and Coastal Cutthroat Trout 5.7 days (Table 8).

Adult Steelhead and Coho Returns

Annual steelhead SAR rates to Mill Creek ranged from 0.28% to 2.0%. with an 8-year pooled average of 0.59%. SARs to Bonneville Dam ranged from 0.3% to 3.10%, with an 9-year pooled average of 1.38% (Tables 9 and 10).

SAR rates of Mill Creek Coho to Bonneville ranged from 0.89% to 6.22% and 0.62% to 3.31% to Mill Creek (Table 11 and 12). The 9-year pooled SAR for Coho returns to Bonneville was 2.36% and the available 4-year pooled SAR for Coho returns to Mill Creek was 1.02% (Tables 11 and 12). The 2023 cohort SAR rate for coho was 3.31% for returns to Mill Creek, which is the highest SAR rate across monitoring years.

Mill Creek steelhead adult run timing to Bonneville Dam was between July and August 15 (Figure 5). Overshoot steelhead occurred at The Dalles Dam by September 15, and were not detected at the Mill Creek array until March 15. In contrast, Mill Creek Coho typically arrived at Bonneville Dam by September 15, reach The Dalles Dam by October 15, and were detected at the Mill Creek array by November 15, demonstrating a much shorter period of freshwater occupancy prior to spawning (Figure 6).

Marine Residence Time

Most Mill Creek-origin steelhead spent two years in the ocean (53%), while 46% spent one year. During Mill Creek monitoring years 2013–2015, two fish were observed to have spent three years in the ocean (Table 13).

Coho marine residence time was uniform, with all tagged fish spending one year in the ocean (Table 14).

Adult Steelhead and Coho Overshoot

Pooled adult returns indicate 12% of steelhead returned directly to Mill Creek after passing Bonneville Dam, 37% exhibited overshoot above The Dalles Dam but subsequently fell back and returned to Mill Creek, 18% were lost between Bonneville and The Dalles Dam (no subsequent detections), and 33% were lost upstream of The Dalles Dam (Table 15).

Pooled adult Coho returns indicated 35% of fish returned directly to Mill Creek after passing Bonneville Dam, 21% overshot The Dalles Dam but fell back and returned to Mill Creek, 35% were lost between Bonneville and The Dalles Dams, and 10% overshot above The Dalles Dam and were lost upstream (Table 16).

Resident *O. mykiss*

Some juvenile steelhead PIT-tagged at Mill Creek across project years did not exhibit migratory behavior following tagging. These fish were assumed to be resident rainbow trout rather than summer steelhead, based on single or repeated detections at the Mill Creek array (MTD) location across calendar years (Table 17).

Adult Out of Basin Stray Returns

Out-of-basin steelhead and Coho of both natural and hatchery origin were intermittently detected at the Mill Creek array (MTD). Throughout the operational period of the MTD array, 13 out-of-basin steelhead were detected, 7 of which were hatchery-origin adult fish (Table 19). Out-of-basin Coho salmon detections totaled 15 individuals, 9 of which were hatchery-origin adult fish (Table 20).

Threemile and Chenoweth Creeks

The initial goals of establishing baselines for juvenile migrant abundance, timing, adult returns, and smolt-to-adult ratios (SARs) were not attainable at Chenoweth Creek and Threemile Creek due to very low sample sizes. As a result, a Scope of Services Change was submitted to OWEB and approved in January 2023, discontinuing monitoring in Chenoweth and Threemile Creeks and continuing monitoring in Mill Creek instead. Fyke traps in Chenoweth and Threemile Creeks captured ten or fewer salmonids annually during operation. In both 2021 and 2022, steelhead and Coho smolts were captured in these streams, indicating that minimal levels of natural production occur in both systems.

Antenna Detection Efficiency

Detection efficiency for the Mill Creek array (MTD) site is summarized in Table 18. Efficiency at the MTD array was generally about 90 percent for operational years. The array was offline for most of 2020 due to power failure. The site was re-powered via grid power December 2020.

For adult fishway passage facilities at Bonneville Dam and The Dalles Dam, we assumed near complete detection (greater than 95%) for salmonids PIT-tagged with 12.5 mm full-duplex tags (Fryer, 2009; Columbia Basin Research, 2025).

FIGURES

Table 1: Mill Creek Rotary Screw Trap Operational Summary for Grant Period

Year	Install Date	Removal Date	Days Cone Raised	Cause for downtime
2020	not operated in 2020			
2021	4/7/2021	5/26/2021	2	
2022	3/31/2022	6/15/2022	13	high water
2023	3/30/2023	6/12/2023	31	high water, trap fixes
2024	4/2/2025	6/5/2025	8	

Table 2: Fyke Trap Operational Summary for Grant Period

Year	Stream	Install Date	Removal Date
2021	Chenoweth	4/9/2021	6/1/2021
2021	Threemile	4/9/2021	5/13/2021
2022	Chenoweth	4/3/2022	6/5/2022
2022	Threemile	4/3/2022	6/5/2022
2023	Fyke traps not operated		
2024	Fyke traps not operated		

Table 3: Summary of trap catch (n) by stream, year, and species over the grant period.

Mill Creek			Chenoweth Creek			Threemile Creek		
Year	Species	n	Year	Species	n	Year	Species	n
2021	Steelhead	1,348	2021	Steelhead	0	2021	Steelhead	4
	Coho	1.277		Coho	9		Coho	2
	Coastal Cutthroat	66		Coastal Cutthroat	0		Coastal Cutthroat	4
	Pacific lamprey, larvae	166		Pacific lamprey, larvae	0		Pacific lamprey, larvae	0
	Pacific lamprey, adults	6		Pacific lamprey, adults	0		Pacific lamprey, adults	0
2022	Steelhead	1,129	2022	Steelhead	1	2022	Steelhead	0
	Coho	4,764		Coho	2		Coho	0
	Coastal Cutthroat	97		Coastal Cutthroat	0		Coastal Cutthroat	0
	Pacific lamprey, larvae	249		Pacific lamprey, larvae	0		Pacific lamprey, larvae	0
	Pacific lamprey, adults	17		Pacific lamprey, adults	0		Pacific lamprey, adults	0
2023	Steelhead	499	2023			2023		
	Coho	377						
	Coastal Cutthroat	28						
	Pacific lamprey, larvae	108						
	Pacific lamprey, adults	0		*Monitoring discontinued*			*Monitoring discontinued*	
2024	Steelhead	411	2024			2024		
	Coho	262						
	Coastal Cutthroat	18						
	Pacific lamprey, larvae	113						
	Pacific lamprey, adults	1						

Table 4. Juvenile migrant steelhead abundance estimates and juvenile migrant Coastal Cutthroat trout abundance estimates for Mill Creek from migration years 2012 – 2024.

Migration Year	Juvenile migrant steelhead	
	Abundance	95% CI
2012	7,274	6,212 – 8,336
2013	8,231	6,571 – 9,891
2014	3,870	2,503 – 5,237
2015	4,655	3,840 – 5,470
2016	4,936	3,437 – 6,435
2017	6,520	5,776 – 7,264
2018	4,954	3,679 – 6,229
2019	3,178	2,308 – 4,047
2020	NA	NA
2021	9,228	8,205 – 10,250
2022	5,825	5,286 – 6,365
2023	3,946	3,154 – 4,739
2024	4,100	2,946 – 5,254

Table 5. Coho salmon smolt production estimates for Mill Creek, 2012 to 2024, by brood and migration year.

Brood year	Migration Year	Juvenile migrant Coho Salmon	
		Abundance	95% CI
2010	2012	1,633	1,425 – 1,841
2011	2013	1,475	1,020 – 1,930
2012	2014		
2013	2015	1,163	899 – 1,427
2014	2016	3,187	2,682 – 3,692
2015	2017	245	89 – 401
2016	2018	1,348	524 – 2,172
2017	2019	7,195	6,141 – 8,249
2018	2020		
2019	2021	3,462	3,117 - 3,807
2020	2022	16,178	15,672 - 16,684
2021	2023	1,725	1,475 - 1,975
2022	2024	1,464	1,145 - 1,783

Table 6. Downstream migrant cutthroat trout production estimates for Mill Creek from migration years 2012 – 2024.

Migration Year	Juvenile migrant Coastal Cutthroat Trout	
	Abundance	95% CI
2012	309	146 – 472
2013		
2014		
2015	198	77 – 319
2016	273	-3 – 549
2017		
2018	33	19 – 47
2019		
2020		
2021	707	257-1158
2022	521	333-709
2023	279	154-404
2024		

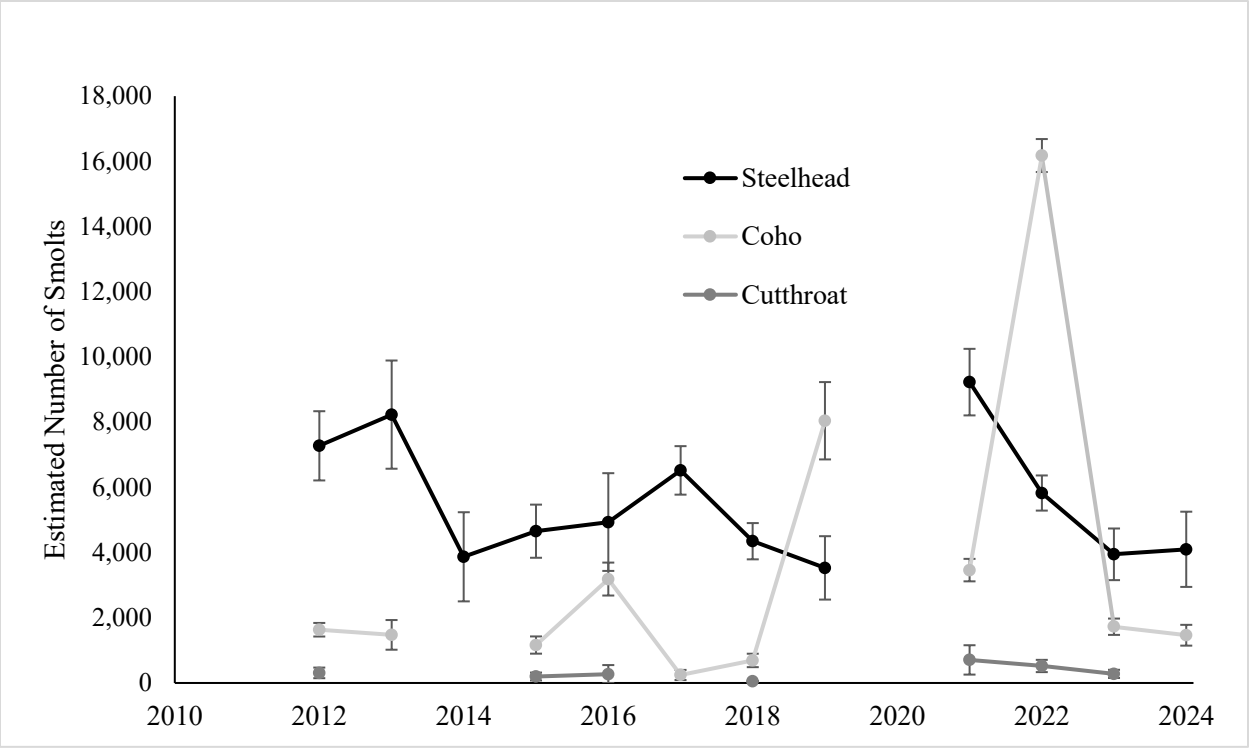

Figure 2: Annual outmigrant abundance estimates for Mill Creek by species from 2012-2024.

Table 7. Outmigrant year, number of sample size (n) and age composition of juvenile steelhead sampled at the Mill Creek trap, 2017 to 2024.

Outmigrant Year	n	Age 1	2	3
2017	767	45%	46%	9%
2018	397	33%	59%	8%
2019	326	35%	60%	5%
2021	1,274	36%	55%	8%
2022	631	30%	64%	7%
2023	386	31%	64%	6%
2024	350	7%	83%	10%
Pooled 2017-2024		31%	61%	8%

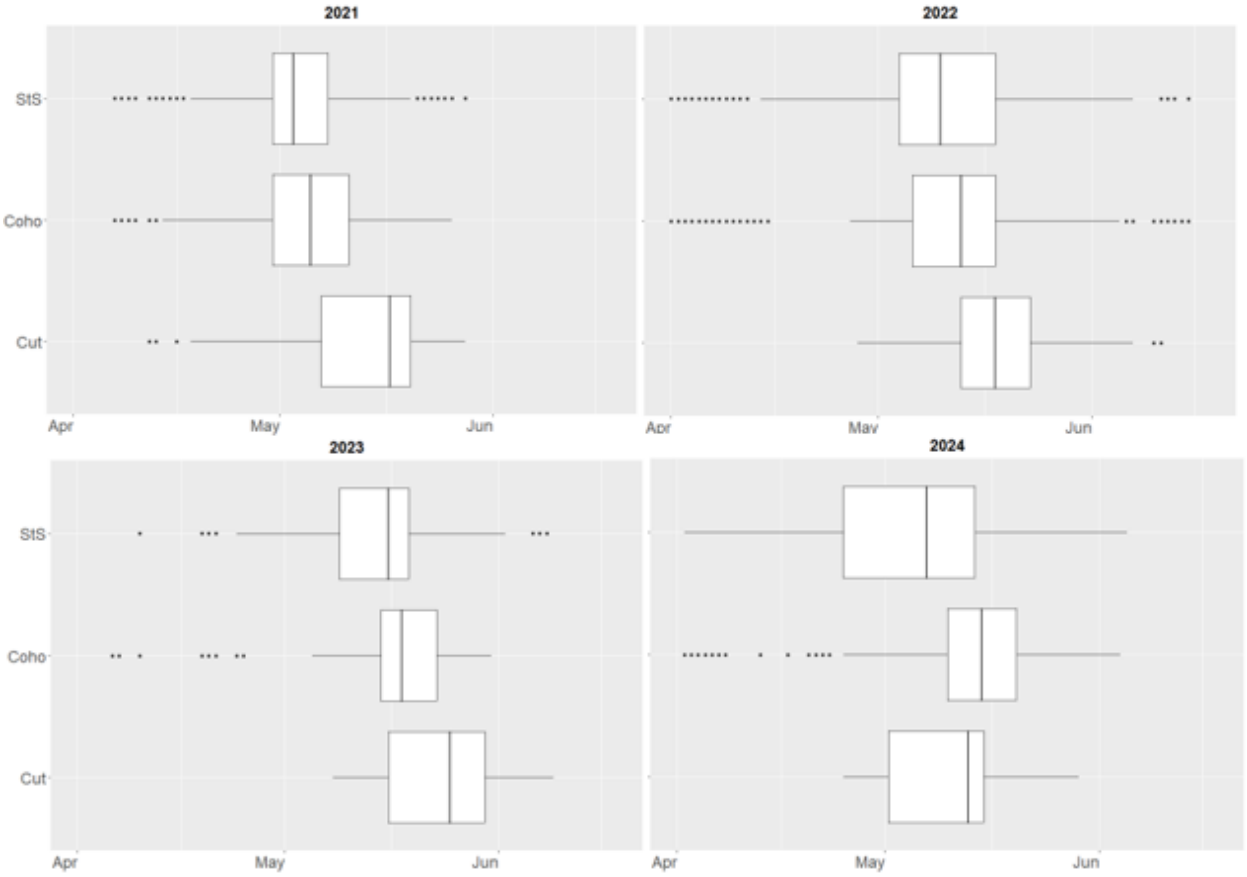

Figure 3: Date of arrival of juvenile migrant steelhead (StS, Coho, and Coastal Cutthroat trout (Cut) at the Mill Creek rotary screw trap from years 2021-2024. Box plots include the median (black vertical line), 25th quartile (left box edge), 75th quartile (right box edge), 1.5 * Interquartile Range (whiskers), and outlier (points) days of arrival across trapping months April – June.

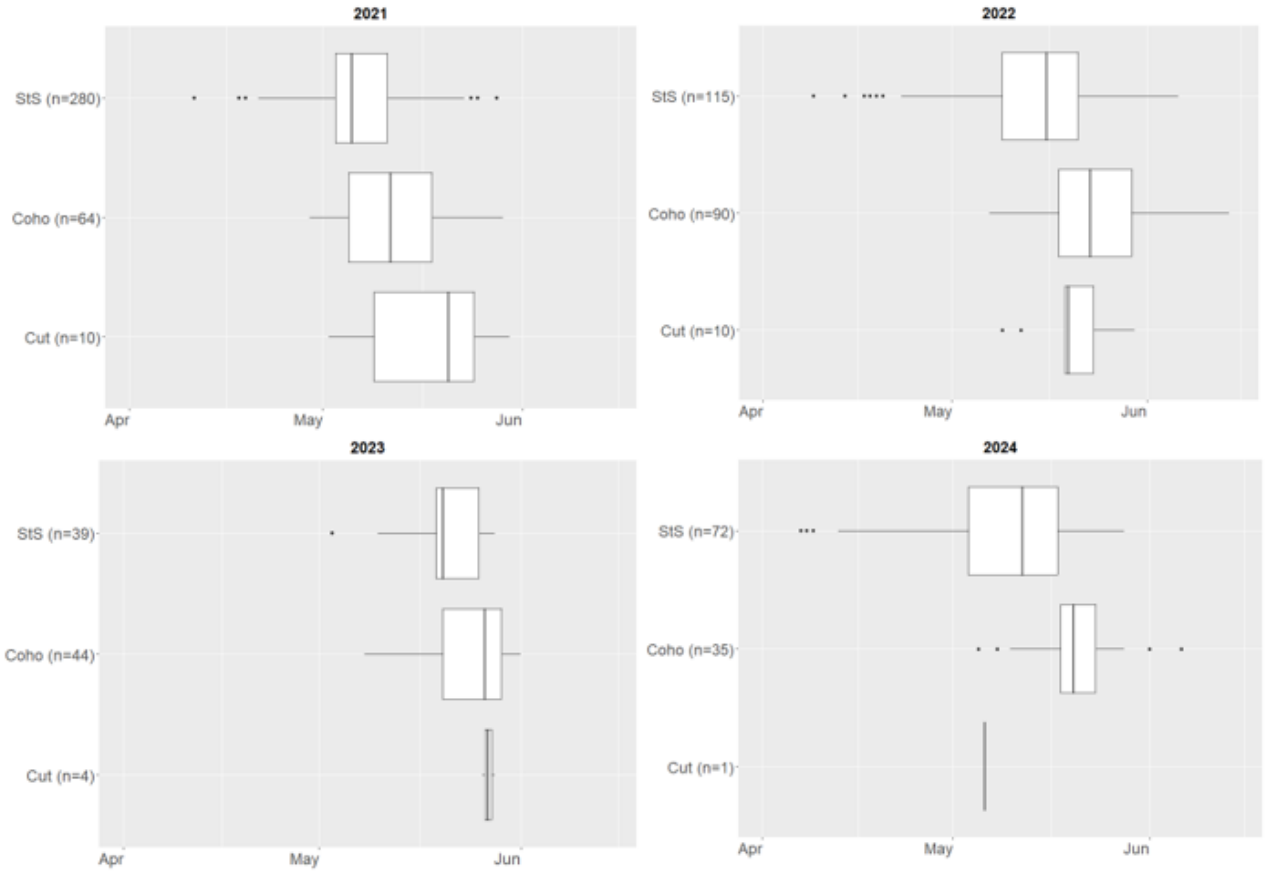

Figure 4: Date of arrival to Bonneville Dam for juvenile migrant steelhead (StS, Coho, and Coastal Cutthroat trout (Cut) tagged at the Mill Creek rotary screw trap from years 2021-2024. Box plots include the median (black vertical line), 25th quartile (left box edge), 75th quartile (right box edge), 1.5 * Interquartile Range (whiskers), and outlier (points) days of arrival across detection months April - June.

Table 8: Average migration time (days) to Bonneville Dam from downstream migrant trap on Mill Creek by species, 2021 to 2024.

	Species		
Year	Steelhead	Coho	Cutthroat
2021	5.4 days	7.9 days	7.2 days
2022	6.1 days	15.2 days	4.6 days
2023	5.6 days	7.2 days	7.1 days
2024	5.5 days	9.5 days	3.7 days

Table 9. Mill Creek steelhead migration year cohort smolt-to-adult return rate (SAR) to Bonneville Dam based on number of PIT tagged juvenile migrants and the number of PIT tagged adults detected at Bonneville Dam, 2012 to 2019.

Migration Year Cohort	Number of tagged smolt	Number of adults returned to Bonneville Dam	SAR	SAR%
2012**	999	22	0.022	2.20%
2013**	745	23	0.031	3.10%
2014	306	14	0.046	4.60%
2015	727	2	0.002	0.20%
2016	509	8	0.016	1.60%
2017	1,064	5	0.005	0.50%
2018	529	9	0.017	1.70%
2019	358	1	0.003	0.30%
2020	0			
2021	1,361	20	0.015	1.50%
2022	1,069	24	0.022	2.20%
2023*	501	17		
2024*	423	4		
2013 – 2022 Pooled	**7,667**	**106**	**.0138**	**1.38%**

*Incomplete returns for SAR, complete returns will be in 2027

**Mill Creek Array not operational until 2015; incomplete Mill Creek SAR rates

Table 10. Mill Creek steelhead migration year cohort smolt-to-adult return rate (SAR) to Mill Creek based on number of PIT tagged juvenile migrants and the number of PIT tagged adults detected, 2012 – 2019.

Migration Year Cohort	Number of tagged smolt	Number of adults returned to Mill Creek	SAR	SAR%
2012**	999			
2013**	745	7	0.0094	0.94%
2014	306	6	0.0200	2.0%
2015	727	2	0.0028	0.28%
2016	509	4	0.0079	0.79%
2017	1,064	2	0.0019	0.19%
2018	529	4	0.0076	0.76%
2019	358			
2020	0			
2021	1,361	10	0.0073	0.73%
2022	1,069	10	0.0094	0.94%
2023*	501	3		
2024*	423			
2013 -2022 Pooled	**7,667**	**45**	**0.0059**	**0.59%**

*Incomplete returns for SAR, complete returns will be in 2027

**Mill Creek Array not operational until 2015; incomplete Mill Creek SAR rates

Table 11. Mill Creek Coho salmon brood year cohort smolt-to-adult return rate (SAR) to Bonneville Dam based on number of PIT tagged juvenile migrants and the number of PIT tagged adults detected at Bonneville Dam, assumed brood year, by migration year, 2012 to 2024.

Brood Year Cohort	Migration Year	Number of tagged smolt	Number of adults returned to Bonneville Dam	SAR	SAR%
2010	2012	312	4	0.0128	1.28%
2011	2013	193	12	0.0622	6.22%
2012	2014	1	0		
2013	2015	234	1	0.0043	0.43%
2014	2016	643	14	0.0218	2.18%
2015	2017	34	1	0.0294	2.94%
2016	2018	36	0		
2017	2019	671	6	0.0089	0.89%
2018	2020				
2019	2021	388	23	0.0593	5.93%
2020	2022	974	16	0.0164	1.64%
2021	2023	332	13	0.0392	3.92%
*2022**	*2024*	*264*	*9*	*0.0341*	*3.41%*
Migration Year 2012-2023 Pooled		**3,818**	**90**	**0.0236**	**2.36%**

*Pending SAR rate, complete return will be in 2026

Table 12. Mill Creek Coho salmon brood year cohort smolt-to-adult return rate (SAR) to Bonneville Dam based on number of PIT tagged juvenile migrants and the number of PIT tagged adults detected at Bonneville Dam, migration years 2012 – 2024. Assumed brood year is also shown. Mill Creek array not operational until 2015.

Brood Year Cohort	Migration Year	Number of tagged smolt	Number of adults returned to Mill Creek	SAR	SAR%
2010	2012	312			
2011	2013	193			
2012	2014	1			
2013	2015	234			
2014	2016	643	12	0.0186	1.86%
2015	2017	34	0		
2016	2018	36	0		
2017	2019	671	1		
2018	2020				
2019	2021	388	10	0.0258	2.58%
2020	2022	974	6	0.0062	0.62%
2021	2023	332	10	0.0301	3.01%
2022*	2024	264			
Migration Year 2012-2023 Pooled		**3,818**	**39**	**0.0102**	**1.02%**

*Incomplete returns, SAR complete return will be in 2026

Table 13. Return year – spawn year, number (n) of returning PIT tagged adult steelhead detected at Bonneville Dam and number of years each returning fish spent in the ocean for return years 2013 – 2020. Number of years spent in the ocean was assumed based on the year migrating fish were PIT tagged at the Mill Creek rotary screw trap compared to the adult return year at Bonneville Dam.

Return Year-Spawn Year	n	Saltwater Age 1	2	3
2013-2014	13	13	*	
2014-2015	23	14	9	
2015-2016	15	6	9	
2016-2017	8		8	
2017-2018	8	6	2	
2018-2019	4	2	2	
2019-2020	5	2	3	
2020-2021	7		7	
2021-2022**	1		1	
2022-2023**	7	7		
2023-2024**	19	7	12	
2024-2025	22	4	17	1
2013 – 2024 Pooled	132	61 (46%)	70 (53%)	1 (0.8%)

**2020 outmigrant cohort not represented through PIT tags, no screw trap operated in 2020

Table 14. Return year, number (n) of returning PIT tagged Coho detected at Bonneville Dam and number of years each returning fish spent in the ocean prior to spawning for return years 2013 – 2024. Number of years spent in the ocean was assumed based on the year migrating fish were PIT tagged at the Mill Creek rotary screw trap compared to the return year at Bonneville Dam.

Return Year	n	Saltwater Age 1	2	3
2013	4	4		
2014	12	12		
2015	0	0		
2016	1	1		
2017	14	14		
2018	1	1		
2019	0	0		
2020	6	6		
2021*				
2022	23	23		
2023	16	16		
2024	13	13		
2013 – 2024 Pooled	90	90 (100%)		

*Mill Creek RST not operated in 2020, no tagged fish for that outmigrant cohort year.

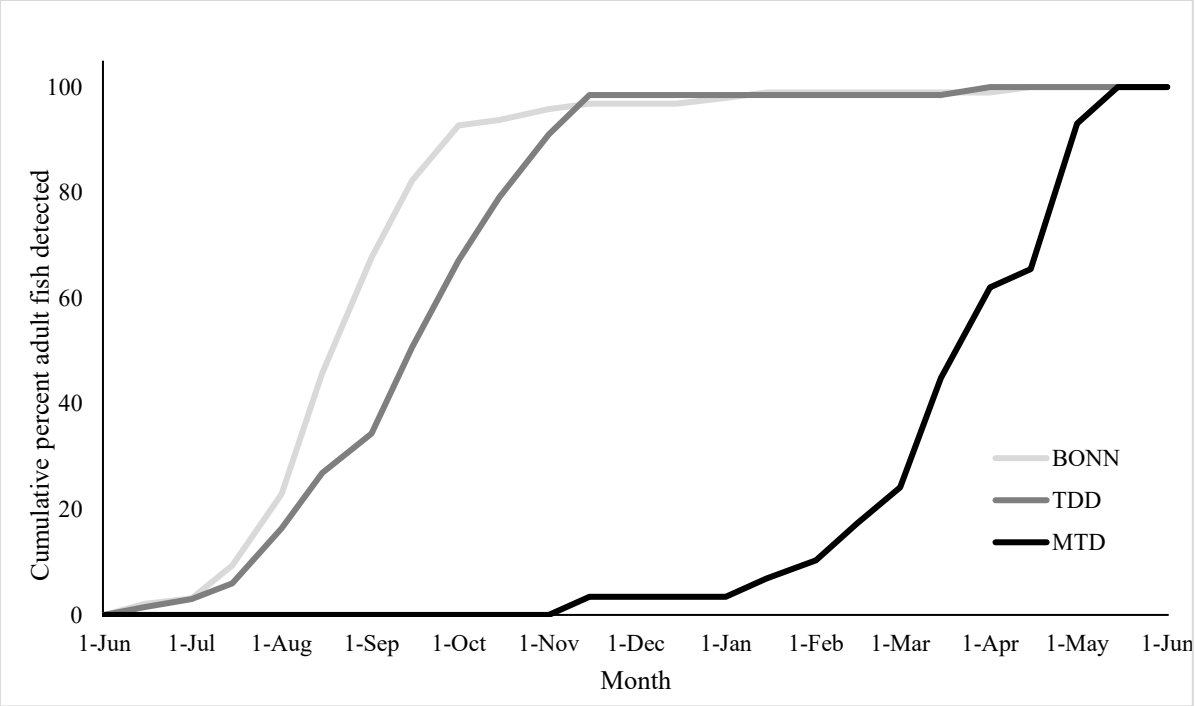

Figure 5. 2021-2024 arrival times for Mill Creek-origin adult steelhead at Bonneville Dam (BONN), The Dalles Dam (TDD), and the Mill Creek array (MTD) based on PIT-tag detections.

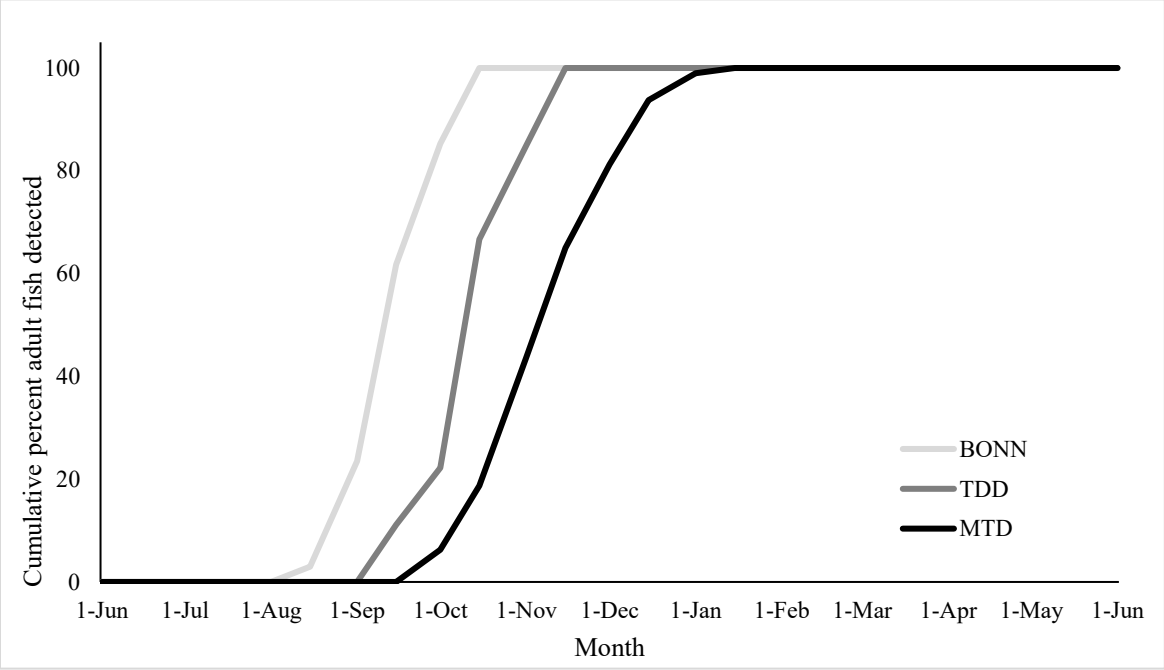

Figure 6. 2021-2024 arrival times for Mill Creek-origin Coho Salmon at Bonneville Dam (BONN), The Dalles Dam (TDD), and the Mill Creek array (MTD) based on PIT-tag detections.

Table 15. Dispostion of returning PIT tagged adult steelhead from Mill Creek. Fish are categorized based on PIT tag detection histories. "Direct to Mill Creek" fish were detected at Bonneville with subsequent detection(s) only at Mill Creek. "Overshoot and fallback fish to Mill Creek" fish were detected at interrogation sites upstream of the Mill Creek mouth and ultimately detected at Mill Creek. "Lost below TDD" fish were detected at Bonneville but not subsequently. "Overshoot & lost above TDD" fish were detected at interrogation facilities at or about The Dalles Dam but not detected to return to the Mill Creek array.

Return Year	Adults at BON	Direct to Mill Creek		Overshoot & fallback to Mill Creek		Lost below TDD		Overshoot & lost above TDD	
2013*	13								
2014*	23								
2015	15	0	0%	10	67%	1	7%	4	27%
2016	8	0	0%	3	38%	2	25%	3	38%
2017	8	1	13%	4	50%	1	13%	2	25%
2018	5	1	20%	3	60%	1	20%	0	0%
2019	5	1	20%	0	0%	3	60%	1	20%
2020	7	2	29%	2	29%	1	14%	2	29%
2021	1	0	0%	0	0%	0	0%	1	100%
2022	7	1	14%	3	43%	1	14%	2	29%
2023	19	3	16%	6	32%	4	21%	6	32%
2024	22i	3	14%	5	23%	3	14%	11	41%
2015-2024 Pooled	**97**	**12**	**12%**	**36**	**37%**	**17**	**18%**	**32**	**33%**

*Mill Creek array (MTD) installed 2015

Table 16. Disposition of returning PIT tagged adult Coho from Mill Creek. Fish are categorized based on PIT tag detection histories. "Direct to Mill Creek" fish were detected at Bonneville with subsequent detection(s) only at Mill Creek. "Overshoot and fallback fish to Mill Creek" fish were detected at interrogation sites upstream of the Mill Creek mouth and ultimately detected at Mill Creek. "Lost below TDD" fish were detected at Bonneville but not subsequently. "Overshoot & lost above TDD" fish were detected at interrogation facilities at or about The Dalles Dam but not detected to return to the Mill Creek array.

Return Year	Adults at BON	Direct to Mill Creek		Overshoot & fallback to Mill Creek		Lost below TDD		Overshoot & lost above TDD	
2017	14	8	57%	4	29%	2	14%		
2018									
2019	1							1	100%
2020	6	1	17%			5	83%		
2021									
2022	23	6	26%	4	17%	12	52%	1	4%
2023	15	4	27%	2	13%	5	33%	4	27%
2024	13	6	46%	4	31%	1	8%	2	15%
2017-2024 Pooled	**72**	**25**	**35%**	**15**	**21%**	**25**	**35%**	**7**	**9%**

Table 17. Mill Creek-origin O.mykiss detected at the Mill Creek array (MTD) that exhibit resident rather than anadromous migratory patterns.

Detection Year	Assumed resident trout at MTD array (n)
2015	2
2016	2
2017	6
2018	7
2019	1
2020	
2021	2
2022	2
2023	
2024	3

Table 18. Mill Creek array (MTD) detection efficiency across project years.

Year	Array Efficiency	CI Lower	CI Upper
2015	99.6%	98.9%	99.9%
2016	99.4%	98.8%	99.7%
2017	98.5%	97.5%	99.1%
2018	97.1%	95.2%	98.4%
2019	98.3%	97.3%	98.9%
2020	Not operated		
2021	96.7%	95.7%	97.6%
2022	94.0%	91.1%	96.3%
2023	98.9%	97.2%	99.8%
2024	92.0%	87.1%	95.4%

Table 19. Out-of-basin steelhead detected at the Mill Creek array (MTD) across operational years 2015 – 2025. Release date reflects the date of release from juvenile out-of-basin tagging stie or hatchery facility.

Mill Creek Detection Date	Release Date	Fish Type	Release Site
3/21/2017	4/23/2014	Hatchery Reared	Dworshak NFH, mainstem Clearwater
1/28/2016	4/20/2015	Hatchery Reared	Klickitat River
2/22/2016	5/18/2013	Wild	Lower Granite Dam
3/7/2016	4/22/2014	Hatchery Reared	Tucannon River
3/10/2016	5/10/2013	Wild	Lower Granite Dam
2/25/2017	4/24/2015	Wild	Fifteen Mile Creek, near The Dalles, OR
3/23/2019	4/2/2016	Wild	Fifteen Mile Creek, near The Dalles, OR
3/31/2019	4/13/2017	Hatchery Reared	Tucannon River
4/3/2019	9/5/2018	Hatchery Reared	Priest Rapids Dam
4/8/2019	9/4/2018	Wild	Lemhi River
4/10/2019	4/15/2017	Hatchery Reared	Curl Lake Rearing Pond
3/22/2021	4/21/2019	Hatchery Reared	Cottonwood Acclimation Pond
3/24/2025	6/7/2022	Wild	Lower Granite Dam

Table 20. Out-of-basin Coho detected at the Mill Creek array (MTD) across operational years 2015 – 2025. Release date reflects the date of release from juvenile or adult out-of-basin tagging site or hatchery facility.

Mill Creek Detection Date	Release Date	Rear Type	Release Site Name
10/5/16	5/3/2016	Wild	Eightmile Creek, Fifteenmile Creek Watershed
10/6/16	5/6/2016	Wild	Fifteen Mile Creek, near The Dalles, Oregon
12/31/17	10/4/2017	Unknown	Lewis River to Bonneville Dam (km 140-234)
10/13/18	3/26/2018	Hatchery Reared	Kooskia National Fish Hatchery
9/25/19	5/9/2019	Wild	Eightmile Creek, Fifteenmile Creek Watershed
1/16/21	4/30/2019	Wild	Eightmile Creek, Fifteenmile Creek Watershed
11/14/21	5/5/2020	Hatchery Reared	Rolfing Acclimation Pond, Wenatchee River
10/30/22	3/30/2021	Hatchery Reared	North Lapwai Valley Acclimation Pond
12/31/22	11/8/2022	Hatchery Reared	Lyle Falls Adult Fish Trap, Klickitat River
12/4/23	6/6/2022	Wild	Fifteen Mile Creek, near The Dalles, Oregon
12/6/23	10/19/2023	Hatchery Reared	Lyle Falls Adult Fish Trap, Klickitat River
10/30/24	4/26/2023	Hatchery Reared	Twisp Acclimation Pond (WDFW)
12/18/24	10/8/2024	Hatchery Reared	Lyle Falls Adult Fish Trap, Klickitat River
12/24/24	12/18/2024	Hatchery Reared	Lyle Falls Adult Fish Trap, Klickitat River
12/29/24	10/18/2024	Hatchery Reared	Lyle Falls Adult Fish Trap, Klickitat River
12/26/24	10/30/2024	Hatchery Reared	Lyle Falls Adult Fish Trap, Klickitat River
12/29/24	10/1/2024	Wild	Lyle Falls Adult Fish Trap, Klickitat River

DISCUSSION

Overshoot of adult summer steelhead and Coho salmon presents population-level threats by directly reducing annual spawner abundance. Individuals returning to Mill Creek exhibited a high incidence of this behavior. Overshoot in the Columbia Basin has been linked to multiple factors, including flow conditions, physiological stress, and fish passage design (Richins & Skalski, 2018). In Mill Creek, the subsurface concrete box culvert and outlet at the Columbia confluence may reduce tributary attraction and represents a potential restoration opportunity. Comparable overshoot rates have been observed in the Fifteenmile Basin, likely driven by diminished attraction associated with unnaturally low surface flows or altered hydraulics and olfactory cues near the tributary confluence due to dam operations (Faber, 2025).

Reducing overshoot has the potential to increase reproductive success in Mill Creek populations by increasing spawner escapement. Pooled detection histories across monitoring years indicate that 33% of returning Mill Creek–origin steelhead were lost above The Dalles Dam following overshoot events. Similarly, 9% of returning Mill Creek–origin Coho were lost after overshoot at The Dalles Dam.

High occurrence of overshoot and subsequent fallback patterns in adult Mill Creek steelhead and Coho underscores the importance of adequate downstream surface passage facilities at The Dalles Dam. Pooled detection histories for Mill Creek steelhead and coho indicate that, respectively, 31% and 21% of returning adults overshot The Dalles Dam but then successfully fallback over The Dalles Dam prior to entering Mill Creek. Currently, the sluiceway provides downstream surface passage for adults from March 1 through December 15 each year. From December 16 through February 28, the only downstream route regularly available to adults is through the turbines (U.S. Army Corps of Engineers, 2025). Adult downstream passage rates are significantly higher when the sluiceway surface flow route is open, and fish demonstrate a clear preference for sluiceway passage over turbine migration (Khan et al., 2013). Given the frequency of Mill Creek overshoot and the typical arrival timing of steelhead in Mill Creek (November–March), extending sluiceway operation could potentially increase the number of overshoot Mill Creek–origin steelhead and Coho successfully returning to their natal stream.

PIT tag detection histories of out-of-basin steelhead and Coho of both natural and hatchery-origin in Mill Creek indicate the out-of-basin spawners comprise some component of the active spawning population. Out of basin hatchery steelhead spawners have been documented to pose a risk to recipient populations, particularly depressed populations, such as Mill Creek (Keefer & Caudill, 2014). While the reasons why adult salmon and steelhead enter non-natal streams permanently or temporarily are not entirely understood, it is thought to be related to proximity to natal stream, discharge, temperature, and anthropogenic alterations to migratory patterns, such as barging or passage facilities primarily related to the hydro system. (Richins & Skalski, 2018, Keefer & Caudill, 2012). It is not known how these out of basin fish contribute to production in Mill Creek annually but it is likely site fidelity to Mill Creek for out of basin fish is low for the same reasons Mill Creek-origin salmon and steelhead exhibit low site fidelity.

Study Objectives

1) Annual estimation of juvenile outmigrant abundance (smolts)

Steelhead smolt abundance in Mill Creek, synthesized across 13 monitoring years ranged from 3,178 to 9,228 individuals. Coho smolt abundance, synthesized across 11 monitoring years, exhibited greater variability, ranging from 245 to 16,178 individuals. Coastal Cutthroat trout smolt abundance was estimated sporadically across seven monitoring years and consistently remained below 1,000 individuals. These long-term smolt abundance estimates establish a quantitative baseline that can be utilized to evaluate future population responses to habitat restoration or other watershed management actions.

2) Evaluate peak juvenile outmigration from Mill Creek and subsequent migration timing to Bonneville Dam

During monitoring years 2021–2024, the median arrival window for steelhead, Coho, and Coastal Cutthroat trout occurred in May. Outmigration timing was slightly staggered among species, with steelhead initiating migration earliest, followed by Coho, and subsequently Coastal Cutthroat trout. Travel time to Bonneville Dam exhibited a similar staggered pattern; however, the median arrival timing for all three species converged in May. These results indicate a relatively synchronized seasonal migration window across species. Incorporation of additional covariates such as discharge and temperature in future analyses would enable evaluation of environmental factors influencing annual smolt outmigration dynamics.

3) Establishing a four-year baseline of SAR's by species for each stream.

The eight-year pooled Mill Creek steelhead SAR (year 2013-2018, 2021-2022) Mill Creek steelhead was 0.59%. Steelhead SARs were well below 2%, except the 2014 cohort, which indicates an at-risk population based on ESA recovery plan metrics (NMFS 2009). The Mid-Columbia River Steelhead Recovery Plan established an SAR return goal metric of 2% for minimum viability and 4% for recovery. Diminished SAR rates in Mill Creek are consistent with patterns observed in the neighboring Fifteenmile Watershed (Faber, 2025). Determining SARs for Coho in Mill Creek were challenging in most years during this study due to low sample size, however, 2019 and 2023 cohorts showed rates above 2%. The pooled, four-year SAR for Mill Creek coho was 1.02 % (years 2016, 2021-2023). Mid-Columbia Coho are not ESA-listed, thus population objectives for SARs have not been defined. Adult returns to Coastal Cutthroat trout were too infrequent to provide determination of SAR rates and no SAR objective is defined for this population.

Mill Creek origin steelhead SAR return rates to Bonneville Dam averaged 1.39% across cohorts, whereas returns to Mill Creek averaged 0.59%. This discrepancy highlights substantial post-Bonneville loses prior to Mill Creek-origin steelhead returning to their natal tributary. (Table 9, Table 10). Mill Creek origin Coho exhibit similar post-Bonneville losses with an average SAR rate to Bonneville of 2.36% and a substantially reduced average SAR rate to Mill Creek of 1.02%.

4) Monitoring the timing of adult returns of steelhead and Coho to Bonneville Dam and natal streams was another objective of this grant.

Protracted freshwater occupancy represents a significant risk factor for Columbia Basin summer steelhead and likely contributes to post-passage mortality following Bonneville Dam. The extended freshwater

residency observed in Mill Creek origin steelhead is consistent with a summer-run ecotype and aligns with migratory timing documented in nearby tributaries (Faber, 2025). Mill Creek steelhead remain in freshwater for approximately six months after passing Bonneville, confirming their classification as summer-run rather than the previously assumed winter-run designation (Figure 5). While prolonged freshwater residency is a natural life-history trait of Columbia Basin summer steelhead and is crucial for long freshwater migrations to the interior basin, this extended duration exposes them to multiple stressors, including elevated water temperatures, fishery pressure, and cumulative dam impacts (Murdoch et al., 2022).

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