PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

Lewis River Fish Passage Program
2020 Annual Report (*Final*)

Monitoring and Evaluation (M&E) Plan Metrics

FERC Project Nos. 935, 2071, 2111 and 2213

Salmonid fry and other small fish species being sampled at the Swift FSC
Photo by Steve Yuncevich

PacifiCorp
&
Public Utility District No.1 of Cowlitz County

April 14, 2021

TABLE OF CONTENTS

LIST OF APPENDICES

Appendix A	Upper Lewis River Nutrient Enhancement - Final Report (2020)
Appendix B	Eagle Cliff Rotary Screw Trap Operation Summary – Technical Memorandum 2020
Appendix C	Swift Reservoir Floating Surface Collector Smolt Collection Efficiency Evaluation – 2020 Final Report
Appendix D	Spawn Timing, Distribution and Abundance of Transported Fishes – 2020 Final Report

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ACC	Aquatics Coordinating Committee
ATE	Adult Trap Efficiency
ATS	Aquatic Technical Subgroup (formally the H&S Subgroup)
AWS	Auxiliary Water Supply
BWT	Blank Wire Tag
CE	Collection Efficiency
cfs	Cubic Feet Per Second
Cowlitz PUD	Public Utility District No. 1 of Cowlitz County
CWT	Coded Wire Tag
EA	Electro-Anesthesia
ESA	Endangered Species Act
FCE	Fish Collection Efficiency
FERC	Federal Energy Regulatory Commission
FL	Fork Length
fps	Feet per Second
Fry	A recently hatched fish that has reached the stage where its yolk-sac has almost disappeared and its swim bladder is operational to the point where the fish can actively feed for itself. Juveniles referred to as fry are <60 mm based on ability to safely tag.
FSC	Swift Floating Surface Collector
ft	Foot
H&S	Hatchery and Supplemental Plan or Subgroup
HOR	Hatchery-origin recruit
HR	Hatchery returns
HRL	Hatchery return line
LCFEG	Lower Columbia Fish Enhancement Group
LWS	Ladder Water Supply
mm	millimeter
M&E	Monitoring and Evaluation
NF	North Fork
NMFS	National Marine Fisheries Service
NOR	Natural-origin recruit
NTS	Net Transition Structure
ODS	Overall Downstream Survival
Parr	A young salmonid that is older than a fry and younger than a smolt, having dark marks (i.e., parr marks) on their sides. Juveniles referred to as parr generally range in size from 60 to 120 mm.
PIT	Passive Integrated Transponder tag
Project	Lewis River Hydroelectric Project
PTAGIS	Pacific Northwest Regional PIT Tag Database
RMIS	Regional Mark Information System
ROV	Remotely Operated Vehicle
SA	Settlement Agreement
SAR	Smolt-to-adult ratio
Services	National Marine Fisheries Service and U.S. Fish and Wildlife Service

Smolt	A juvenile salmon that is ready to migrate out to the sea, smolts can be described as losing their camouflage bars (i.e., parr marks) and are in the process of physiological changes that allow them to survive a shift from freshwater to saltwater. Smolts are silvery in color and shed scales readily. Smolts can range from 120 to 300 mm depending on fish species.
USFS	U.S. Forest Service
UPS	Upstream Passage Survival
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
Utilities	PacifiCorp and Public Utility District No. 1 of Cowlitz County
UW	University of Washington
WDFW	Washington Department of Fish and Wildlife
ZOI	Zone of Influence

EXECUTIVE SUMMARY

The purpose of this report is to document results of the field assessments associated with implementation of the fish passage program that are outlined in the current Lewis River Aquatic Monitoring and Evaluation Plan[1] (M&E Plan) during 2020. The M&E Plan was developed as part of the Lewis River Settlement Agreement (SA) to evaluate performance measures outlined in the new FERC License for the Lewis River Hydroelectric Project, which was issued on June 26, 2008 to PacifiCorp and the Public Utility District No. 1 of Cowlitz County (Utilities). This report summarizes both upstream and downstream fish passage and collection metrics as well as provides an overview of environmental conditions and key procedural changes that occurred or were further implemented in 2020. The following is a brief summary of relevant performance metrics documented in this report:

Description	Ref. to Page	M&E Obj.	Performance Goal	2020 Estimate	Summary
Number of Juveniles Passing Eagle Cliff During Screw Trap Operations	Page 12	Obj. 7 Task 7.1	Monitoring	69,714 coho 539 Chinook 11,514 steelhead 1,047cutthroat	Estimates of the total number of juvenile coho, Chinook, steelhead, and cutthroat were made over a 19-week period using screw trap catch information. The trap was located at the head of Swift Reservoir at Eagle Cliff.
Number of Juveniles Entering Swift Reservoir	Page 12	Obj. 7 Task 7.2	Monitoring	148,552 coho 84,291 Chinook 38,864 steelhead 9,250 cutthroat	Estimates of the total number of juvenile coho, Chinook, steelhead, and cutthroat that entered Swift Reservoir during 2020.
Number of Fish Collected at the Swift Floating Surface Collector (FSC)	Page 21	Obj. 6	Monitoring	31,974 coho 15,763 Chinook 4,585 steelhead 508 cutthroat 21 bull trout 2,081 hatchery rainbow trout	A total 54,932 salmonids were captured by the FSC in 2020. Of these fish, 51,196 were transported and released downstream of Merwin Dam.
Juvenile Migration Timing	Page 23	Obj. 8	Monitoring	Various	Overall, the run timing in 2020 followed a normal frequency distribution in the spring, with peak migration occurring in late-May. The late-fall migration component was substantially smaller in 2020 than seen in previous years. Over 92% of all fish collected at the FSC in 2020 were collected between March 1 and June 30.

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[1] The methods used in this report follow the revised methods for the M&E Plan dated 2017 (PacifiCorp and Cowlitz PUD 2017).

Description	Ref. to Page	M&E Obj.	Performance Goal	2020 Estimate	Summary
FSC Collection Efficiency (CE)	Page 35	Obj. 2	Juvenile Collection Efficiency ≥ 95%	Coho 39% Chinook 44% Steelhead 42%	In 2020, CE was evaluated with acoustic transmitters. Estimates of efficiency were down for juvenile coho and Chinook and up for steelhead compared to the 2019 estimates. The 2020 effort continued to demonstrate that the vast majority of out-migrants entering the Swift Dam forebay are finding the entrance to the FSC, but are not successfully captured.
Swift FSC Injury	Page 38	Obj. 5	Smolt and Fry ≤ 2%	Fry (0.0%) Smolt (2.51%)	Annual injury rates for smolt were slightly higher than the performance standard of 2.0% overall. This was largely attributed to heavy debris accumulation that occurred at the facility during spring 2020. Parr were combined with smolt to derive estimates of injury for smolt.
Swift FSC Survival	Page 38	Obj. 4	Fry ≥ 98.0% Smolt ≥ 99.5% Bull trout = 99.5%	Fry (100.0%) Smolt (93.3%) Bull trout (100.0%)	The survival rate for salmonid fry (S_{COL}) met the 98% performance standard in 2020. However, the survival rate (CS) for smolts did not. Heavy debris accumulation that occurred at the facility during spring largely contributed to lower survival rates in 2020. Parr were combined with smolt to derive estimates of CS for smolt.
Overall Downstream Survival (ODS)	Page 45	Obj. 1	≥ 80%	Coho 19.6% Chinook 16.6% Steelhead 10.3% Cutthroat 6.7%	During 2020, 1,452 coho, 194 Chinook, 343 steelhead, and 59 cutthroat were tagged and released for the ODS study. Of these fish, 300 coho, 36 Chinook, 38 steelhead, and 4 cutthroat were recaptured at the FSC and passed downstream. These out-migrants were used to calculate ODS.
Number of Adult Fish Collected at the Merwin Fish Collection Facility	Page 48	Obj. 11	Monitoring	Various	A total 18,932 fish were captured at the Merwin Trap in 2020. A total of 1,052 winter steelhead, 634 spring Chinook, 8,119 early coho, 1,367 late coho, and 86 cutthroat were transported upstream and released above Swift Dam as part of the reintroduction program in 2020.

Description	Ref. to Page	M&E Obj.	Performance Goal	2020 Estimate	Summary
Adult Upstream Passage Survival (UPS)	Page 51	Obj. 9	≥ 99.50%	Coho (S) 98.9% Coho (N) 99.9% Chinook 99.8% Steelhead 99.9% Cutthroat 100%	Ninety-two early (S) coho, one late (N) coho, one spring Chinook, and one winter steelhead mortality were observed. No cutthroat mortalities were observed during the trap and haul process.
Adult Trap Efficiency (ATE)	Page 52	Obj. 10	≥ 98%	Not completed	The ATE evaluation was not completed in 2020 as modifications are underway for redesigning the facility's lift and conveyance system. It is anticipated that this work will be completed by 2023 and that ATE studies will resume at that time.
Determine Spawner Abundance, Timing, and Distribution of Transported Adult Anadromous Fish	Page 53	Obj. 15	Monitoring	Total coho redd estimate = 4,865; Winter steelhead redds counted = 33	Coho estimates suggest that most (if not all) adult female coho transported upstream during 2020 spawned. Early coho spawning peaked in October, late coho spawned from November onward. Chinook spawning surveys were not conducted in 2020 due to low abundance of transported adults. Winter steelhead redds were observed throughout the surveyed reservoir tributaries in 2020 from mid-April through early-June. While all tributaries surveyed did have some observed spawning, Drift Creek and Swift Creek accounted for the majority (64 percent) of the observed winter steelhead redds.

1.0 INTRODUCTION

The Lewis River Hydroelectric Project (Project) begins approximately 10 miles east of Woodland, Washington (Figure 1.0-1), and consists of four impoundments. The sequence of the four Lewis River impoundments upstream of the confluence of the Lewis and Columbia rivers is: Merwin, Yale, Swift No. 2, and Swift No.1. These four impoundments are licensed separately by the Federal Energy Regulatory Commission (FERC). Merwin (FERC No. 935), Yale (FERC No. 2071), and Swift No. 1 (FERC No. 2111) are owned and operated by PacifiCorp. Swift No. 2 (FERC NO. 2213) is owned by Public Utility District No. 1 of Cowlitz County (Cowlitz PUD) and is operated by PacifiCorp in coordination with the other impoundments. Combined, the Lewis River Projects have a generation capacity of approximately 606 megawatts.

On June 26, 2008, FERC issued Orders approving the Settlement Agreement (SA) and granting new licenses for the North Fork Lewis River Hydroelectric Projects to PacifiCorp and Cowlitz PUD. Among the conditions contained within the SA was a requirement for reintroducing anadromous salmonids and providing fish passage upstream of Merwin Dam. The overarching goal of this comprehensive reintroduction program is to achieve genetically viable, self-sustaining, naturally reproducing, harvestable populations of anadromous salmonids upstream of Merwin Dam. The target species identified in the SA for reintroduction are spring Chinook salmon (*Oncorhynchus tshawytscha)*, early-run (S-type) coho salmon (O. *kisutch)*, and winter steelhead (*O. mykiss*).

The SA called for a phased approach for reintroduction that occurs over a seventeen-year period following issuance of the new Licenses. The phased approach provides a carefully devised plan to protect the Endangered Species Act (ESA) listed species and to verify the effectiveness of passage facilities as the reintroduction program takes effect. Among the tasks identified for Phase I of the reintroduction plan were establishing a downstream passage facility in the forebay of Swift No.1 Dam, and making upgrades to the existing adult fish capture facility at Merwin Dam. Subsequent phases may establish facilities for both upstream and downstream passage at Merwin, Yale, and Swift No.1 Dams. In December of 2020, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS; collectively the "Services") submitted Preliminary Section 18 Fishway Prescriptions to the FERC. The prescriptions call for PacifiCorp and Cowlitz PUD to forgo constructing salmon and steelhead fish passage into and out of Merwin Reservoir and instead invest $21 million in aquatic habitat restoration upstream of Swift Reservoir. The Services will defer a fish passage decision for Yale Reservoir, for a period of 10 years, until 2031. Additionally, bull trout fish passage facilities are to be constructed providing these fish transport between the three reservoirs. Although the Preliminary Section 18 Fishway Prescriptions was submitted to FERC, additional steps remain before the decision is final. Additional information on this decision can be found at: https://www.pacificorp.com/energy/hydro/lewis-river.html.

The Lewis River Aquatic Monitoring and Evaluation Plan (M&E Plan; PacifiCorp and Cowlitz PUD 2017) was developed as part of the SA to evaluate performance measures outlined in the SA. The primary focus of the M&E Plan is to provide methods for monitoring and evaluating the fish passage program. In accordance with the SA, the Utilities shall consult with the Aquatic Coordination Committee (ACC) as necessary, but no less often than every five years, to determine if modifications to the M&E Plan are warranted (Section 9.1 of the SA). The original M&E Plan was finalized and approved by the ACC in June 2010. The first revision of the M&E Plan was completed in 2017, and was fully implemented that year (PacifiCorp and Cowlitz PUD 2017). The purpose of this report is to document

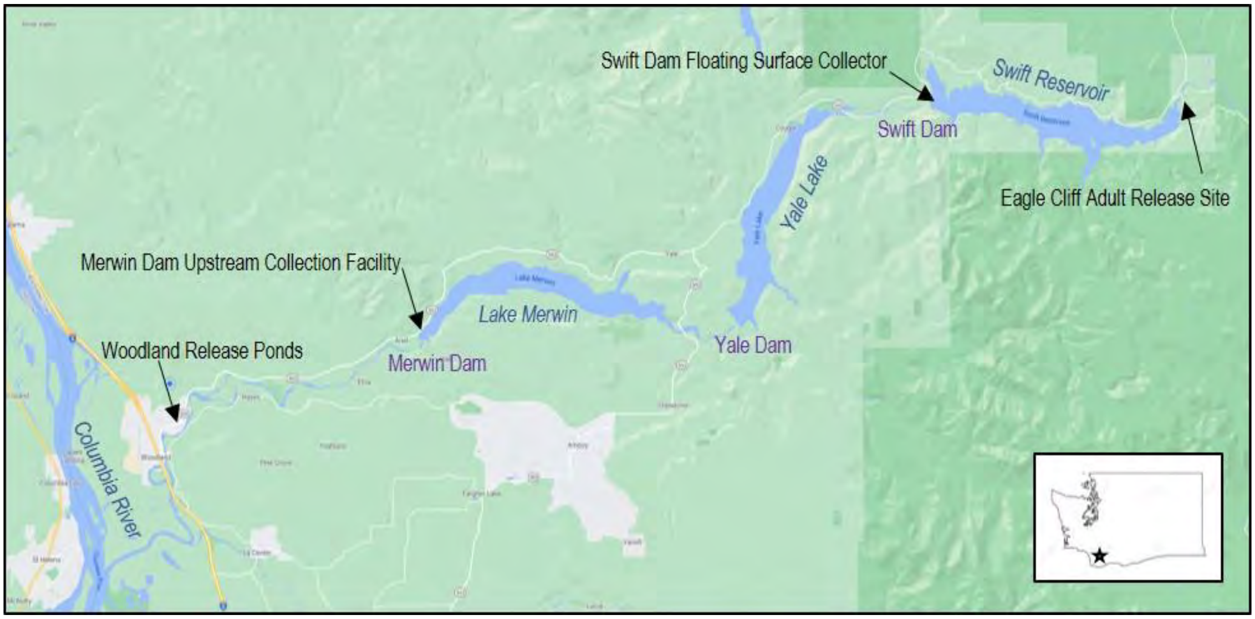

Figure 1.0-1. An overview of key features of the North Fork Lewis River Hydroelectric Project and key fish passage facilities and other infrastructure located in southwest Washington.

results of the field assessments associated with implementation of the fish passage program in the existing M&E Plan during 2020.

Some noteworthy environmental conditions and procedural changes occurred, or continued to be implemented, in 2020. These are summarized below:

- *Minimum Flow Requirement Below Merwin Dam:* Inflows during 2020 allowed for minimum flow levels stipulated in the June 26, 2008 FERC licenses to be met. In general, annual flows below Merwin Dam were lower than the 10-year average (Figure 1.0-2).

- *Floating Surface Collector (FSC) Summer Outage and Maintenance Period:* In March 2015, the ACC accepted operational changes that allowed the FSC to be turned off during warm reservoir conditions that occur in the summer. This was done because data indicated that once reservoir surface temperatures reach approximately 18°C, catch rates of fish declined precipitously. Those fish that were collected also experienced high levels of mortality. Annual maintenance activities are to be performed during this summer outage period. It was also decided that while the FSC was off line, operation of the Merwin Dam Adult Fish Facility would be changed from a seven-day per week schedule to a five-day per week schedule. This temporary schedule allows the fish lift and conveyance system to remain operational seven days per week; however, daily sorting of fish only occurs Monday through Friday. These operational changes continued to be followed in 2020. A detailed description of these changes can be found in the Lewis River Fish Passage Program Annual Report for 2015 (PacifiCorp 2015).

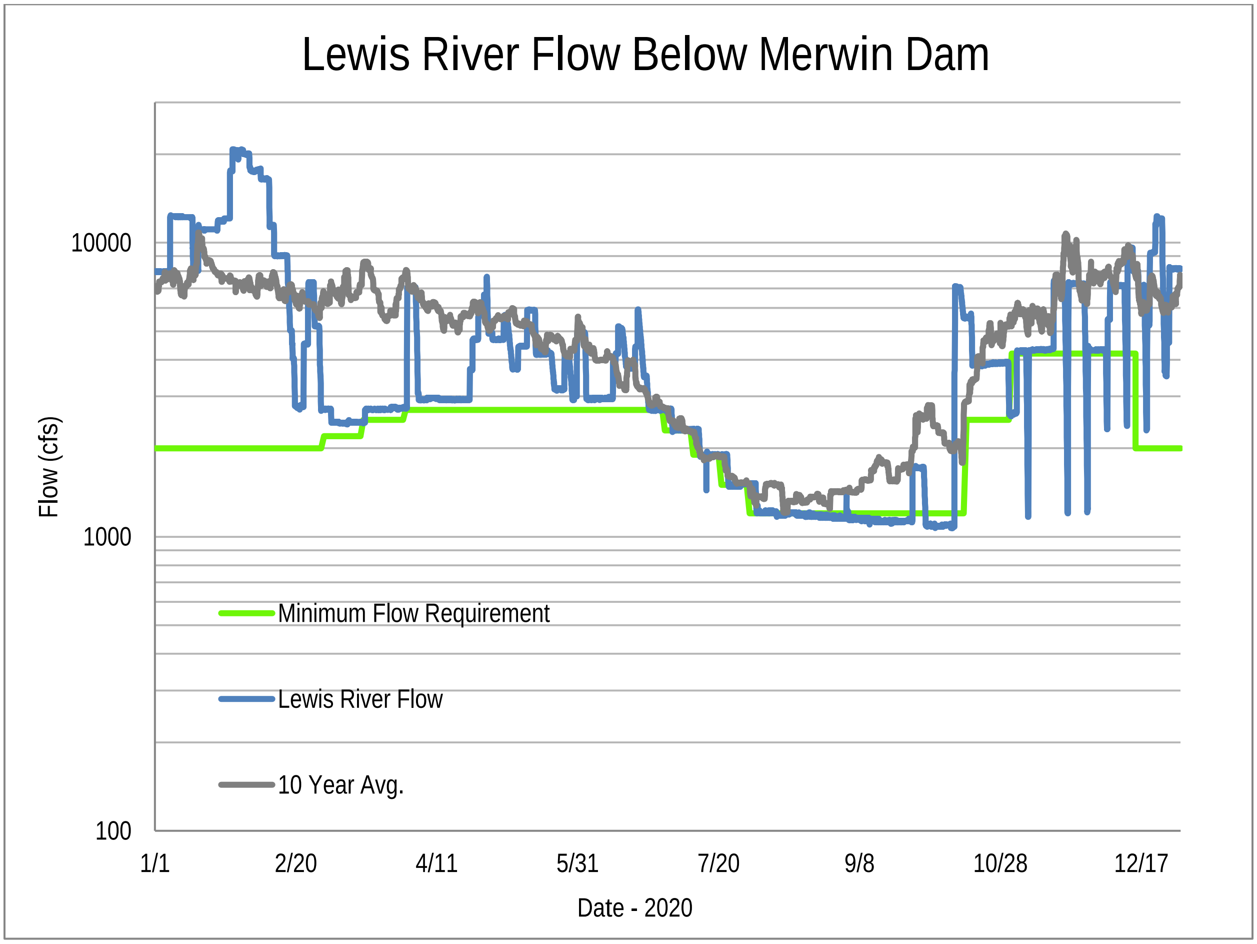

Figure 1.0-2. Lewis River flow below Merwin Dam as recorded by USGS gage (14220500 Ariel WA). Minimum flow requirements are also shown. The sharp 'dips' in flow during November and December are scheduled drawdowns associated with WDFW fall Chinook carcass surveys. (Note: lines above may not be exact due to calibration anomalies.)

- *Modification of the Supplementation Protocols for Adult Coho Transported Upstream of Swift Dam:* In July 2015, the Lewis River Aquatic Technical Subgroup (ATS) formally the Hatchery and Supplementation (H&S)[2] subgroup met to discuss the protocol for adult coho supplementation upstream of Swift Dam in fall 2015. As part of this discussion, several important modifications were proposed and were ultimately accepted by the ACC during the August 2015 meeting. A detailed description of these protocol changes can be found in the Lewis River Fish Passage Program Annual Report for 2015 (PacifiCorp 2015) and briefly described below:
    - Reduction in the number of coho supplemented from 9,000 to 7,500 adults upstream of Swift Dam;

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[2] In December 2018, the H&S subgroup voted to change the group's name to the Aquatic and Technical Subgroup (ATS) to reflect the expanded technical role of the group, which included Monitoring and Evaluation related topics.

  - The addition of late-run (Type – N) coho as an upstream supplementation species; and

  - Extending the upstream transport schedule to include both early (Type – S) and late (Type – N) stocks of adult coho.

  At the September 2019 ACC meeting, adult coho release strategies were reviewed, and restored back to 9,000 adults to be transported upstream. The proportion of fish distributed between early- verses late-stock, and natural- verses hatchery-origin remained the same in 2020 and as outlined in the current Annual Hatchery and Supplementation Operating Plan (PacifiCorp and Cowlitz PUD 2014).

- *Releases of Acclimation Fish Changed From Upstream Releases to Downstream Releases:* On May 31, 2018, the Lewis River ATS (formally the H&S subgroup) met to discuss the spring Chinook Acclimation Program above Swift Dam. The original program called for 100,000 hatchery reared juvenile spring Chinook salmon to be released at various acclimation sites upstream of Swift Dam. These fish would then be held for up to a month before being released and allowed to volitionally migrate downstream. The primary purpose of the program was to promote the distribution of returning adults throughout the available upper basin habitat for spawning. As naïve hatchery spring Chinook adults transported above Swift Dam in 2017 and 2018 spawned widely across the available habitat (i.e., throughout the upper North Fork Lewis River and Muddy River watersheds), it was thought that the acclimation of juvenile spring Chinook may not be necessary. It was recommended that releasing an additional 100,000 fish in the lower river to return as adults and be taken upstream would be a better strategy to meet recovery goals.

  PacifiCorp developed a release strategy memo that outlined three potential options for releasing the 100,000 spring Chinook smolt formally allocated to the upper basin acclimation ponds over the next five years (2019 – 2024). A copy of the memo can be found in the Lewis River Fish Passage Program 2018 Annual Report (PacifiCorp 2019). The ATS recommended that beginning in 2019, all juvenile spring Chinook formally allocated to the upper basin release ponds will be fully integrated into the existing Lewis River hatchery spring Chinook program, thereby increasing the overall annual program goal from 1.25 to 1.35 million per year. By increasing hatchery production in the lower river and ultimately returning adults, more adults will be available to be taken upstream as part of the reintroduction efforts. This increase in fish numbers would also help to increase sample sizes for spring Chinook as part of the ongoing ATS release strategy evaluation. This action was discussed and approved at the June 14, 2018 Lewis River ACC Meeting. These recommendations by the ATS were adopted beginning in 2019 and continued in 2020.

- *Acclimation Pond Decommissioning:* On December 5, 2017, PacifiCorp filed with FERC a request for Commission approval to decommission the juvenile fish acclimation pond facilities located along the Muddy River, Clear Creek and upper Lewis River near Crab Creek within the Gifford Pinchot National Forest. On January 4, 2018, the Commission responded with an order approving the December 5, 2017 request. The acclimation site located on the Muddy River was decommissioned from August through October of 2018. The acclimation sites located along Clear Creek and in the upper Lewis River near Crab Creek were both decommissioned from August through November 2019. All sites were restored to pre-construction condition. The final decommissioning report was filed with FERC on December 12, 2019 (a copy of the filing can be found in the Lewis River Fish Passage Program 2019 Annual Report; PacifiCorp 2020).

- *Nutrient Enhancement Above Swift Dam:* The possibility of using surplus hatchery-reared adult coho carcasses for nutrient enhancement upstream of Swift Dam was originally discussed at the June 27, 2019 Lewis River ATS Meeting. The general consensus was that if enough carcasses were available and there was staffing to help support the distribution of carcasses, this effort should be considered on an annual basis. The use of adult coho carcasses for nutrient enhancement above Swift Dam in fall 2019 was approved by the Lewis River ACC at the July 11, 2019 meeting. This initial effort was considered a pilot year with the support of Lower Columbia Fish Enhancement Group (LCFEG), Washington Department of Fish and Wildlife (WDFW), United States Forest Service (USFS), and the Utilities. A total of 1,850 adult coho carcasses were evenly distributed at three locations in the upper basin of the Lewis River that first year, and those efforts were summarized in the Lewis River Fish Passage Program 2019 Annual Report; PacifiCorp 2020). Based on the success of the 2019 effort, the intent was to continue nutrient enhancement efforts above Swift Dam in 2020; however, there was uncertainty on whether these efforts could occur with COVID-19 protocols in place. Fortunately, enhancement efforts did occur, and was led by LCFEG. A total of 1,446 adult coho carcasses were eventually distributed in 2020 among the three sites previously identified. A summary of this effort is provided in Appendix A.

- *Adjustments to Annual Rainbow Trout Stocking into Swift Reservoir*: At the October 8, 2020 meeting, the ACC approved a reduction in the number of resident rainbow trout being stocked annually into Swift Reservoir from 20,000 pounds to 14,400 pounds beginning in spring 2021. This reduction was made over concern of possible direct and/or indirect effects of these fish on juvenile salmon and steelhead in both Swift Reservoir and below Merwin Dam when they are transported downstream incidentally with juvenile out-migrants. To offset this reduction, an additional 5,600 will be stocked in the Swift No.2 power canal located just below Swift Dam for recreational fishing opportunity in the area. This decision was intended to be temporary and serves as a placeholder action until a more long-term solution can be determined. The Utilities are required to stock 20,000 pounds of resident rainbow trout into Swift Reservoir annually in the spring for recreational fishing per the Lewis River Settlement Agreement (Section 8.6). A more detail description of this decision can be found in the October 8, 2020 meeting notes of Lewis River ACC.

- *Temporary Operational Changes due to COVID-19*: Temporary changes to daily fish passage operations were made due to the COVID-19 pandemic in 2020. In an effort to reduce the risk of COVID-19 transmission, PacifiCorp implemented a modified fish transport schedule at the Merwin Trap. Under this modified schedule, the fish lift and conveyance system operated 7-days per week, with fish sorting and transport taking place weekdays only. This modified schedule prevented the need to have contracted fisheries staff entering the Merwin Dam facility over the weekend, and thereby reducing the risk of COVID-19 transmission. This modified schedule at the Merwin Trap was implemented on March 21, 2020, and remained in effect until October 17, 2020 when a record number of adult coho began entering the trap and weekend operations were required. Daily operation of the Swift FSC was maintained throughout the spring of 2020 as overall fish numbers remained low, which allowed for reduced crew sizes.

2.0 PASSAGE FACILITIES

2.1 Swift Reservoir Floating Surface Collector

The Swift Reservoir FSC began daily operations on December 26, 2012. The facility is located at the south end of Swift Dam near the turbine intake (Figure 2.1-1), and consists of five primary structures:

- Fish Collection Barge
- Truck Access Trestle
- Mooring Tower
- Barrier and Lead (Guide) Nets
- Net Transition Structure

The FSC is a floating barge that measures 170 feet long, 60 feet wide and 53 feet tall. The purpose of the FSC is to provide attraction flow at the surface of the reservoir where juvenile salmonids are migrating and to capture them. Fish enter the FSC via the Net Transition Structure (NTS), which funnels water and fish into an artificial stream channel created by electric pumps. The stream channel then entrains and guides fish into the collection facility that automatically sorts fish by size (i.e., life-stage: fry, parr/smolt, and adult) and then routes them to holding tanks for biological sampling and transport downstream[3]. The artificial stream channel is maintained at a capture velocity of approximately 7 feet per second (fps) with 600 cubic feet per second (cfs) attraction flow during normal operations (80 percent of full flow capacity).

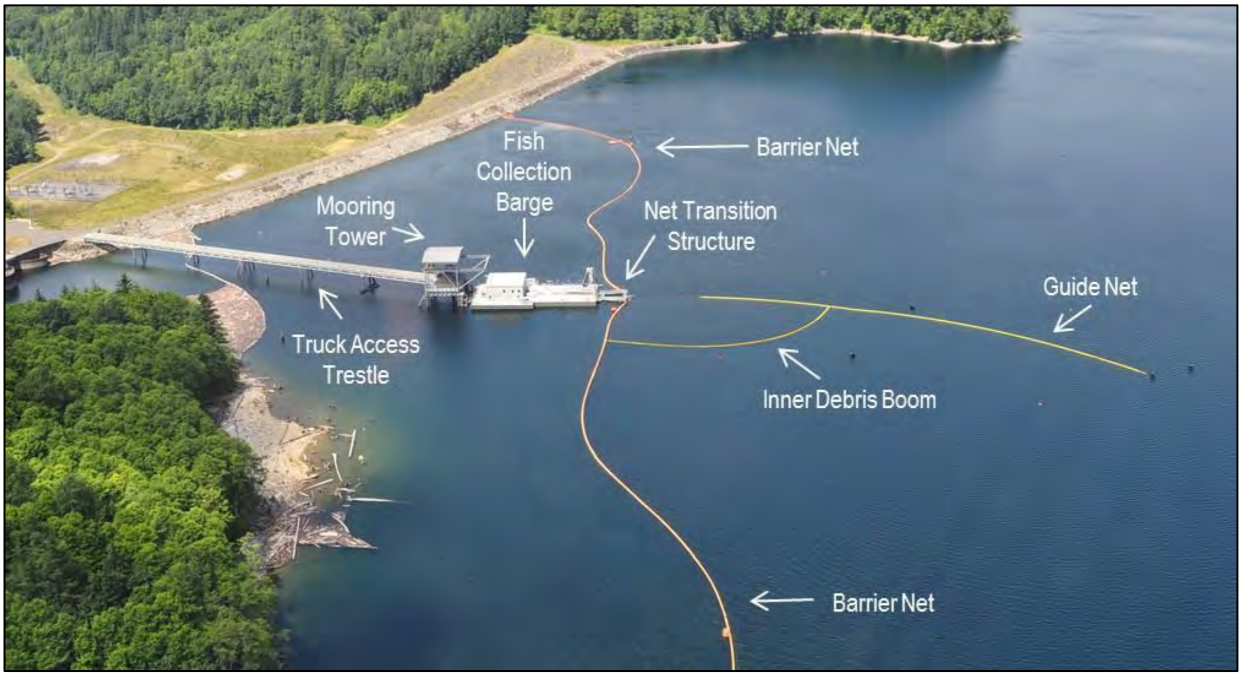

Figure 2.1-1. Aerial photo of the Swift Reservoir Floating Surface Collector.

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[3] Following transport downstream, out-migrants are released into the Woodland Releases Ponds located near Woodland, Washington. Fish are held in these ponds before being allowed to volitionally enter the lower Lewis River.

The purpose of the 660-foot access trestle is to provide fish transport trucks access to the 280-foot-tall mooring tower. The mooring tower doubles as a hopper-to-truck fish transfer structure, allowing operators to move fish from the FSC to the truck across a broad range of reservoir surface elevations[4].

The portion of the exclusion net located perpendicular to the front of the FSC is approximately 1,700 feet long and consists of three distinct vertical panel materials. The upper section of the net is solid material running 0-15 feet below the surface. The middle net section (15-30 feet) is fine net material (Dyneema™) with 1/8-inch mesh opening. The lower-most section (30 feet and beyond) is also constructed of Dyneema™ with 3/8-inch mesh opening. In addition to the forward-facing exclusion net, there are two side nets that begin at each of the turning points and extend to shore. Each side net is constructed of nylon material. The upper portion (0-15 feet) of the net has a mesh opening of 1/8-inch and the lower portion (15 feet and beyond) has a mesh opening of 3/8-inch.

Soon after the FSC began operation in late December 2012, the exclusion net sustained damage during severe weather conditions. The extent of this damage was evaluated with a number of dive and remotely operated vehicle (ROV) surveys of the net beginning in early February 2013. It was determined that the net separated at both north and south turning points. These tears compromised the effectiveness of the net throughout the 2013 migration season. Efforts to repair the net began in December 2013 and were completed by April 2014. During this repair period, the FSC was turned off. The FSC resumed operation on April 1, 2014.

In March 2016, a lead net was installed at the entrance of the FSC. The purpose of the lead net is to orient out-migrants towards the entrance of the collector and improve collection efficiency. The total length of the lead net is 650 feet and it is oriented nearly perpendicular to the existing FSC barrier net. The top 30 feet of the guide net is constructed from Dyneema© with a 3/32-inch mesh gap and the lower 30 feet is constructed from polyester with a 1/4-inch mesh gap, for a total net depth of 60 feet. The net originally extended approximately 30 feet inside the entrance of the existing NTS to prevent fish from easily swimming back out the opposite side of the FSC. However, it was found that this configuration was conducive for the net to block portions of the NTS's outer entrance, and would create hydraulic "hot spots" that would prevent fish from entering the FSC. In 2018, the lead net was removed from the inside of the NTS as to prevent this from occurring. In the modified configuration, the lead net now terminates approximately 20 feet from the outer entrance of the NTS.

The original entrance of the NTS measured 30 feet wide by 37 feet deep (1,110 square feet). The floor of the NTS then sloped up to a depth of 12 feet at the connection with the FSC fish channel. In February 2019, the NTS was modified to increase water velocity (i.e., attraction flow) at the entrance. A false floor was installed at a depth of 22 feet from the entrance of the FSC running horizontally downstream until connecting to the NTS floor at about half way down the flow-wise length of the NTS. In doing this the cross sectional area of the entrance was decreased from 1,110 square feet to 660 square feet. During the spring of 2019, the baffles of the dewatering screens in both the primary and secondary channels were re-tuned to operate under maximum attraction flow capabilities. This increased the FSC regular operating flow from 600 cfs to approximately 860 cfs. With the reduced area at the entrance of the NTS combined with high flow volume, the entrance water velocity at the FSC increased from 0.5 fps to approximately 1.3 fps.

In early 2020, the starboard fish conveyance flume was widened to allow woody debris to more readily pass through the system. The port fish conveyance flume was replaced in 2019 and this work was a

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[4] The Swift FSC has an operation range of approximately 100 feet in reservoir elevation change.

continuation of ongoing modifications designed to improvement debris management and improve fish survival within the FSC. In addition to the work on the fish conveyance flumes, new fish sorting bars were installed prevent debris build-up in the area were water and fish enter the sorting facility. No other substantial alternations or modifications were made to the FSC in 2020.

The FSC operated 24-hours a day through 2020 except during periods when it was necessary to shut the facility down due to power outages, debris removal, facility modification, or scheduled maintenance (Table 2.1-1).

Table 2.1-1. List of FSC outages that occurred in 2020

Date	Reason For Outage
1/1/20 - 3/1/20	Access stairs repairs, installation of surge suppression, and smolt flume modifications
03/03/20	Debris removal in fish channel
05/08/20 - 05/11/20	Debris removal and adult tank screen repair
07/17/20 - 10/14/20	Scheduled summer maintenance period
11/10/20 - 11/11/20	Electrical repairs to fry tank debris conveyor
12/24/20 - 12/31/20	Heavy debris loading and debris removal

2.2 Merwin Dam Upstream Collection Facility

The new upstream collection and transport facility (Figure 2.2-1) at Merwin Dam was considered substantially complete in April 2014. The intent of the modifications made to the existing collection facility was to provide safe, timely and effective passage of adult salmonids being transported upstream per the Lewis River SA, Section 4.1.4.).

The new facility was designed to be constructed in phases, offering the ability to incrementally improve fish passage performance (if needed) in the future to meet biological performance goals. Depending on the biological monitoring of the facility's performance (which began in spring 2015 and as outlined in Section 4.3 below), there are up to four additional phases that will increase flow into the fishway attraction pools, and add a second fishway with additional attraction flow, if necessary (per the Lewis River SA, Section 4.1.6.).

Phase I represents the initial construction, consisting of four major features (Figure 2.2-1):

- Auxiliary Water Supply Pump Station and Conveyance Pipe
- Fishway Entrance Number 1
- Fish Lift and Conveyance System
- Sorting Facility

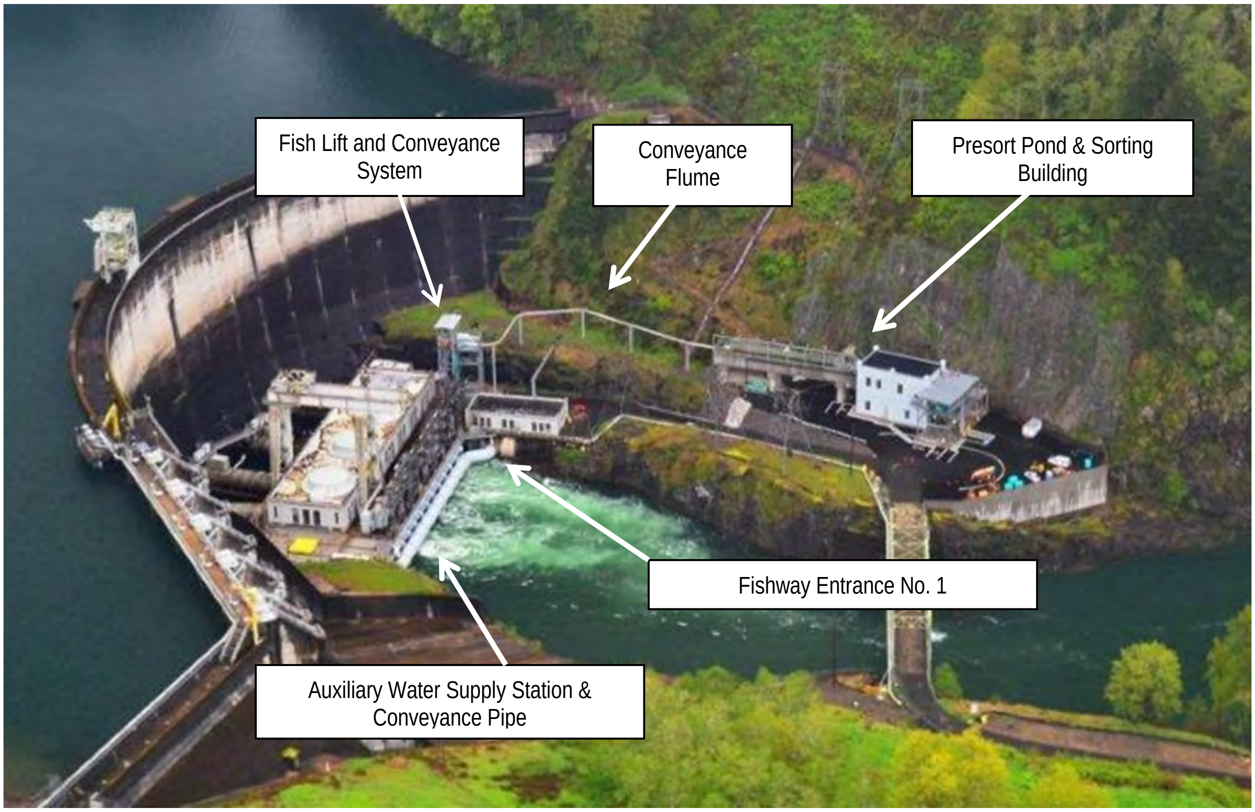


Figure 2.2-1. Merwin Dam Upstream Collection Facility.

The auxiliary water supply (AWS) system provides pumped water from the tailrace to the fishway entrance pools to attract fish from the tailrace. This system uses hydraulic turbines to power attraction water pumps. Tailrace water is used (as opposed to reservoir water) to allow generation with the attraction flow with the high head dam prior to the water's use in the fishway. The AWS system also includes a 108-inch pipeline and conveyance conduits to deliver the water from the tailrace to the lower fishway entrance pools (Pool 1-1). The AWS system has a flow capacity of 400 cfs attraction flow (Phase 1) with the capacity to increase flows to 600 cfs (Phase 2) if needed.

The entrance of Fishway 1 is located in the tailrace of Merwin Dam adjacent to the discharge of Turbine Unit 1 in the south corner of the powerhouse. The entrance pool (Pool 1-1) contains flow diffusers that introduce the AWS attraction water flow along the Pool 1-1 walls. The diffusers are made of construction pickets with 7/8-inch clear spacing, with baffle panels mounted immediately upstream of the diffusers to dissipate energy and provide uniform flow across the diffusers. Upstream of the lower entrance pool (Pool 1-1) are a series of ladder steps. The ladder has two intermediate pools (Pool 1-2 and Pool 1-3) leading to a loading pool (Pool 1-4). The fish ladder is designed to operate at 30 cfs, and is a "vertical slot" style fish ladder. Water is supplied from hatchery return line (HRL) (approximately 11 cfs) and the ladder water supply (LWS) system (approximately 19 cfs). The vertical slots allow the pool levels to self-regulate the water surface elevation. Depending on tailrace elevation, the designed water elevation changes between pools ranges from 0.25 to 1.0 foot.

To prevent fish from returning to the tailrace once they have entered the lower fish ladder, a vertical fyke was installed on the upstream side of the Pool 1-2 weir in November 2016. The "V" style fyke was constructed with one inch stainless steel bars with a spacing of two inches on center and has an exit slot width of six inches.

The loading pool (Pool 1-4) is the last in the fishway and contains the fish crowder which automatically loads fish into the hopper of the lift and conveyance system. The lift and conveyance system then transports fish from the fish ladder over to the sorting building. Fish are transported from the top of the elevator shaft to the pre-sort pond by the 16-inch-diameter conveyance flume (Figure 2.2-2). Fish are held in the Pre-sort Pond until they are sorted by biologists on a daily basis.

All fish sorting is performed manually on the sorting table within the sorting building. Fish are moved from the Pre-sort Pond into the sorting building via a false weir and crowder system. An electro-anesthesia (EA) system temporarily anesthetizes the fish to allow easier handling by staff and to reduce the stress of handling on the fish during sorting. Once sorted, fish are routed into holding tanks for transport by truck to their final destination (i.e., transported upstream, to the hatchery, or returned to the lower Lewis River).

The Merwin Dam Upstream Fish Collection Facility operated 24-hours a day through 2020 except during periods when it was necessary to shut the facility down due to tailrace water elevation exceeding the facility's operational limits, facility modifications, scheduled maintenance, or emergency repairs (Table 2.2-1).

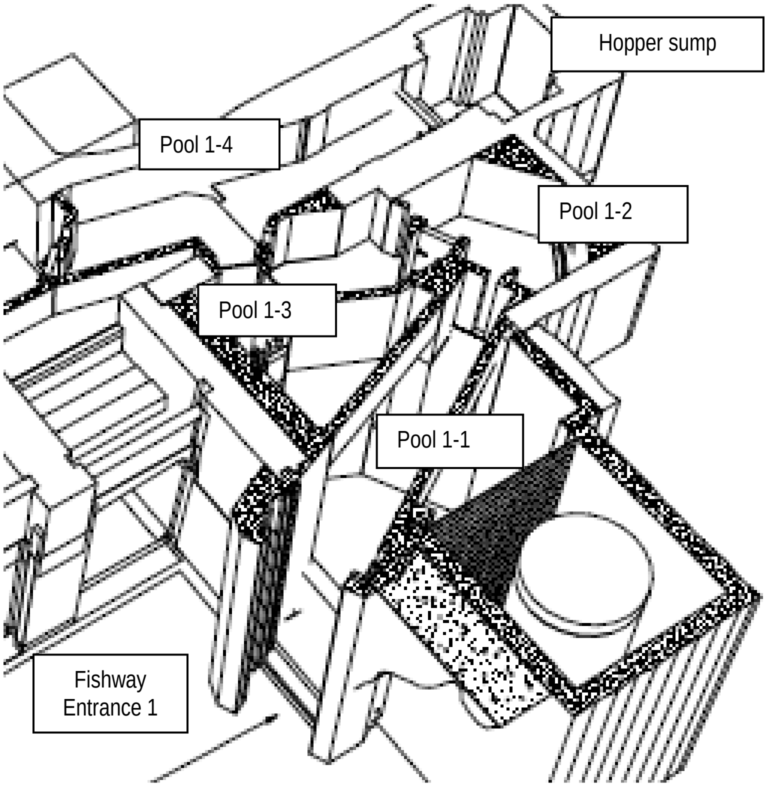


Figure 2.2-2. Merwin Dam fish ladder entrance and pool configuration.

Table 2.2-1. List of scheduled and unscheduled outages at the Merwin Fish Sorting Facility in 2020.

Outage Duration	Purpose for Outage
1/27/20 - 2/13/19[a]	Tailwater elevation exceedance (high water spill event)
5/22/20 - 5/28/20	Broken cable on fish crowder
6/30/20[a]	Brush replacement on vertical crowder
7/28/20 - 7/29/20[b]	COVID-related staffing issues
8/31/20 - 9/3/20	Scheduled quarterly maintenance
10/31/20 - 11/3/20	Cable replacement on crowder assembly
11/9/20 - 11/12/20	Sheave replacement on crowder assembly
12/9/19	Limit switch replacement
12/16/20 - 12/31/20	Crowding assembly track repair

[a] The fish ladder and fyke remained operational - only the fish lift and conveyance system was not operated.

[b] The fish ladder, lift and conveyance system remained operational – only fish were not sorted and transported at the facility.

2.3 Woodland Release Ponds

Construction of the Woodland Release Pond Facility was completed on December 15, 2017. The facility's purpose is to allow for stress reduction and determination of transport survival for out-migrants transported downstream from the Swift FSC before volitional release into the lower Lewis River at approximately river mile 8.5.

The Woodland Release Pond Facility is comprised of four cast in place concrete smolt release ponds (Figure 2.3-1). Each pond has a volume of 1,760 cubic feet and a 475 gallon per minute continuous flow rate. Water is supplied by a series of alternating pumps that lift water from the main river channel and into the ponds. Once transferred from the transport truck to the ponds, fish are held for approximately 24-hours and any mortalities are manually enumerated. Following the holding period, an isolation gate is lifted and out-migrants are allowed to exit the ponds volitionally. Any remaining fish are forced from the ponds within 48 hours. Out-migrants exit through a fish transfer flume and outfall into the lower Lewis River.

The Woodland Release Ponds were operated in concurrence with the Swift FSC operation, and no unscheduled outages were necessary in 2020. When circumstances required an alternate release location, out-migrates transported from the Swift FSC were released directly into the lower Lewis River at the WDFW boat ramp on Pekin Ferry Rd. at approximately river mile 3.0.

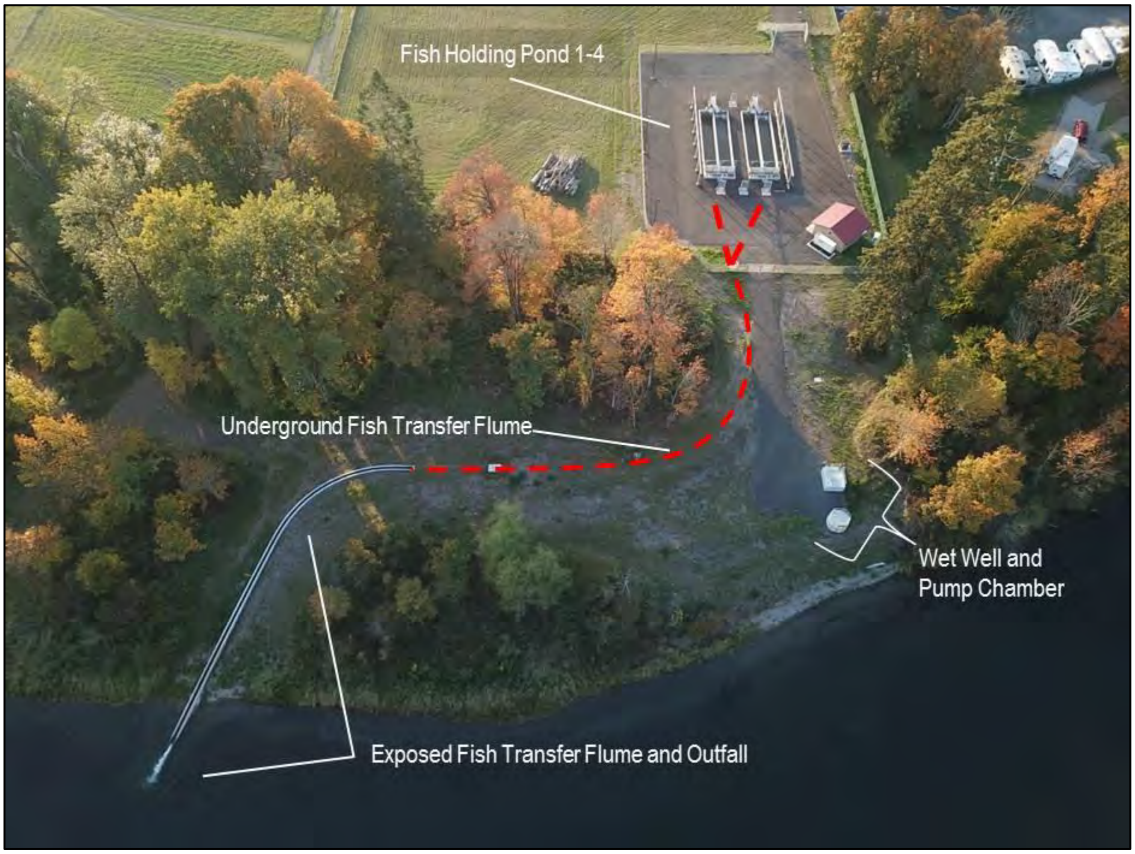


Figure 2.3-1. Aerial photo of the Woodland Release Ponds and associated infrastructure near Woodland, WA.

3.0 DOWNSTREAM COLLECTION AND PASSAGE METRICS

3.1 Number of Juveniles Entering Swift Reservoir

3.1.1 Overview/Methods

Developing an annual estimate of the total number of juveniles entering Swift Reservoir is required under Section 9.2.1 of the SA and is identified as Objective 7 of the M&E Plan. Historically, numbers of juveniles entering Swift Reservoir were estimated through screw trap operations in the mainstem of the North Fork Lewis River near Eagle Cliff during the spring outmigration period from approximately mid-March through the end of June each year. However, historic data from the FSC indicate that a considerable number of juvenile anadromous fishes likely migrate into Swift Reservoir out-side of the March-June screw trap operation period. Additionally, these historical estimates do not include fish that enter Swift Reservoir from reservoir tributaries (e.g., S20, Swift, Drift creeks, etc.).

The revised M&E Plan addressed this issue by dividing Objective 7 into two separate parts. The first part (Objective 7, Task 7.1) estimates the timing and number of juveniles entering Swift Reservoir from the Upper North Fork Lewis River sub-basin through traditional screw trapping operations near Eagle Cliff during the traditional spring migration period (March – June). Because unsampled periods and reservoir tributaries were not accounted for in this analysis, this information is to serve as an annual index that could be compared over the same general time period among years. The second part (Objective 7, Task 7.2) estimates the total number of juveniles entering Swift Reservoir in a given year from annual Passive Interrogated Transmitter (PIT) tag data collected at the Swift FSC.

Objective 7 Task 7.1

Following the M&E Plan, weekly estimates of the total juvenile out-migration by species during the trapping season were calculated using the formula for use of a single partial trap described in Volkhardt et al. (2007), in which the estimated number of unmarked fish migrating during discrete sample period *i* ($\hat{U}$), weekly or monthly, is dependent on actual recapture rates observed:

$$\hat{U}_i = \frac{u_i(M_i+1)}{m_i+1} \quad \textbf{Equation 3.1-1}$$

Where:

u_i = Number of unmarked fish captured during discrete period *i*
M_i = Number of fish marked and released during period *i*
m_i = Number of marked fish recaptured during period *i*

Discrete sample period variance:

$$V(\hat{U}_i) = \frac{(M_i+1)(u_i+m_i+1)(M_i-m_i)u_i}{(m_i+1)^2(m_i+2)} \quad \textbf{Equation 3.1-2}$$

Weekly estimates of juvenile migration were combined to calculate the total number of juveniles migrating downstream during the monitoring period (season) using the following formula:

$$\hat{U} = \sum_{i=1}^{n} \hat{U}_i \quad \textbf{Equation 3.1-3}$$

Entire monitoring period variance:

$$V(\hat{U}) = \sum_{i=1}^{n} V(\hat{U}_i) \quad \textbf{Equation 3.1-4}$$

95 percent Confidence Interval:

$$\hat{U} \pm 1.96\sqrt{V(\hat{U})} \quad \textbf{Equation 3.1-5}$$

In addition, total estimates of fish passing the trap and their associated 95 percent confidence intervals were generated using the Bootstrap Method (Thedinga et al. 1994).

Objective 7 Task 7.2

Using PIT tag records from the FSC, PIT tagged fish used to estimate the Eagle Cliff screw trap efficiency are also to be used to estimate the joint probability of focal fishes that survive passage through Swift Reservoir and are captured by the FSC (Overall Downstream Survival [ODS] see Section 3.7

below). These data are also to be used to estimate the total number of juvenile migrants in Swift Reservoir using mark-recapture.

Recent hydroacoustic and PIT tag re-capture information has shown reservoir hold-over/rearing from one year to the next (Reynolds et.al 2015; Caldwell et.al 2017; Anchor QEA 2018; PacifiCorp 2019). Comparing the size class of fish captured at the screw trap to those at the FSC, in addition to assessing long-term mark-recapture data, may be used to parse yearly estimates of total fish (by species) entering the reservoir by size/year class as the long-term mark-recapture data set is developed. For 2020, parsing was done based on length and separated (for all species) by fish less than 60 mm, fish between 60 and 79 mm, and fish greater than or equal to 80 mm.

Estimated number of juvenile fish entering Swift Reservoir during the entire migration period were calculated using Equation 3.1-1 above, where:

u_i = Total estimate of unmarked fish captured during the monitoring period at the FSC derived from equation 3.2-1 in Section 3.2;

M_i = Number of fish marked and released during the monitoring period from the screw trap; and

m_i = Number of marked fish recaptured during the monitoring period at the FSC.

Discrete sample period variance was calculated using bootstrap methodology (Thedinga et al. 1994). The 95 percent confidence interval was calculated using Equation 3.1-5 above.

3.1.2 Results/Discussion

Objective 7 Task 7.1

A detailed technical memorandum describing the methods and results of the 2020 effort can be found in Appendix B. A summary of this report is provided below.

Field crews operated the Eagle Cliff 8-foot-diameter rotary screw trap (trap) from March 9, 2020 to July 15, 2020, and checked the trap on a daily basis. The trap was turned off (cone raised) on April 30, 2020 to make repairs. The trap was re-initiated that same day.

A total of 1,502 coho and 18 Chinook salmon, and 260 rainbow/steelhead and 60 cutthroat trout were marked and released upstream of the trap to estimate trap efficiency via mark-recapture (Table 3.1-1). Fish were marked with a PIT tag or alcian blue tattoo. Only fish great than 60 mm FL were used for mark-recapture efficiency tests. Due to low capture rates, all salmonid species efficiency tests were combined to generate weekly trap efficiency estimates (Table 3.1-2). It is important to note that all Chinook captured in the screw trap in 2020 were of natural origin. No hatchery-raised spring Chinook that were formally stocked as acclimation juveniles have been planted above Swift Dam since August 11, 2017.

Overall, out-migrating salmonids collected at the screw trap ranged in size from less than 60 mm to slightly greater than 300 mm in length (Figures 3.1-1 and 3.1-2), though one adult cutthroat over 400 mm in length was collected. The majority of juvenile coho (77 percent), Chinook (63 percent), and rainbow/steelhead (60 percent) captured were less than 80 mm in fork length (FL).

Capture timing for both juvenile coho and rainbow/steelhead remained consistently low for much of March and through early-May with the majority of fish coming out in late-May and June (Figures 3.1-3 and 3.1-4). There were too few captures of juvenile Chinook and cutthroat to form any discernable run timing, but generally speaking they appeared to have a similar pattern as to coho and rainbow/steelhead.

In total, 69,714 coho, 539 naturally produced Chinook, 11,514 rainbow/steelhead, and 1,047 cutthroat were estimated to pass the trap during trapping operations using the Bootstrap Method (March 9 to July 15, 2020; Table 3.1-3). The difference between the total outmigration estimates by species generated by the Bootstrap and Volkhardt methods is not statistically significant. These estimates should only be viewed as an index of the total fish that passed the trap during the trapping period (~March through June) and not total species out-migration abundance for the year.

Table 3.1-1. Summary of Eagle Cliff screw trap total captures, 2020.

Species	Total Hatchery Produced ≥ 60 mm FL	Total Naturally Produced < 60 mm FL	Total Naturally Produced ≥ 60 mm FL	Total Marked - Released Upstream ≥ 60 mm FL	Total Recaptures
Coho Salmon	NA	1,422	1,914	1,502	81
Chinook Salmon	NA	9	18	18	3
Steelhead Trout	NA	296	264	260	12
Rainbow Trout	3	0	1	0	NA
Cutthroat Trout	NA	0	61	60	2
Bull Trout	NA	0	42	0	NA
All Salmonids Combined		*1,727*	*2,300*	*1,840*	*98*

Species	Total
Dace	8
Lamprey	2
Sculpin	94
Sucker	3
Three-spined Stickleback	6
Whitefish	5

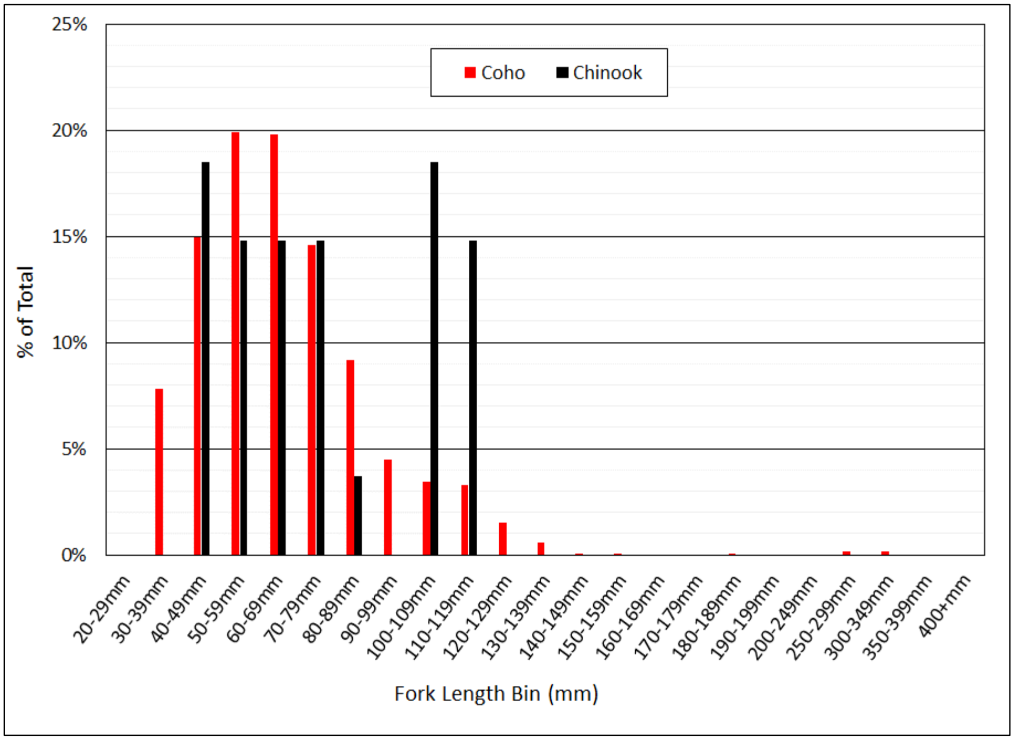


Figure 3.1-1. Length frequency distribution of juvenile salmon, 2020.

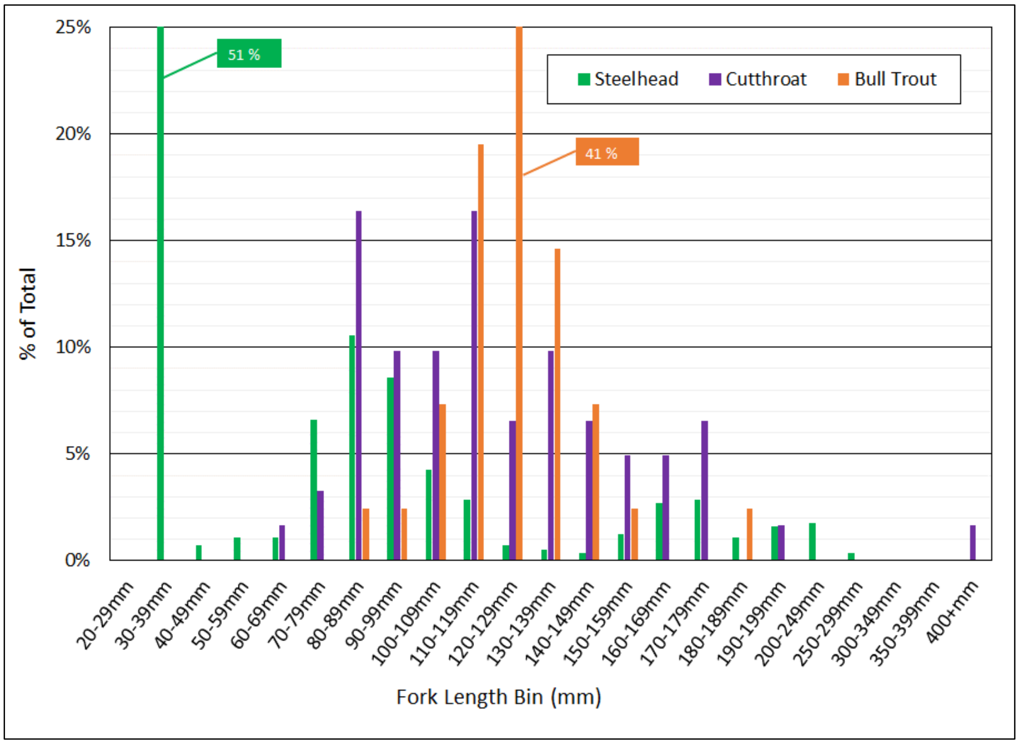


Figure 3.1-2. Length frequency distribution of naturally produced trout/char, 2020.

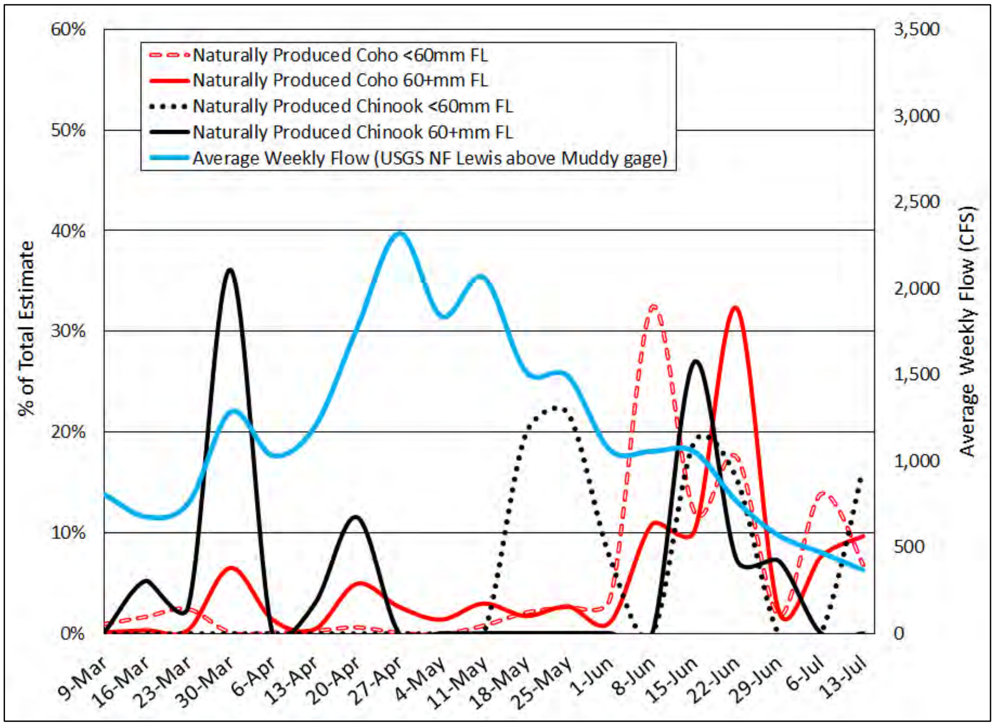


Figure 3.1-3. Naturally produced salmon migration timing, 2020.

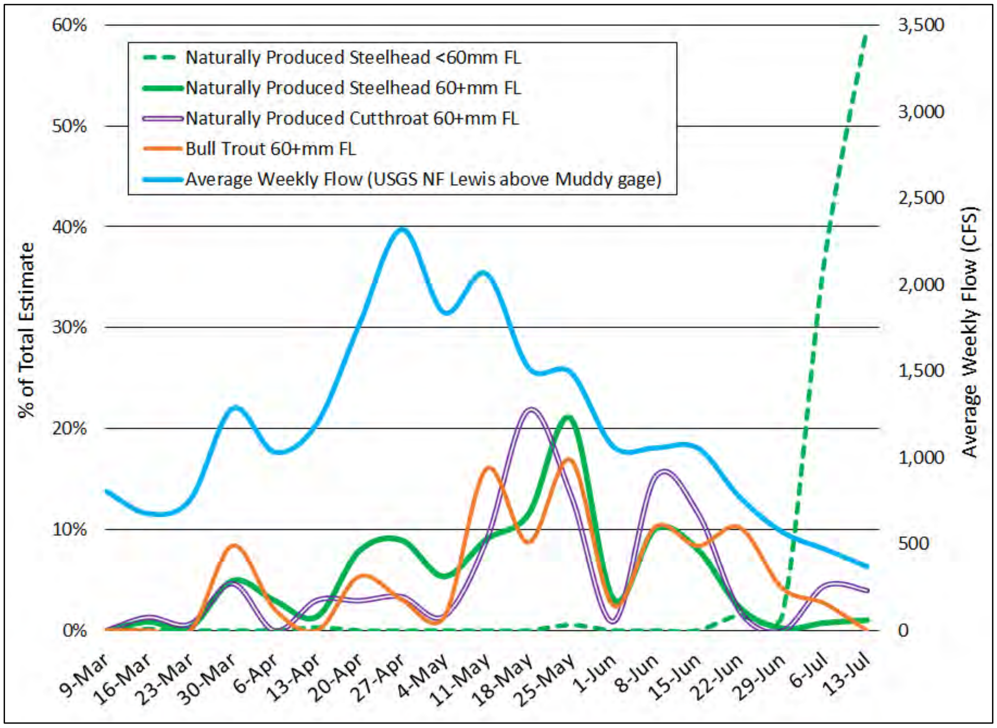


Figure 3.1-4. Naturally produced trout/char migration timing, 2020.

Table 3.1-2. Summary of mark-recapture tests of trap efficiency for the Eagle Cliff screw trap, 2020.

Week (first day)	Total Salmonids **Caught ≥60** mm Fl[A]	Total Marked & Released Upstream **≥60 mm FL**	Total Recaptured	Trap Efficiency	Average Weekly Flow (cfs)[B]	Weekly Average Cone RPMs	Adjusted Efficiency Based on Flow
3/9/2020	8	8	1	0.125	807	3.4	0.125
3/16/2020	22	22	1	0.045	676	3.0	0.083[C]
3/23/2020	18	14	2	0.143	757	3.3	0.083
3/30/2020	83	83	2	0.024	1,284	3.9	0.024
4/6/2020	41	40	2	0.050	1,032	3.0	0.050
4/13/2020	27	27	2	0.074	1,200	3.2	0.074
4/20/2020	53	53	1	0.019	1,771	4.3	0.019
4/27/2020	61	60	2	0.033	2,320	6.2	0.033
5/4/2020	78	77	6	0.078	1,839	5.3	0.078
5/11/2020	79	79	3	0.038	2,064	5.1	0.038
5/18/2020	45	43	1	0.023	1,519	3.4	0.023
5/25/2020	119	119	5	0.042	1,491	3.4	0.042
6/1/2020	90	90	11	0.122	1,064	3.1	0.122
6/8/2020	169	169	5	0.030	1,057	3.0	0.030

Week (first day)	Total Salmonids **Caught ≥60** mm Fl[A]	Total Marked & Released Upstream **≥60 mm FL**	Total Recaptured	Trap Efficiency	Average Weekly Flow (cfs)[B]	Weekly Average Cone RPMs	Adjusted Efficiency Based on Flow
6/15/2020	129	124	3	0.024	1,055	3.1	0.024
6/22/2020	855	470	28	0.060	768	2.8	0.060
6/29/2020	124	124	15	0.121	569	2.9	0.121
7/6/2020	132	132	5	0.038	471	1.9	0.038
7/13/2020	124	106	3	0.028	369	1.8	0.028
Total	*2,257*	*1,840*	*98*	*0.053*			

[A] Total Coho, Chinook, Steelhead, and Cutthroat (Bull Trout were not used for efficiency tests as specified in the ESA take permit). Rainbow Trout (1 naturally produced, and 4 hatchery produced) were also not used for efficiency tests.

[B] USGS Gage 14216000 Lewis River Above Muddy River Near Cougar, WA.

[C] Combined efficiency measured during weeks with similar and constant mean daily flow after review of full hydrograph (weeks of 16-March and 23-March).

Table 3.1-3. Estimates of total naturally produced salmonids passing the Eagle Cliff trap (2020) by species.

Species	Capture Efficiency Applied	Total Maiden Captures	Bootstrap Method Mean Estimate (95% CI) (CV%)	Volkhardt Method Estimate (95% CI) (CV%)
Coho (< 60 mm FL)[a]	0.045	1,422	32,489 (+/- 10,850) (17%)	29,952 (+/- 10,577) (18%)
Coho (60-79 mm FL)[b]	0.047	1,147	25,021 (+/- 8,314) (17%)	21,324 (+/- 6,394) (15%)
Coho (≥ 80 mm FL)[c]	0.063	767	12,204 (+/- 3,669) (15%)	13,694 (+/- 4,886) (18%)
Total Coho Estimate		3,336	69,714 (+/- 14,152) (10%)	64,970 (+/- 13,290) (10%)
Chinook (< 60 mm FL)[a]	0.045	9	205 (+/- 146) (36%)	198 (+/- 157) (41%)
Chinook (60-79 mm FL)[b]	0.047	8	173 (+/- 137) (40%)	196 (+/- 190) (50%)
Chinook (≥ 80 mm FL)[c]	0.063	10	161 (+/- 107) (34%)	227 (+/- 224) (50%)
Total Chinook Estimate		27	539 (+/- 227) (22%)	620 (+/- 333) (27%)
Steelhead (< 60 mm FL)[a]	0.045	296	6,769 (+/- 2,403) (18%)	6,662 (+/- 3,822) (29%)
Steelhead (60-79 mm FL)[d]	0.045	43	996 (+/- 460) (24%)	1,186 (+/- 987) (42%)
Steelhead (≥ 80 mm FL)[e]	0.060	221	3,749 (+/- 1,045) (14%)	4,278 (+/- 1,586) (19%)
Total Steelhead Estimate		560	11,514 (+/- 2,660) (12%)	12,126 (+/- 4,254) (18%)
Cutthroat (< 60 mm FL)	NA	None		
Cutthroat (60-79 mm FL)[d]	0.045	3	70 (+/- 82) (60%)	69 (+/- 91) (68%)
Cutthroat (≥ 80 mm FL)[e]	0.060	58	977 (+/- 347) (18%)	1,306 (+/- 623) (24%)
Total Cutthroat Estimate		61	1,047 (+/- 357) (17%)	1,375 (+/- 630) (23%)
Bull Trout (< 60 mm FL)	NA	None		
Bull Trout (60-79 mm FL)	NA	None		
Bull Trout (≥ 80 mm FL)[e]	0.060	41	692 (+/- 270) (20%)	802 (+/- 349) (22%)
Total Bull Trout Estimate		41	692 (+/- 270) (20%)	802 (+/- 349) (22%)

[a] Capture efficiency applied based on all salmonids combined 60-79 mm, 807 marked and 36 recaptured (< 60 mm not marked).

[b] Capture efficiency applied based on Coho and Chinook combined 60-79 mm, 764 marked and 36 recaptured.

[c] Capture efficiency applied based on Coho and Chinook combined ≥ 80 mm, 756 marked and 48 recaptured.

[d] Capture efficiency applied based on all salmonids combined 60-79 mm, 807 marked and 36 recaptured.

[e] Capture efficiency applied based on all salmonids combined ≥ 80 mm, 1,033 marked and 62 recaptured.

Shown below in Table 3.1-4 is a comparison of migration estimates for fish (greater than or equal to 60 mm fork length) passing Eagle Cliff based on seasonal screw trapping (similar to that described above) from 2016-2020. Compared to the past five years, estimates derived for juvenile coho, rainbow/steelhead, and cutthroat in 2020 were similar with estimates derived in previous years. Juvenile coho saw the largest estimate to date in 2020, although estimates have remained generally similar for coho since 2017. Estimates for rainbow/steelhead have remained generally similar from year to year. Yearly cutthroat estimates are very similar over this time period. Among the species evaluated, estimates for juvenile Chinook have been the most varied during the sampling period, likely because adult spring Chinook transport upstream of Swift Dam is highly variable each year due to variability in returns to the Lewis River basin. Overall, estimates for juvenile Chinook have remained low (20-588 fish annually) over the years except in 2019 when 4,120 fish were estimated passing the screw trap during the sampling period.

Table 3.1-4: A summary of screw trap Bootstrap Method estimates for each species from 2016-2020. Estimates are for fish greater than or equal to 60 mm fork length.

Year	Trap Operation Period	Coho		Chinook		Steelhead		Cutthroat	
		Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
2016	3/24 to 6/30	7,164	4,485	77	100	3,832	1,976	1,104	623
2017	4/20 to 5/30	33,385	10,212	20	38	2,366	615	1,057	355
2018	3/13 to 6/30	22,974	4,509	588	218	3,195	767	1,365	385
2019	3/5 to 7/19	31,071	6,258	4,120	1,170	4,855	1,168	1,050	348
2020	3/9 to 7/15	37,225	9,087	334	174	4,745	1,142	1,047	357

Objective 7 Task 7.2:

All PIT tags used in the screw trap operations at Eagle Cliff (Task 7.1 above) were also used in Task 7.2. In addition to these tags, PacifiCorp also PIT tagged juvenile coho captured at the FSC and released them at the head of Swift Reservoir. This was done to bolster sample size of ODS estimates. Combining these data, a total of 1,452 coho, 194 Chinook, 343 steelhead, and 59 cutthroat juveniles were tagged and released at the head of Swift Reservoir for analysis. It is important to note that within each species pooled group exists different cohorts of fish that were tagged either from the Eagle Cliff screw trap or Swift FSC. The bootstrapping methodology was applied to estimate both the mean and variances of the total number of fish per species entering Swift Reservoir during 2020. From this analysis, it was estimated that 148,552 coho, 84,291 Chinook, 38,864 steelhead, and 15,765 cutthroat juveniles entered Swift Reservoir during 2020 (Table 3.1-5). These estimates only consider fish parr size and greater (i.e., ≥60 mm FL), which could be PIT tagged. Comparing these estimates to the number of juveniles estimated to pass Eagle Cliff during screw trapping operations in 2020 suggests that the majority of juvenile fish enter Swift Reservoir during times when the screw trap was not in operation and/or from other independent Swift Reservoir tributaries outside the upper NF Lewis River watershed.

Table 3.1-5. Estimates of total naturally produced fish (adipose fin intact and ≥60 mm FL) entering Swift Reservoir during 2020 by species (bootstrap method).

Species	Tags Released	Tags Recaptured at FSC	Reservoir Survival (S_{RES}) Applied	Total untagged fish captured at FSC[A]	Bootstrap Mean Total Estimate	95% CI +/-
Coho	1,452	300	0.21	31,121	*148,552*	15,508
Chinook	194	36	0.19	15,724	*84,291*	25,152
Steelhead	343	38	0.11	4,170	*38,864*	12,425
Cutthroat	59	4	0.07	503	*9,250*	12,577

[A] Includes parr and smolt life-stages; no fry were PIT tagged.

Included in Task 7.2 is a comparison of size of fish captured at the screw trap to those at the FSC, in addition to a longer term assessment of mark-recapture data from PIT tags to parse yearly estimates of total of focal fish in the reservoir by size/year class. This additional analysis was not completed in 2020. For now, Task 7.2 should be interpreted as *'the number of fish in the reservoir in 2020'* as in previous years, rather than *'the number of fish that entered the reservoir in 2020'*.

3.2 Fish Numbers Collected at the FSC

3.2.1 Overview/Methods

Section 9.2.1(j) of the SA requires PacifiCorp to enumerate the number of salmonids collected at FSC (FSC_{COL}) by species and life-stage. This requirement is identified as Objective 6 in the M&E Plan. The M&E Plan originally stated that the number of juvenile fish entering the FSC would be calculated through both subsampling and by automatic fish counters. During development of the original M&E Plan, the accuracy of the automatic fish counters were unknown, thus conducting both methods of enumeration was recommended initially. However, during the operating years of 2013 and 2014, many tests and calibrations took place. From this work, it was ultimately determined that the scanners were unreliable, and falsely assigned debris and turbulence as fish. Because the automatic fish counters were shown to be unreliable for long term daily operation, estimating total number of fish collected at the FSC was achieved through subsampling counts as described in Section 2.6.1 of the current M&E Plan (2017); the key assumption inherent in the methodology is that the subsampled fish are representative of the general population.

Subsampling Counts

Diversion gates on the FSC allow for smolts to be diverted into either a subsample tank or a general population tank. The diversion gates operate on a time-driven interval within a ten minute time frame (i.e., during a 10 percent sample period the diversion gate would operate one minute out of every ten minute cycle). The intent is that during periods of low migration the sampling rate is set to 100 percent and all fish collected are manually biosampled and enumerated. When capture rates increase (i.e., during peak outmigration – historically April through June), only a portion of fish are sampled and the rest are diverted to the general population tanks (which are not enumerated or biosampled). As described in the current M&E Plan (2017), the daily subsample totals, as well as the associated variance estimators, are calculated by:

Total Number of Fish (subsampling period):

$$T = N\bar{y} = \frac{N}{n}\sum_{i=1}^{n} y_i \quad \textbf{Equation 3.2} - \textbf{1}$$

With associated variance estimator:

$$\boldsymbol{s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2} \quad \textbf{Equation 3.2} - \textbf{2}$$

And 95 percent Confidence Interval:

$$O + T \pm t_{(0.025,n-1)}\sqrt{\frac{N(N-n)s^2}{n}} \quad \textbf{Equation 3.2} - \textbf{3}$$

Where,

T = total number of fish during the subsampling period
O = total number of fish during 100 percent enumeration period
r = subsampling rate
n = number of sampling periods (days sampled)
N = n/r (sampling intensity)
y_i = discrete daily fish count
$\bar{y}$ = average number of fish counted per day
s^2 is the sample variance
t is the t-statistic for n-1 degrees of freedom and $\alpha/2$

The Swift FSC did not operate during January and February 2020 due to modifications being completed to the smolt conveyance flume leading to the starboard smolt sample tank. The FSC was placed back into service on March 1, 2020 once the smolt flume modifications were completed. Sample rates were set to 100 percent for the first half of March due to manageable fish counts. The subsample rate was adjusted to 25 percent on March 17, 2020, where it remained until the FSC went into the summer maintenance period on July 17, 2020. For the period in which fish were subsampled, the equations described above were used to derive the total number of fish collected on a given day, as well as the associated variance and error.

3.2.2 Results/Discussion

A total of 54,932 (95 percent CI range: 46,402 - 63,462) salmonids were captured by the FSC in 2020, with nearly all (93.2 percent) being transported downstream (Tables 3.2-1 through 3.2-3). Juvenile coho accounted for the highest proportion of the overall estimated catch (57.4 percent), followed by juvenile Chinook (28.7 percent), steelhead (7.8 percent), and coastal cutthroat trout (0.9 percent). A total of 1,040 hatchery reared rainbow trout and 21 bull trout were also collected in 2020 and returned to the reservoir. An additional 1,041 hatchery rainbow trout were estimated to be collected and passed downstream of Merwin Dam during the peak out-migration season when subsampling was occurring (March-July) and not all fish were handled. All 21 bull trout captured in 2020 were collected when 100 percent of the fish were being directed to the subsample tank (i.e., not in subsampling mode). No bull trout appeared in the sampling tank during the spring subsampling period; however, it is possible that bull trout may have entered the general population tank and were subsequently transported downstream undetected.

Based on the total number of fish transported downstream, 2020 was the third largest out-migration year (51,196 fish transported downstream) since the FSC has been in operation behind 2016 and 2019, when 68,175 and 111,702 fish were transported, respectively (Table 3.2-4). As with all previous years, coho were the most abundant species transported downstream in 2020; however, the most juvenile Chinook ever recorded at the FSC passed in 2020 (n=15,377).

3.3 Juvenile Migration Timing

3.3.1 Overview/Methods

In accordance with Section 9.2.1(a) of the SA, PacifiCorp is required to determine natural juvenile migration timing by tracking abundance at the FSC each year. This task was identified as Objective 8 in the M&E Plan with the assumption that run-timing is an index that applies to fish arriving at the FSC.

Following the current M&E Plan (2017), an index of juvenile migration was developed by tracking the number of fish captured each day at the FSC over time. The number of fish collected each day at the FSC (FSC_{col}) was calculated by equation 3.2.-1, and plotted on a daily basis.

In addition to monitoring migration timing, PacifiCorp also monitored juvenile FL to describe, temporally, the size (or life-stage) of fish entering the FSC. Size distributions for coho, Chinook, steelhead and coastal cutthroat were calculated on a seasonal basis for the periods January – March, April – June and October – December. Size distributions were not calculated for the time period from mid-July through early-October as the FSC was off for annual summer maintenance.

3.3.2 Results/Discussion

The run timing in 2020 followed a normal frequency distribution, with peak migration occurring in late May. The late-fall migration component was substantially smaller in 2020 than seen in previous years. Historically, the late-fall migration period was composed of mostly juvenile spring Chinook. However, in 2020, this did not materialize. In fact, 87.6 percent of spring Chinook emigrated in 2020 did so earlier in the spring between March 2 and April 30, 2020. For coho salmon, steelhead and cutthroat trout, the most out-migration occurred between April 15 and June 30, 2020, which is consistent with previous years. Within this time frame, 88.8 percent of the steelhead, 77.5 percent of the coho, and 65.5 percent of the cutthroat were collected relative to the total annual catch (Figures 3.3-1 through 3.3-12).

Table 3.2-1. Estimated monthly and annual totals of all salmonids collected at the FSC in 2020.

	Coho				Chinook			Steelhead					Cutthroat					
Month	Fry	Parr	Smolt	Adult	Fry	Parr	Smolt	Fry	Parr	Smolt	Adult	Kelt	Fry	<13 in	>13 in	Bull Trout	Rainbow Trout	Total Trapped
January[A]																		
February																		
March	8	2,729	486	0	0	2,394	4,752	0	4	70	3	0	0	38	6	7	248	10,745
April	3	336	1,807	0	0	504	6,044	1	21	1,296	82	8	1	100	8	4	244	10,459
May	27	503	11,354	0	0	8	1,096	3	16	2,337	80	54	0	234	11	2	1,024	16,749
June	41	219	10,939	0	3	96	579	0	4	351	18	48	0	51	2	6	548	12,905
July	0	58	583	0	0	35	45	60	1	29	2	10	0	2	0	1	8	834
August	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
October	0	681	737	131	0	0	140	2	0	33	1	3	0	15	1	1	1	1,746
November	2	226	390	248	0	1	25	1	5	21	0	1	0	12	1	0	1	934
December	7	316	57	86	0	1	40	0	3	17	0	0	0	26	0	0	7	560
Annual Total	*88*	*5,068*	*26,353*	*465*	*3*	*3,039*	*12,721*	*67*	*54*	*4,154*	*186*	*124*	*1*	*478*	*29*	*21*	*2,081*	*54,932*

[A] Swift FSC was offline from January 1, 2020 to March 1, 2020 due to construction activities (see Table 2.1-1 above).

Table 3.2-2. Estimated annual totals of salmonids transported downstream in 2020.

Coho				Chinook				Steelhead					Cutthroat			Bull Trout	Rainbow Trout	Target Species Downstream[A]
Fry	Parr	Smolt	Adult	Fry	Parr	Smolt	Adult	Fry	Parr	Smolt	Adult	Kelt	Fry	<13 in	>13 in	All sizes	All Sizes	
88	4,925	25,940	0	3	2,927	12,447	0	67	53	4,063	0	180	1	474	28	0	1,041	51,196

[A] The total number of target species downstream does not include hatchery origin rainbow trout stocked for recreational fishing in Swift Reservoir.

Table 3.2-3. Estimated annual totals of salmonids and life stage collected by the FSC in 2020.

Species/Lifestage	Estimated Number Collected	95% C.I. [A]
Coho Fry	88	65 - 111
Coho Parr	5,068	4,869 - 5,287
Coho Smolt	26,353	21,643 - 31,063
Coho Adult	465	0
Chinook Fry	3	0
Chinook Parr	3,039	2,605 - 3,473
Chinook Smolt	12,721	11,008 - 14,434
Steelhead Fry	67	0
Steelhead Parr	54	37 - 71
Steelhead Smolt	4,154	3,385 - 4,923
Steelhead Adult	186	0
Steelhead Kelt	124	0
Cutthroat Fry	1	0
Cutthroat <13 in	478	396 - 560
Cutthroat >13 in	29	14 - 43
Bull Trout	21	0
Rainbow Trout	2,081	1,610 - 2,752
Total	54,932	46,402 - 63,462

[A] For some species, estimates and corresponding CI's for fry and adults captured could not be made as all fish were counted.

Table 3.2-4. Estimated annual totals of salmonids transported downstream for years 2013 through 2020.

Year	Coho				Chinook				Steelhead					Cutthroat			Bull Trout	Rainbow Trout	Target Species Downstream[A]
	Fry	Parr	Smolt	Adult	Fry	Parr	Smolt	Adult	Fry	Parr	Smolt	Adult	Kelt	Fry	< 13 in.	> 13 In.			
2013	*na*	*na*	15,074	0	*na*	*na*	1,431	0	*na*	*na*	166	0	9	*na*	550	6	1	453	17,690
2014	*na*	*na*	7,588	0	*na*	*na*	2,164	0	*na*	*na*	539	0	7	*na*	854	3	0	0	11,155
2015	*na*	6,478	25,441	0	*na*	227	5,174	0	*na*	47	1,277	0	28	*na*	763	48	0	290	39,483
2016	836	11,307	48,833	0	6	673	3,114	0	32	74	2,095	0	66	32	1,036	33	0	1,713	68,175
2017	3,598	9,576	14,924	0	0	278	5,523	0	19	73	1,724	0	9	14	744	46	0	444	36,972
2018	998	4,843	35,880	0	31	462	4,187	0	13	18	7,863	0	19	4	854	18	0	146	55,336
2019	2,734	4,510	89,573	0	64	2,828	7,994	0	8	63	2,941	0	47	1	895	44	0	2,992	111,702
2020	88	4,925	25,940	0	3	2,927	12,447	0	67	53	4,063	0	180	1	474	28	0	1,041	51,196

[A] The total number of target species downstream does not include hatchery origin rainbow trout stocked for recreational fishing in Swift Reservoir.

Coho Size Distributions

The size distribution for coho was normally distributed during the late-winter and in the fall. However, during the spring outmigration period (April-June), an asymmetrical bimodal size distribution was observed (Figure 3.3-11). Prior to April, the majority of the catch was composed largely of parr less than 121 mm. Beginning in April, median lengths for coho began to increase, and the majority (89.8 percent) of coho out-migrants had lengths generally greater than 121 mm (Figure 3.3-11). Overall lengths of juvenile coho that were collected in the fall and early-winter (October – December) decreased, and were generally distributed around a mean of 131mm.

Chinook Size Distributions

All juvenile Chinook collected in 2020 represented fish naturally produced in the upper basin from adult spring Chinook transported upstream; no juveniles released as part of the last acclimation program release in August 2017 were collected. Juvenile Chinook lengths observed prior to April 2020 indicated a greater relative abundance, around 80 percent, of smaller class fish (ranging from 101 to 160 mm; Figure 3.3-12), with some larger fish, ranging 191 to 290 mm, also being collected. These smaller fish were likely the progeny of spring Chinook adults released at Eagle Cliff in 2018, while the larger fish from adults in 2017. A similar broad size distribution for Chinook was also observed into the spring with fish ranging in size from 71 mm to 280 mm being collected. Very few juvenile Chinook were collected in the fall and early-winter (October-December) period in 2020. The fish collected during this time period ranged in length from 130 to 180 mm, and appeared to be holdovers from the cohort that out-migrated the previous spring.

Steelhead Size Distributions

Juvenile steelhead size distributions observed in 2020 were similar to those seen in previous years. The overall mean fork length for steelhead captured in 2020 was 198 mm, compared to a mean fork length of 200 mm in 2019, 223 mm in 2018, and 223 mm in 2017. In contrast to previous years, there only appear to be a single cohort of juvenile steelhead out-migrating in spring 2020. In previous years, juvenile steelhead had been shown to have a bimodal size distribution with peaks at around 160 mm and 270 mm. It is likely that this bi-modal distribution existed in 2020, although too few fish were sampled for length (n=18) in the spring to provide a realistic representation. Although some steelhead fry (n=67) that were generally < 80 mm had been captured in 2020, all fish sampled had fork lengths of >120 mm (Figure 3.3-13). Steelhead were not readily available during the October-December sampling period, resulting in no fish lengths being taken for that time period.

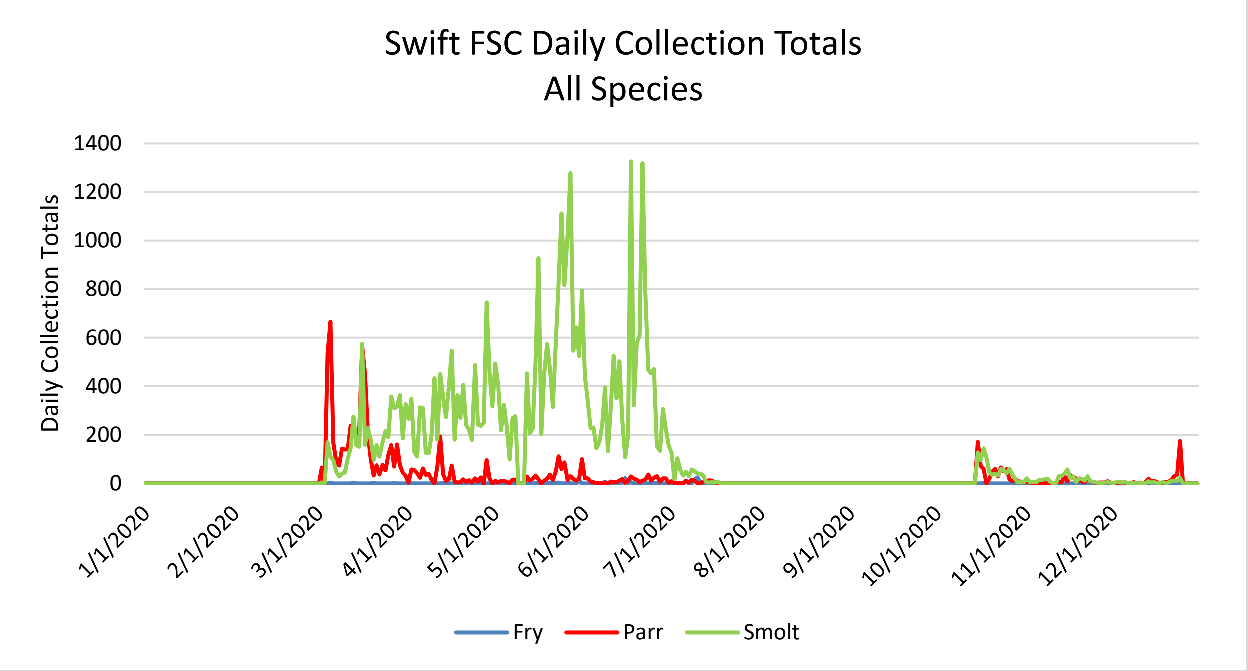


Figure 3.3-1. Estimated daily collection totals for all species at Swift FSC, 2020. Note: The Swift FSC was not operational from January 1 through March 2, 2020, or July 17 through October 14, 2020 due to schedule outages.

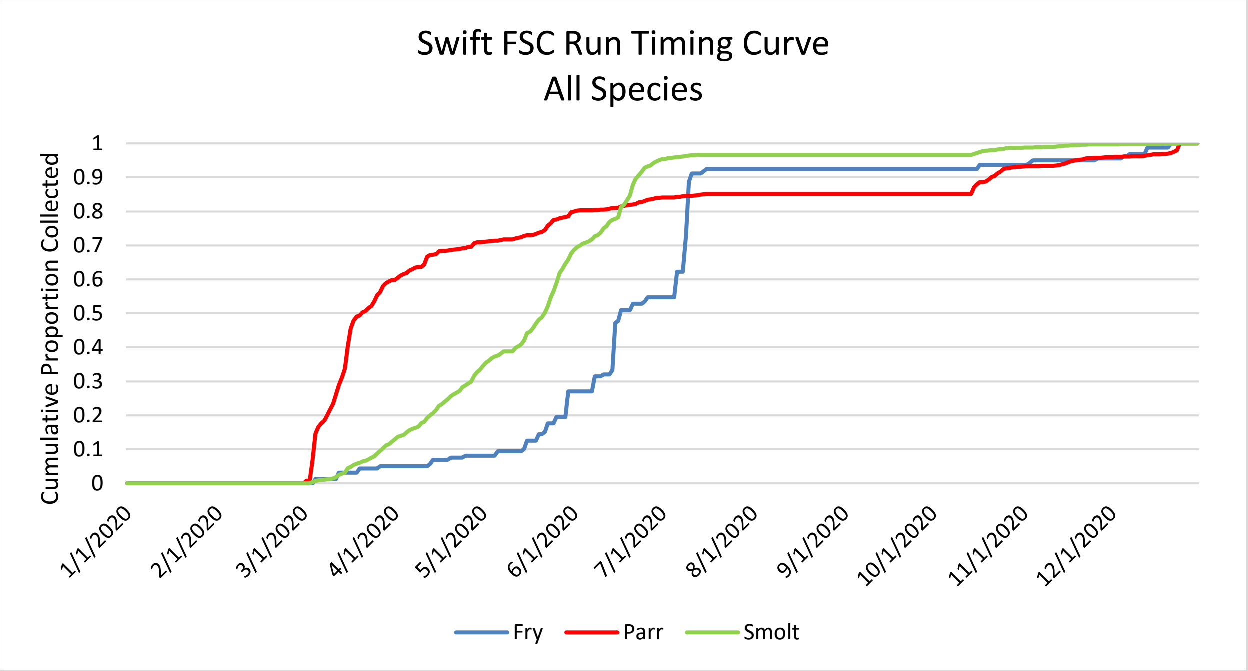


Figure 3.3-2. Cumulative migration timing among all species at Swift FSC, 2020.

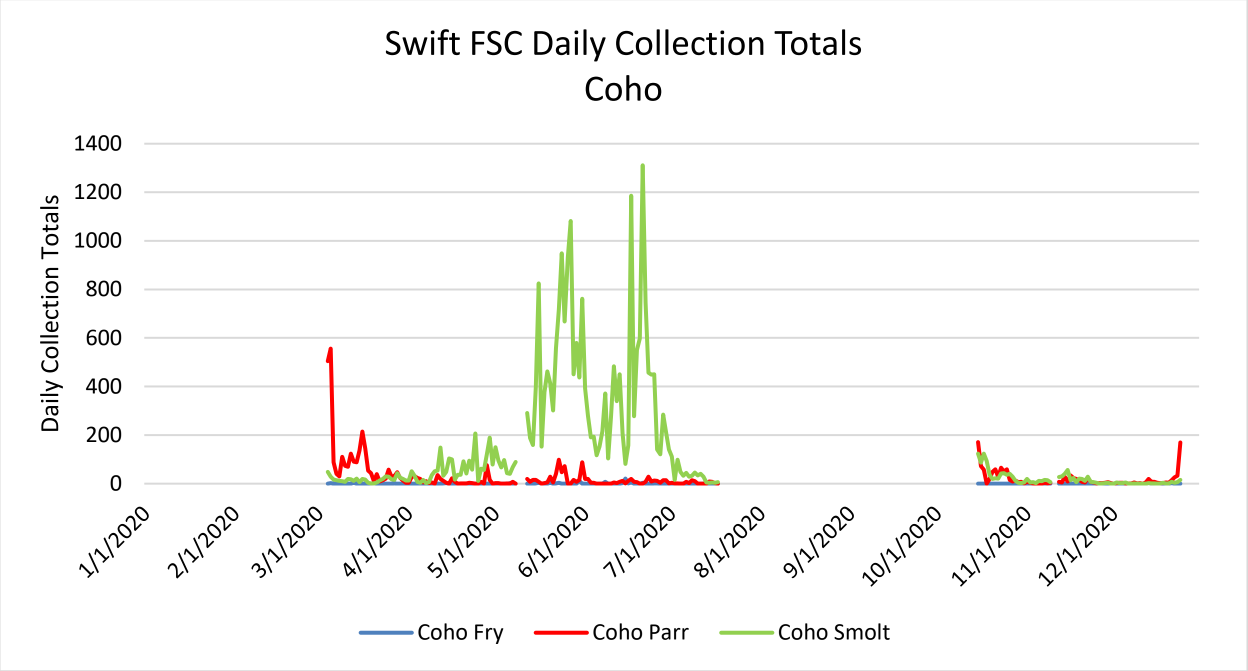


Figure 3.3-3. Estimated daily collection totals of juvenile coho at Swift FSC, 2020. Note: The Swift FSC was not operational from January 1 through March 2, 2020, or July 17 through October 14, 2020 due to schedule outages.

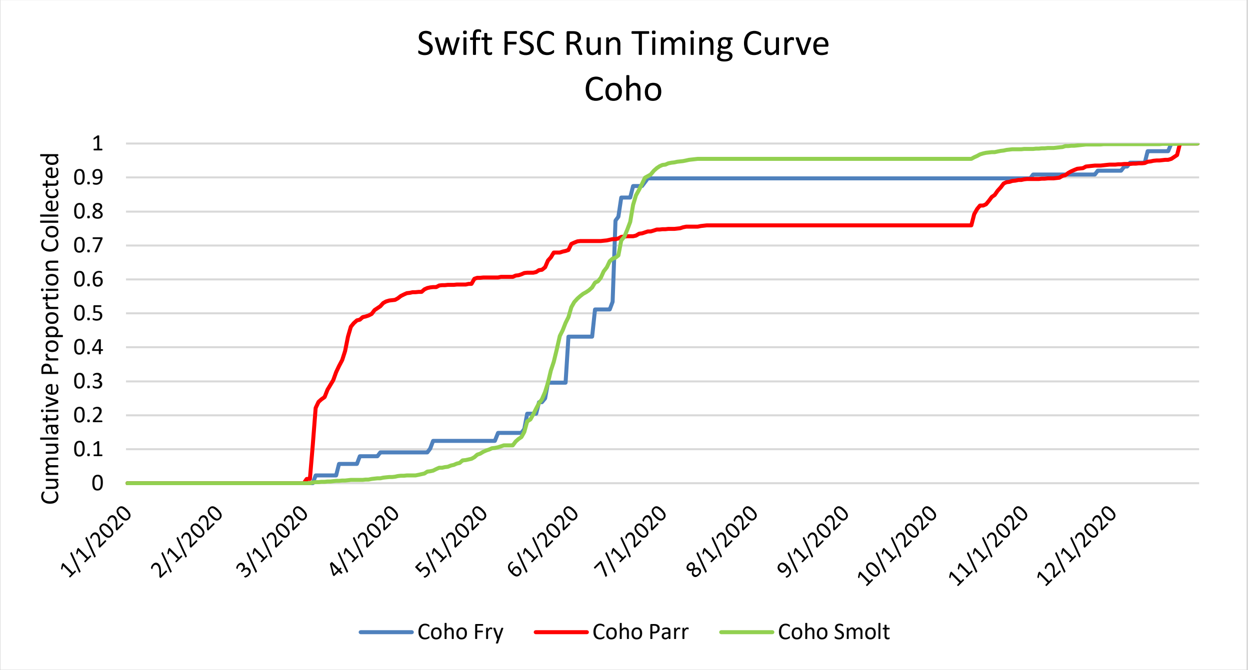


Figure 3.3-4. Cumulative migration timing of juvenile coho at Swift FSC, 2020.

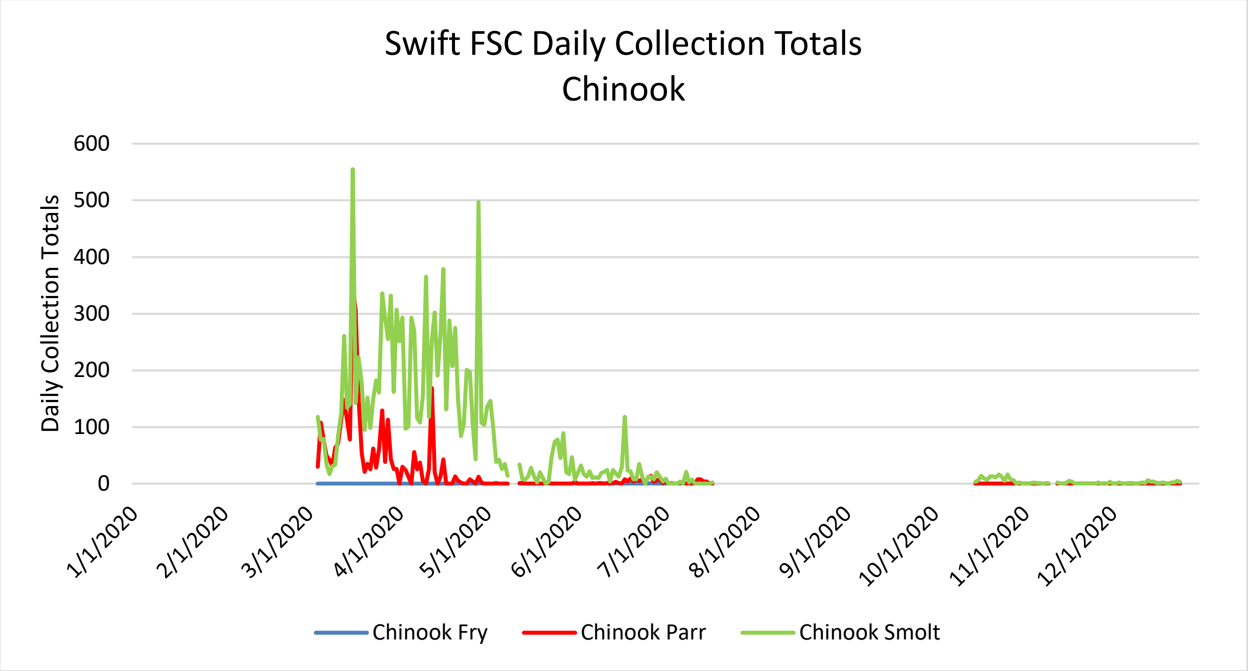


Figure 3.3-5. Estimated daily collection totals of juvenile Chinook at Swift FSC, 2020. Note: The Swift FSC was not operational from January 1 through March 2, 2020, or July 17 through October 14, 2020 due to schedule outages.

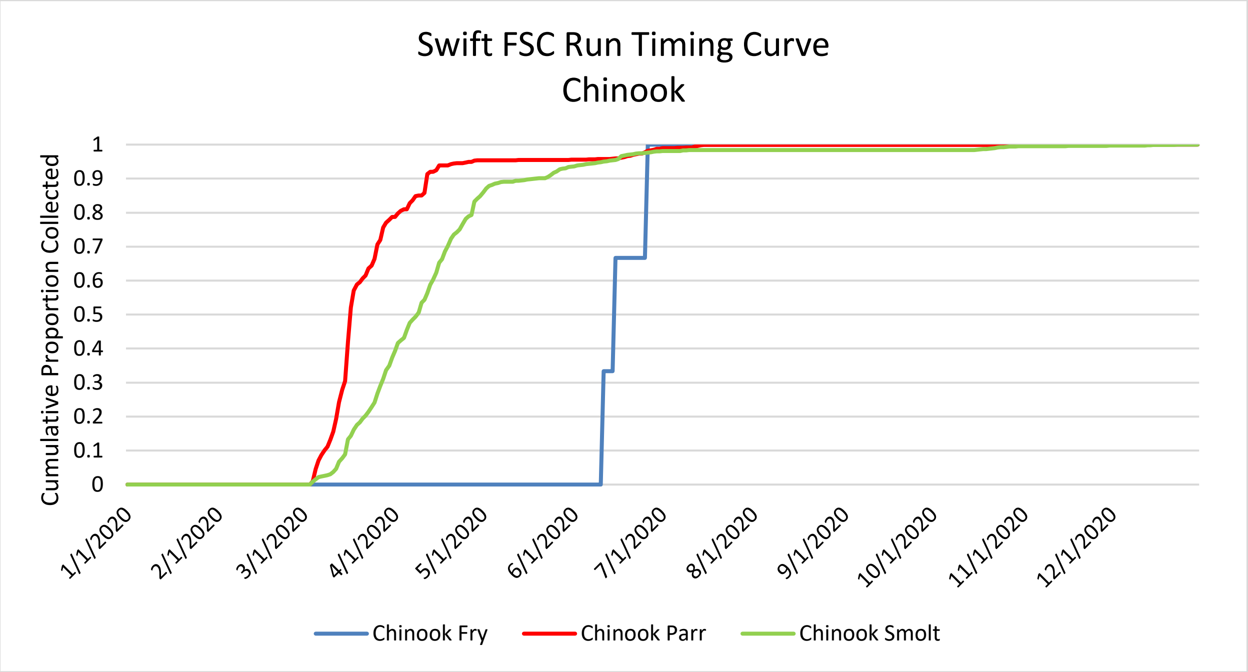


Figure 3.3-6. Cumulative migration timing of juvenile Chinook at Swift FSC, 2020.

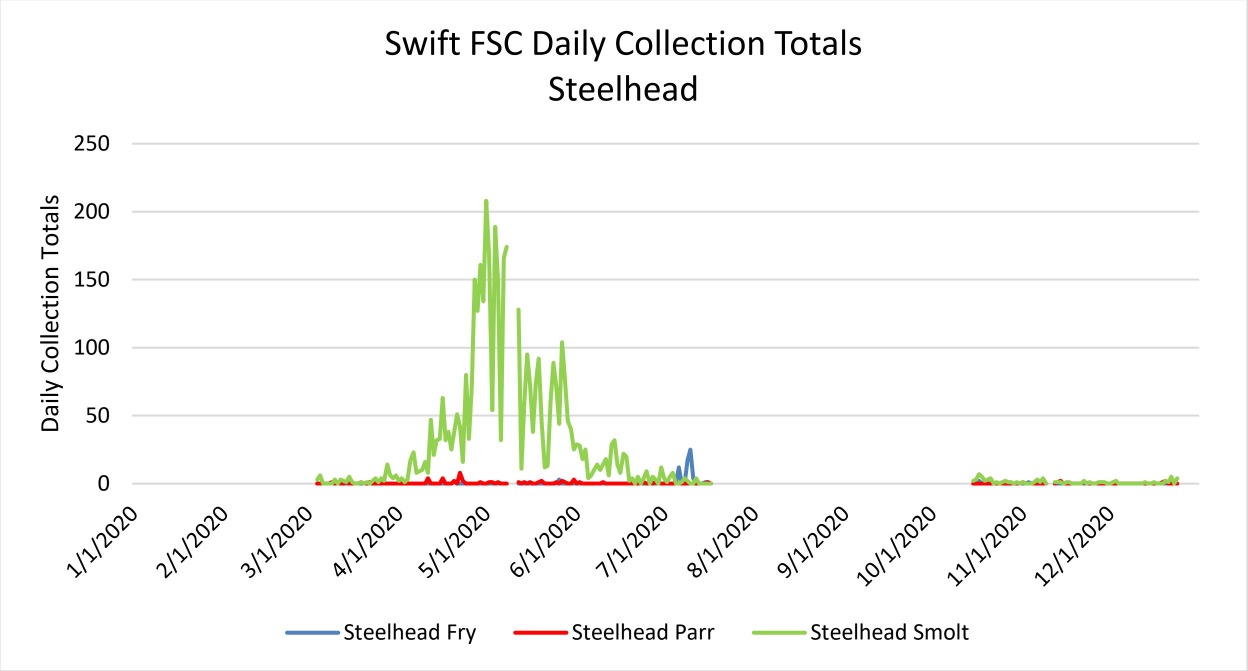


Figure 3.3-7. Estimated daily collection totals of juvenile steelhead at Swift FSC, 2020. Note: The Swift FSC was not operational from January 1 through March 2, 2020, or July 17 through October 14, 2020 due to schedule outages.

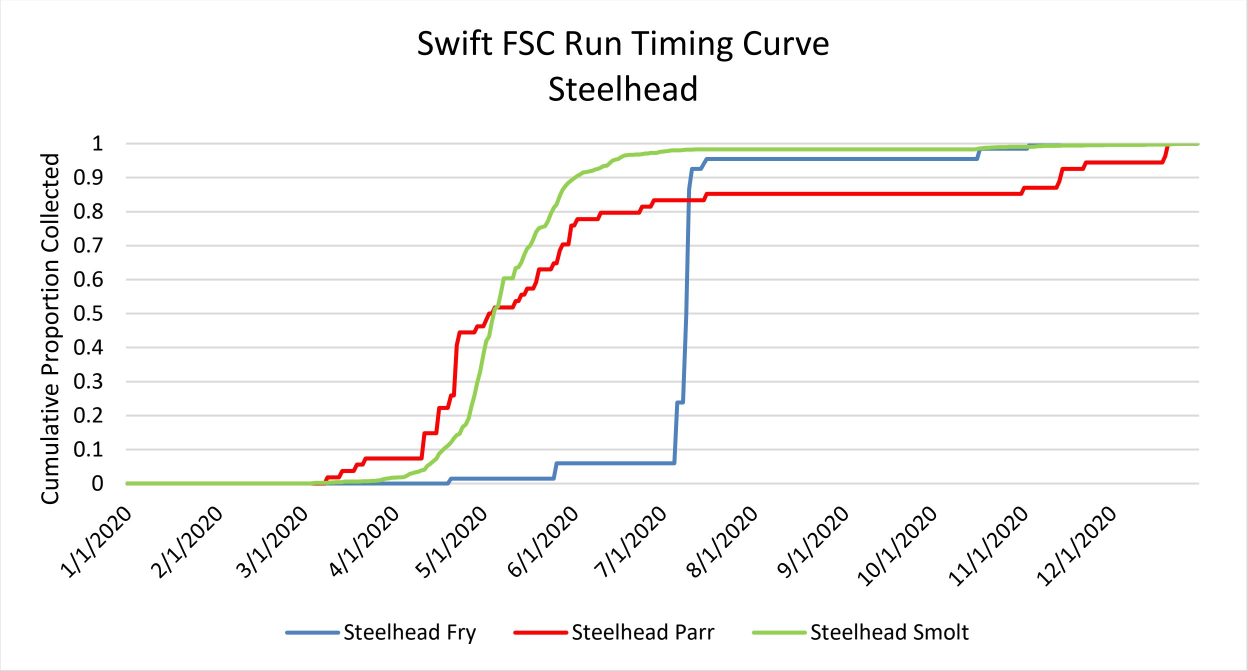


Figure 3.3-8. Cumulative run timing of juvenile steelhead at Swift FSC, 2020.

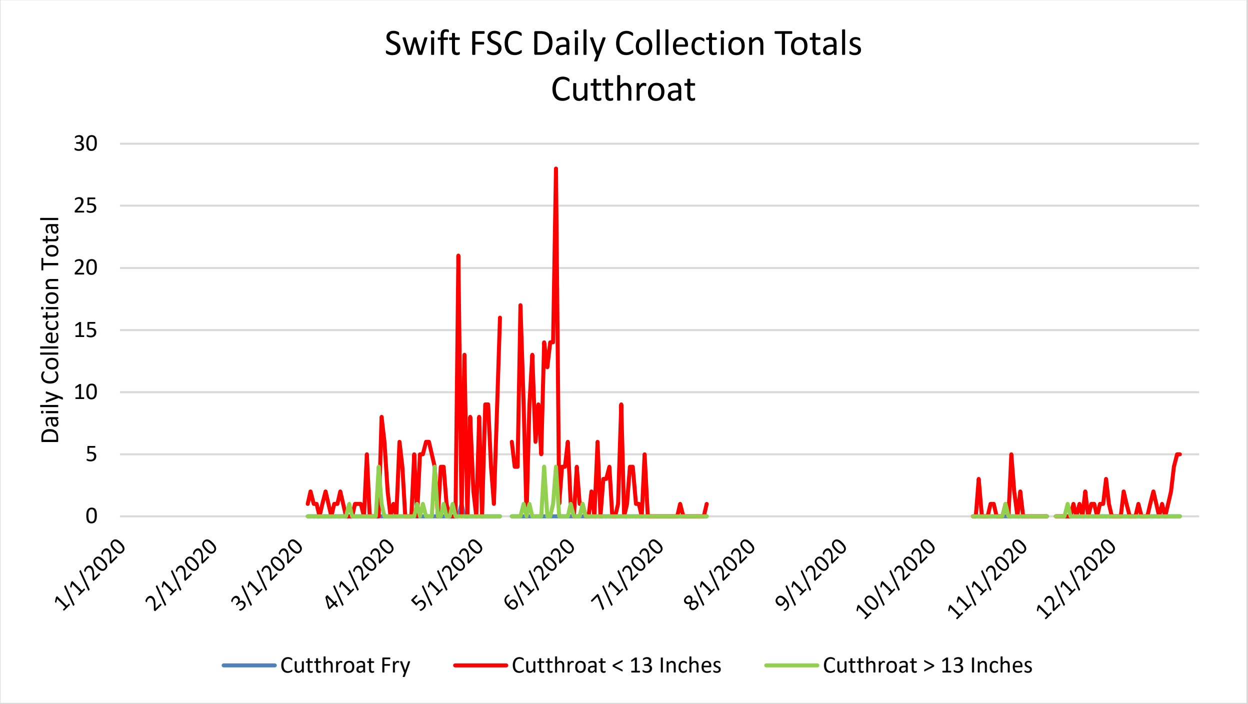


Figure 3.3-9. Estimated daily collection totals of juvenile cutthroat trout at Swift FSC, 2020. Note: The Swift FSC was not operational from January 1 through March 2, 2020, or July 17 through October 14, 2020 due to schedule outages.

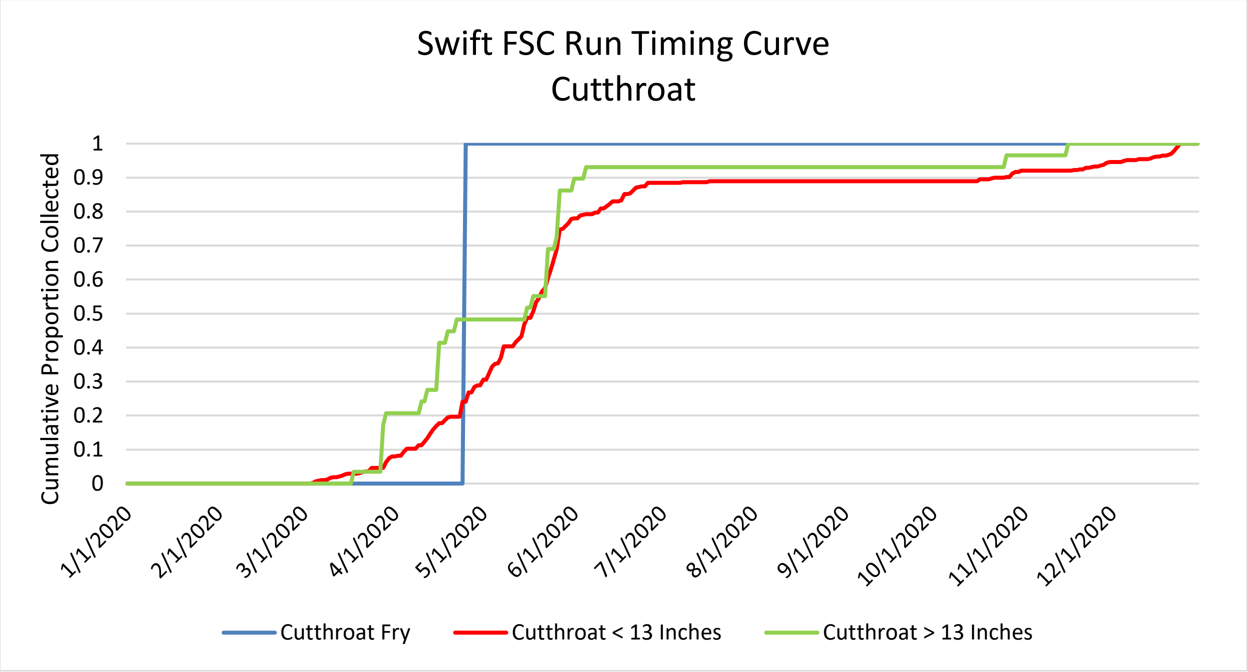


Figure 3.3-10. Cumulative run timing of juvenile cutthroat trout at Swift FSC, 2020.

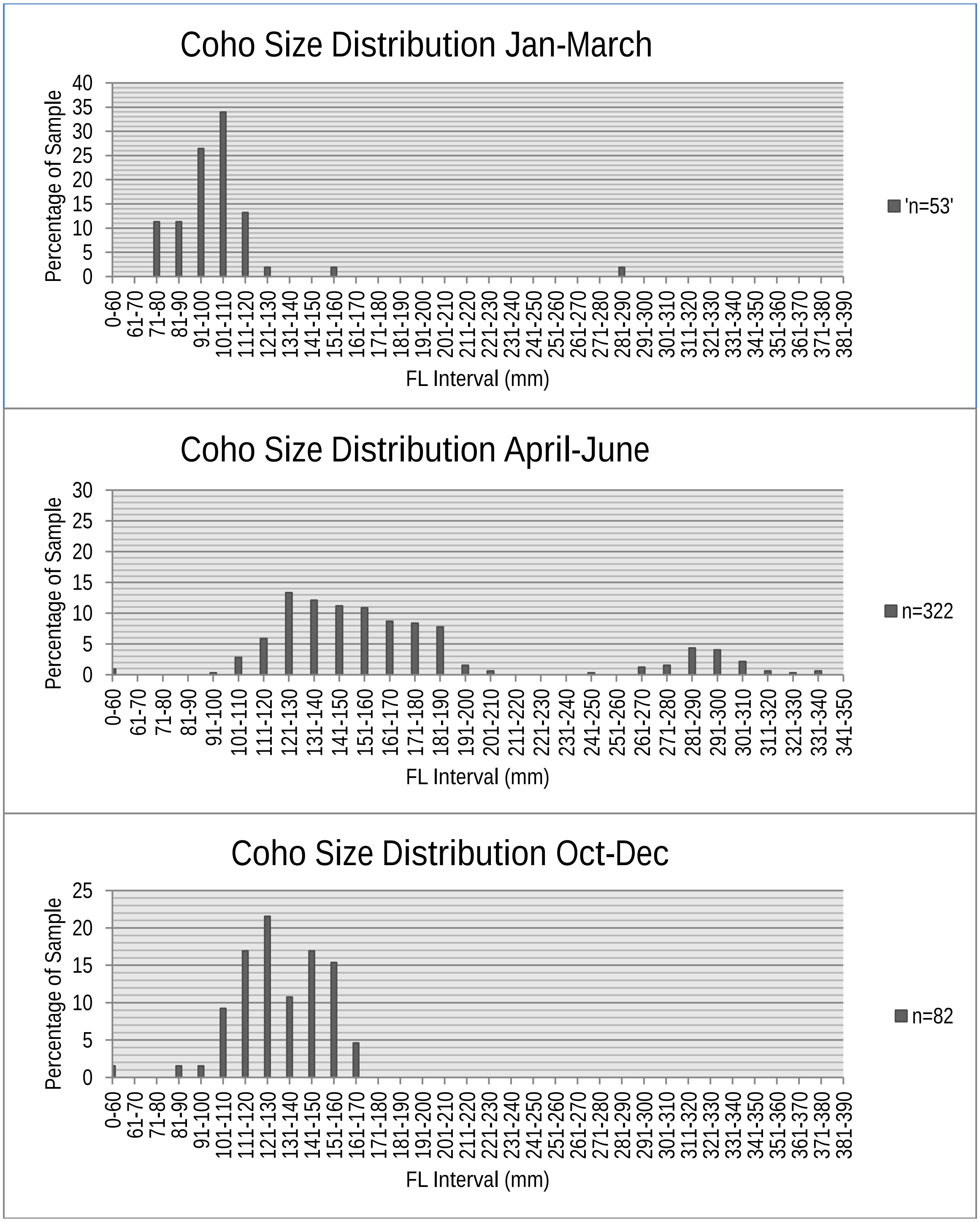


Figure 3.3-11. Size distribution of coho migrants collected at the Swift FSC in 2020.

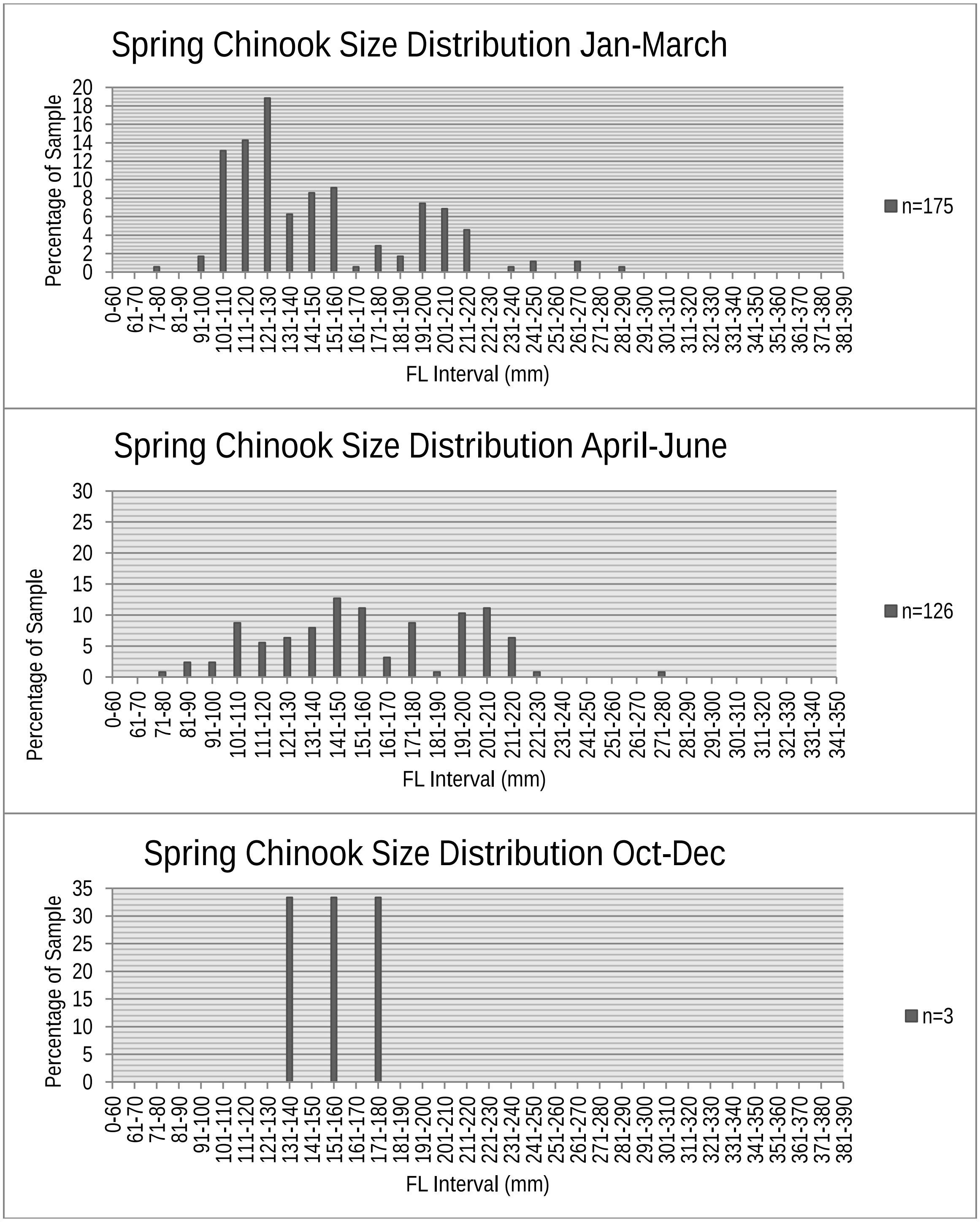
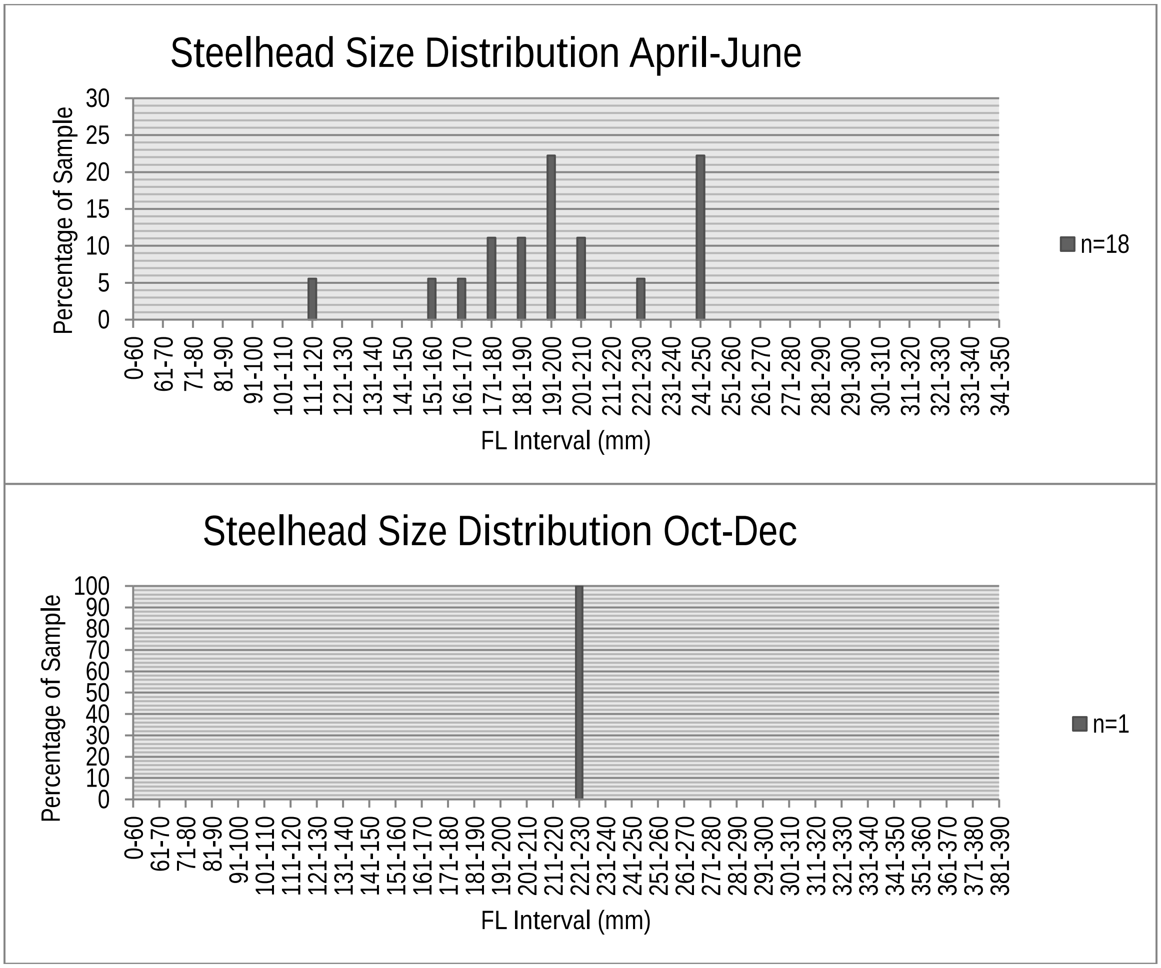


Figure 3.3-12. Size distribution of spring Chinook migrants collected at the Swift FSC in 2020.


Steelhead Size Distribution April-June

Steelhead Size Distribution Oct-Dec

Figure 3.3-13. Size distribution of steelhead migrants collected at the Swift FSC in 2020.

3.4 FSC Collection Efficiency

3.4.1 Overview/Methods

The use of biotelemetry to measure collection efficiency (P_{CE}) of juvenile salmonids at the FSC was further used in spring 2020. This evaluation was in accordance with Section 9.2.1(c) of the SA and based on findings and recommendations from the 2013 pilot study (Courter et al. 2013), 2014 evaluation (Stroud et. al 2014), 2015 evaluation (Reynolds et.al 2015), 2016 evaluation (Caldwell et. al 2017), 2017 evaluation (Anchor QEA 2018), 2018 evaluation (PacifiCorp 2019), and 2019 evaluation (Four Peaks Environmental 2021). Objective 2 of the current M&E Plan (2017) defines P_{CE} as the percentage of juvenile salmonids emigrating from Swift Reservoir that are available for collection and that are actually collected. A juvenile that is available for collection is one that is enters the zone of influence (ZOI); the area roughly 150 feet in radius immediately outside the NTS that was thought to be influenced by flow entering the FSC. A performance standard of 95 percent or greater for out-migrating smolts[5] was agreed upon for P_{CE}.

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[5] P_{CE} is only calculated for out-migrating juvenile Chinook, coho, and steelhead. Cutthroat smolts may be included in future studies if it is determined that anadromous life histories exist.

The primary goals of the 2020 Swift Reservoir out-migration study were: 1) determine collection efficiency for juvenile coho, spring Chinook, and steelhead smolts at the FSC; 2) continue to characterize the behavior of out-migrating smolts once they entered the Swift Reservoir forebay and as they interface with the FSC guide net and NTS; and 3) examine fine-scale fish behavior and movement within the collection channel to identify locations within the extent of the structure where fish reject and turn back upstream.

The specific study objectives of the 2020 FSC collection efficiency evaluation were to:

1. Estimate an adjusted encounter rate (P_{ZOI}), the proportion of downstream migrants that are tagged, released, and are detected in the FSC flow net attraction area immediately outside the Swift FSC in the ZOI;

2. Estimate entrance efficiency (P_{ENT}), the proportion of downstream migrants that enter the zone of influence and enter the FSC attraction channel;

3. Estimate P_{CE}, the proportion of downstream migrants that enter the ZOI and successfully pass into the FSC and are captured;

4. Estimate collection efficiency (P_{RET}), the proportion of downstream migrants that enter the collection channel and successfully pass into the FSC and are captured;

5. Estimate channel efficiency (P_{CHAN}), the proportion of downstream migrants that enter the NTS and successfully pass into the collection channel; and

6. Describe the behavior of downstream migrants once they enter the fish channel, specifically in relation to the number of passage attempts, progress through the fish channel and any holding behavior, and last location prior to returning to the reservoir for fish that are not successfully captured.

3.4.2 Result/Discussion

A detailed report describing the methods and results of the 2020 effort can be found in Appendix C. A brief summary of this report is provided below.

A total of 521 fish were dual PIT and acoustic tagged and released upstream of FSC between March 19 and May 28, 2020, to measure system performance and monitor fish behavior. At total of 183 Chinook, 185 coho, and 153steelhead juveniles were tagged and released (Table 3.4-1). All study fish were released near Eagle Cliff at the head of Swift Reservoir. The proportion of fish successfully transiting the reservoir during the study period was quantified in 2020 using the P_{ZOI} metric. P_{ZOI} summarized the proportion of all dual-tagged study fish that were detected within the ZOI before the conclusion of the 2020 Study. In 2020, P_{ZOI} was 58 percent for Chinook salmon, 62 percent for coho salmon, and 73 percent for steelhead.

Collection efficiency (P_{CE}) is a key performance metric that represents the proportion of dual-tagged study fish reaching the ZOI that were subsequently collected. In 2020, P_{CE} was 44 percent for Chinook salmon, 39 percent for coho salmon, and 42 percent for steelhead. Compared to prior year's results (2019), these proportions represent a 12 percent (6 percentage point) decrease for Chinook, a 23 percent (16 percentage point) decrease for coho, and a 55 percent (15 percentage point) increase for steelhead, bringing all three species back closer to P_{CE} values observed in the 2017 study using passive integrated transponder and acoustic telemetry. Entrance efficiency (P_{ENT}), quantifies the proportion of fish in the ZOI that were then detected within the NTS at the entrance of the FSC. P_{ENT} was near 100 percent for all three species; 95 percent for Chinook and coho salmon and 99 percent for steelhead. Together, these results suggest that a substantial proportion of study fish do not reach the ZOI during the study period (either due to mortality or delayed migration), but once they reach the ZOI, almost all fish enter the FSC.

Nearly three quarters (74 percent) of the fish that entered the NTS were subsequently detected within the collection channel (P_{CHAN}) of the FSC. P_{CHAN} ranged from 67 percent for steelhead to 82 percent for coho salmon. Among these fish that entered the NTS; however, less than half were retained within the FSC and ultimately collected (P_{RET}). P_{RET} was 47 percent for Chinook salmon, 42 percent for coho salmon, and 43 percent for steelhead. Once in the collection channel, 58 percent of study fish were collected (P_{COL}); again, all three species appeared to perform similarly in this regard. Thus, the relatively low observed collection efficiency rates appear to be largely the product of low retention, rather than attraction to the FSC. These relatively low retention rates reflect apparent "turnaround" points for all three species located between the NTS and primary channel, and again between the secondary channel and the FSC.

Acoustic telemetry data collected during the study enabled the analysis of fine scale movements in the fish passage channel of the collector for identifying factors contributing to successful passage. Modeling efforts using these data revealed that smaller fish were more likely to be recaptured (larger fish were most likely to reject the collector), and passage attempts tended to be more successful when initiated at night. The latter effect may be a result of patterns in daylight and/or human activity. Given the results of the study, it appears that P_{RET} continues to be the major bottleneck of collection efficiency at the Swift FSC. PacifiCorp plans to retest collection efficiency through an acoustic tag study in the spring of 2021.

Table 3.4-1. Summary of seasonal corrected passage metrics for tagged fish released at the head of Swift Reservior by species in 2020.

Species	No. Rel.[A]	DET_{ZOI}	DET_{NTS}	DET_{CHA}	DET_{COL}	$\hat{P}_{ZOI}$ (90% CI)[B]	$\hat{P}_{ENT}$ (90% CI)	$\hat{P}_{CHAN}$ (90% CI)	$\hat{P}_{COL}$ (90% CI)	$\hat{P}_{CE}$ (90% CI)	$\hat{P}_{RET}$ (90% CI)
Chinook Salmon	183	104	97	38	47	58% *(52%, 64%)*	95% *(90%, 99%)*	71% *(59%, 83%)*	66% *(53%, 78%)*	44% *(36%, 52%)*	47% *(39%, 55%)*
Coho Salmon	185	112	100	75	45	62% *(56%, 68%)*	95% *(90%, 99%)*	82% *(73%, 91%)*	51% *(41%, 60%)*	39% *(32%, 47%)*	42% *(34%, 50%)*
Steelhead	153	110	108	65	47	73% *(67%, 79%)*	99% *(97%, 100%)*	67% *(59%, 75%)*	63% *(53%, 73%)*	42% *(34%, 50%)*	42% *(35%, 50%)*
All	521	326	305	178	139	64% *(60%, 67%)*	96% *(94%, 99%)*	74% *(69%, 80%)*	58% *(52%, 65%)*	42% *(37%, 46%)*	43% *(39%, 48%)*

[A] Three fish (2 coho salmon and 1 steelhead) released on 28 April 2020 were excluded, due to data entry errors that precluded confidently matching acoustic and PIT tag codes for these fish. All three individuals were detected in the ZOI but not further downstream, and none were collected. (No. Rel. = number released).

[B] 90 percent CIs are reported for each collection metric.

3.5 Swift FSC Injury and Survival

3.5.1 Overview/Methods

Injury and survival of captured juvenile out-migrants, and adult cutthroat, bull trout, and steelhead (kelts) were monitored daily at the FSC during 2020 in accordance with Objectives 4 and 5 of the M&E Plan and Section 9.2.1(d) of the SA.

As outlined in the current M&E Plan (2017), smolt injury and survival was evaluated based on fish collected in the subsample tanks. The methods outlined in the current M&E Plan (2017) assume that rates of fish injury and mortality found in subsampled fish is representative of the general population. PacifiCorp is required to achieve at least 99.5 percent survival and less than (or equal) to 2.0 percent injury for smolts (Table 3.5-1). Parr life-stage was included with smolts for each species to calculated survival and injury. These metrics were calculated separately for fry.

Each day the FSC was operated, biologists anesthetized juvenile out-migrants collected in the subsample tanks, enumerated fish by species, and inspected them for injury or mortality. Classifications for injury types were grouped into three categories: 1) recordable injuries or injuries caused by collection practices that may substantially decrease the chance of surviving; 2) non-recordable injuries or injuries caused by collection purposes that likely will not decrease the chance of survival; and 3) non-trap related injuries or injuries from natural occurrences prior to fish entering the FSC (Table 3.5-2).

Table 3.5-1. Specified injury and survival standards.

Species and Life Stage	Recordable Injury Rate	Survival Rate
Chinook, Coho, Steelhead, Cutthroat Smolts	2.0%	99.5%
Chinook, Coho, Steelhead, Cutthroat Fry	2.0%	98.0%
Bull Trout	2.0%	99.5%

Table 3.5-2. Categories used for documenting visible injury at the FSC.

Recordable Injury		Non-Recordable Injury
Hemorrhaging	Open Wound	Minor Scrap or Open Wound w/ fungus
Gill Damage	Bruising > 0.5 cm diameter	Bruising < 0.5 cm diameter
Loss Of Equilibrium	Descaling > 20%	Descaling < 20%

Any mortality observed in the subsample tank was also recorded. Mortality was classified into two categories: 1) trap related mortality; or, 2) non-trap related mortality. Biologists used various signifiers to determine whether or not mortality was caused by collection practices. Signifiers included presence of fungus, gill coloration, inspection for cause of death (i.e., descaling, brain trauma, predation, hook and line injury), and *rigor mortis*. Any trap related mortality was recorded as S_{COL}.

As specified in the M&E Plan, injury and survival rates were calculated daily and are shown in Equation 3.5-1 and Equation 3.5-2, respectively.

$$\boldsymbol{R_{Inj} = \frac{SS_{Inj}}{SS_{Total}}} \qquad \textbf{Equation 3.5-1}$$

Where:

R_{Inj} = Observed daily injury rate per species;

SS_{inj} = Number of injured fish per species in subsample, mortalities are not included; and

SS_{Total} = Total number of fish per species in subsample, mortalities are not included.

$$CS = S_{COL} * S_{TRAN} \qquad \textbf{Equation 3.5-2}$$

Where:

CS[6] = Observed combined collection and transport survival rate per species, and is the percentage of juvenile anadromous fish of each of the species collected that leave the Release Ponds alive;

S_{COL} = Survival probability through the collector; expressed as the ratio between the number of alive fish in the subsample and the total number of fish examined in the subsample; and

S_{TRAN} = Survival probability through the smolt transport system; expressed as the ratio of alive marked fish in the transport system to the total number of marked fish released in the transport system. *Note: A detailed description of how* S_{TRAN} *is calculated is provided in Section 3.7 below.*

3.5.2 Results/Discussion

Injury Rate

Combined annual injury rates for each target species ranged from 0 to 2.7 percent (Table 3.5-3). Juvenile coho had the highest overall injury rate (2.7 percent), followed by juvenile Chinook (2.3 percent) and steelhead (1.9 percent). Adult steelhead and cutthroat trout had injury rates of 0.53 and 0.35 percent, respectively. No injuries to salmonid fry were recorded, which may have been due to the FSC not being operational during the historical peak of the fry collection period of late-winter and early-spring. As in previous years, descaling accounted for the greatest proportion of the injuries observed (75.1 percent) in all species, followed by fin damage (13.5 percent), hemorrhaging (5.4 percent), bruising (3.5 percent), open wounds (2.2 percent), and loss of equilibrium (0.9 percent; Figure 3.5-1).

Annual injury rates for all salmonid fry, as well as juvenile (smolt and parr) steelhead and cutthroat met the required performance standard maximum of 2.0 percent. However, the injury rates for both juvenile coho (2.7 percent) and Chinook (2.3 percent) slightly exceeded the injury performance standard.

PacifiCorp has continued to address sources of injury at the FSC. Debris accumulation in both the smolt transport flume and adult fish holding tank have been a significant source of injury and mortality to date. In an effort to reduce injury and mortality caused by debris loading, PacifiCorp is currently in the process of making modifications to both of these areas. The new starboard smolt flume was completed in February 2020, which was shown to decrease debris-related mortality and injury. Modifications to the adult tank will begin during the summer maintenance period in 2021, and will include a debris conveyor, similar to the one recently installed in the fry holding tank. PacifiCorp has also implemented several

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[6] CS was calculated for smolts (combined with parr), whereas only S_{COL} was recorded for fry. Fry were transported downstream in 2020; however, once collection efficiency at the FSC reaches >60 percent, it is intended that this life-stage be returned to the reservoir.

debris management measures in Swift Reservoir to minimize debris entrainment at the FSC. These have included installation of several debris booms located at the head of the reservoir as well as in and around the forebay near the FSC (Figure 3.5-2). PacifiCorp also actively manages debris on the reservoir by using containment and removal procedures.

Table 3.5-3. Annual injury rates for target species collected at the FSC are shown with the associated 95 percent confidence interval.

	No. Injured [A]	No. Sampled [B]	Injury Rate (%)
Coho (Fry)	0	88	0
Chinook (Fry)	0	3	0
Steelhead (Fry)	0	67	0
Cutthroat (Fry)	0	1	0
Combined (Fry)	0	159	0
Coho (Parr & Smolt)	402	14,603	2.7 ± 0.26
Chinook (Parr & Smolt)	196	8,545	2.3 ± 0.32
Steelhead (Parr & Smolt)	33	1,709	1.9 ± 0.65
Cutthroat (Parr & Smolt)	1	284	0.35 ± 0.69
Combined (Parr & Smolt)	632	25,141	2.51 ± 0.2
Steelhead Adults	1	186	0.53 ± 1.1
Steelhead Kelts	0	124	0
Bull Trout	0	21	0

[A] Mortalities with injuries are not assigned as injured fish; they are assigned to mortality totals.

[B] The number sampled for injury rate calculations does not include mortalities.

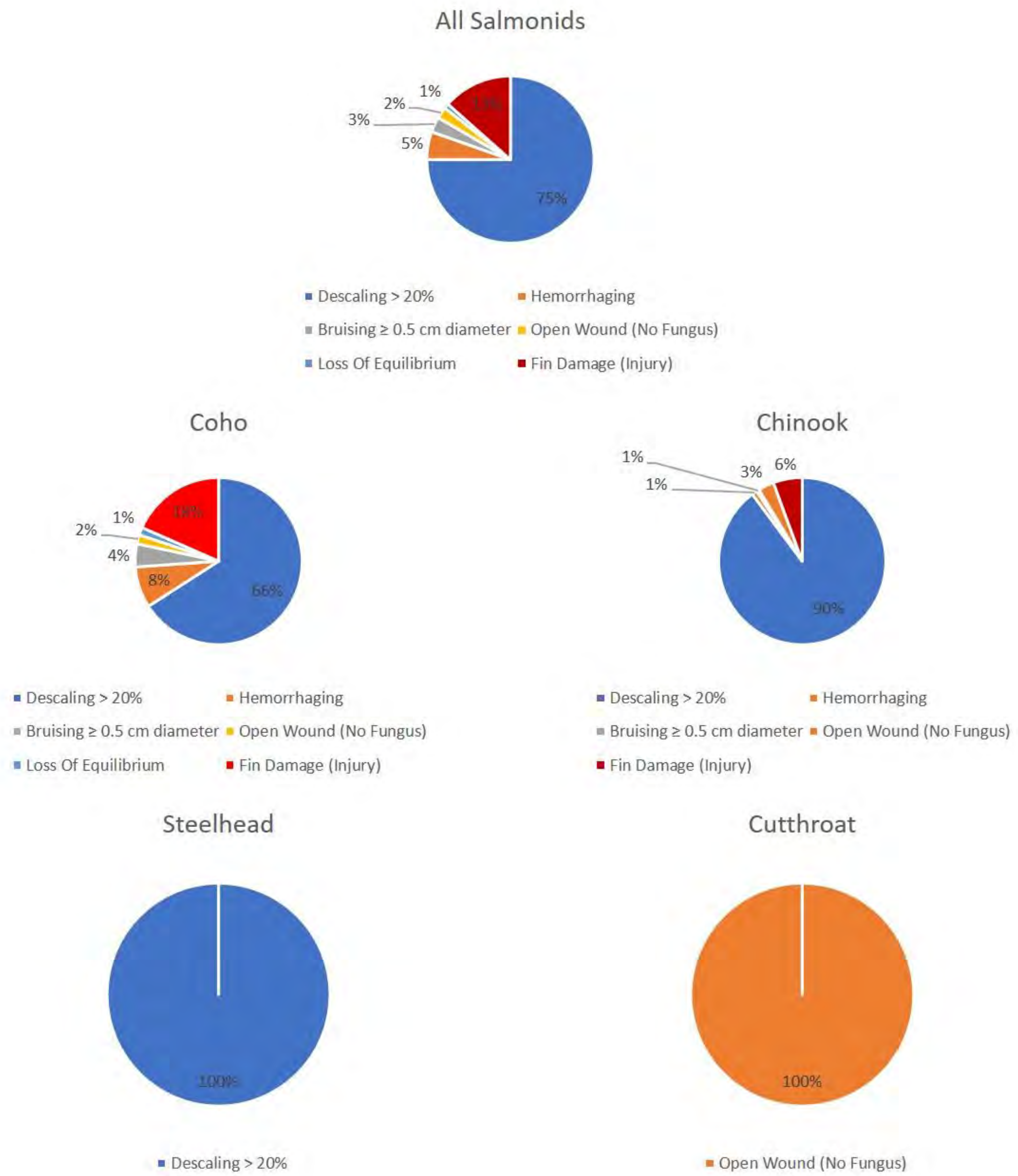

Figure 3.5-1. Composition of injury type occurrences by species in 2020. Percentages reflect the proportion of injury type observed of the total number of fish injured, not the total number of fish evaluated. Percentages reflect parr and smolts numbers sampled that are referenced in Table 3.5-3.

Figure 3.5-2. Woody debris accumulated behind the upper debris boom located near the head of Swift Reservoir.

Survival Rate

The combined survival rate (*CS*) for all larger out-migrants (parr and smolt) were generally low in 2020 for all target species with values ranging from 89.4 to 98.2 percent (Table 3.5-4). Nearly all mortality observed onboard the FSC and during transport was associated with direct or indirect interactions with debris and/or debris accumulation. The 2020 out-migration years was characterized as a heavy-debris loading year, with large quantities of all sizes of woody debris and associated material found in and around the FSC for most of the spring out-migration period (April – June). Debris accumulation on the fish sorting bars and in the holding tanks was the largest contributor to mortality (Figure 3.5-3). As mentioned above regarding modifications to minimize fish injury, PacifiCorp is continuing to make improvements to reduced mortality. Modifications to the adult fish holding tank to improve debris handling inside the FSC are scheduled to begin in the summer of 2021. Summaries of data used to calculate S_{COL} and S_{TRAN} are provide in Tables 3.5-5 and 3.5-6.

While survival estimates for larger out-migrants (parr and smolt) were generally below the performance standard of 98 percent for most target species, survival estimates for small out-migrants (fry) were high 2020 (Table 3.5-7). Of the 159 fry collected in 2020, no mortality was observed. This was in large part due to modifications to the FSC that improved debris management within the small fish (fry) holding tank. This project was completed in spring 2018.

Table 3.5-4. Combined annual survival rates for juvenile salmonids (parr and smolt) collected and transported from the Swift FSC (CS).

Species	Combined S_{COL} Survival% (from Table 3.5-5)	S_{TRAN} Survival% (from Table 3.5-6)	Combined Survival % (CS) with 95%CI
Coho	96.5	98.2	94.8 ± 0.28
Chinook	95.5	93.7	89.4 ± 0.43
Steelhead	96.7	96.3	93.1 ± 0.81
Cutthroat	98.2	100.0	98.2 ± 1.53
Overall	96.2	97.0	93.3 ± 0.23

Table 3.5-5. Annual survival rates for juvenile salmonids (parr and smolt), cutthroat, bull trout, and adult steelhead collected at the Swift FSC (S_{COL}).

Species	No. of Mortalities	No. Sampled	S_{COL} Survival%	Combined Survival% with 95%CI
Coho Parr	143	4,516	96.8%	96.5 ± 0.30
Coho Smolts	365	10,087	96.4%	
Chinook Parr	112	2,262	95.0%	95.5 ± 0.44
Chinook Smolts	275	6,283	95.6%	
Steelhead Parr	1	42	97.6%	96.7 ± 0.84
Steelhead Smolts	55	1,667	96.7%	
Cutthroat(< 13 inches)	4	267	98.5%	98.2 ± 1.53
Cutthroat (> 13 inches)	1	17	94.1%	
Total	956	25,141	Overall	96.2± 0.23
Steelhead Adults	16	186	91.4%	92.9 ± 2.86
Steelhead Kelts	6	124	95.2%	
Bull Trout	0	21	100.0%	100

Table 3.5-6. Annual transport survival rates (S_{TRAN}) for salmonid fry.

Species	Tagged and Transported	No. Dead	Survival% (S_{TRAN}) with 95%CI
Coho (Parr/Smolt)	949	17	98.2 ± 0.84
Chinook (Parr/Smolt)	347	22	93.7 ± 2.56
Steelhead (Parr/Smolt)	162	6	96.3 ± 2.91
Cutthroat (Parr/Smolt)	19	0	100.0
Overall	1,477	45	97.0 ± 0.88

Table 3.5-7. Annual survival rates (S_{COL}) for salmonid fry.

Species	No. of Mortalities [A]	No. Sampled	Survival% (CS)
Coho Fry	0	88	100.0
Chinook Fry	0	3	100.0
Steelhead Fry	0	67	100.0
Cutthroat Fry	0	1	100.0
		Overall:	100.0

[A] Fry were transported downstream in 2020; however, once collection efficiency at the FSC reaches > 60 percent, it is intended that this life-stage be returned to the reservoir. No mortality was observed during transport of fry downstream in 2020.

Figure 3.5-3. Woody debris accumulated within the fish passage channel (A), and on the sorting bars (B) within the Swift FSC in 2020.

3.6 Swift Powerhouse Entrainment Evaluation

Assessing the proportion of fish entering the intake of the Swift No.1 Powerhouse is required under Section 9.2.1(f) of the SA and identified as Objective 3 of the M&E Plan. However, this M&E Objective will not be quantified until downstream passage facilities are installed at Yale and Merwin Dams.

3.7 Overall Downstream Survival

3.7.1 Overview/Methods

The SA requires that the Utilities achieve an overall downstream survival (ODS) rate of greater than (or equal) to 80 percent[7]. ODS is defined in Section 4.1.4 of the SA as:

> *The percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 that enter the reservoirs from natal streams and survive to enter the Lewis River below Merwin Dam by collection, transport and release via the juvenile fish passage system, passage via turbines, or some combination thereof, calculated as provided in Schedule 4.1.4.*

In other words, ODS is the percentage of fish entering the Lewis River reservoirs that are successfully captured and released alive below the Project (e.g., Merwin Dam). Estimates of ODS were developed for juvenile coho, Chinook, and steelhead. ODS estimates for sea-run cutthroat trout will be delayed until data indicate that this cutthroat life-history is present in the upper Lewis River basin and that the number of juveniles produced is sufficient, as determined by the USFWS, for experimental purposes.

PIT tags compatible with those used throughout the Columbia Basin for salmonid evaluations and direct enumeration of fish collected and transported from the FSC are used to develop estimates of ODS. All PIT tags used are entered into the Pacific Northwest Region PIT tag database (PTAGIS[8]).

Consistent with the SA, juveniles passing Swift Dam either through the turbines or spill will not be counted toward meeting the ODS standard because they are unlikely to survive passage through multiple dams and reservoirs not equipped with passage facilities.

The methods for developing estimates of ODS as outlined in the current M&E Plan are as follows:

- Test fish were obtained from the screw trap operated at the head of Swift Reservoir (i.e., located at Eagle Cliff), or at the FSC. Fish collected at the FSC were only used if enough fish could not be collected at the screw trap. Using fish collected from two different locations is not preference as this may introduce bias associated with previous expose to the reservoir environment, difference in size/age class, and life-stage.
- Fish captured at the traps were identified to species, measured for length and tagged with PIT tags. Only fish greater than, or equal to, 60 mm in length were tagged in 2020.
- Fish were released at the head of Swift Reservoir weekly throughout the spring out-migration period (April-June). To reach the desired statistical power (assuming a precision of 0.025 with 80

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[7] An ODS of greater than or equal to 80 percent is required until such time as the Yale Downstream Facility is built or the Yale in Lieu Fund becomes available to the Services, after which ODS shall be greater than or equal to 75 percent. The parties to the SA acknowledge that ODS rates of 80 percent or 75 percent are aggressive standards and will take some time to achieve.

[8] The Columbia Basin PIT Tag Information System (PTAGIS) is the centralized database for PIT-tagged fish in the Columbia River Basin. PTAGIS provides custom software for contributors to collect tagging and interrogation data, manages the database, and coordinates with fishery agencies and organizations. In addition, PTAGIS collects automated detection data and designs, installs, and maintains the equipment that records those detections. All data contributed to and collected by PTAGIS are freely available online (www.ptagis.org).

percent recapture rate and 95 percent detection efficiency), a total of 996 fish of each species is the sample size goal needed for each species for each 6-week spring test period. PIT tag releases were to continue into the summer and fall as long as a persistent juvenile migration exists.

- Sample size goals for the release was based on a reservoir survival rate of 80 percent, tag detection probability of 95 percent and a precision of 0.025. Test fish captured and tagged at the FSC were held for 24 hours prior to release to quantify any potential handling mortality. Fish PIT tagged at the screw were released immediately after tagging.

- PIT-tag detectors located on the FSC and at the exit of the Woodland Release Ponds were used to confirm passage downstream and to generate the tag detection histories to estimate ODS.

- Throughout the out-migration period, the FSC, transport trucks, and release ponds were inspected daily for fish mortality occurring during the handling and transport processes. All dead fish were identified to species, measure for length, and inspected for source of injury and PIT tags. All dead fish found in the FSC and release ponds were assigned to collection loss (S_{COL}) and transport loss (S_{TRAN}), respectively. All PIT tag detections were recorded and reviewed for tagging date and location.

The seasonal ODS estimate were based on pooling release–recapture data over the season. Because some proportion of tagged fish are likely to overwinter in the reservoir, any fish captured in subsequent years (determined by PIT tags) were retrospectively added to the ODS estimate for their release year. The ODS calculation is shown in Equation 3.7-1.

$$\boldsymbol{ODS = S_{RES} * S_{COL} * S_{TRAN}} \qquad \textbf{Equation 3.7-1}$$

Where:

S_{RES} = Survival probability through reservoir; expressed as the ratio between the total number of marked fish release at the head of the reservoir and the total number of marked fish subsequently recaptured at the FSC;

S_{COL} = Survival probability through the collector; expressed as the ratio between the number of alive fish in the subsample and the total number of fish examined in the subsample;

S_{TRAN} = Survival probability through the smolt transport system; expressed as the ratio of alive marked fish in the transport system to the total number of marked fish released in the transport system.

3.7.2 Results/Discussion

Estimates of ODS were derived in 2020 using 1,452 coho, 194 Chinook, 343 steelhead, and 59 cutthroat (Table 3.7-1). Only PIT tag interrogations at the FSC and Woodland Release Ponds recorded on or before December 31, 2020 were included in the analysis. Due to low numbers of fish captured at the Eagle Cliff screw trap that could be PIT tagged (see Section 3.1, Task 7.1 above for details), additional releases of smolts collected/tagged at the FSC and released at the head of Swift Reservoir were used. Of the total number of fish used to derive ODS in 2020, 29.2 percent (n=424) of the coho, 92.8 percent (n=180) of the Chinook, and 25.9 percent (n=89) of the steelhead released were from the FSC. All cutthroat trout were tagged and release from the screw trap. It is important to note that because of inadequate numbers of fish to tag, no species received the required 996 tags (during a six week period) from the screw trap alone. Also fish tagged and released from the screw were combined with those from the FSC for analysis.

Using PIT tag detections at the FSC across the year, a total of 300 coho, 36 Chinook, 38 steelhead, and 4 cutthroat were recaptured. This resulted in an annual S_{RES} estimate of 20.6 percent for coho, 18.5 percent for Chinook, 11.1 percent for steelhead, and 6.8 percent for cutthroat.

Pooling data annually for 2020, S_{COL} was 96.5 percent for coho, 95.5 percent for Chinook, 96.7 percent for steelhead, and 98.1 percent for cutthroat (Table 3.7-1). Estimates for S_{TRAN} during the same time period were 98.2 for coho, 93.7 percent for Chinook, and 96.3 percent for steelhead. S_{TRAN} for cutthroat was 100 percent.

Overall, estimates of ODS were less than 20 percent for all species in 2020 (Table 3.7-1). Whiles these estimates are low, they are generally consistent with estimates of ODS from previous years. The highest ODS recorded for coho since the FSC was brought online in 2013 was 50.8 percent in 2019 (see Table 3.7-2 below), and 45.0 percent for steelhead in 2018. ODS estimates for juvenile Chinook have remained around 30 percent since 2019 once the upper basin acclimation program had been discontinued and when only NOR fish were in the system (See Section 1.0-1 above). It is anticipated that estimates derived in 2020 will increase once tagged fish holding-over in the reservoir are collected in 2021. The ODS estimate for cutthroat should also be interpreted with the understanding that little is yet known about the life-history patterns of cutthroat in the upper Lewis River watershed.

Table 3.7-1. Annual ODS estimate for each species (performance standard for all species is ≥ 80 percent).

Species	Tagged and Released in 2020	FSC Recaptured in 2020	S_{RES} (%)	S_{COL} (%)[A]	S_{TRAN} (%)[B]	2020 ODS (%) with ±95% CI
Coho	1,452	300	20.6	96.5	98.2	19.6 ± 2.1
Chinook	194	36	18.5	95.5	93.7	16.6 ± 5.5
Steelhead	343	38	11.1	96.7	96.3	10.3 ± 3.3
Cutthroat	59	4	6.8	98.1	100.0	6.7 ± 6.4

[A] S_{COL} derived as part of combined survival (CS) outlined in Section 3.5 above and provided in Table 3.5-5.

[B] S_{TRAN} derived as part of combined survival (CS) outlined in Section 3.5 above and provided in Table 3.5-6.

The M&E Plan addresses the fact that a portion of tagged fish are likely to overwinter in the reservoir and that any fish captured in subsequent years will be retrospectively added to the ODS estimate for their release year. The adjusted 2019 ODS estimates are summarized below in Table 3.7-2. An additional 59 tagged coho, 19 steelhead, 14 Chinook, and 2 cutthroat from the 2019 ODS study were captured by the FSC during 2020. No additional tags from the 2018 ODS study were captured in 2019.

Table 3.7-2. 2019 adjusted annual ODS estimate for each species (functionally S_{RES} as the release ponds were not yet in operation) is shown (performance standard for all species is ≥ 80 percent).

Species	Tagged and Released in 2019	FSC Recaptured 2019	2019 ODS (%) with ±95%CI	FSC Recaptured 2020	Total Recaptured (Combined Years)	2019 Combined ODS (%) with ±95%CI
Coho	1,064	481	42.3 ± 3.0	59	540	50.8 ± 3.0
Chinook	223	56	24.4 ± 5.7	14	70	31.4 ± 6.1
Steelhead	280	23	8.2 ± 3.2	19	42	15.0 ± 4.2
Cutthroat	51	4	7.6 ± 7.4	2	6	11.8 ± 8.8

4.0 UPSTREAM COLLECTION AND PASSAGE METRICS

4.1 Summary

The historic adult fish trap at Merwin Dam was operated by PacifiCorp staff until June 28, 2013, when it was decommissioned for construction of the new passage facility. The new upstream sorting facility at Merwin Dam was considered substantially completed in April 2014, and has actively operated since.

All adult salmonids collected were identified to species and sorted by origin (i.e., hatchery or wild), broodstock (i.e., hatchery or supplementation), or as upstream target species.

A total 18,932 fish were captured at the Merwin Trap in 2020 (Table 4.1-1). Among the species collected, early coho accounted for the largest proportion of fish captured (n=10,036) followed by summer steelhead (n=2,289), winter steelhead (n=1,865), spring Chinook (n=2,267), late coho (n=1,689), fall Chinook (n=750), cutthroat (n=86), sockeye salmon (n=12), and chum salmon (n=1).

Of the 2,289 summer steelhead collected at Merwin trap in 2020, 635 fish were recaptured as part of WDFW's Recreational Angler Recycle Program. A total of 1,389 hatchery summer steelhead were captured at Merwin Trap and marked with a caudal clip. These fish were transported and released back into the lower Lewis River to re-ascend the river back to Merwin Dam and provide angling opportunities to recreational anglers. Once those fish previously recycled are recaptured at Merwin Dam, they are sent to Merwin Dam Fish Hatchery to be given to food banks or used as nutrient enhancement.

A record number of natural origin (NOR) early run coho (n=3,660), late run coho (n=711), and winter steelhead (n=456) were collected at the Merwin Trap in 2020. An additional 609 NOR late run coho and 247 NOR early run coho were collected at the Lewis River Hatchery. In terms of relative abundance, NOR fish also made up a substantial proportion of the runs. Approximately 42.1 percent of all late run coho, 36.5 percent of early run coho, and 25.3 percent of the winter steelhead collected in 2020 were of natural origin. A total of 253 PIT tagged adult salmonids returned to the Merwin Trap in 2020 (124 coho, 99 steelhead, 8 Chinook, 5 cutthroat, and 17 orphan tags), the highest number recorded since the facility was completed. Adult and winter steelhead accounted for the majority of the PIT interrogations in 2020. All PIT tag interrogation records collected at Merwin Trap wee uploaded to the PTAGIS database.

A total of 8,119 early coho, 1,367 late coho, 1,052 wild winter steelhead (blank wire tag and NOR combined), 634 spring chinook, and 86 cutthroat were transported upstream and released above Swift Dam as part of the reintroduction program in 2020 (Table 4.1-2). Lewis River Hatchery provided 1,926 early coho, 758 late coho, 153 spring Chinook, and 36 NOR winter steelhead, and three Blank Wire Tag winter steelhead for upstream transport. The remaining fish were collected at the Merwin Trap. Of the wild winter steelhead transported upstream, a total of 327 were of natural origin, and 725 were blank wire tag fish. NOR late coho were transported upstream only after meeting brood integration goals. All cutthroat that were transported upstream were collected at the Merwin Trap.

Table 4.1-1. Total number of salmonids collected at Merwin Trap during 2020. Resident rainbow trout and cutthroat were not gender-typed.

Characteristic	AD Clip			CWT			Wild			Wild Recap			Wild-BWT		Recap		Misc.		
Species	M	F	J	M	F	J	M	F	J	M	F	J	M	F	M	F	Not sexed	Total	%
Spring Chinook [a]	219	162	565	490	405	256	76	53	41									2,267	12.0
Fall Chinook	124	93	119	23	7	12	152	187	33									750	4.0
Early Coho	1,492	1,888	2,076	218	296	406	1,481	1,993	186									10,036	52.9
Late Coho	321	349	132	52	58	66	340	346	25									1,689	8.9
Summer Steelhead	649	1,031					3	1							159	446		2,289	12.1
Winter Steelhead	352	272					246	210					339	383				1,802	9.5
Sockeye Salmon							6	6										12	0.1
Chum Salmon							1											1	0.0
Pink Salmon																		0	0.0
Cutthroat (>13 inches)																	86	86	0.5
Cutthroat (< 13 inches)																		0	0.0
Rainbow (< 20 inches)																		0	0.0
Bull Trout (> 13 inches)																		0	0.0
Bull Trout (< 13 inches)																		0	0.0
															Total			18,932	100

[a] Counts of male and female spring Chinook may vary slightly from those reported by WDFW broodstock counts.

Table 4.1-2. Total salmonids transported above Swift Dam in 2020 (totals include Merwin Trap and Lewis River Hatchery Trap captures).

	Hatchery Origin			*Natural Origin*						
Species	Male	Female	Jack	Male	Female	Jack	Not sexed	Female:Male Ratio	Jack:Adult Ratio	Total
Spring Chinook	115	0	343	78	56	42	-	0.1	1.55	*634*
Early Coho	2,070	2,174	0	1,600	2,070	205	-	1.1	0.03	*8,119*
Late Coho	176	190	13	473	477	38	-	0.95	0.04	*1,367*
Winter Steelhead	339	386	-	176	151	-	-	1.03	-	*1,052*
Cutthroat >13' inch	-	-	-	-	-	-	86	-	-	*86*
Bull Trout >13' inch	-	-	-	-	-	-	-	-	-	*0*
									Total	*11,258*

4.2 Adult Passage Survival

4.2.1 Overview/Methods

Section 9.2.1(h) of the SA requires upstream passage survival (UPS) of adult salmonids and bull trout to be equal to or greater than 99.5 percent. The methods to calculate adult passage survival are outlined in Objective 9 of the current M&E Plan (2017). Adult bull trout and cutthroat trout are defined as fish with FL greater than 13 inches (330 mm). UPS is defined as the survival from the time adult target species enter the adult upstream facility to their release above Swift Dam. UPS is calculated based on Equation 4.2-1:

$$UPS = 1 - \frac{AD_{TRAP} + AD_{REL}}{N} \qquad \textbf{Equation 4.2-1}$$

Where:

N = Number of total adults collected;
AD_{TRAP} = Number of dead adults in trap; and
AD_{REL} = Number of dead adults at release site.

4.2.2 Results/Discussion

A total of 11,258 adult salmonids (8,119 early coho, 1,367 late coho, 1,052 winter steelhead, 634 spring Chinook, and 86 cutthroat) were transported upstream of Swift Dam in 2020. All cutthroat survived the trapping and transport processes resulting in a UPS of 100 percent. Late coho and winter steelhead demonstrated the second highest overall survival rate (99.9 percent), followed by spring Chinook (99.8 percent), and early coho (98.8 percent). The majority (60 percent) of the early coho mortalities occurred on a single occasion, and was likely the result of seasonally low dissolved oxygen levels, combined with a high number of fish simultaneously entering the fish lift and conveyance system. Approximately two thirds (66.3 percent) of all mortalities encountered in 2020 were fish of hatchery origin (63 early coho, one late coho, and one spring Chinook). Almost all (96.9 percent) mortalities observed in 2020 occurred during the trapping process (92 early coho, one late coho, one spring Chinook, and one winter steelhead). The remaining 3.1 percent occurred during transport (three early coho). A total of 98 mortalities were observed across all species, resulting in a UPS of 99.1 percent (Table 4.2-1).

Table 4.2-1. Overall upstream passage survival for Merwin Trap in 2020.

Species	Number Transported	Trap Mortalities	Transport Mortalities	Upstream Passage Survival (%)
Early Coho	8,119	92	3	98.8
Late Coho	1,367	1	0	99.9
Spring Chinook	634	1	0	99.8
Winter Steelhead	1,052	1	0	99.9
Coastal Cutthroat	86	0	0	100
Total	*11,258*	*95*	*3*	*99.1*

4.3 Adult Trap Efficiency

4.3.1 Overview/Methods

Adult trap efficiency (ATE) is defined in Section 4.1.4 of the SA as:

> *The percentage of adult Chinook, coho, steelhead, bull trout, and sea-run cutthroat that are actively migrating to a location above the trap and that are collected by the adult trap at Merwin Dam.*

The current M&E Plan (2107) defines a performance standard of 98 percent collection efficiency (ATE) for fish that enter the Merwin Dam tailrace.

Following the methods outlined in Objective 10 of the M&E Plan, the first year of study began in spring 2015. During that initial year, all three study species were evaluated including: winter steelhead, spring Chinook salmon, and coho salmon. However, due to low return rates of spring Chinook and coho salmon, samples sizes of these two species were well below the target of approximately 150 fish. Results of the 2015 evaluation indicated a relatively high success rate for tagged fish at locating the trap entrance, but lower rates of fish being successfully captured by the fish crowder and lift assembly.

In 2016, PacifiCorp implemented a second year of study. In addition to generating core passage metrics, the 2016 study focused efforts on resolving fish behaviors in and around the fish crowder and lift assembly using an ARIS sonar camera. Low return numbers of both spring Chinook and coho salmon in 2016 prevented inclusion of these species in the study; consequently, the 2016 ATE study focused exclusively on winter steelhead.

Results from both 2015 and 2016 (Stevens et al. 2016; Caldwell et al. 2017, respectively) indicated a relatively high success rate for tagged fish at locating the trap entrance, but lower rates of fish being successfully captured. This indicated fish were exiting the trap before they were collected. Moreover, based on both (1) initial ARIS camera data and (2) operational scenario modeling of network analysis output, it appeared that (A) fish passage was constrained at the hopper, and that (B) the frequency of fish crowder operation strongly affected the rate of successful passage. In general, fish were found to move in and out of the trap entrance and fish crowder at will, in some instances making over 100 trips between the tailrace and the trap without being captured by the fish crowder and lift assembly. One outcome that was informed by these early findings was the installation of a single V-style fyke to prevent fish from returning to the tailrace once they have entered the trap. The V-style fyke was installed in November 2016. In addition, increased frequency of hopper operation was also implemented to improve ATE in 2017.

Similar to the observations made in 2015 and 2016, results of the 2017 evaluations (winter steelhead and coho salmon) also indicated a relatively high success rate for tagged fish locating the trap entrance (P_{EE}), but slightly lower rates of fish being successfully captured. However, the discrepancy between these two metrics was significantly lower in 2017 than in previous years for both winter steelhead and coho salmon. This difference was directly correlated to the presence of the new V-style fyke in Pool 2, which prevented fish from returning to the tailrace once they had entered the trap. Although collection efficiency increased for both species in 2017, it was still below the performance standard of 98 percent. Cross-year comparisons using three years of data on winter steelhead (2015-2017) were made in 2017 to better understand how operational conditions (e.g., overall discharge from Merwin Dam, discharge from power generating turbines) might influence observed ATE_{test}. Based on these comparisons, there was limited evidence to suggest an effect of discharge from a power generating turbine in front of the trap entrance on trap entrance itself. However, there was some evidence that once overall discharge from Merwin Dam increased above 8,000 cfs, fewer fish reached the area outside the trap entrance or entered the trap. The results of this study also suggest there may be negative bias in estimating ATE_{test} using the current study design associated with: 1) using trap non-naïve test fish; 2) using hatchery origin fish rather than fish from the upper basin; and 3) not accounting for natural straying rates and fish condition. These possible factors were evaluated in 2018 and subsequently in 2019.

The primary goal of the 2018 Merwin Dam ATE study was to continue to evaluate the performance of the Merwin Trap using radio telemetry. In particular, this study was designed to assess whether passage metrics differ between test fish that are captured and tagged downstream of the trap (trap-naïve fish) and those that are collected after passing through the trap once, tagged and released back downstream (trap non-naïve fish). In 2018 the trap-naïve group had a low sample size although statistically it was shown trap-naïve fish had a higher efficiency. The focus of the 2018 effort was on winter steelhead and coho salmon because it was anticipated that low numbers of spring Chinook would be returning to the Lewis River in 2018. Further study was completed in 2019, which built on the 2018 study with the intention of achieving a larger sample of trap-naïve test fish. In 2019 an additional group of test fish was also created where trap non-naïve fish were tagged and released further downstream at the Pekins Ferry boat launch (trap non-naïve$_{PF}$) – approximately 15 river miles downstream of Merwin Dam. This additional group was introduced to asses if release location may affect performance between groups. This was because the historical release point for trap non-naïve fish had been at Merwin Dam boat launch, which is in close proximity (less than 0.2 mile) to the dam and trap entrance. Only winter steelhead were evaluated in the 2019 ATE study due to low numbers of returning coho and spring Chinook in 2019.

No evaluation for adult trap efficiency was completed in 2020.

4.3.2 Results/Discussion

In review of the past five years (2013 – 2019) of evaluation, the ACC determined that reliable operation of the facility's fish lift and conveyance system was the largest contributor to the success of fish being captured at Merwin Dam. At the December 12, 2019 ACC meeting, members agreed to postpone the ATE Evaluations in 2020 and requested PacifiCorp to develop a memorandum outlining the proposed steps for moving forward with the Merwin Trap for the ACC to review. In early 2020, PacifiCorp began reviewing possible alternative designs to the current lift and conveyance system, particularly aimed toward modifying the system's crowder that automatically crowds adults from the head of the fish ladder into the lifting hopper. As of December 2020, PacifiCorp has begun the formal process of redesigning the facility's crowding mechanism. It is anticipated that a final design will be reached by late-2021 with construction occurring sometime in 2022. Once the redesigned crowder is in place, it is intended that the ATE studies will resume for the target transport species.

4.4 Spawn Timing, Distribution, and Abundance of Transported Fishes

4.4.1 Overview/Methods

Section 9.2.2 of the SA identified the need to determine the spawn timing, distribution, and abundance for transported anadromous species that are passed upstream of Merwin Dam, which is included in the M&E Plan as Objective 15. The primary objective of this task is to identify preferred spawning areas in order to: 1) inform revisions to the Hatchery and Supplementation Plan (H&S Plan; PacifiCorp and Cowlitz PUD 2014) and the Upstream Transport Plan (PacifiCorp 2009); and 2) guide the ACC in determining how to direct restoration efforts with the Aquatics Fund.

Two methodologies for determining spawn timing, distribution, and abundance of transported fishes were developed. For adult coho salmon, comprehensive spawning ground surveys were conducted in the potentially accessible river and stream reaches upstream of Swift Dam in 2020. Due to limited access and anticipated heavy snow accumulations during the spawning season for winter steelhead, a combination of aerial radio telemetry surveys, fixed-station radio antennas, and ground surveys of reservoir tributaries were to conducted. A detailed description of each method is outlined in Objective 15 of the current M&E Plan.

4.4.2 Results/Discussion

Coho and Chinook Salmon

Coho Salmon spawning surveys were conducted from October 1, 2020 through December 31, 2020. Per Objective 15 of the current M&E Plan (2017), surveys were conducted to provide the basis for estimating the spawner abundance, timing, and distribution of transported adult anadromous fish in the North Fork (NF) Lewis River upstream of Swift Dam. Due to the low number of adult female spring Chinook transported upstream in 2020, spawning surveys specifically for spring Chinook in September were not conducted. The report summarizing these data is provided in Appendix D.

One female spring Chinook spawned-out carcass was observed in the NF Lewis River mainstem on October 10, 2020 in a deep bedrock pool just below Curly Creek bridge. No potential spring Chinook redds were identified during the October through December 2020 coho spawning surveys.

A total of 791 coho redds were counted during the 2020 survey season within the year-3 panel of survey reaches, of which 28 (3.5 percent) were determined to be new redds superimposed on redds previously counted. Most redds (84 percent) were counted in the NF Lewis River and Muddy River watersheds, and nearly the same number of redds were counted within each watershed. The NF Lewis River mainstem, Clear Creek, and the Muddy River mainstem had particularly high coho redd counts. Drift Creek (Swift Reservoir tributary) also had a relatively high total coho redd count. In some smaller streams, such as Spencer Creek, all potential spawning gravel patches within the survey reach contained at least one redd. Only four redds were counted in the Pine Creek watershed, all in P8 Creek, within the year-3 panel of survey reaches. However, while conducting bull trout spawning surveys in October, 48 coho redds were observed in the lower half of the mainstem of Pine Creek (outside the year-3 survey panel), which are not included in the total 791 redds reported above. Overall, few coho redds were found in Pine Creek, which is consistent with all prior years' surveys.

New coho redds were observed on the first survey on October 1, 2020 in Clear Creek, and by October 8 many redds were counted in the NF Lewis River mainstem. The last new redds counted were in the NF Lewis River mainstem on December 29, 2020. The survey data suggests that coho began spawning sometime before October 1 and continued spawning through December 2020 and likely into January 2021. In 2020, 85 percent of female coho were transported upstream and 80 percent of the total redds were counted by November 3, 2020.

Using the adjusted estimate of total redds based on the range of assumed detection probability and assuming one spawning female per redd, yields an estimate of 1.26 (bootstrap 95 percent confidence interval of 0.75 to 1.96) as the proportion of transported female coho that spawned in 2020, which is the highest of all estimates made since the fish passage program began in 2012. Proportions of 1.0 (or greater) suggest that all transported females spawned (assuming one redd per female). Proportions substantially greater than 1.0 indicate that actual detection probabilities are higher than assumed and/or that female coho may build more than one redd on average. Due to excellent survey conditions present after the majority of coho were transported upstream in October, it is suspected that the actual redd detection probability in 2020 was much greater than the range assumed in the analysis (0.3 to 0.6), which probably results in an over estimation of total redds and spawning success. However, even the lower bounds of the 2020 estimate of the proportion of transported females that actually spawned (0.75) is still higher than the actual estimate for all other years since the fish passage program began in 2012. Overall, the redd counts and estimates of spawning success suggest that most (if not all) adult female coho transported upstream during 2020 spawned.

Winter Steelhead

Aerial surveys scheduled to detect the distribution of spawning radio tagged winter steelhead in the upper basin above Swift Dam were canceled due to COVID-19 restrictions. Because of this cancellation, winter steelhead were not radio tagged in 2020. However, winter steelhead spawning "ground" surveys were conducted on immediate tributaries to Swift Reservoir on seven different surveys from April 6, 2020 through June 5, 2020.

The intent of the ground surveys along reservoir tributaries was to provide some reference to spawning activity lower in the system and in areas that could be accessible by foot. The ground surveys were to be performed weekly from early-April until spawning activity was no longer observed, which generally occurs by early-June. A survey consists of visiting each Swift Reservoir tributary and surveying the lower half mile. The Swift Reservoir tributaries surveyed are Swift, Diamond, Range, S10, Drift, S15 and S20 Creeks While every attempt to survey each tributary weekly is made, some restriction may occur due to high flows during spring runoff.

A total of 33 winter steelhead redds were observed throughout the surveyed reservoir tributaries in 2020 (Table 4.4-1). Spawning occurred from mid-April through the beginning of June with peak spawning activity taking place during the first two weeks of May. While all tributaries surveyed did have some observed spawning, Drift Creek and Swift Creek accounted for the majority (64 percent) of the observed winter steelhead redds in 2020.

Table 4.4-1: Summary of 2020 winter steelhead redd counts of Swift Reservoir immediate tributaries.

Survey Date (2020)	Swift Creek	Diamond Creek	Range Creek	Drift Creek	S10	S15	S20	Total
4/6	0	0	0	0	0	0	0	0
4/17	4	1	1	0	0	0	1	7
4/27	1	0	0	0	0	0	0	1
5/6	2	0	0	7	1	0	0	10
5/18	0	1	2	2	0	4	0	9
5/26	2	0	1	2	0	0	0	5
6/5	1	0	0	0	0	0	0	1
Total	*10*	*2*	*4*	*11*	*1*	*4*	*1*	*33*

5.0 OCEAN RECRUIT ANALYSIS

5.1 Overview/Methods

An analysis of ocean recruitment is stipulated in the SA to determine when the hatchery and natural adult production targets established for the upstream passage program were met. These targets were defined in Section 8.1 of the SA and described as:

> *"…total escapement (fish that naturally spawned above Merwin Dam and hatchery fish) plus harvest (including ocean, Columbia River, and Lewis River Harvest)."*

For this analysis, the average number of ocean recruits over a five-year period will be evaluated (i.e., five consecutive brood years). These data will be evaluated to determine if and when hatchery production levels should be altered. A detailed description of the methodology for this analysis is outlined in Objective 12 of the M&E Plan. The M&E Plan calls for utilizing three different methods of estimation including: 1) return-year recruitment estimates; 2) brood year recruitment estimates; and, 3) fishery plus escapement. These three approaches are to be used to supply information for run-reconstruction estimates of each return year. Steelhead are an exception because of their multi-year life cycle so WDFW recommended using a catch plus escapement approach. Some of this work depends on an accurate creel census program to estimate fishery-related mortalities, but a creel program will not be implemented until adequate numbers of spring Chinook return to warrant the effort.

5.2 Results/Discussion

Ocean recruit analysis was initiated in fall of 2013 and continued through the rest of the year. Halfway through the process of determining a methodology, investigators realized that the use of coded-wire tags (CWT) and the Regional Mark Information System (RMIS) does not account for CWT detection in fish that still have their adipose fin. The alternative methods for estimating ocean recruits are outlined in the current the M&E Plan **(**2017**)**. It will take at least five years of analysis before investigators can confidently report ocean recruit numbers and begin evaluating hatchery goals for the Lewis River. Given dramatic improvements in collection efficiency of out-migrants at the FSC in 2019 and to a lesser degree in 2020, it is anticipated that this analysis will begin in 2024.

6.0 PERFORMANCE MEASURES FOR INDEX STOCKS

6.1 Overview/Methods

The H&S Plan (PacifiCorp and Cowlitz PUD 2014) recommends that Lewis River hatchery production and other Lower Columbia River stocks be used as index groups to determine whether the success or failure of the Lewis River reintroduction program is the result of in-basin or out-of-basin factors. This would be determined by comparing the survival rates of hatchery and natural-origin fish produced in other basins (such as the Cowlitz River) with releases made in the Lewis River. Methods to address this recommendation are outlined in Objective 13 of the current M&E Plan (2017).

In past years (pre-2019) adult returns of NOR fish from the upper Lewis River had not occurred in numbers large enough for meaningful analysis of metrics related to performance. However, in 2020, there were sufficient numbers of returning NOR coho and winter steelhead returning from the upper basin above Swift Dam to make some inference on metrics related to performance. There were not enough returning natural origin spring Chinook from the upper basin to perform any meaningful analyses in 2020 and were therefore omitted.

For this initial analysis, productivity was calculated for returning adult coho and winter steelhead in 2020 by recruit per spawner (R/S), or the number of adult offspring produced per parent. For coho, the number of adults transported in 2017 were used to represent the number of spawners (S), and those adults returning in 2020 the recruits (R). Jacks were not included in this analysis. For winter steelhead, the number of adults transported in 2016 were used as spawners (S) for the adults returning in 2020.

In addition to R/S, performance was also estimated for returning coho and winter steelhead in 2020 by using brood year freshwater productivity from spawner to smolt (Smolt/S) and smolt-to-adult ratio

(SAR). Using the total number of juvenile out-migrants from each species transported downstream of the Swift Dam provided the abundance estimates for "smolts" produced by each spawning cohort (S). For this analysis, all parr and fry were excluded. For coho, smolts out migrating in 2019 were used, and for winter steelhead all smolts out-migrating in 2018 were used. While it is recognized that these are overly simplified direct comparisons for spawners and subsequent out-migrants, they are generally supported by PIT tag detections and comparing date of tagging and origin for returning adults in 2020. Nearly all returning adult coho that had PIT tags from the upper basin in 2020 (121/123 – 98 percent) were tagged in 2019, whereas nearly all winter steelhead (33/35 – 94 percent) were tagged in 2018. It should also be noted that this simplified comparison does not take into account any lose associated with recreational or commercial fisheries both in freshwater and in the ocean, and it also assumes that all natural origin adults returning to Merwin trap or Lewis River Hatchery are offspring from adults transported above Swift Dam. SARs for hatchery reared (HOR) coho and Blank Wire Tag winter steelhead also returning in 2020 as adults were used for comparison. These data were provided by WDFW. No out-of-basin comparisons were made at this time.

6.2 Results/Discussion

Based on metrics related to performance for NOR coho and winter steelhead adults returning in 2020, it appears that for both populations, replacement still was not been achieved. However, recruitment for the NOR stocks was considerably higher compared complementary Lewis River HOR populations of the same species returning in 2020 (Tables 6.2-1 and 6.2-2).

The R/S values for NOR coho and winter steelhead were 0.61 and 0.77, respectively. Both R/S values being less than one signifies that recruitment in 2020 was not at a level of replacement. That is, additional returning adults will be needed to sustain the population. Only R/S values greater than or equal to one lead to a growing population.

SAR values for both NOR coho (6.0 percent) and winter steelhead (5.8 percent) were high. While these numbers may be inflated by the assumption that all NOR coho and wild winter steelhead returning to Merwin Trap or Lewis River Hatchery are offspring of adults transported above Swift Dam, they are considerably higher than SAR's observed for hatchery coho (0.8 percent) and BWT winter steelhead (1.4 percent) returning over the same time period. It is worth noting that the BWT winter steelhead are offspring of a NOR adult that are mined from the lower river and used for the reintroduction broodstock program.

The smolt produced per spawner (Smolt/S) was 13.1 for coho (2019 out-migrants from 2017 parents) and 10.2 for NOR winter steelhead (2018 out-migrants from 2016 parents). For an R/S value of greater than or equal to one the Smolt/S ratio would have needed to be 16.7 for NOR coho and 17.2 for wild winter steelhead. It is believed that the collection efficiency of the FSC is the main bottleneck for holding R/S values below one. For instance, the FSC collection efficiency was 64 percent for coho (2019) and 49 percent for wild winter steelhead (2018). To achieve a smolt per spawner for replacement ($R/S \geq 1$) the collection efficiency would have needed to be at least 81 percent for 2019 wild coho smolts and 83 percent for 2018 wild winter steelhead smolts.

Table 6.2-1: Performance metrics for 2020 returning natural origin adult coho and late-winter steelhead.

Species (NOR)	Adults Transported Above Swift Dam [A]	Smolts Transported Downstream [B]	NOR Adults Returning to Lewis River 2020 [C]	Smolt to Adult Return (SAR%)	Recruit per Spawner (R/S)	Smolt per Spawner [D]	Smolt per Spawner for Replacement [E]
Coho	6,813	89,573	5,395	6.0%	0.79	13.1	16.7
Late-Winter Steelhead	772	7,869	456	5.8%	0.59	10.2	17.2

[A] For coho, the number of adults transported in 2017 were used to represent the number of spawners (S), and for winter steelhead, the number of adults transported in 2016 were used as spawners (S).

[B] For coho, smolts out-migrating in 2019 were used, and for winter steelhead all smolts out-migrating in 2018 were used.

[C] This is all NOR adults returning to both Merwin Trap and Lewis River Hatchery. This includes any mortalities, fish returned downstream, and fish used for brood.

[D] The smolts in this ‘smolt per spawner ratio are smolts that were captured at the FSC and transported downstream alive. This is not 'produced' number of smolts that would typically be calculated in a passable riverine system.

[E] This is the number of smolts that would have needed to be caught by the FSC and transported downstream alive to have a recruit per spawner ratio of 1 (replacement) for the 2020 return year.

Table 6.2-2: Smolt to adult performance metrics returning hatchery coho and late-winter steelhead.

Species (HOR)	Smolts Downstream	Adults Returning to Lewis River 2020	Smolt to Adult Return (SAR%)
Coho	2,193,389	18,363	0.8%
Late-Winter Steelhead (BTW)	52,119	728	1.4%

7.0 REINTRODUCED AND RESIDENT FISH INTERACTIONS

7.1 Overview/Methods

As called for in Section 9.7 of the SA, the Utilities will monitor the interaction between reintroduced anadromous salmonids and resident fish species. Of specific interest to the Settlement parties was the possible effect resident trout released in Swift Reservoir may have on reintroduced salmonids and the effect of anadromous fish introductions on the kokanee populations in Yale Lake. Additionally, concern was expressed that anadromous fish may impact the health and viability of ESA listed bull trout populations. This task is one of the assignments of the Fish Passage Feasibility Study conducted by the US Geological Survey (USGS) and University of Washington (UW), Department of Fisheries. The final report was issued in December 2016 (PacifiCorp 2016).

7.2 Results/Discussion

The USGS/UW group completed their analysis and provided results as follows:

1) Used existing data and empirical data to identify the structure of food webs in the three reservoirs;

2) Provided estimates of predation potential and consumption of juvenile salmonids by resident native and non-native species across different seasons;
3) Provided estimates of potential competition among different resident species and anadromous salmonids for resources;
4) Quantified spatial overlap within Pine Creek and habitat use by anadromous smolts and resident fishes; and,
5) Provided estimates of predation and competition among species in Pine Creek using stable isotope methods.

This effort covered a three-year period but the M&E subgroup suggested that this effort be repeated to assess interactions once the reintroduction program is fully operational.

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APPENDICES

APPENDIX A

UPPER LEWIS RIVER NUTRIENT ENHANCEMENT – 2020 FINAL REPORT

Thursday, December 10, 2020

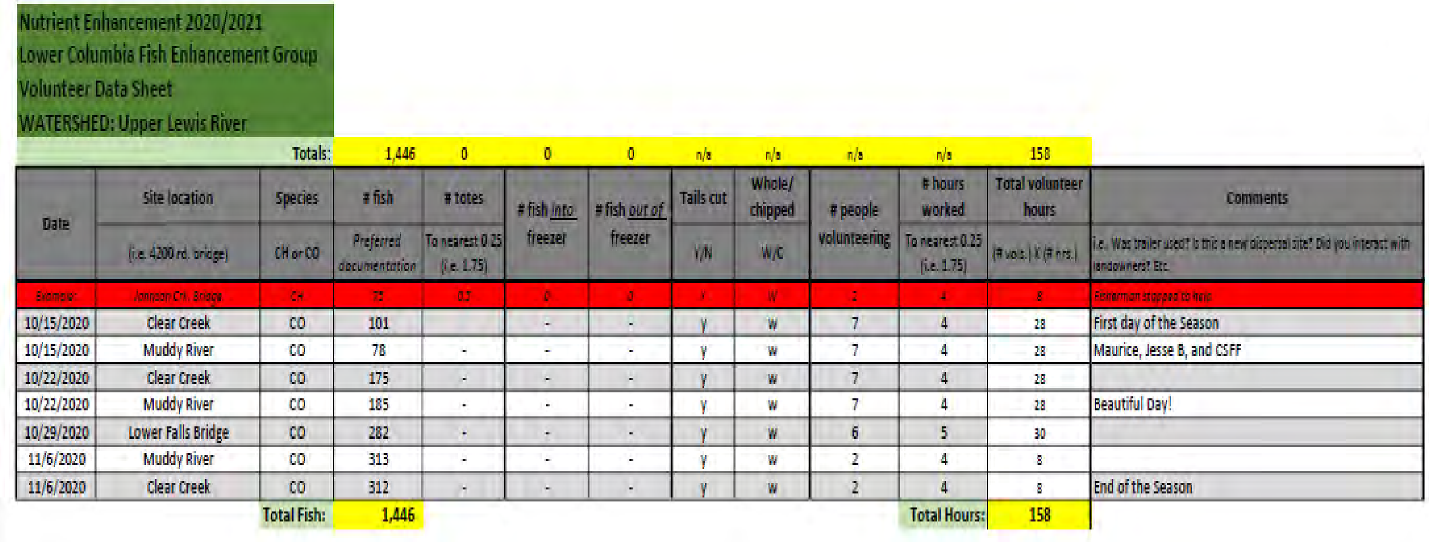
To:
Chris Karchesky
Fish Passage Program Supervisor
Lewis River Hydroelectric Facility
105 Merwin Village Ct.
Ariel, WA 98603

From:
Maurice Frank
Project Manager
Lower Columbia Fish Enhancement Group
12404 SE Evergreen Highway
Vancouver, WA 98683
(360) 953-1480

2020/2021 Upper Lewis River Nutrient Enhancement Report

Project Overview

During the summer of 2019, PacifiCorp approached the Lower Columbia Fish Enhancement Group (LCFEG) and asked us to assist and oversee their nutrient enhancement (NE) activities in the upper Lewis River. We discussed placement sites, carcass numbers, and logistics. Clear Creek bridge, Lower Falls bridge, and the Muddy River bridge were the placement sites that we agreed on. No changes were to the scope of work for upper Lewis River NE were made, so we continued the same activity this year (2020-2021). Between all three locations, we placed 1,446 carcasses and dedicated ~ 158 volunteer hours. See the attached table below for further details. Our immediate goal is to secure funding through the ACC to continue NE efforts in the upper Lewis River.



Nutrient Enhancement 2020/2021
Lower Columbia Fish Enhancement Group
Volunteer Data Sheet
WATERSHED: Upper Lewis River

Date	Site location	Species	# fish	# totes	# fish *into* freezer	# fish *out of* freezer	Tails cut	Whole/ chipped	# people volunteering	# hours worked	Total volunteer hours	Comments
	Totals:		1,446	0	0	0	n/a	n/a	n/a	n/a	158	
	(i.e. 4200 rd. bridge)	CH or CO	*Preferred documentation*	To nearest 0.25 (i.e. 1.75)			Y/N	W/C		To nearest 0.25 (i.e. 1.75)	(# vols.) X (# hrs.)	i.e. Was trailer used? Is this a new dispersal site? Did you interact with landowners? Etc.
Example:	*Johnson Crk. Bridge*	*CH*	*75*	*0.5*	*0*	*0*	*Y*	*W*	*2*	*4*	*8*	*Fisherman stopped to help*
10/15/2020	Clear Creek	CO	101		-	-	y	w	7	4	28	First day of the Season
10/15/2020	Muddy River	CO	78	-	-	-	y	w	7	4	28	Maurice, Jesse B, and CSFF
10/22/2020	Clear Creek	CO	175	-	-	-	y	w	7	4	28	
10/22/2020	Muddy River	CO	185	-	-	-	y	w	7	4	28	Beautiful Day!
10/29/2020	Lower Falls Bridge	CO	282	-	-	-	y	w	6	5	30	
11/6/2020	Muddy River	CO	313	-	-	-	y	w	2	4	8	
11/6/2020	Clear Creek	CO	312	-	-	-	y	w	2	4	8	End of the Season
		Total Fish:	1,446							Total Hours:	158	

Respectfully, Maurice Frank

APPENDIX B

EAGLE CLIFF ROTARY SCREW TRAP OPERATION SUMMARY-TECHNICAL MEMORANDUM 2020

Meridian
Environmental, Inc.

Environmental Sciences
Regulatory Planning
Project Management

Memorandum

To: Erik Lesko, PacifiCorp
From: Jason Shappart, Senior Fisheries Scientist
Date: December 18, 2020
Re: North Fork Lewis River Upstream of Swift Reservoir Rotary Screw Trap Summary – 2020

2020 Eagle Cliff Rotary Screw Trap Operation Summary

This memorandum summarizes results of rotary screw trapping conducted in the North Fork Lewis River upstream of Swift Reservoir in 2020. Meridian biologists operated an 8-foot diameter rotary screw trap located adjacent to Eagle Cliff at the upstream end of Swift Reservoir (Figure 1) from 9-March to 15-July (2020) under contract with PacifiCorp. Methods followed those described under Task 7.1 (Estimate the Timing and Number of Juveniles Entering Swift Reservoir from the Upper North Fork Lewis River Subbasin) as described in the Aquatic Monitoring and Evaluation Plan for the Lewis River (PacifiCorp and Cowlitz PUD 2017). The trap operated continuously and was checked daily during the monitoring period. However, it was turned off (cone raised) for one day (30-April) to make repairs. Estimates of the number of fish that may have passed the trap during this time were not generated.

The total number of fish captured by species during the monitoring period is summarized in Table 1. Fork length distributions of salmonid fish species are presented in Figure 2 (salmon) and Figure 3 (trout/char). Scatter plots of fork lengths of salmonids captured daily by species are presented in Figure 4 (Coho), Figure 5 (Chinook), Figure 6 (Steelhead), Figure 7 (Cutthroat), and Figure 8 (Bull Trout). Marked Coho, Chinook, Steelhead, and Cutthroat were released upstream of the trap daily (as fish were available from trap captures) to estimate trap efficiency via mark-recapture methods. Fish ≥60 mm fork length (FL) were marked with a PIT-tag or alcian blue tattoo for mark-recapture efficiency tests (1,354 PIT-tagged, 486 tattoo-marked). Per the monitoring plan (PacifiCorp and Cowlitz PUD 2017), fish <60 mm FL were not marked for efficiency tests. Because relatively few fish were available to determine mark-recapture rates in 2020, all salmonid species efficiency tests were combined to generate weekly trap efficiency estimates (Table 2). Salmonid fish species capture timing is presented in Figure 9 (salmon) and Figure 10 (trout/char) and was calculated by estimating total fish passing the trap on a weekly basis using the adjusted weekly trap efficiencies summarized in Table 2.

Capture efficiency was significantly different for salmonids <80 mm fork length compared to larger salmonids. Therefore, fork length-range specific capture efficiencies were applied to calculate total estimates of salmonids passed the trap for each species for the entire trapping period. Total estimates of fish passing the trap and their associated 95 percent confidence intervals were generated using the Bootstrap Method (Thidenga et al. 1994) and are summarized in Table 3. The sum of discrete interval method for calculating total outmigration described by Volkhardt et al. (2007) for a single partial capture trap was used to make a secondary estimate (Table 3) using the measured weekly trap efficiencies for the same specific fork-length ranges and species mark-recapture combinations used in the Bootstrap estimate (Table 2). These outmigration estimates should be viewed as the estimated total fish that passed the trap during the monitoring period.

In summary, 4,027 naturally produced salmonids and three hatchery trout were captured in the Eagle Cliff trap during the 2020 monitoring period (Table 1). These data suggest that during the 2020 monitoring period, the bulk of juvenile Coho passed the trap in June (Figure 9), while Steelhead, Cutthroat, and Bull Trout passed the trap over a more protracted period (Figure 10). None of the outmigration timing appeared to be associated directly with the peak spring flow (see figures 4 through 10). Note that very few adult Chinook were transported upstream to spawn in 2019 (among them only 12 adult female Chinook), which resulted in the low number of Chinook captured in the Eagle Cliff screw trap during the 2020 monitoring period.

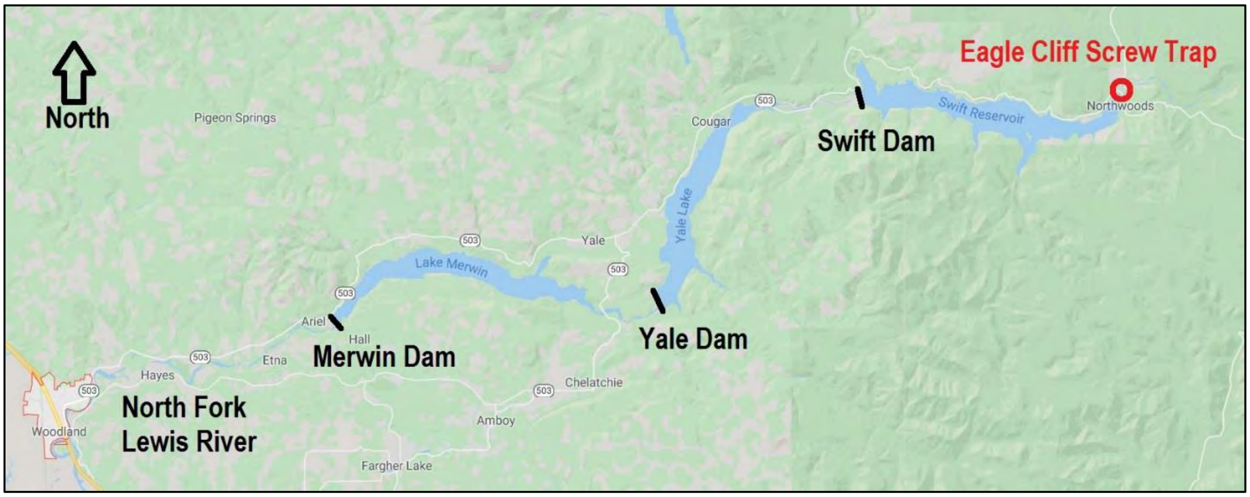


Figure 1. Study area.

Table 1. Summary of total captures (Eagle Cliff trap 2020).

Species	Total Hatchery Produced **≥60 mm FL**	Total Naturally Produced <60 mm FL	Total Naturally Produced **≥60 mm FL**	Total Marked - Released Upstream **≥60 mm FL**	Total Recaptures
Coho Salmon	NA	1,422	1,914	1,502	81
Chinook Salmon	NA	9	18	18	3
Steelhead Trout	NA	296	264	260	12
Rainbow Trout	3	0	1	0	NA
Cutthroat Trout	NA	0	61	60	2
Bull Trout	NA	0	42	0	NA
All Salmonids Combined		1,727	2,300	1,840	98

Species	Total
Dace	8
Lamprey	2
Sculpin	94
Sucker	3
Three-spined Stickleback	6
Whitefish	5

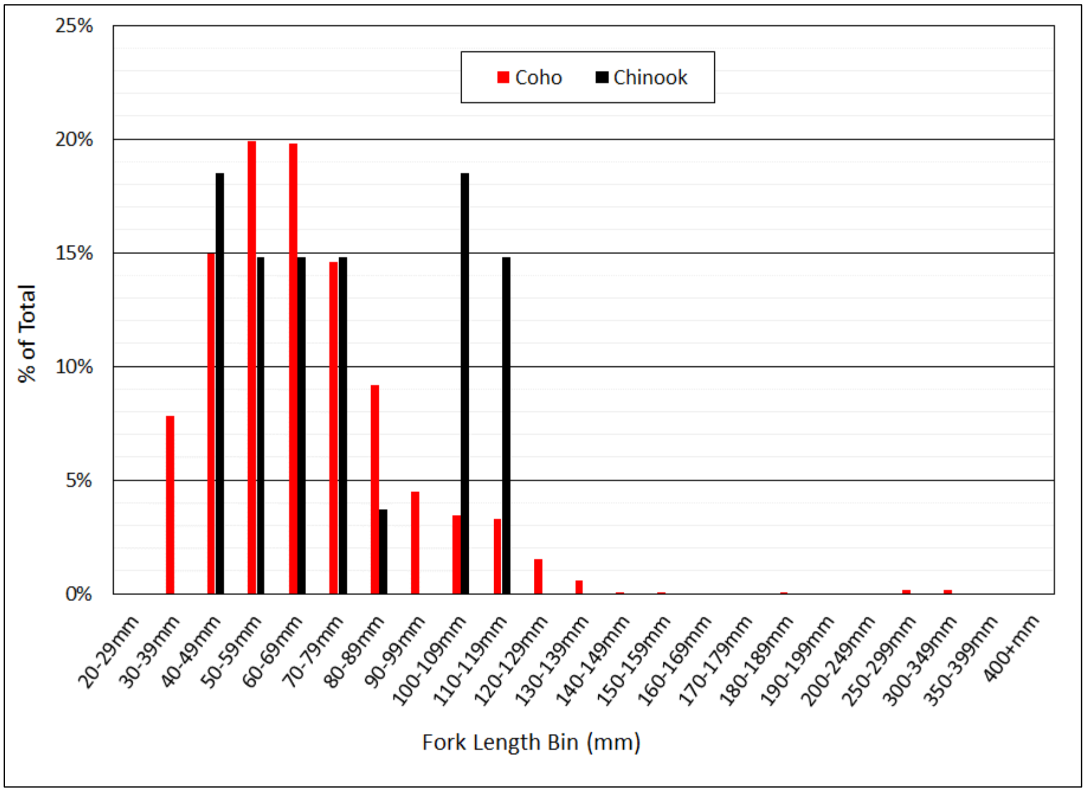


Figure 2. Length frequency of naturally produced salmon (Eagle Cliff trap 2020).

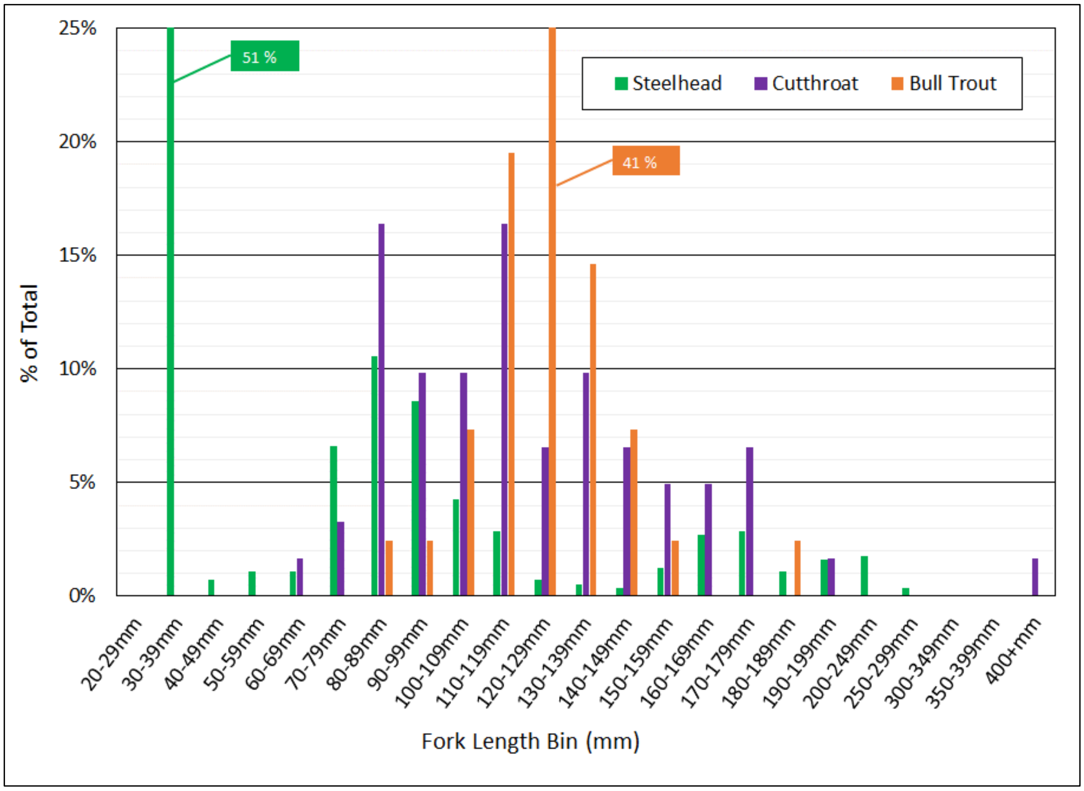


Figure 3. Length frequency of naturally produced trout/char (Eagle Cliff trap 2020).

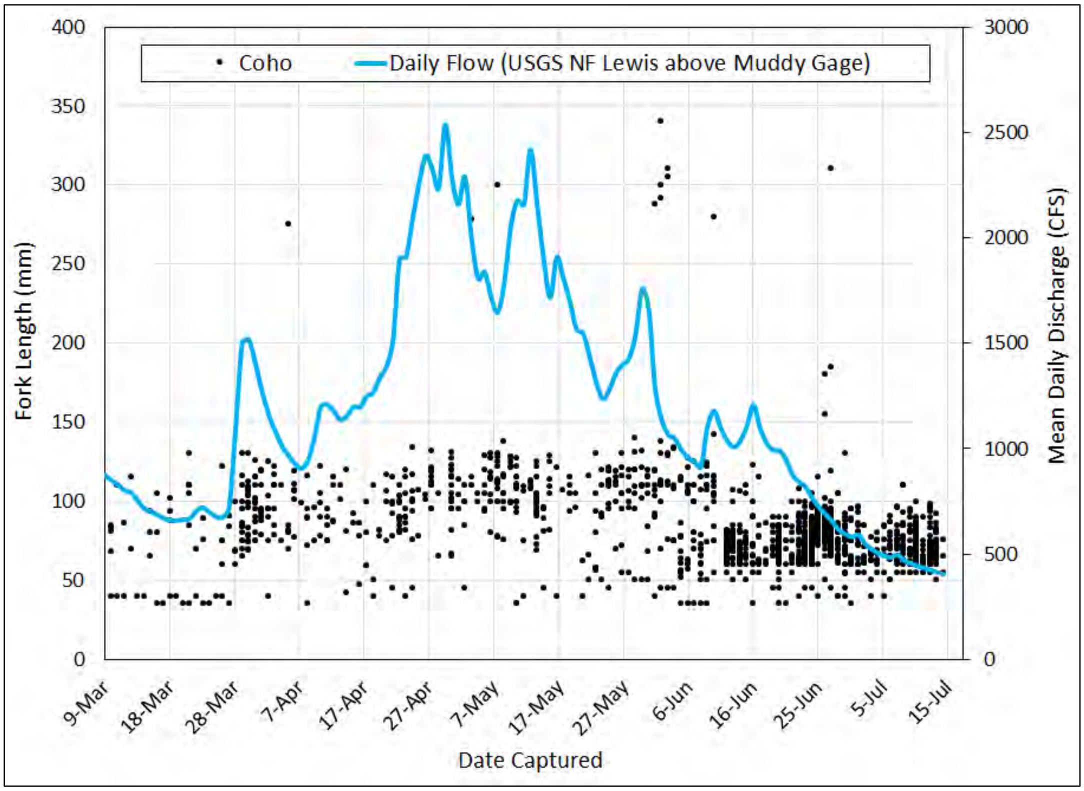


Figure 4. Fork length of maiden Coho captured each day (Eagle Cliff trap 2020).

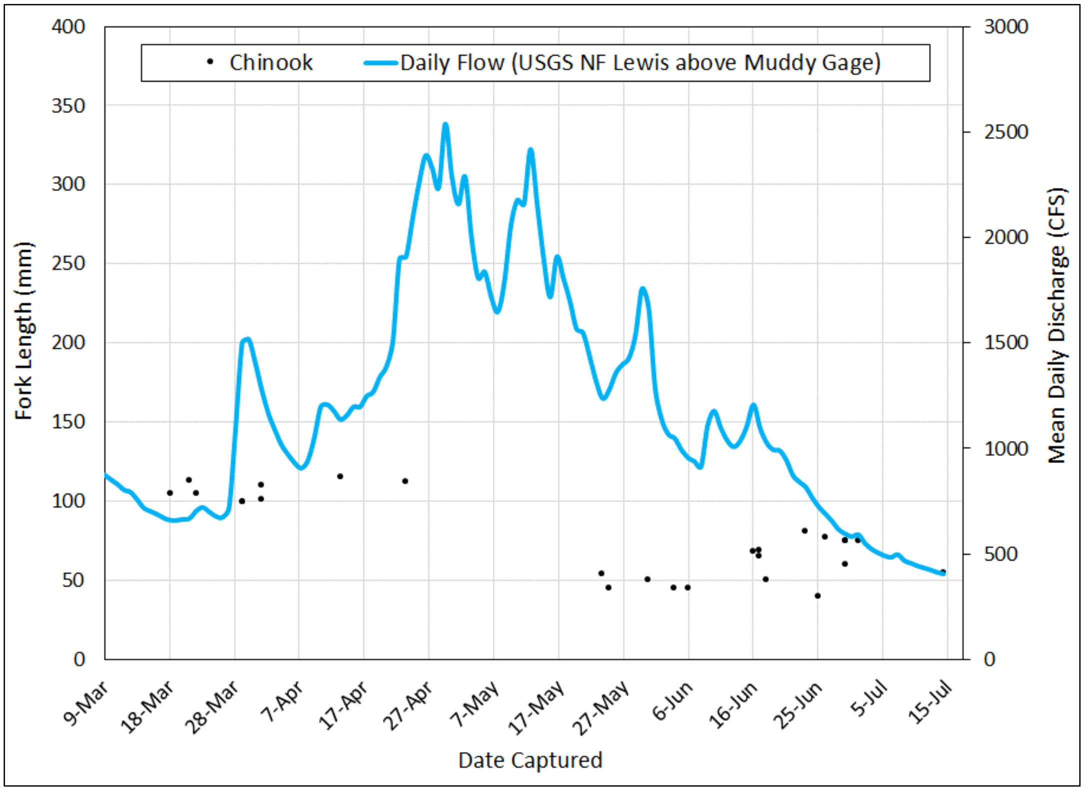


Figure 5. Fork length of maiden Chinook captured each day (Eagle Cliff trap 2020).

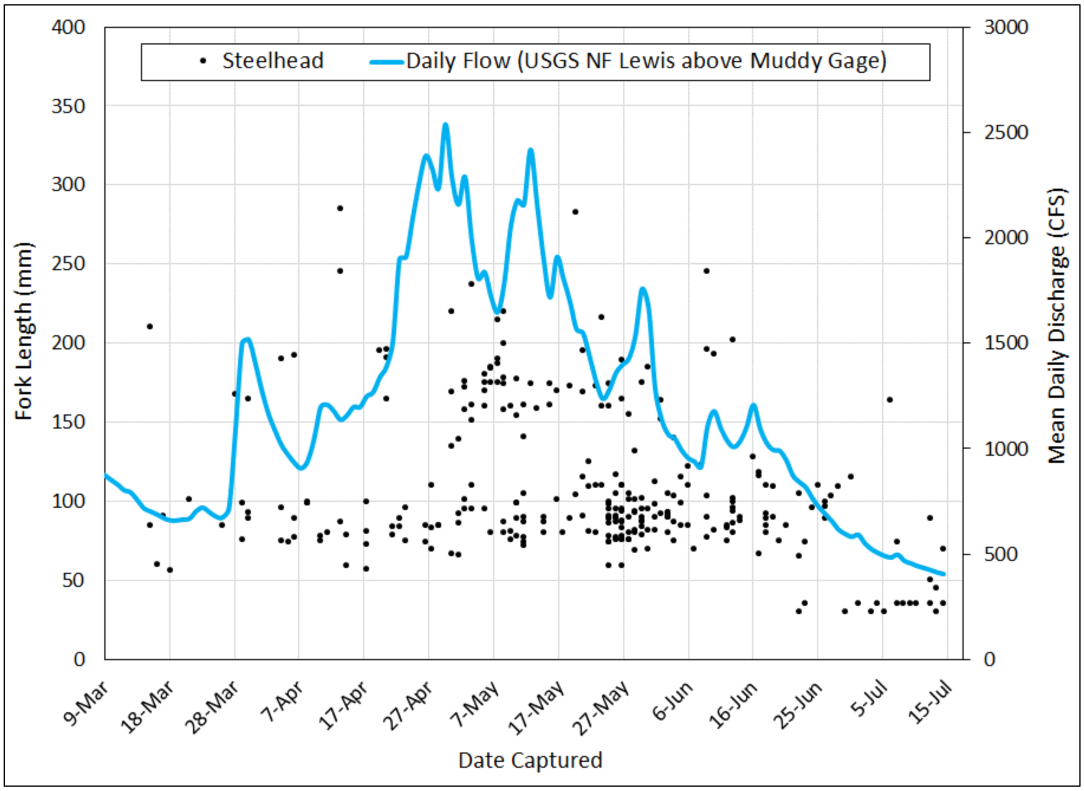


Figure 6. Fork length of maiden Steelhead captured each day (Eagle Cliff trap 2020).

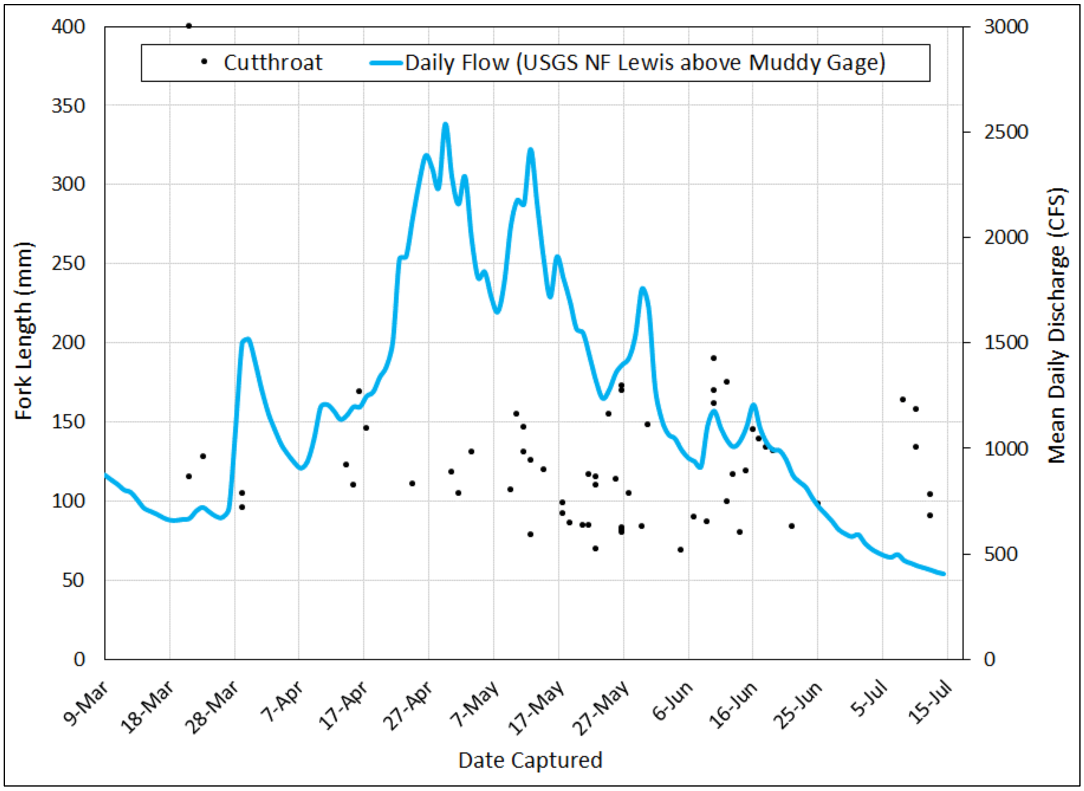


Figure 7. Fork length of maiden Cutthroat captured each day (Eagle Cliff trap 2020).

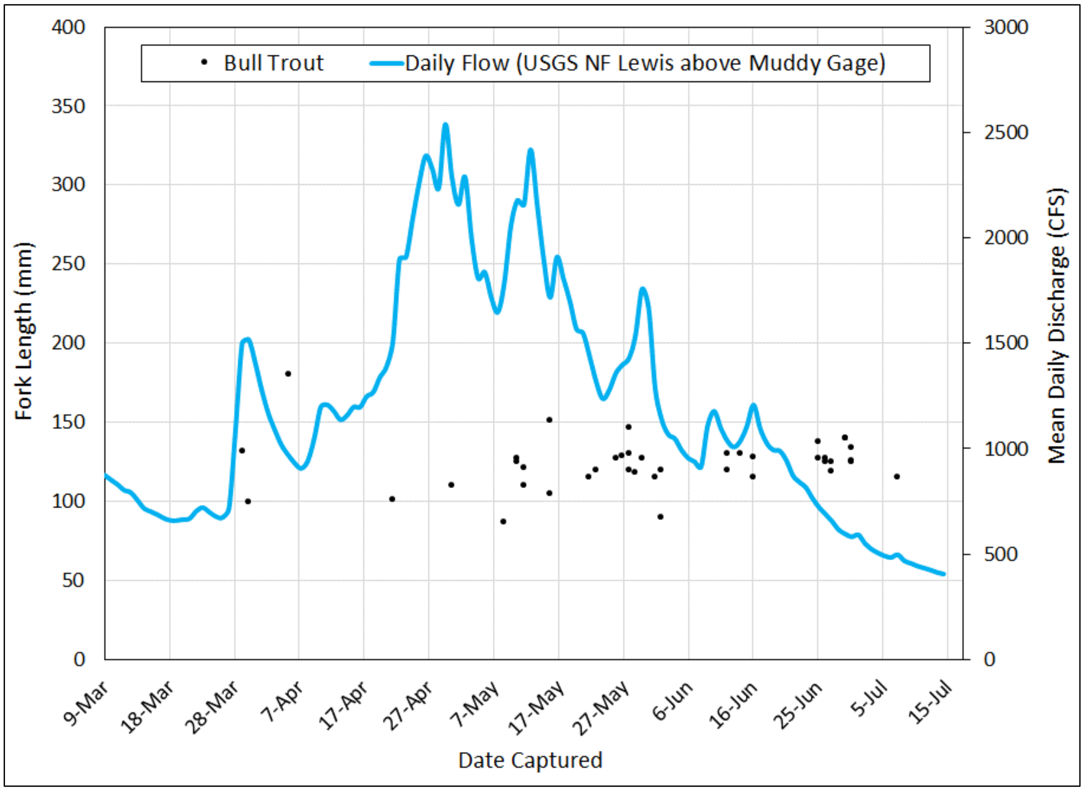


Figure 8. Fork length of maiden Bull Trout captured each day (Eagle Cliff trap 2020).

Table 2. Summary of weekly mark-recapture efficiency tests (Eagle Cliff trap 2020).

Week (first day)	Total Salmonids **Caught ≥60** mm FL[a]	Total Marked & Released **Upstream ≥60** mm FL	Total Recaptured	Trap Efficiency	Average Weekly Flow (cfs)[b]	Weekly Average Cone RPMs	Adjusted Efficiency Based on Flow
3/9/2020	8	8	1	0.125	807	3.4	0.125
3/16/2020	22	22	1	0.045	676	3.0	0.083[c]
3/23/2020	18	14	2	0.143	757	3.3	0.083[c]
3/30/2020	83	83	2	0.024	1284	3.9	0.024
4/6/2020	41	40	2	0.050	1032	3.0	0.050
4/13/2020	27	27	2	0.074	1200	3.2	0.074
4/20/2020	53	53	1	0.019	1771	4.3	0.019
4/27/2020	61	60	2	0.033	2320	6.2	0.033
5/4/2020	78	77	6	0.078	1839	5.3	0.078
5/11/2020	79	79	3	0.038	2064	5.1	0.038
5/18/2020	45	43	1	0.023	1519	3.4	0.023
5/25/2020	119	119	5	0.042	1491	3.4	0.042
6/1/2020	90	90	11	0.122	1064	3.1	0.122
6/8/2020	169	169	5	0.030	1057	3.0	0.030
6/15/2020	129	124	3	0.024	1055	3.1	0.024
6/22/2020	855	470	28	0.060	768	2.8	0.060
6/29/2020	124	124	15	0.121	569	2.9	0.121
7/6/2020	132	132	5	0.038	471	1.9	0.038
7/13/2020	124	106	3	0.028	369	1.8	0.028
Total	2257	1840	98	0.053			

[a] Total Coho, Chinook, Steelhead, and Cutthroat (Bull Trout were not used for efficiency tests as specified in the ESA take permit). Rainbow Trout (1 naturally produced, and 4 hatchery produced) were also not used for efficiency tests.

[b] USGS Gage 14216000 Lewis River Above Muddy River Near Cougar, WA.

[c] Combined efficiency measured during weeks with similar and constant mean daily flow after review of full hydrograph (weeks of 16-March and 23-March).

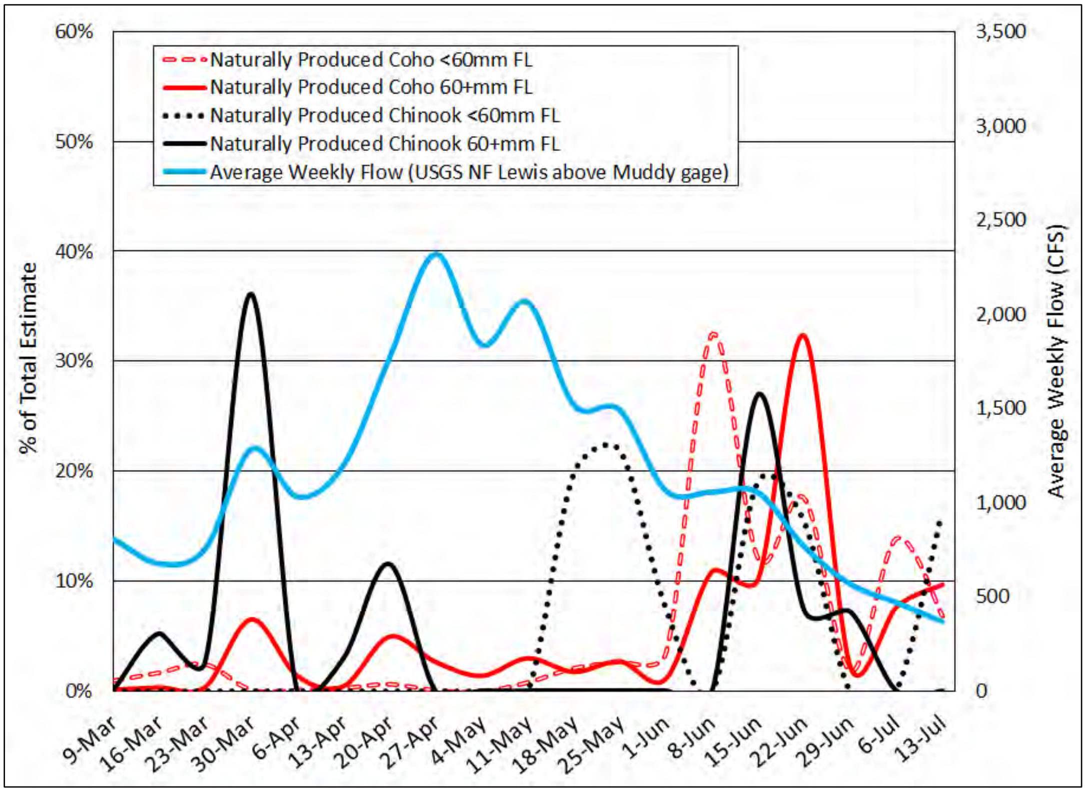


Figure 9. Naturally produced salmon migration timing (Eagle Cliff trap 2020).

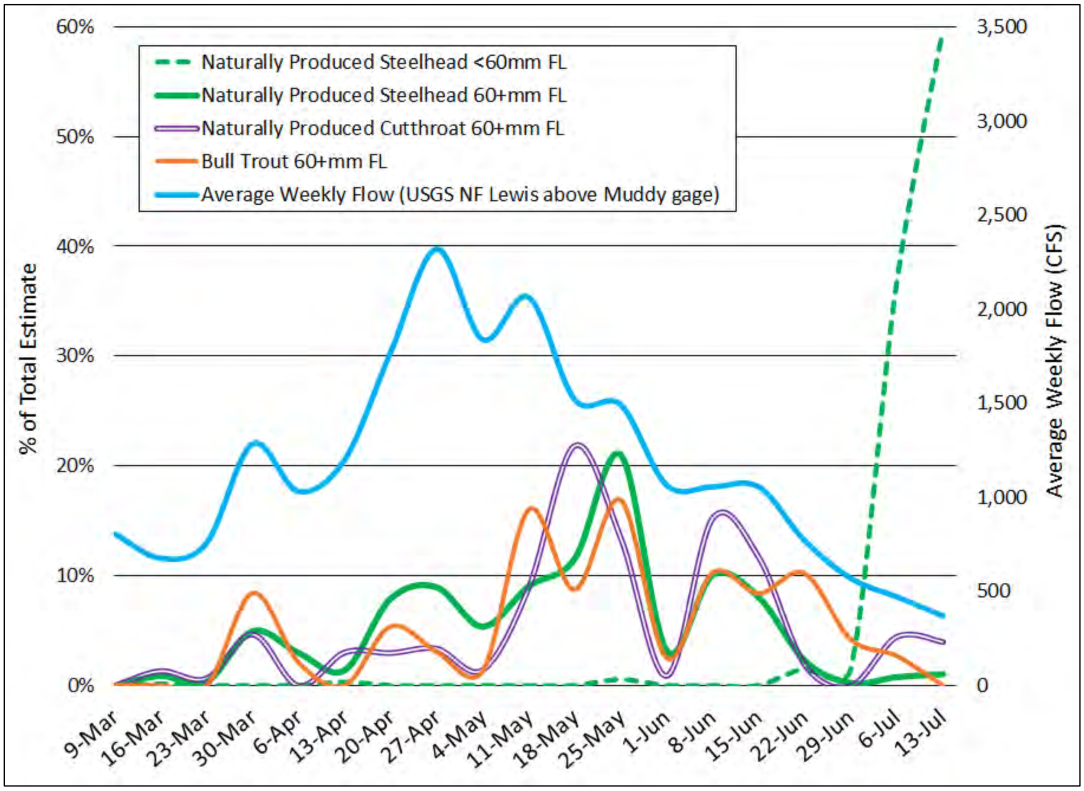


Figure 10. Naturally produced trout/char migration timing (Eagle Cliff trap 2020).

Table 3. Estimates of total naturally produced salmonids passing the Eagle Cliff trap (2020) by species.

Species	Capture Efficiency Applied	Total Maiden Captures	Bootstrap Method Mean Estimate (95% CI) (CV%)	Volkhardt Method Estimate (95% CI) (CV%)
Coho (<60 mm FL)[a]	0.045	1,422	32,489 (+/- 10,850) (17%)	29,952 (+/- 10,577) (18%)
Coho (60-79 mm FL)[b]	0.047	1,147	25,021 (+/- 8,314) (17%)	21,324 (+/- 6,394) (15%)
Coho (≥80 mm FL)[c]	0.063	767	12,204 (+/- 3,669) (15%)	13,694 (+/- 4,886) (18%)
Total Coho Estimate		3,336	69,714 (+/- 14,152) (10%)	64,970 (+/- 13,290) (10%)
Chinook (<60 mm FL)[a]	0.045	9	205 (+/- 146) (36%)	198 (+/- 157) (41%)
Chinook (60-79 mm FL)[b]	0.047	8	173 (+/- 137) (40%)	196 (+/- 190) (50%)
Chinook (≥80 mm FL)[c]	0.063	10	161 (+/- 107) (34%)	227 (+/- 224) (50%)
Total Chinook Estimate		27	539 (+/- 227) (22%)	620 (+/- 333) (27%)
Steelhead (<60 mm FL)[a]	0.045	296	6,769 (+/- 2,403) (18%)	6,662 (+/- 3,822) (29%)
Steelhead (60-79 mm FL)[d]	0.045	43	996 (+/- 460) (24%)	1,186 (+/- 987) (42%)
Steelhead (≥80 mm FL)[e]	0.060	221	3,749 (+/- 1,045) (14%)	4,278 (+/- 1,586) (19%)
Total Steelhead Estimate		560	11,514 (+/- 2,660) (12%)	12,126 (+/- 4,254) (18%)
Cutthroat (<60 mm FL)	NA	None		
Cutthroat (60-79 mm FL)[d]	0.045	3	70 (+/- 82) (60%)	69 (+/- 91) (68%)
Cutthroat (≥80 mm FL)[e]	0.060	58	977 (+/- 347) (18%)	1,306 (+/- 623) (24%)
Total Cutthroat Estimate		61	1,047 (+/- 357) (17%)	1,375 (+/- 630) (23%)
Bull Trout (<60 mm FL)	NA	None		
Bull Trout (60-79 mm FL)	NA	None		
Bull Trout (≥80 mm FL)[e]	0.060	41	692 (+/- 270) (20%)	802 (+/- 349) (22%)
Total Bull Trout Estimate		41	692 (+/- 270) (20%)	802 (+/- 349) (22%)

[a] Capture efficiency applied based on all salmonids combined 60-79 mm, 807 marked and 36 recaptured (<60 mm not marked).
[b] Capture efficiency applied based on Coho and Chinook combined 60-79 mm, 764 marked and 36 recaptured.
[c] Capture efficiency applied based on Coho and Chinook combined ≥80 mm, 756 marked and 48 recaptured.
[d] Capture efficiency applied based on all salmonids combined 60-79 mm, 807 marked and 36 recaptured.
[e] Capture efficiency applied based on all salmonids combined ≥80 mm, 1,033 marked and 62 recaptured.

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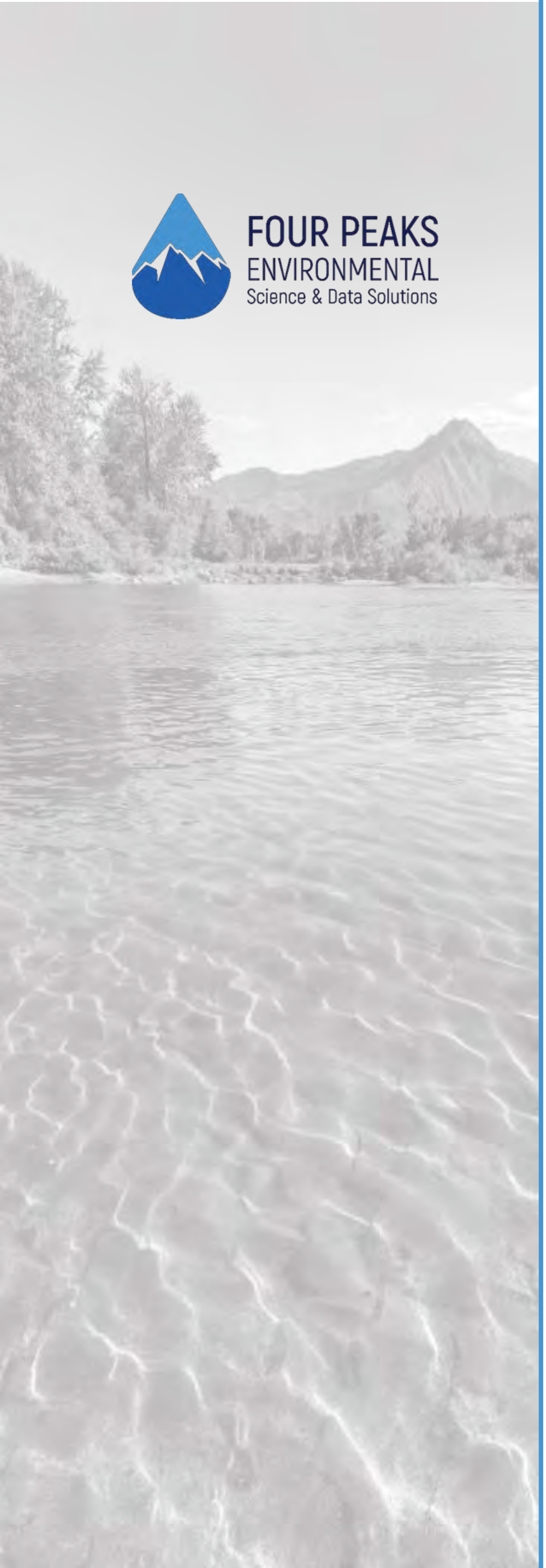
APPENDIX C

SWIFT RESERVOIR FLOATING SURFACE COLLECTOR SMOLT COLLECTION EFFICIENCY EVALUATION – 2020 FINAL REPORT



SWIFT RESERVOIR FLOATING SURFACE COLLECTOR COLLECTION EFFICIENCY EVALUATION 2020: ANNUAL REPORT

January 2021

Prepared for
PacifiCorp
Lewis River Hydroelectric Facility
105 Merwin Village Court
Ariel, Washington 98603

Prepared By
Four Peaks Environmental
Science & Data Solutions
5 South Wenatchee Ave #210
Wenatchee, Washington 98801

Table of Contents

Appendices

List of Figures

List of Tables

Abbreviations

Abbreviation	Definition
2004 Settlement Agreement	Relicensing of the Lewis River Hydroelectric Projects – FERC Project Nos. 935, 2071, 2111, 2213, Cowlitz, Clark and Skamania Counties, Washington
2020 Study	2020 Swift Reservoir Floating Surface Collector Passage Evaluation
ATS	Advanced Telemetry Systems
AUC	area under the curve
CCH	collection channel
CI	confidence interval
primary channel	primary screen collection channel
secondary channel	secondary screen collection channel
FERC	Federal Energy Regulatory Commission
FL	fork length
FSC	floating surface collector
IQR	interquartile range
M&E Plan	Aquatic Monitoring and Evaluation Plan for the Lewis River
ML	machine learning
NTS	the net transition structure
PIT	passive integrated transponder
Project	PacifiCorp Swift No. 1 Project FERC No. 2111
ROC	receiver operating characteristic
SMOTE	synthetic minority over-sampling technique
TOAD	time-of-arrival difference
WRP	Woodland Release Ponds
ZOI	zone of influence
ZPC	zone presence criteria
ZPTS	zone presence time series

Executive Summary

The 2020 Swift Reservoir Floating Surface Collector Passage Evaluation (2020 Study) measured the collection efficiency of the Swift Floating Surface Collector (FSC) and assessed the behavior of juvenile salmonids (Chinook Salmon *Oncorhynchus tshawytscha*, Coho Salmon *O. kisutch*, and steelhead *O. mykiss*) released near the head of Swift Reservoir as they approached and interfaced with the Swift FSC. The purpose of the 2020 Study was to evaluate FSC effectiveness, primarily as measured by collection efficiency (P_{CE}), but also using additional performance metrics and a series of behavioral analyses.

An array, comprising 13 acoustic receivers across three distinct subarrays, was deployed in the Swift Dam forebay. These subarrays included the zone of influence (ZOI) subarray, installed in the Swift Dam forebay upstream of the FSC, the net transition structure (NTS) subarray, installed within the NTS that guides fish into the collection channel, and the collection channel subarray, installed within the fish collection channel that leads directly to the FSC entrance. For behavioral analyses, the collection channel subarray was partitioned further into the primary screen collection channel and secondary screen collection channel.

A total of 524 fish were dual passive integrated transponder and acoustic tagged and released at the upper end of Swift Reservoir between 19 March and 28 May 2020, to measure system performance and monitor fish behavior. The 524 study fish comprised 185 Chinook Salmon, 185 Coho Salmon, and 154 steelhead. Sample sizes were determined to provide 90% confidence with a 6% margin of error, assuming that P_{CE} and P_{RES} would be similar to that observed in 2019. Because of irreconcilable data entry errors, three of these 524 study fish (2 Chinook Salmon and 1 steelhead) were excluded from computations or analyses. This left 521 fish, comprising 183 Chinook Salmon, 185 Coho Salmon, and 153 steelhead. This group represents the 2020 study fish.

The proportion of fish successfully transiting the reservoir during the study period was quantified in 2020 using the P_{ZOI} metric. P_{ZOI} summarizes the proportion of all dual-tagged study fish that were detected within the ZOI before the conclusion of the 2020 Study. In 2020, P_{ZOI} was 58% for Chinook Salmon, 62% for Coho Salmon, and 73% for steelhead.

Collection efficiency (P_{CE}) is a key performance metric that represents the proportion of dual-tagged study fish reaching the ZOI that were subsequently collected. In 2020, P_{CE} was 44% for Chinook Salmon, 39% for Coho Salmon, and 42% for steelhead. Compared to 2019 results, these proportions represent a 12% (6 percentage point) decrease for Chinook, a 23% (16 percentage point) decrease for Coho, and a 55% (15 percentage point) increase for steelhead, bringing all three species back closer to P_{CE} values observed in the 2017 study using passive integrated transponder and acoustic telemetry. Entrance efficiency (P_{ENT}), quantifies the proportion of fish in the ZOI that were then detected within the NTS at the entrance of the FSC. P_{ENT} was near 100% for all three species, ranging from 95% for Chinook Salmon to 99% for steelhead. Together, these results suggest that, although a nontrivial proportion of study fish do not successfully traverse the reservoir during the study period (either due to mortality or delayed migration), once they reach the ZOI, almost all fish enter the FSC.

Nearly three quarters (74%) of the fish that entered the NTS were subsequently detected within the collection channel (P_{CHAN}). P_{CHAN} was similar among species, ranging from 67% for steelhead to 82% for Coho Salmon. Among these fish that entered the NTS, however, less than half were retained within the FSC and ultimately collected (P_{RET}). P_{RET} was 44% for Chinook Salmon, 39% for Coho Salmon, and 42% for steelhead. Once in the collection channel, 58% of study fish were collected (P_{COL}); again, all three species appeared to perform similarly in this regard. Thus, the relatively low observed collection efficiency rates appear to be largely the product of low retention, rather than attraction to the FSC. These relatively low retention rates reflect apparent “turnaround” points for all three species located between the NTS and primary channel, and again between the secondary channel and the collector.

Acoustic telemetry data collected during the study enabled the analysis of fine scale movements in the fish passage channel of the collector for identifying factors contributing to successful passage. Modeling efforts using these data revealed that smaller fish were more likely to be recaptured (larger fish were most likely to reject the collector), and passage attempts tended to be more successful when initiated at night. The latter effect may be a result of patterns in daylight and/or human activity.

1 Introduction

1.1 Study Purpose and Objectives

The 2020 Swift Reservoir Floating Surface Collector Passage Evaluation (2020 Study) was conducted to collect and analyze data that informs decisions related to the operation and performance of the Swift floating surface collector (FSC). Swift FSC performance is evaluated within the context of metrics that summarize fish behaviors within the Swift Reservoir and FSC. These metrics are computed for a sample of smolts (study fish) captured at the Swift FSC, dual tagged with passive integrated transponder (PIT) and acoustic tags, then released 7.5 miles upstream (east) of the FSC, at the head of Swift Reservoir, near Swift Forest Camp Boat Launch. After release, study fish were monitored as they approached, interacted with, and were potentially collected in the FSC.

Previous studies (Anchor QEA 2018; Smith et al. 2018; Four Peaks 2020) found that study fish successfully locate and enter the net transition structure (NTS), the fish collection channel transition structure located at the entrance of the FSC. However, too many fish reject collection after entering the collector to achieve the performance standard for collection efficiency of 95% for each species (2004 Settlement Agreement; PacifiCorp et al. 2004). These previous studies identified the collection channel (the reach between the NTS and collection at the FSC) as the primary bottleneck to achieving performance targets. As such, the 2020 Study focused on fish behaviors within the NTS and collection channel.

As in previous study years, the performance of the FSC was evaluated using collection efficiency (P_{CE}). P_{CE} is calculated as the proportion of study fish arriving in the attraction flow field of the FSC (zone of influence [ZOI]) that are ultimately collected. Additional performance metrics were calculated to evaluate transitions among sub-reaches between the ZOI and collection within the FSC. As much as possible, given constraints associated with changes in study design and acoustic telemetry array layout, these metrics are consistent with previous study years to enable comparisons. As needed, other metrics were added to provide additional resolution within the FSC collection channel.

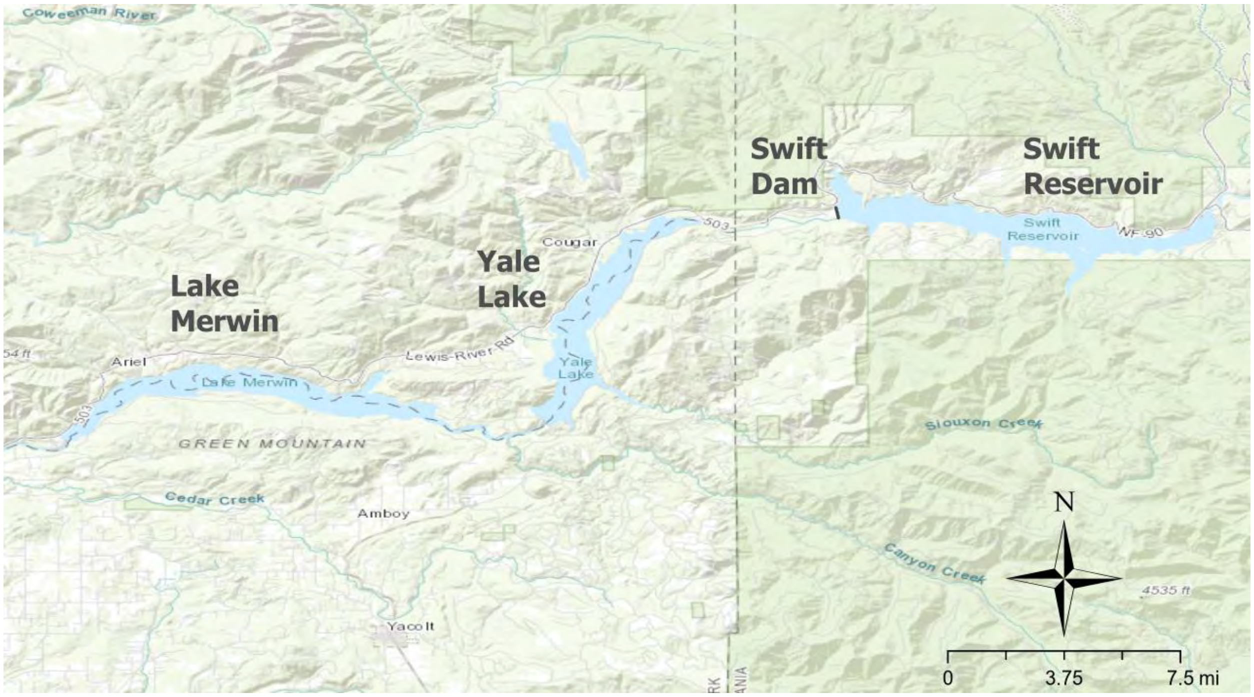
The metrics used in the 2020 Study included the following:

- Estimated proportion within the ZOI (P_{ZOI} – the proportion of released study fish that are detected in the ZOI
- Estimated entrance efficiency (P_{ENT}) – the proportion of study fish detected in the ZOI that enter the NTS
- Estimated channel efficiency (P_{CHAN}) – the proportion of study fish detected in the NTS that enter the collection channel
- Estimated channel-collector transition rate (P_{COL}) – the proportion of study fish detected in the collection channel that are re-captured at the FSC
- Estimated retention efficiency (P_{RET}) – the proportion of study fish detected in the NTS that are re-captured at the FSC
- Estimated collection efficiency (P_{CE}) – the proportion of study fish detected in the ZOI that are re-captured at the FSC

The 2020 study also examined fine-scale fish behavior within the collection channel to identify locations within the extent of the structure where fish reject and turn back upstream. These fine-scale behavioral analyses also examined factors that might explain rejection rates.

1.2 Background

The PacifiCorp Swift No. 1 Project (Federal Energy Regulatory Commission [FERC] Project No. 2111; [Project]) is the furthest upstream and largest hydroelectric project in the Lewis River system (Figure 1). The Project consists of Swift Dam No. 1, which is a 412-foot-high by 2,100-foot-long embankment dam that impounds a 4,600-acre reservoir known as Swift Reservoir.



Spatial Reference: GCS WGS 1984; Aerial imagery source: ESRI, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, ESRI Japan, METI, ESRI China (Hong Kong), OpenStreetMap contributors, and the GIS User Community.

Figure 1. Vicinity map of the Swift Reservoir and Swift Dam on the Lewis River.

In 2008, the Project was issued a new FERC license (FERC 2008) that includes provisions for restoring anadromous salmonids to the Lewis River Basin. As a component of the overall restoration goal, the license incorporates specific measures from 2004 Settlement Agreement, including the construction and operation of a modular FSC at the lower end of Swift Reservoir near Swift Dam to collect migrating juvenile salmonids for subsequent transportation downstream of the Project (PacifiCorp et al. 2004). In addition, the 2004 Settlement Agreement requires monitoring and evaluation of the P_{CE} at the FSC, and the subsequent Aquatic Monitoring and Evaluation Plan for the Lewis River (M&E Plan) has identified a P_{CE} performance target of 95% at a 0.05 precision level for the FSC (PacifiCorp and Cowlitz County PUD 2017). For the purposes of the M&E Plan, P_{CE} is defined as the proportion of juvenile anadromous fish of each of the species designated in the 2004 Settlement Agreement[1] that is available for collection and is actually collected. For the 2020 study, fish that had reached the ZOI were considered “available for collection.”

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[1] Species designated in Section 4.1.7 of the 2004 Settlement Agreement are spring-run Chinook Salmon, winter steelhead, Coho Salmon, Bull Trout, and sea run Cutthroat Trout.

1.3 Summary of Previous Studies

Since 2013, the performance of the FSC has been evaluated using radio telemetry, PIT, and combined PIT and acoustic telemetry methodologies (Courter et al. 2013; Stroud et al. 2014; Reynolds et al. 2015; Caldwell et al. 2017; Anchor QEA 2018; PacifiCorp and Cowlitz County PUD 2019, 2020; Four Peaks 2020). Although there has been variation in study design and year-to-year results (**Error! Reference source not found.**), several trends have emerged from these studies. Most importantly, observed P_{CE} for all species tested has been consistently lower than the 95% performance target in all years, ranging from 6% in the 2013 pilot study year (Courter et al. 2013) to 55% in 2019 (Four Peaks 2020), when averaged across test species (Table 1).

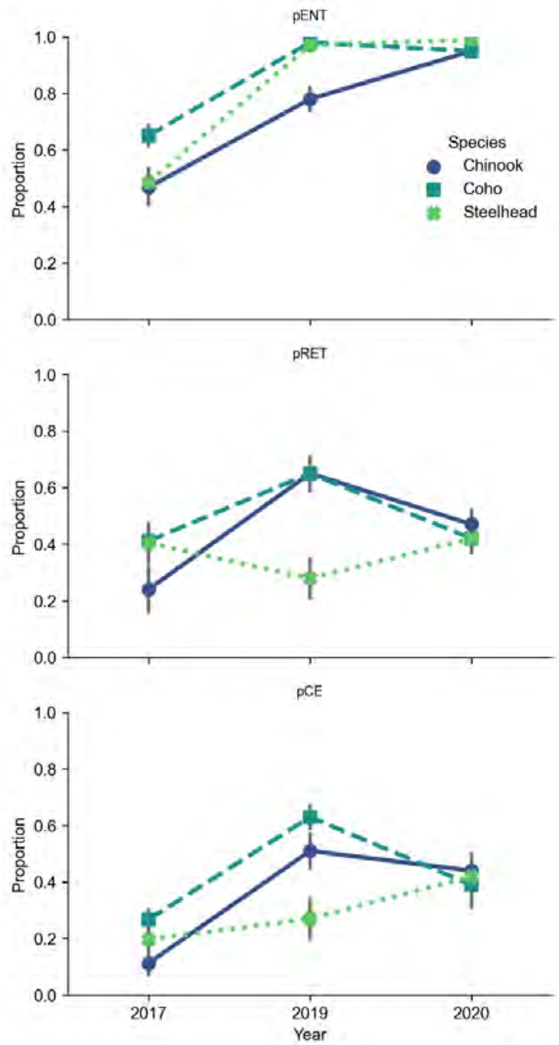


Figure 2. Swift floating surface collector performance metrics computed during 2017, 2019, and 2020 study years. Error bars indicate +/- one standard deviation returned using the mark-recapture model.

Although P_{CE} estimates consistently have been below the target, these previous studies demonstrate that comparatively high percentages of fish do successfully transit Swift Reservoir to the ZOI, approach the FSC, and enter (Table 1) (Reynolds et al. 2015; Caldwell et al. 2017; Anchor QEA 2018). The occurrence of fish migrating to—but not being successfully collected within—the FSC suggests that FSC effectiveness continues to be constrained by its ability to retain, rather than attract, outmigrating juvenile salmonids.

To address this limitation, a series of modifications have been made by PacifiCorp to improve FSC performance, and these appear to have affected P_{CE}. For example, installation of a fish lead net in front of the FSC in 2016 appears to have improved P_{CE} by directing more fish towards the entrance of the FSC. However, substantial numbers of fish still rejected the collector, indicating that FSC attraction but not retention had improved (Caldwell et al. 2017).

In late 2017, FSC sorting area flow pumps were reprogrammed to reduce vibrations that may have deterred smolts from entering the FSC (PacifiCorp and Cowlitz County PUD 2019). PIT-tag studies conducted in 2018 indicated an increase in recapture rate of study fish, suggesting that pump modifications may have further increased P_{CE} (PacifiCorp and Cowlitz County PUD 2019).

In 2019, additional adjustments were made to the FSC to improve retention. These included adjusting baffles along the primary screens in the collection channel and raising the NTS floor to increase the attraction flow velocity and encourage fish to enter the FSC. Results of an acoustic telemetry study in 2019 showed that most of the study fish in the ZOI find and enter the NTS, thus identifying the collection channel as the current bottleneck to improving collection efficiency (Four Peaks 2020).

Table 1. Summary of results from Swift floating surface collector collection efficiency studies conducted between 2013 and 2019.

Study Attributes						Detection Numbers (Total)			Detection Estimates (Total)[1]			
Year	**Study Type**	**Capture Location**	**Release Location**	**Species**	**Release Numbers**	**Detected Forebay**	**Detected ZOI**	**Captured at FSC**	**P_{ZOI} Estimate**	**P_{ENT} Estimate**	**P_{RET} Estimate**	**P_{CE} Estimate**
2013	Radio Telemetry	FSC	<3.1 miles east of FSC	Chinook Salmon	58	NA	46	0	79%	NA	NA	0%
				Coho Salmon	82	NA	44	6	54%	NA	NA	6%
				Steelhead	NA	NA	NA	NA	NA	NA	NA	NA
2014	Radio Telemetry	FSC	2 miles east of FSC	Chinook Salmon	20	NA	3	0	15%	NA	NA	0%
				Coho Salmon	157	NA	31	9	20%	NA	NA	29%
				Steelhead	16	NA	4	1	25%	NA	NA	25%
2015	Dual PIT/ Acoustic Telemetry	Eagle Cliff Rotary Screw Trap/Hook and Line	Swift Forest Camp Boat Launch	Chinook Salmon	14	9	6	0	28%	NA	NA	0%
				Coho Salmon	139	126	110	13	72%	NA	NA	12%
				Steelhead	47	43	43	8	84%	NA	NA	19%
2016	Dual PIT/ Acoustic Telemetry	FSC and Eagle Cliff Rotary Screw Trap	Swift Forest Camp Boat Launch	Chinook Salmon	3	1	1	0	11%	NA	NA	0%
				Coho Salmon	156	140	98	30	56%	NA	NA	31%
				Steelhead	40	28	17	4	30%	NA	NA	24%
2017	Dual PIT/ Acoustic Telemetry	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	108	75	62	7	57%	47%	24 %	11%
				Coho Salmon	232	184	164	46	74%	65%	41%	27%
				Steelhead	180	117	107	21	59%	48.6	40%	20%
2018	PIT	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	396	--	--	94	--	NA	NA	24%[2]
				Coho Salmon	484	--	--	191	--	NA	NA	40%[2]
				Steelhead	278	--	--	136	--	NA	NA	49%[2]
2019	Dual PIT/Acoustic Telemetry	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	155	88	75	42	54%	78%	65%	51%
				Coho Salmon	300	175	167	156	82%	98%	65%	64%
				Steelhead	70	40	37	11	58%	97%	28%	27%

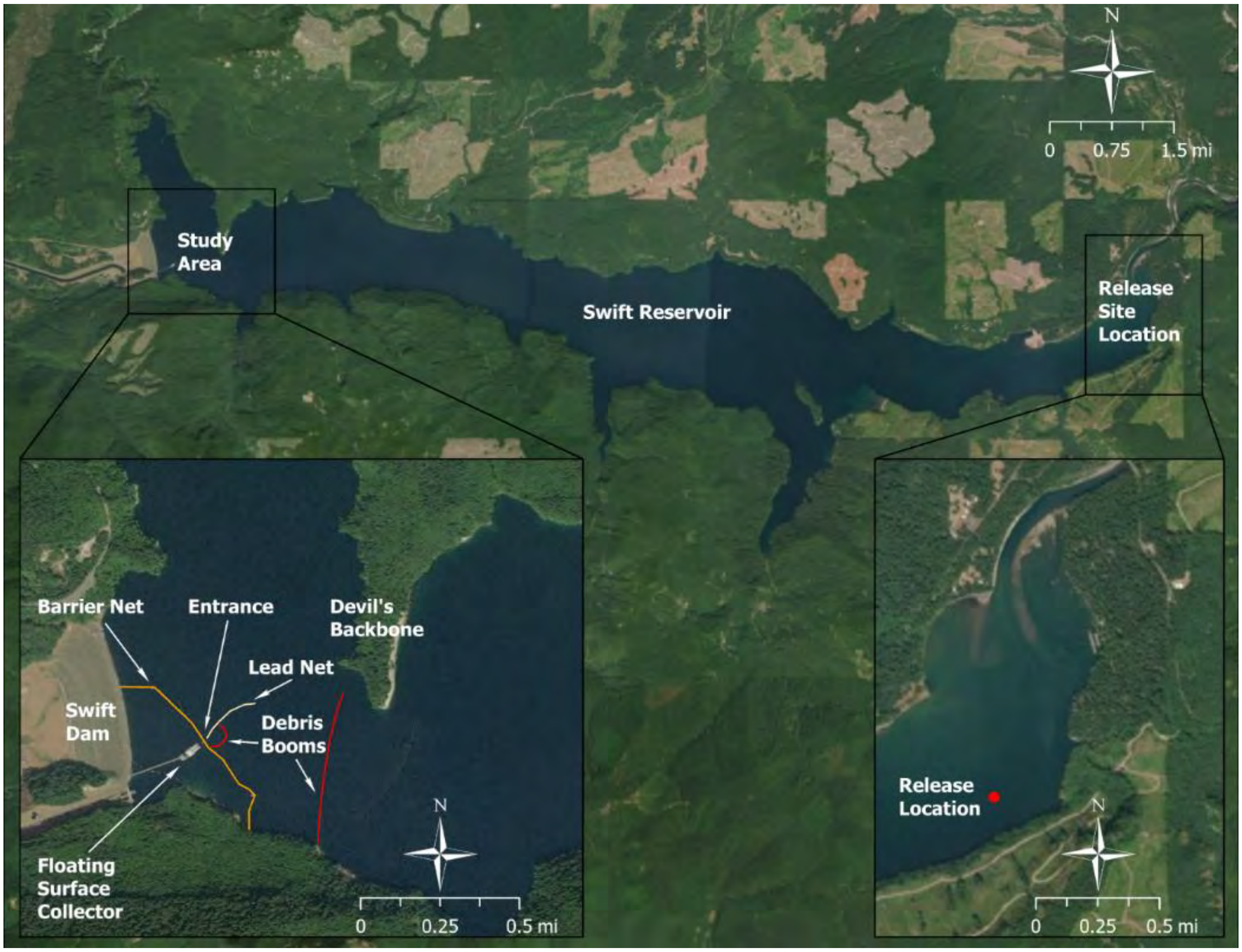
Notes:
Source: Courter et al. 2013; Stroud et al. 2014; Reynolds et al. 2015; Caldwell et al. 2017; Anchor QEA 2018; PacifiCorp and Cowlitz County PUD 2019; Four Peaks 2020
1. For 2013 through 2017, seasonal performance metrics have been corrected for array detection efficiency.
2. In 2018, survival probability through reservoir (SRES) was used as a surrogate for collection efficiency.
-- = not calculated
NA = not applicable

2 Methods

2.1 Study Location and Timing

The 2020 Study examined behavior of dual PIT- and acoustic-tagged fish that were captured at the FSC, tagged, then released near the head of Swift Reservoir. After release, these tagged fish were then tracked to describe their behaviors in front of and within the Swift FSC, a floating barge in the Swift Dam forebay that captures juvenile salmonids migrating near the surface of the reservoir. Fish are guided to the FSC by attraction flows created using pumps and by the barrier and lead nets (Spatial Reference: GCS WGS 1984; Aerial imagery source: ESRI DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGrid, IGN, and the GIS User Community

Figure 3), a series of booms extending into the forebay help to shield the collector from large logs and debris.



Spatial Reference: GCS WGS 1984; Aerial imagery source: ESRI DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGrid, IGN, and the GIS User Community

Figure 3. Vicinity map of the floating surface collector and release area for tagged fish within Swift Reservoir.

Fish enter the FSC via the NTS, a rigid structure affixed to the FSC that funnels water and fish into an artificial stream channel (the collection channel). The collection channel entrains and guides fish from the NTS into the collection facility, where fish are size sorted to separate life-stages (i.e., fry, smolt, and adult), before being routed to holding tanks for biological sampling. Most fish are then transported and released downstream. However, fish included in the current study (study fish) are subsampled as they enter the collector, tagged, held in recovery tanks for 24 hours, then transported back upstream and released near the head of the Swift Reservoir, approximately 9 miles (14.5 km) east of the FSC, near the south shore of the reservoir opposite from Swift Forest Camp Boat Launch.

On 11 occasions between 19 March and 28 May 2020, study fish were selected from the run-at-large collected at the FSC, tagged, transported to the upstream end of the reservoir, and released (Figure 4). Fish were then monitored using acoustic receivers deployed in the ZOI and collector until daily catch rates at the FSC had decreased below the level at which the collector could be shut down for summer maintenance (on 17 July 2020), at which point receivers were then removed from the water. Five study fish were still being detected on the receiver array as of 17 July 2020, largely in the ZOI and in front of the NTS; however, daily catch rates at the FSC had decreased below the level at which the collector could be shut down for summer maintenance (PacifiCorp 2015). The period from first release (19 March) to the date when the receivers were removed (17 July) is thus considered to be the study period for the 2020 Study.

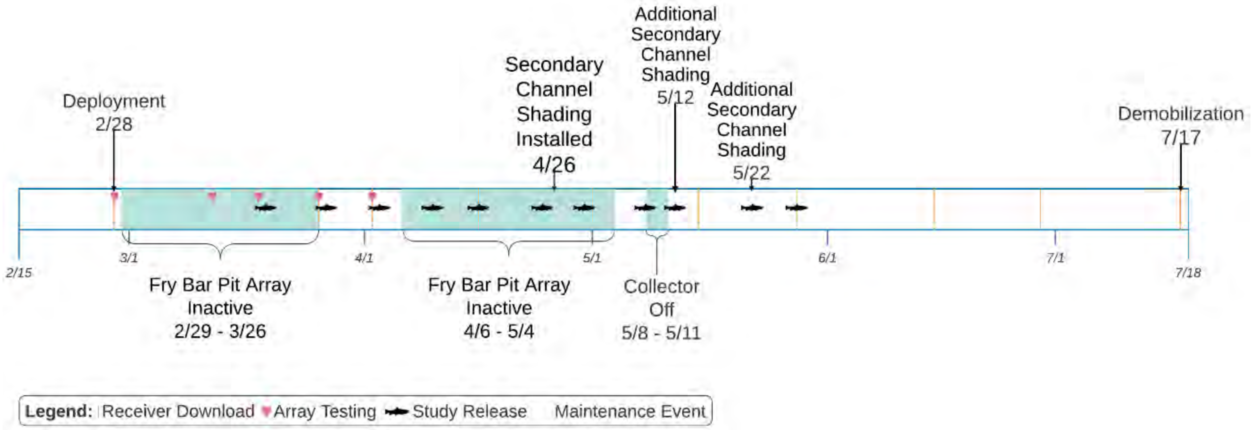


Figure 4. Timeline of key milestones associated with 2020 Swift floating surface collector passage evaluation.

2.2 Biotelemetry

2.2.1 Fish Tagging and Release

On 11 occasions between 19 March 2020 and 28 May 2020, PacifiCorp staff selected study juvenile fish from the run-at-large captured by the Swift FSC (APPENDIX A). This collection strategy is consistent with that employed during the 2017 and 2019 studies. For studies prior to 2017, attempts were made to collect test fish from a screw trap at Eagle Cliff (just upstream of the head of Swift Reservoir); however, fish collected at Eagle Cliff were generally too small to be acoustically tagged, and thus since 2017, all fish have been collected and tagged at the FSC. For the purpose of comparing results between 2017 and subsequent study years, any non-naïve bias is assumed to be consistent across years.

After collection, each fish was anesthetized with MS-222 (Tricaine methanesulfonate) and surgically implanted with an Advanced Telemetry Systems (ATS) SS400 acoustic transmitter (Table 2) and a Biomark 12.5 mm, 134.2 kilohertz ISO FDX-B PIT tag using the methodology described in Reynolds et al. (2015).

Following tagging, fish were allowed to recover overnight and then transported by boat to the Swift Forest Camp release site at the eastern end of Swift Reservoir (Figure 3) where they were subsequently released.

PIT tags were scanned using an HPR Plus reader after implantation and uploaded to PTAGIS using P4 software with associated information on species, length, and paired acoustic tag code. Acoustic tag activation was confirmed using a hydrophone and receiver that were deployed to monitor acoustic tag signals in the recovery tank.

Table 2. Technical specifications for acoustic tags used in the 2020 Swift floating surface collector passage evaluation.

Parameter	Value
Length	14.98 mm
Diameter	3.21 mm
Mass	217 mg
Ping Rate	3 seconds
Expected Tag Life	48 days

2.2.2 Fish Detection and Recapture

Tagged fish were tracked as they approached and interacted with the Swift FSC, using a combination of PIT and acoustic technology. This included an array of hydrophones and associated acoustic telemetry receivers deployed to the forebay and FSC, focusing on the NTS and collection channel, with coarser resolution in the ZOI. This array detected fish as they approached the collector, entered through the NTS and transited the collection channel. Collection in the FSC was confirmed with a series of PIT antennas on the sorting and collection flumes inside the FSC (Figure 5).

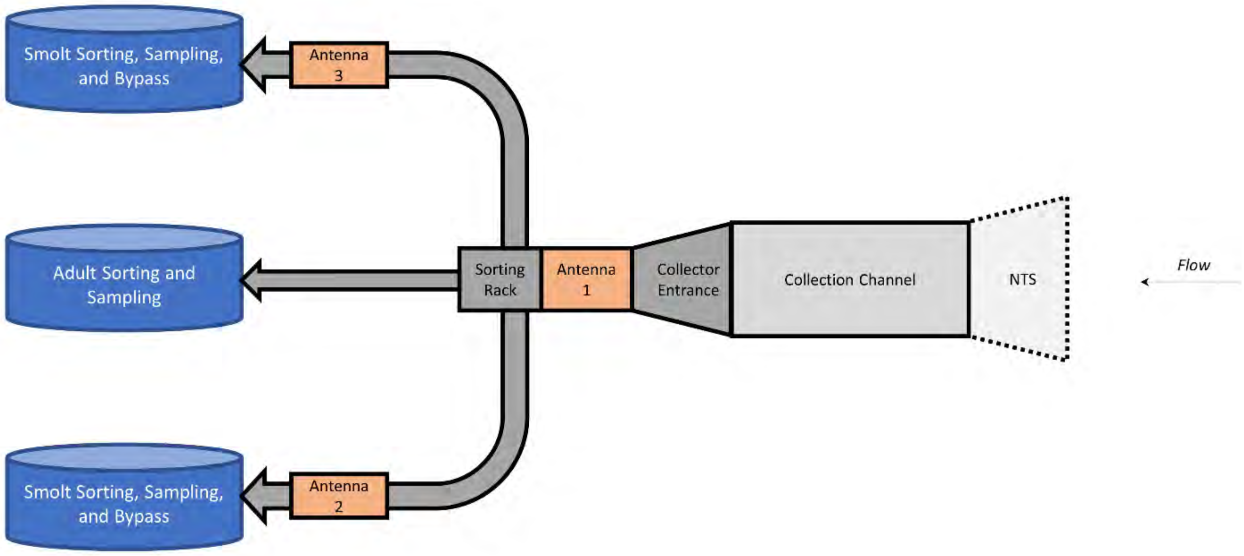


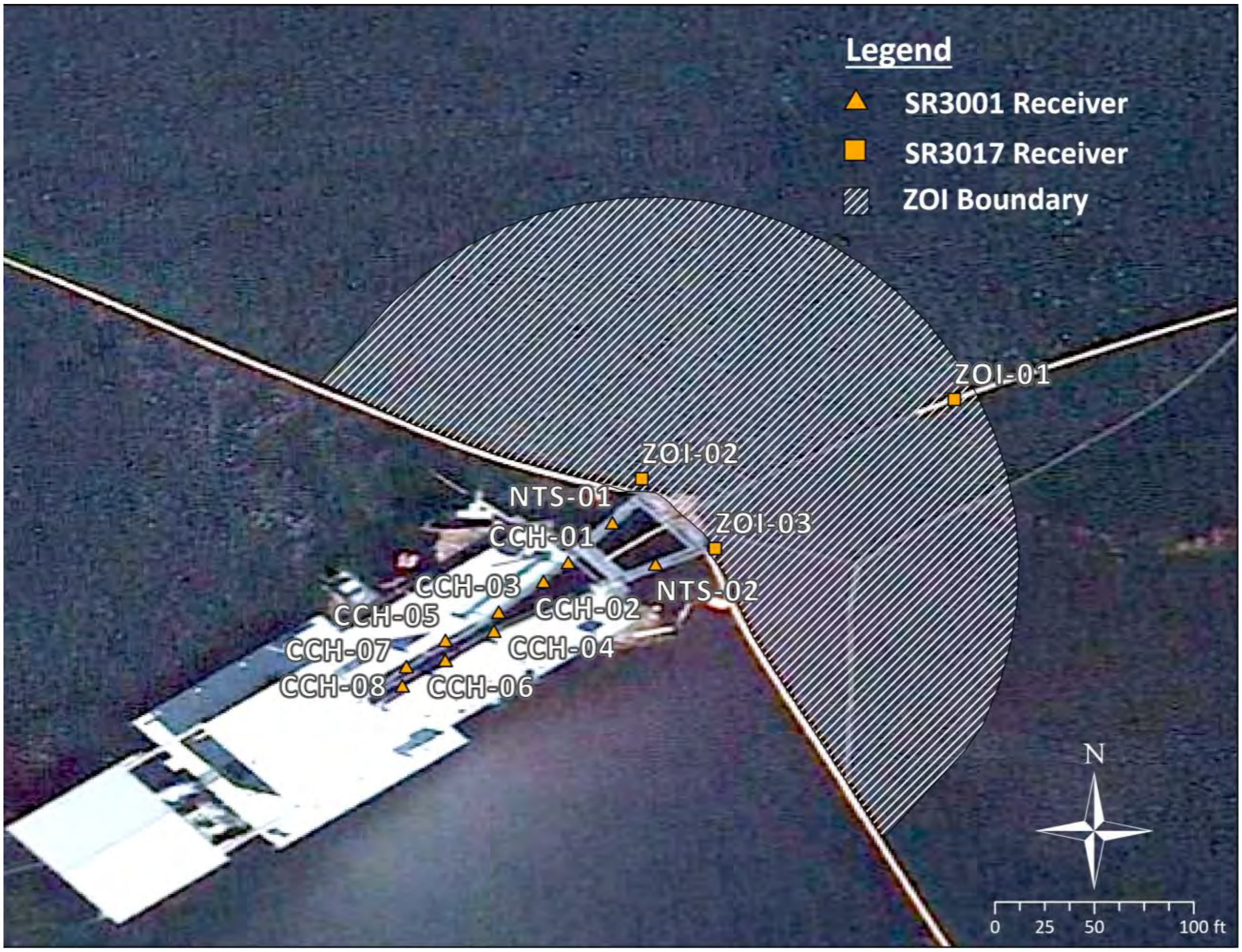
Figure 5. Swift hydroelectric project passive integrated transponder interrogation site antenna configuration inside the floating surface collector (redrawn, after https://www.ptagis.org/sites/interrogation-site-metadata?IntSiteCode=SHP).

The sorting bar PIT antenna was not functioning for several weeks in the earlier part of the study (Figure 5, Antenna 1). During this time, detections on the smolt flume PIT antennas (Figure 5, Antennas 2 and 3), from hand-wanding within the FSC by PacifiCorp staff and contractors, and at downstream interrogation sites (detection points) within PacifiCorp's Lewis River fish passage system were used to verify collection. These downstream sites included PIT antennas at the Woodland Release Ponds (WRP) approximately 2.5 river miles upstream from the town of Woodland, Washington, where juvenile fish are transported after collection.

2.2.3 Acoustic Telemetry Array

From 24 through 28 February 2020, Four Peaks staff installed an acoustic telemetry array comprising 13 receivers in the Swift Dam forebay (Spatial Reference: GCS WGS 1984; Aerial imagery source: Google. Additional cartography data sources: ESRI. Map conceived and drawn using ArcGIS Pro.

Figure 6), plus a remote receiver within the recovery tank for confirming tag activation. The 13 forebay receivers covered three zones that were defined in terms of two-dimensional ("x-y") areas: the ZOI, the NTS, and the collection channel (CCH). The collection channel was further divided into the primary screen collection channel (primary channel) and the secondary screen collection channel (secondary channel). Each of these zones was monitored with a subarray of receivers: three autonomous receivers in the ZOI (ZOI-01 to ZOI-03), two cabled receivers in the NTS (NTS-01, NTS-02), three cabled receivers in the primary channel (CCH-01 to CCH-03), and five cabled receivers in the secondary channel (CCH-04 to CCH-08).



Spatial Reference: GCS WGS 1984; Aerial imagery source: Google. Additional cartography data sources: ESRI. Map conceived and drawn using ArcGIS Pro.

Figure 6. Overview of acoustic telemetry receiver array locations within the Swift floating surface collector and forebay.

Hydrophone deployments in the collection channel required careful consideration given the fast-flowing water and confined area, the combined effects of which create an acoustically noisy environment making it difficult to detect tags in the channel. To address these challenges, hydrophones were deployed behind the dewatering screens, in a cone shaped baffle, with the tip of the hydrophone pointed towards the dewatering screen, perpendicular to the direction of flow (Figure 7). This deployment kept the collection channel hydrophones out of the fast-moving collection channel water and reduced noise levels at the hydrophone enough to detect study tags. Details of deployment methods are provided in APPENDIX A.

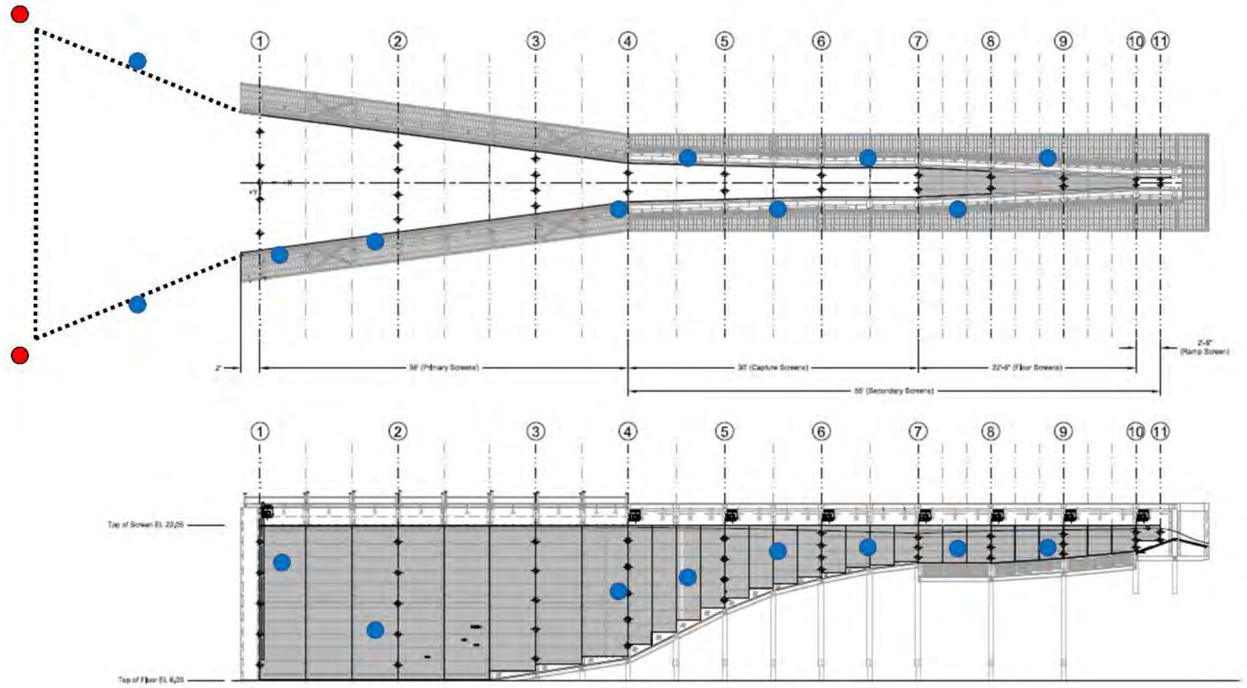


Figure 7. Swift floating surface collector schematic diagram, showing plan view (top) and longitudinal cross-section (bottom) of the collection channel. The net transition structure is shown with dotted lines in the top plan view, and approximate locations of cabled hydrophones and autonomous receivers are shown as blue and red circles, respectively.

2.2.4 Telemetry Array Testing and Validation

Field testing of the acoustic telemetry equipment was conducted during and after deployment Figure 4. Field testing included a series of tag drags, floats, and holds, using test acoustic telemetry tags. Data collected during testing included known time and position of the test tags during the tests and the data collected by the acoustic receivers. These data were then used to verify that the receivers were functioning and to evaluate the ability of the data processing computer code to determine the presence of a tag within a given zone (Section 2.2.6).

This regular schedule of preseason and mid-season testing verified that equipment was deployed properly and could accurately assess tag presence within the subarray zones (ZOI, NTS, and collection channel). Detailed testing methods are described in APPENDIX A.

2.2.5 Data Processing and Quality Control

Throughout the study season, Four Peaks staff maintained and downloaded the array on a regular basis (Figure 4 and APPENDIX A).This regular schedule of maintenance verified that the acoustic telemetry equipment deployed as part of this study functioned as expected, and that malfunctions were detected and addressed before having major impacts on the data collected for the study.

Detection data were downloaded from the receivers on an approximately bi-weekly schedule (Figure 4) and backed-up to secure cloud-based storage. After downloading data from each receiver, a new formatted memory card was placed in the receiver. Only after ensuring successful backup of the data were the memory cards reformatted. A more detailed data processing schedule is provided in APPENDIX A.

Upon download, acoustic data were filtered to remove multipath and false positive signals using methods described in Weiland et al. (2009). In the ZOI, an additional filtering step was performed to limit spurious tag detections. This filter required three detections of an acoustic tag within a 180-second window on a given receiver to be considered a valid detection. This filter was not applied to data collected on receivers in the NTS and the collection channels because the faster-flowing water in the NTS and collection channel areas limited the number of detection opportunities for a tag on a single receiver in these areas. The filtered data were combined across multiple receivers to create a single file with all acoustic detections in the period, which was carried forward for further processing (Section 2.2.6).

Automated diagnostic processing scripts were applied to the acoustic data after each download to check the quality of data. These diagnostics enabled the team to quickly verify that receivers were functioning correctly and that corrupt records were removed. Furthermore, these diagnostics provided insight into ambient noise conditions at the FSC enabling detection of conditions that required additional investigation.

2.2.6 Zone Presence Estimates

After initial filtering (Section 2.2.5), acoustic detection data were further processed to determine when fish were present within a given zone along the approach to collection (i.e., ZOI, NTS, primary channel, secondary channel). The output of this additional processing was the time series of zone presences for each tag and is termed the zone presence time series (ZPTS).

ZPTS processing uses a simplified time-of-arrival difference analysis (Deng et al. 2011). As described by Deng et al., time-of-arrival difference is a method for 3D positioning. However, technical constraints associated with the array design used in the 2020 Study meant that 3D positioning was not possible. Instead, the simplified time-of-arrival difference method applied was a form of 1D positioning, with a target of identifying longitudinal position within a linearized array schema.

This positioning method estimates which zone the tag is in when it transmits a signal (ping) by comparing detection times of a ping on multiple receivers. The method relies on grouping together detections across receivers for a single tag code and then ordering them chronologically to provide an understanding of where an individual is in the array. Figure 8 provides a visual depiction of this process, in which a single ping is detected by receivers in the NTS, primary channel, and ZOI. The order in which this detection occurs is then combined with logic developed empirically using the test data collected during deployment to estimate which zone the individual is in within the acoustic array.

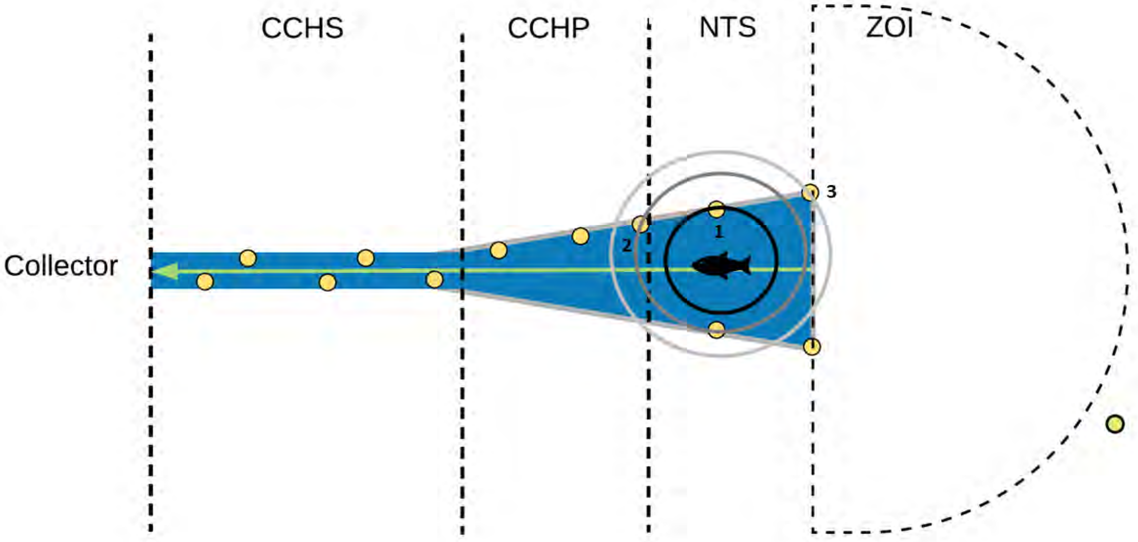


Figure 8. Visual depiction of an acoustic signal being emitted from a tag within a fish and being detected in the net transition structure, primary screen collection channel, and zone of influence. The numbers depict the order in which each receiver picks up the tag signal; in this case, the signal is heard first on NTS-01, then on CCH-01, and finally on ZOI-02. Based on time-of-arrival difference values across these receivers, the tag would be positioned within the net transition structure.

The zone presence processing computer code was developed by establishing, testing, and then iteratively adjusting a suite of zone presence criteria (ZPC). These criteria evaluate an acoustic signal logically and quantitatively to determine its location. ZPC were initially constructed by using acoustic data collected during pre-season testing (Section 2.2.4) and then developing logical criteria that correctly assigned zones for tags at known times and locations during test holds, floats, and drags. After formulating the initial set of ZPC for each zone, these criteria were verified by running them on a separate set of test data (that were collected during tests performed throughout the early part of the season), and evaluated their performance by calculating zone presence efficiency, which is defined as the frequency at which the tag was positioned in the correct zone. The final ZPC are explained in detail in APPENDIX A. Once ZPC were established, it allowed the construction of a presence-absence matrix for the entire study that was used to inform mark-recapture models.

2.3 Performance Metrics

Key performance metrics for the 2020 Study included P_{ZOI}, P_{ENT}, P_{CHAN}, P_{COL}, P_{RET}, and P_{CE} (Table 3). These metrics quantify the probability that a study fish within a given zone will transition downstream. Each is calculated as a proportion of fish in two zones, where the denominator is the number of fish detected in the upstream zone, and the numerator is the number of fish detected in both the upstream and downstream zones. Correction factors based on downstream detections are then applied to these raw proportions to account for receiver detection efficiency (White and Burnham 1999). Periodic estimates of performance were provided throughout the fish passage season to PacifiCorp to allow FSC performance and implementation of the 2020 Study to be tracked. Discussion of how individual metrics were calculated and estimated is provided in Table 3 and APPENDIX A.

Table 3. Performance metrics; ∩ symbol indicates the intersection of two sets, i.e., fish detected in both zones.

Metric	Description	Calculation (Uncorrected)[1]
Encounter Rate (P_{ZOI})	The proportion of study fish that are detected in the ZOI	$P_{ZOI} = \frac{DET_{ZOI}}{R}$
Entrance Efficiency (P_{ENT})	The proportion of study fish detected in the ZOI that enter the NTS	$P_{ENT} = \frac{(DET_{ZOI} \cap DET_{NTS})}{DET_{ZOI}}$
Channel Entrance Efficiency (P_{CHAN})	The proportion of study fish detected in the NTS that enter the collection channel.	$P_{CHAN} = \frac{(DET_{NTS} \cap DET_{CHAN})}{DET_{NTS}}$
Channel Collection Efficiency (P_{COL})	The proportion of study fish detected in the collection channel that are re-captured at the FSC	$P_{COL} = \frac{(DET_{CHAN} \cap C)}{DET_{CHAN}}$
Retention Efficiency (P_{RET})	The proportion of study fish detected in the NTS that are re-captured at the FSC	$P_{RET} = \frac{(DET_{NTS} \cap C)}{DET_{NTS}}$
Collection Efficiency (P_{CE})	The proportion of study fish detected in the ZOI that are re-captured at the FSC	$P_{CE} = \frac{(DET_{ZOI} \cap C)}{DET_{ZOI}}$

Note:
1. Equations associated with Program MARK computations are presented in APPENDIX A.

2.3.1 Floating Surface Collector Performance Metrics Computation

Once zone presence was established for all individuals (Section 2.2.6), the corresponding presence-absence matrix was computed. The presence-absence matrix describes the detection history for each study fish (APPENDIX B). The presence-absence matrix was used to fit Cormack-Jolly-Seber mark-recapture models to estimate zonal survival and detection probabilities. The R (R Core Team 2020) package RMark (Laake 2019) was used to implement a version of Program MARK (White and Burnham 1999), which itself constructs a Cormack-Jolly-Seber mark-recapture model. All survival and detection probability parameters were estimated within this mark-recapture model framework fit using maximum likelihood methods.

These parameter estimates were used to provide estimates of the key project metrics along with associated confidence intervals (CIs). A separate suite of mark-recapture models were also constructed to separately estimate survival and detection through the primary and secondary channels. This allowed transition into each of these reaches to be individually estimated to identify if areas within the channel impeded migration. While the estimates corresponding to these models were not used to directly inform collection efficiency metrics, they are useful in identifying bottlenecks within the FSC that might affect overall passage.

2.4 Passage Attempt Behavioral Analysis

To develop insights about specific locations of collector rejection and about factors hypothesized to affect recapture, behaviors of study fish that entered the collector were examined further. This process included categorizing zone presence sequences into groups inferred to represent distinct “passage attempts,” then analyzing attributes of these passage attempts including biometric and other metadata describing the fish undertaking the passage attempts. The goal of these efforts was to increase understanding regarding specific environmental, operational, and biological factors that may influence fish passage success at the Swift FSC.

2.4.1 Initial Data Processing to Identify Attempts

The ZPTS (APPENDIX A) of fish that entered the collector was processed to build a dataset of "passage attempts." A passage attempt is defined from the time a given fish is first detected transitioning into the collection channel to the time when it exits. "Exits" includes fish moving downstream to collection within the FSC and fish moving back upstream and exiting the collection channel via the NTS. Data were processed to assign each passage attempt with start and end times and with the furthest downstream zone reached during the attempt. Biometric attributes of each study fish (e.g., species, length) and associated metadata (e.g., date of tagging) were also assigned to the passage attempt records.

2.4.2 Attempt Filtering

After acoustic detections of dual-tagged study fish were grouped into passage attempts, time series plots depicting the sequence of zone presence for each fish were developed (APPENDIX A). These plots were then evaluated along with a set of logical criteria to filter the attempt dataset and remove apparent attempts that may not represent true passage attempts. The logical criteria are summarized here and explained in detail in APPENDIX A:

1. Attempt duration must be longer than 10 seconds. Filtering these very short attempts eliminated spurious channel zone presences that were more likely caused by fish holding in the NTS near the entrance to the channel than actual attempts to enter the collection channel.
2. Collected fish must have been detected on the sorting bar PIT array or smolt flumes, not only detected by hand wand or at the release ponds. Final passage attempts for these fish have an artificially long duration due to the delay in PIT detection after actual collection. This could bias analyses that consider attempt duration.
3. Time series plots of the ZPTS must resemble active fish behavior. This eliminated spurious detections associated with noise, fish holding station near zone boundaries, and other activity not likely to reflect an actual attempt.

This process resulted in a filtered set of passage attempts, with each fish exhibiting 1-105 attempts (Section 3.4). The resulting group of retained attempts was used for most visualizations (unless otherwise indicated) and statistical comparisons among groups discussed below. For analyses more appropriate to single passage attempts, the final attempt for each fish was retained.

2.4.3 Analyses

2.4.3.1 Exploratory Data Analysis

The set of reliable passage attempts (Section 2.4.2) was analyzed for differences among groups of fish. An initial phase of exploratory data analysis was conducted by summarizing and visualizing the passage attempts dataset across multiple parameters. All visualizations were performed within Python, using the Seaborn library (Waskom et al. 2020). Many of these factors were not ultimately pursued. For example, the following relationships were explored but dropped from further consideration due to their apparent lack of importance:

- Success as a function of the duration of passage attempt
- Success as a function of the total number (or preceding number) of passage attempts
    - Number of passage attempts as a function of fork length
    - Number of passage attempts as a function of days at large since release after tagging

- Success as a function of days at large since release after tagging (i.e., travel time)

After this initial data exploration, the following parameters of interest were retained and further analyzed using a series of statistical models and comparison tests:

- Fork length
- Time of day of passage attempt
- Date of passage attempt
- Species

2.4.3.2 Statistical Analysis and Modeling

A recapture model was developed to investigate the factors that might affect passage attempt success. The purpose of this model was to understand environmental and biological factors that affect juvenile fish passage at the Swift FSC. The variables considered by the model include total number of attempts, species, fork length, mass, release date after tagging, days at large since tagging, date of passage attempt initiation, and hour of passage attempt initiation. For the group of study fish included (i.e., the filtered set resulting from the process described in Section 2.4.2), the model estimates how much each of the variables contributes to passage attempt success.

Briefly, this entailed a multipronged approach to modeling recapture probability that included balancing the dataset, eliminating insignificant model factors, and then parameterizing and testing both a binary classification model using machine learning and a classic logistic regression model. Comparisons among groups were conducted using Welch's unequal variance (independent) *t*-tests (*t*-tests), Tukey's honestly significant difference tests (Tukey's HSD), or chi-squared (χ^2) tests for equality of proportions, depending on the metric and number of groups being compared. Because a priori hypotheses did not predict a direction of the effect examined, all tests were conducted "two-sided." Detailed methods are provided in APPENDIX A.

2.5 Collector Outage Effects

To make repairs caused by heavy debris loading, the FSC was shut down from approximately 10:00 on 8 May to 13:00 on 11 May 2020. Many fish attempted passage during this period, and PacifiCorp staff expressed interest in the rate at which these fish were ultimately collected to understand the potential magnitude of this incident on study estimates of P_{CE}. To evaluate potential effects, the group of study fish attempting passage was queried to identify all fish with qualifying attempts that occurred during this period. Capture efficiency (P_{CE}) for this group was computed, then visually compared to P_{CE} for the entire group of study fish.

2.6 Recapture Rates of Passive Integrated Transponder- and Dual-Tagged Fish

Collection of outmigrating fish at the FSC yields groups of fish that are dual-tagged (for the current study), as well as a larger group of fish that is only PIT tagged. To explore the possibility of tagging effects, or representativeness of the dual-tagged group, recapture rates (*not* P_{CE}) were visually compared between PIT-tag only and dual-tagged groups of each species).

2.7 Delayed Migration

Discussions with PacifiCorp staff and results from previous studies (Caldwell et al. 2017) suggest that a small number of fish delay outmigration from Swift Reservoir through the FSC, instead moving out of the reservoir in the fall, after the completion of the annual study. For the 2019 study season, this would encompass fish outmigrating after 22 July 2019. To develop estimates of the occurrence and frequency of delayed migration among study fish, the PTAGIS database was queried for detections of 2019 study fish PIT tags after completion of the 2019 study, up until 15 October 2020. Numbers of delayed migrants were summarized by species and the proportion of totals from 2019. These data were used to infer the likelihood of delayed migration notably affecting FSC performance metrics derived using current and previous study methods.

To quantify potential effects on the 2020 FSC performance metrics that could result from including delayed migrants, a simple analysis was conducted to provide “worst-case scenario” (lower bound) and “best-case scenario” (upper bound) adjusted P_{CE} values for each species. The worst-case scenario (i.e., lowest possible FSC collection efficiency) is if all fish not detected on the acoustic array or PIT antennas in the FSC or WRP during the 2019 study season were delayed migrants that survived and migrated to the ZOI after the 2019 study. The best-case scenario (i.e., highest possible FSC collection efficiency) is if only fish that were successfully detected in the FSC or WRP after the 2019 study season were delayed migrants that survived and migrated to the ZOI after the 2019 study. While neither of these scenarios is likely, they bound the possible range of P_{CE} if adjusting to account for delayed migrants. The adjusted P_{CE} estimates resulting from this analysis were not further adjusted to account for detection efficiency at each node in the array due to the lack of reliable downstream PIT detection sites.

In both the worst-case and best-case scenarios, fish that were released with activated acoustic tags and subsequently detected on the PIT antennas at the FSC or WRP after the 2019 study are considered to have been successfully collected at the FSC. Along with fish released with active acoustic tags that were successfully collected during the 2019 study, these fish are included in the numerator of computations of both adjusted P_{CE} estimates. Under the worst-case scenario, all fish with active acoustic tags that were not detected in the acoustic array or FSC or WRP PIT antennas during the 2019 study are considered delayed migrants and thus added to the denominator in computations of an “Adjusted Worst-Case Scenario P_{CE}” ($P_{CE-Adj-Worst}$, Equation 1).

$$P_{CE-Adj-Worst} = \frac{Collected\ during\ 2019\ study + Detected\ at\ FSC\ or\ WRP\ after\ 2019\ study}{Detected\ in\ ZOI\ during\ 2019\ study + Never\ Detected\ during\ 2019\ study} \tag{1}$$

Under the best-case scenario, only those fish released with active acoustic tags that were detected on FSC or WRP PIT antennas after the 2019 study are considered delayed migrants and thus added to the denominator in computations of an “Adjusted Best-Case Scenario P_{CE}” ($P_{CE-Adj-Best}$, Equation 2)

$$P_{CE-Adj-Best} = \frac{Collected\ during\ 2019\ study + Detected\ at\ FSC\ or\ WRP\ after\ 2019\ study}{Detected\ in\ ZOI\ during\ 2019\ study + Detected\ at\ FSC\ or\ WRP\ after\ 2019\ study} \tag{2}$$

Then, by assuming identical “correction rates,” based on the percent difference between adjusted and unadjusted 2019 P_{CE} values, “provisionally adjusted” 2020 P_{CE} values were developed. These are referred to here as provisional because they reflect worst-case and best-case scenarios that assume identical rates of non-detection during the study period and of delayed migration as were reported for the 2019 study, neither of which assumptions can be tested with currently available data.

3 Results

3.1 Array Performance

Equipment testing conducted during deployment and throughout the 2020 Study indicated that the acoustic telemetry array performed as designed, and that computer code developed to process detection data was capable of accurately positioning acoustic tags within each zone. Detailed array performance results are provided in APPENDIX A.

3.2 Tagging Operations

Release of study fish followed a typical seasonal pattern: from study initiation through mid-season (15 April), only Chinook Salmon were tagged and released. From 15 April through the end of May, the number of Chinook tagged decreased, while the numbers of Coho Salmon and steelhead tagged increased. A total of 524 individuals (183 Chinook Salmon, 187 Coho Salmon, and 154 steelhead) were released between 19 March and 28 May 2020 (Table 4). Acoustic release proportions largely followed the run-at-large for Chinook Salmon and steelhead. For Coho Salmon, acoustically-tagged fish were captured and released earlier relative to the run-at-large (Figure 9). Specifically, the median release date for Coho Salmon occurred approximately 1 month prior to the median date of the run-at-large, and the last acoustic tagged Coho Salmon was released nearly 2 months before the end of the run-at-large. A similar comparison of release timing to run-at-large were observed in 2019 though Coho Salmon releases in 2019 were not as far ahead of the run-at-large (median of Coho releases in 2019 were approximately 10 days ahead of the run-at-large and last release was approximately 1 month ahead of the run-at-large).

Table 4. Summary of the number and length of salmonids tagged with dual passive integrated transponder and acoustic tags during the 2020 Swift floating surface collector passage evaluation.

Release Date	Chinook Salmon		Coho Salmon		Steelhead	
	No. Tagged	Mean Fork Length (mm)	No. Tagged	Mean Fork Length (mm)	No. Tagged	Mean Fork Length (mm)
19-Mar-20	20	128	-	-	-	-
27-Mar-20	30	139	-	-	-	-
3-Apr-20	30	142	-	-	-	-
10-Apr-20	30	151	-	-	-	-
16-Apr-20	44	156	6	138	9	224
24-Apr-20	18	158	22	145	15	216
30-Apr-20	-	-	27	145	33	189
8-May-20	11	172	20	148	27	189
12-May-20	-	-	60	139	-	-
22-May-20	-	-	52	145	8	205
28-May-20	-	-	-	-	62	198
Total	**183**	**148**	**187**	**143**	**154**	**198**

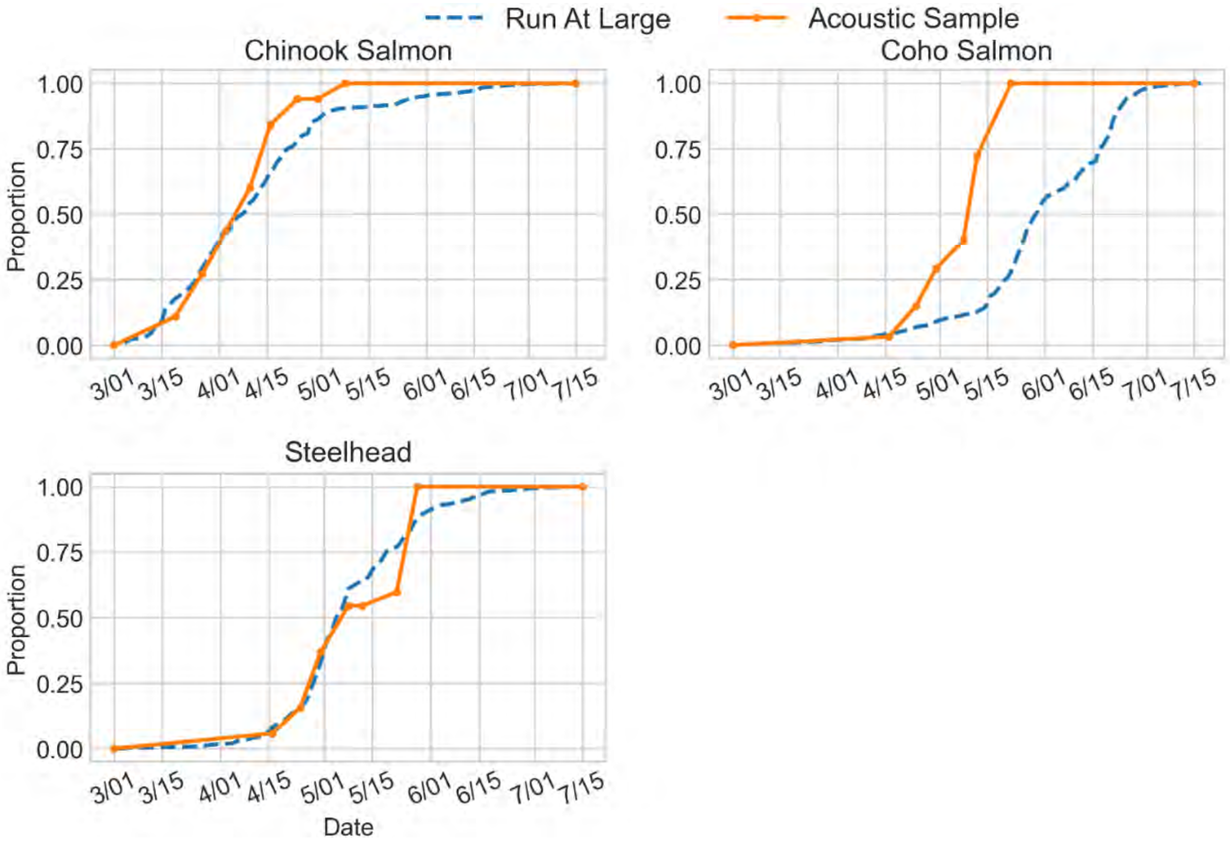


Figure 9. Cumulative distribution functions for each species, showing proportions of the total number of fish tagged and released (solid orange lines), and of the background run-at-large collected at the Swift floating surface collector for transport and release downstream (dashed blue lines).

Dual-tagged Chinook and steelhead study fish were smaller in 2020 compared to both 2019 and 2017; dual-tagged Coho study fish in 2020 were smaller than in 2019, but similar in fork length to 2017 (Figure 10). The magnitude of differences among years varied across species, from approximately 12 mm less in 2020 than 2019 for Chinook (an 8% reduction) to nearly 40 mm less in 2020 than 2019 for Coho (a 21% reduction). All differences in length among years that are depicted as statistically significant in Figure 10 were highly significant (Tukey's HSD, p ≤ 0.003).

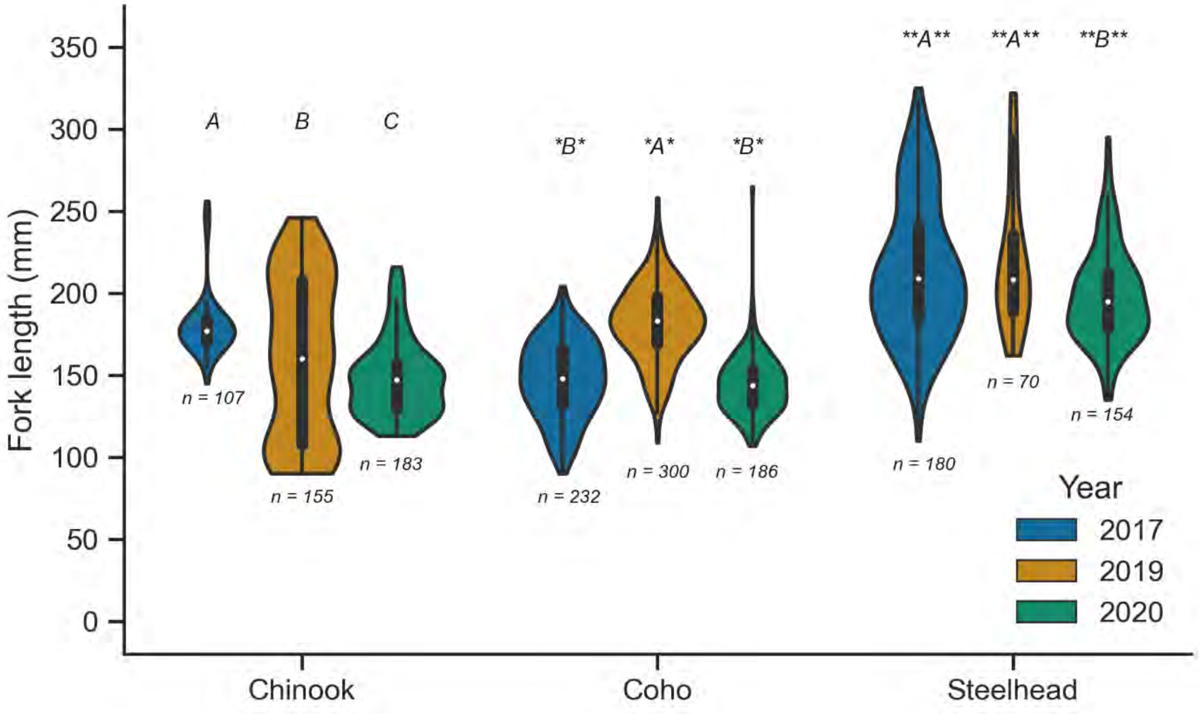


Figure 10. Fork length of dual-tagged study fish during 2019 and 2020. Each violin shape represents a kernel density estimate of the underlying distribution, using Scott's Rule (Scott 1992) for kernel density bandwidth selection. Violin widths are scaled proportional to the sample size for each group, which is annotated under each violin. Symbology within each violin is similar to a traditional boxplot: the white dot denotes the median, the thick line represents the interquartile range (IQR, i.e., 25th – 75th percentile), and the thin lines extend to "Tukey's fences," 1.5*IQR beyond the IQR in each direction. *P*-values summarize results of *t*-tests of difference in length between years, for each species.

3.3 Floating Surface Collector Performance Metrics

3.3.1 Collection Efficiency Metrics

FSC performance metrics calculated for this study are summarized in Table 5 and Figure 11. Of the dual tagged fish released at the upper end of Swift Reservoir, only 64% were detected in the ZOI (P_{ZOI}). Entrance efficiency (P_{ENT}) was 95% or greater for all species. Channel efficiency varied across species, ranging from 67% for steelhead to 82% for Coho. P_{CE} was 42% for all three species. Note that 90% CIs are reported here, per regulatory guidelines, as opposed to 95% CIs reported elsewhere.

Table 5. 2020 Performance metric summary.

Species	No. Rel.[1]	DET_{ZOI}	DET_{NTS}	DET_{CHAN}	DET_{COL}	$\hat{P}_{ZOI}$ (90% CI)[2]	$\hat{P}_{ENT}$ (90% CI)	$\hat{P}_{CHAN}$ (90% CI)	$\hat{P}_{COL}$ (90% CI)	$\hat{P}_{CE}$ (90% CI)	$\hat{P}_{RET}$ (90% CI)
Chinook Salmon	183	104	97	38	47	58% *(52%, 64%)*	95% *(90%, 99%)*	71% *(59%, 83%)*	66% *(53%, 78%)*	44% *(36%, 52%)*	47% *(39%, 55%)*
Coho Salmon	185	112	100	75	45	62% *(56%, 68%)*	95% *(90%, 99%)*	82% *(73%, 91%)*	51% *(41%, 60%)*	39% *(32%, 47%)*	42% *(34%, 50%)*
Steelhead	153	110	108	65	47	73% *(67%, 79%)*	99% *(97%, 100%)*	67% *(59%, 75%)*	63% *(53%, 73%)*	42% *(34%, 50%)*	42% *(35%, 50%)*
All	521	326	305	178	139	64% *(60%, 67%)*	96% *(94%, 99%)*	74% *(69%, 80%)*	58% *(52%, 65%)*	42% *(37%, 46%)*	43% *(39%, 48%)*

Notes:

1. Three fish (2 Coho salmon and 1 steelhead) released on 28 April 2020 were excluded, due to data entry errors that precluded confidently matching acoustic and PIT tag codes for these fish. All three individuals were detected in the ZOI but not further downstream, and none were collected.
2. 90% CIs are reported for each collection metric.

No. Rel. = number released

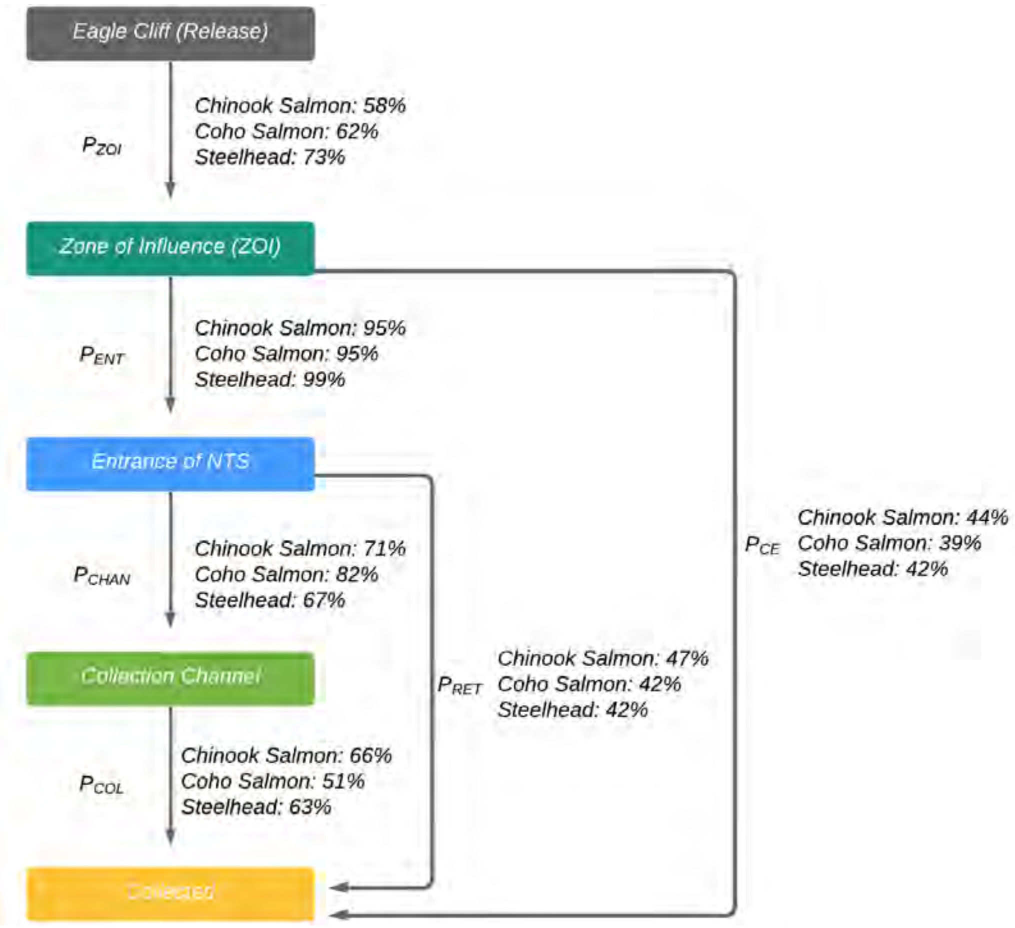


Figure 11. Flow chart summarizing 2020 performance metrics. Note that P_{COL} here represents the proportion of individuals that were positioned in the collection channel that made it to collection.

3.3.2 Zone Detection Efficiency

Mark-recapture models were used to estimate detection efficiencies for each zone in order to correctly estimate the collection efficiency metrics (Table 5). These parameters are estimated by determining the number of individuals positioned in a zone that were not positioned in the previous zone. Because there is no reliable detection station located a reasonable distance downstream from the release ponds, detection efficiency associated with collection is not estimated, but rather assumed to be 100% for the purpose of these computations.

Detection efficiencies were generally high across each zone and species (Table 6). Very few fish were missed in the ZOI and NTS zones that are critical for computation of the performance metrics P_{CE} and P_{RET}, respectively. High efficiency in these zones imparts high confidence in these key performance metrics. The ZOI had the highest level of detection efficiency (~98% across all species) followed closely by the NTS (95%). Among all zones, collection channel detection efficiency was lowest and most variable among species. Chinook had the lowest channel detection efficiency at 53%, while steelhead had the highest at 87%. It appears that collection channel detection efficiency was constrained by aspects of fish biology and behavior more so than technical limitations (see Section 3.4). This conformed with behavioral expectations, with Chinook making quick passage attempts through the channel with limited opportunities for detection, whereas steelhead are able to hold and thus increase chances of being positioned within the channel.

Table 6. Zone detection efficiency by species.

Species	$\mathbf{DET_{ZOI}}$ (95% CI)[1]	No. of Fish Missed in ZOI	$\mathbf{DET_{NTS}}$ (95% CI)	No. of Fish Missed in NTS	$\mathbf{DET_{CCH}}$ (95% CI)	No. of Fish Missed in Channel
Chinook Salmon	98% (92%, 99%)	2	97% (88%, 99%)	2	53% (39%, 67%)	22
Coho Salmon	98% (93%, 100%)	2	93% (85%, 97%)	6	84% (71%, 92%)	7
Steelhead	98% (93%, 100%)	2	97% (89%, 99%)	2	87% (74%, 94%)	6
All	98% (96%, 99%)	6	95% (91%, 97%)	10	75% (67%, 81%)	35

Notes:
1. 95% CIs are reported for each zone detection probability metric.
2. Detection efficiency at the collector is assumed to be 1.0, to provide tangible detection efficiency estimation for previous zones in the mark-recapture model.

3.3.3 Primary and Secondary Screen Collection Channel Results

To better understand where fish reject collection within the channel, the mark-recapture model was refined to estimate collection efficiency metrics and detection efficiency in the primary and secondary channels separately. Here, the mark-recapture model was used to determine the transition probabilities between the NTS and the primary channel, the primary channel and the secondary channel, and the secondary channel to collection. The results of this model (Table 7) show that transition probability from the NTS into the primary channel ranges from 66% for steelhead to 78% for Coho. Transition probability from the primary channel to the secondary channel ranges from 88% for Chinook to 100% for Coho. Transition probability from the secondary channel into the collector (i.e., probability of collection) ranges from 54% for Coho to 75% for steelhead.

Table 7. Transition probabilities between channel subarrays.

Species	NTS to Primary Channel (95% CI)[1]	Primary Channel to Secondary Channel (95% CI)	Secondary Channel to Collection (95% CI)
Chinook Salmon	71% (54%, 83%)	88% (41%, 99%)	75% (52%, 89%)
Coho Salmon	78% (68%, 85%)	100% --[2]	54% (43%, 64%)
Steelhead	66% (56%, 75%)	91% (68%, 98%)	70% (56%, 82%)
All	70% (64%, 75%)	99% --[2]	63% (54%, 71%)

Notes:
1. 95% CIs are reported for each collection metric.
2. MARK estimates near the boundary of p = 1 are unstable and thus not reported.

Zone detection efficiencies for the primary and secondary channel subarrays were calculated in the same manner as for the collection channel as a whole (Section 3.3.2) and was similarly variable among species (Table 8). Zone detection efficiency for Chinook Salmon was low, and partitioning transitions between channel subzones increases uncertainty for the Chinook data.

Table 8. Detection efficiency in channel subarrays.

Species	$DET_{Primary\ Channel}$ (95% CI)[1]	No. of Fish Missed in Primary Channel	$DET_{Secondary\ Channel}$ (95% CI)	No. of Fish Missed in Secondary Channel
Chinook Salmon	42% (30%, 56%)	30	32% (20%, 46%)	32
Coho Salmon	84% (74%, 90%)	12	74% (63%, 83%)	16
Steelhead	82% (70%, 90%)	11	66% (51%, 78%)	12
Total	72% (65%, 78%)	53	57% (48%, 65%)	60

Notes:
1. 95% CIs are reported for each zone detection probability metric.
2. Detection efficiency at the collector is assumed to be 1.0 in order to provide tangible detection efficiency estimation for pervious zones in the mark-recapture model.

As with the main mark-recapture model, the inter-species detection efficiency differences may be related to behavior. Successful Chinook transit the channel quickly, while Coho and steelhead take longer (Figure 12). Although differences among species were not significant (Tukey's honestly significant difference test p > 0.2 for all comparisons), Chinook that were recaptured transited the collection channel nearly 4.5 minutes faster on average than did successful Coho, and nearly 1.5 minutes faster on average than did successful steelhead. This means that Chinook may have fewer opportunities for detection compared to Coho and steelhead.

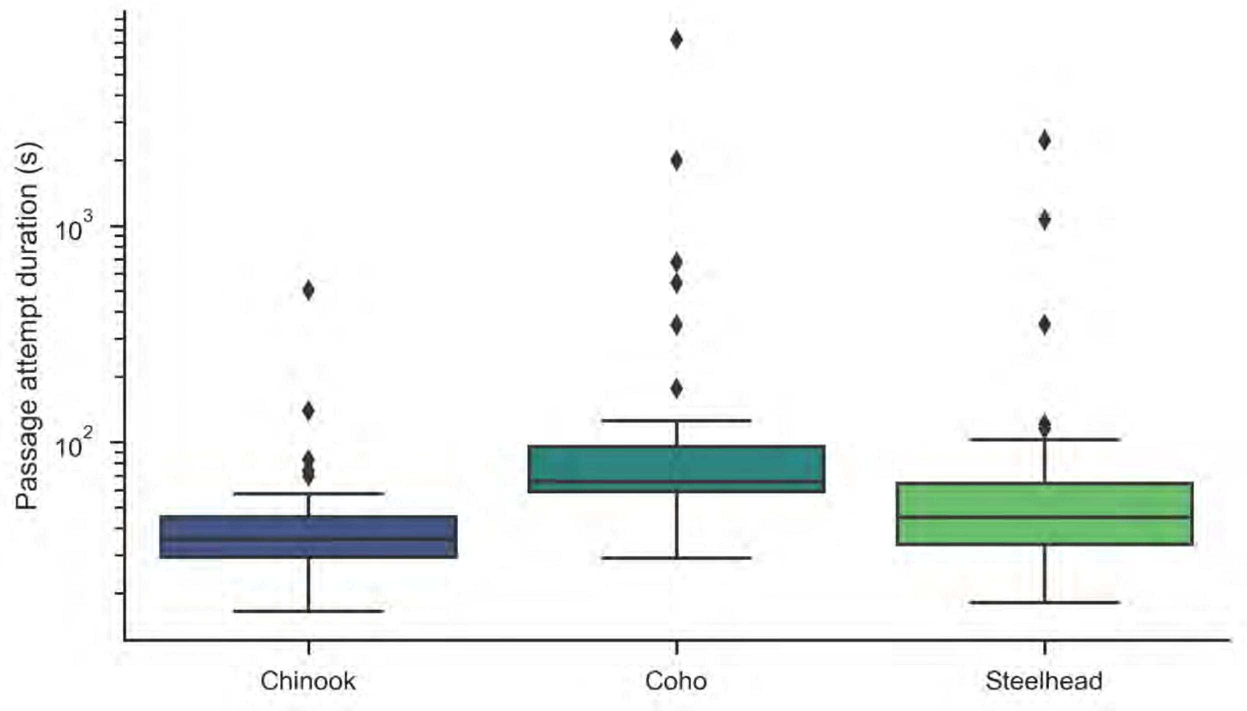


Figure 12. Duration of successful passage attempts for each species. Note log scale y-axis. Midline within each box indicates the median duration of successful attempts for each species, ends of boxes indicate interquartile range (IQR, i.e., 25th – 75th percentile), thin "whiskers" extend to "Tukey's fences," 1.5*IQR beyond the IQR in each direction, and markers beyond the whiskers indicate outlier values.

To help visualize bottlenecks that prevent fish from moving downstream, the transition probabilities from the refined mark-recapture model were applied to counts of study fish within each zone (Figure 13). After release, almost two thirds (63%) of dual-tagged study fish transitioned to the forebay and were detected on the ZOI array (Figure 11, Figure 13). Of the fish detected within the ZOI, most (96%) entered and were detected in the NTS. Among fish detected in the NTS, only two-thirds (70%) proceeded to the primary channel. However, once in the primary channel, almost all (99%) fish then proceeded to the secondary channel. Slightly less than two-thirds (63%) of fish that made it to the secondary channel were eventually collected.

The apparent rejection rate for Chinook may be biased high; 22 Chinook that were collected were not detected within the channel (Table 6), suggesting lower detection efficiency in the channel for Chinook than for Coho and steelhead, possibly due to faster transit time through this zone.

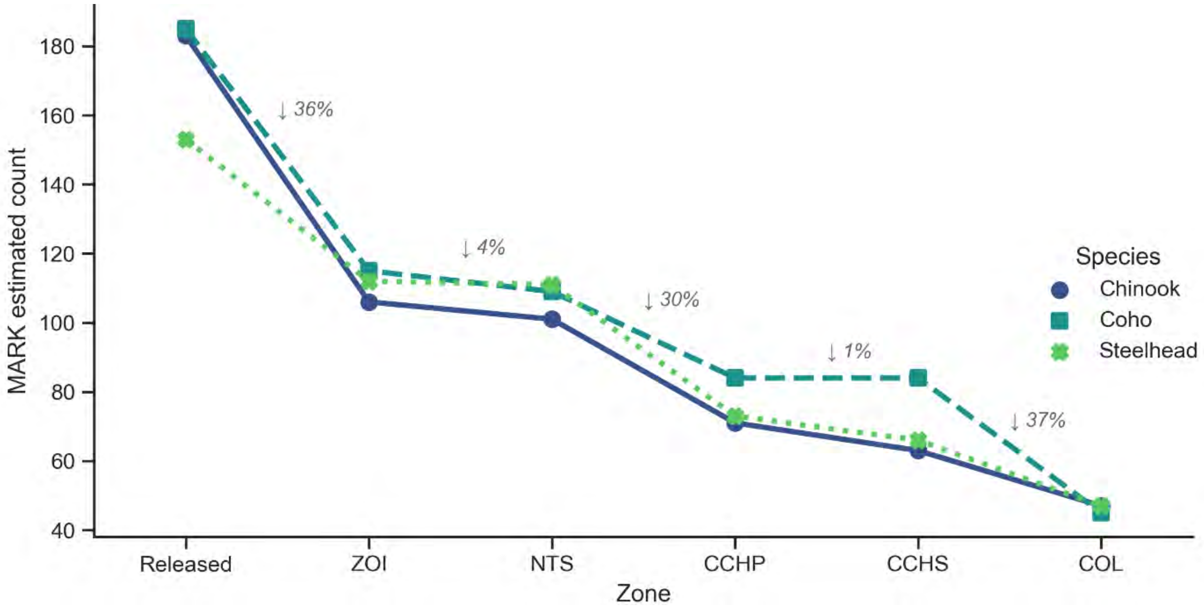


Figure 13. Counts of study fish detected within each zone of the Swift floating surface collector array. Annotation indicates magnitude of species-averaged rejection rates associated with each transition.

3.4 Passage Attempt Behavioral Analysis

Behaviors of fish that 1) attempted passage at the Swift FSC in 2020 and 2) met filtering criteria (Section 2.4) were analyzed to reveal patterns, evaluate differences, and identify potential explanations for why fish reject collection. For these analyses, a passage attempt is defined from the time a given fish is first detected transitioning into the collection channel to the time when it exits (Section 2.4.1). Analyses generally focused on passage attempts that occurred during periods when the collector was operational. These analyses focused on either individual fish, in which case the last passage attempt for each fish was used, or on all passage attempts for each fish. 179 fish were included in the set of retained passage attempts. Fish that only entered the collection channel while the collector was off were not considered. Of these 179 fish, 41 were Chinook, 78 were Coho, and 60 were steelhead.

Since these fish had already entered the channel, recapture rates among this group are analogous to P_{COL} for the overall group of study fish. For each species, recapture rate for fish in this group was slightly greater than, but statistically similar, to P_{COL} for the overall study group (Figure 14). This slight discrepancy is because 10 Chinook, 7 Coho, and 9 steelhead were captured but not detected in the collection channel, so not accounted for in computation of P_{COL}. These fish were, however, included in the behavioral analysis, leading to this slightly higher recapture rate among fish included in the behavioral analysis.

Most fish (54%) that attempted passage (i.e., were detected within the collection channel) made only one attempt, 90% attempted less than 17 times, and 95% attempted less than 30 times (Figure 15). Four Coho attempted 50 or more times, one of which attempted 105 times. The number of passage attempts per fish was similar between fish that rejected the collector and those that recaptured. Although unsuccessful fish of each species tended to make more attempts, for each species the number of passage attempts per fish was statistically similar between fish that rejected the collector and those that were recaptured (*t*-tests for each species, $p \geq 0.15$)

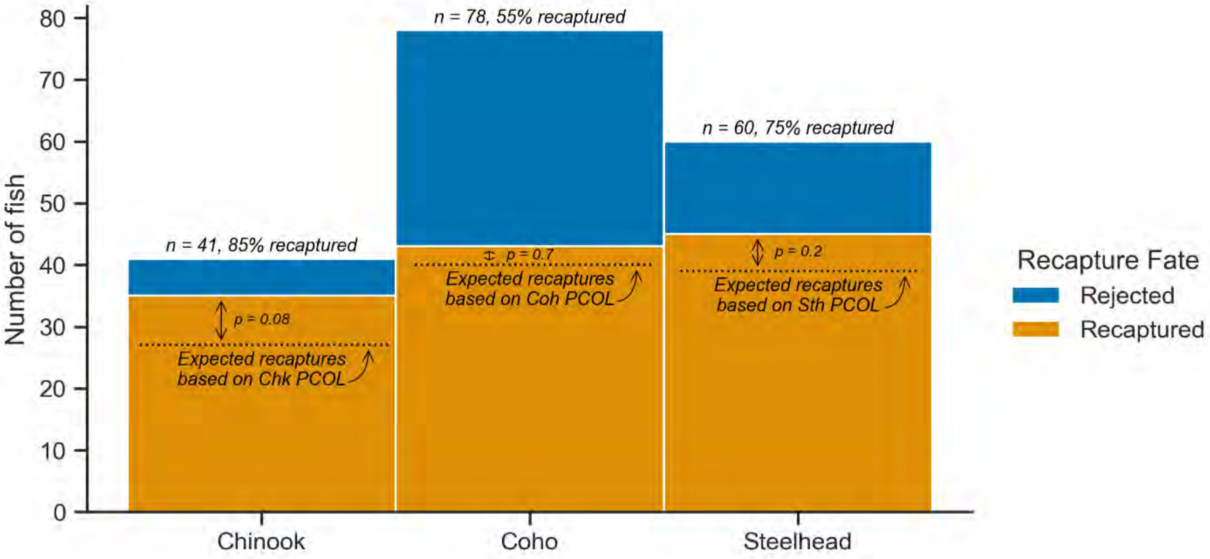


Figure 14. Counts of fish included in behavioral analyses, stacked to show recapture rates (number of fish collected divided by number of fish included in behavioral analysis) for each species. Dotted black line and annotation indicates expected recapture numbers based on P_{COL} values for each species. P-values summarize results of species-specific χ^2 tests for equality of proportions.

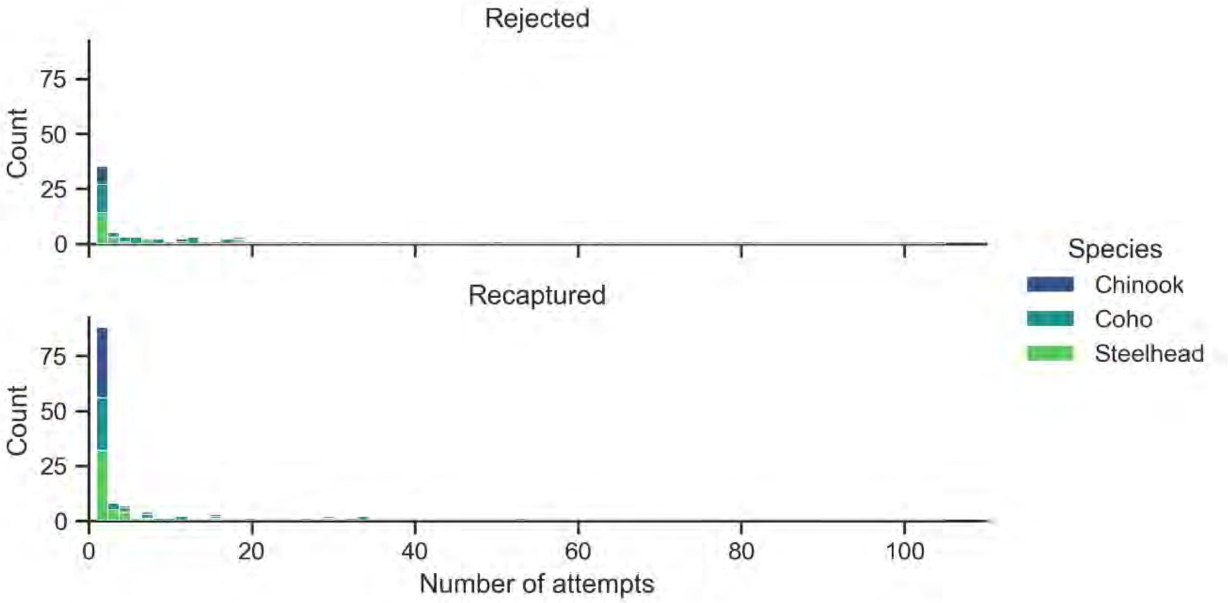


Figure 15. Distribution of the number of Swift floating surface collector passage attempts made by recaptured study fish during 2020.

3.4.1 Seasonal Dynamics

Chinook, Coho, and steelhead outmigration timing was somewhat staggered: 50% of the run-at-large had passed the FSC by 1 April for Chinook, by 1 May for steelhead, and by 1 June for Coho (Figure 9). Study fish tagging operations tracked the run-at-large well for Chinook and steelhead but tended to overrepresent the early portion of the Coho run.

The daily counts of study fish attempting passage at the FSC (i.e., counting each fish once per day) indicate distinct but overlapping modes for each species that generally mirror the run-at-large counts (Figure 16). Outmigration for each species was relatively steady, except steelhead exhibited a peak in the number of fish attempting passage when the collector was turned off in mid-May, and Coho exhibited pulses in activity during late May and June, which coincided with higher collection of the Coho run-at-large in the FSC (data not shown, available on request).

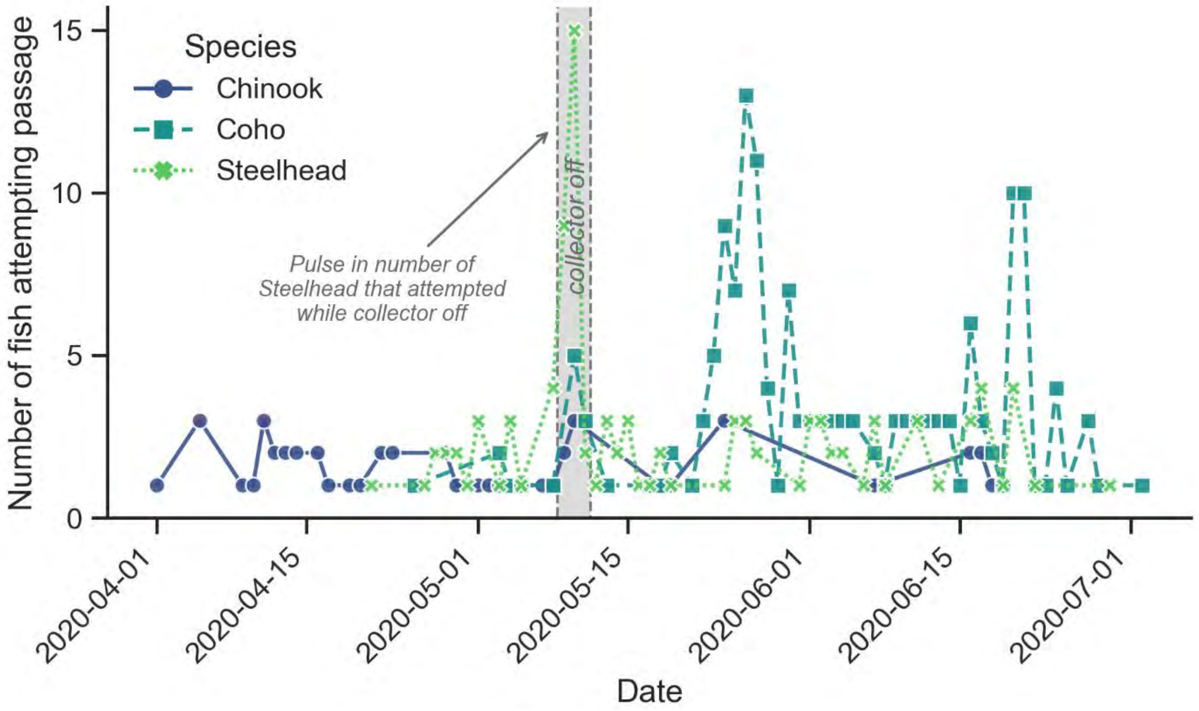


Figure 16. Daily counts of number of fish attempting passage at the Swift floating surface collector during the 2020 season. Shaded box denotes period when the floating surface collector was not operational.

The seasonal profile of daily counts of the number of passage attempts per fish indicates a general trend towards increasing activity (attempts per fish) as the season progressed, for all species (Figure 17).

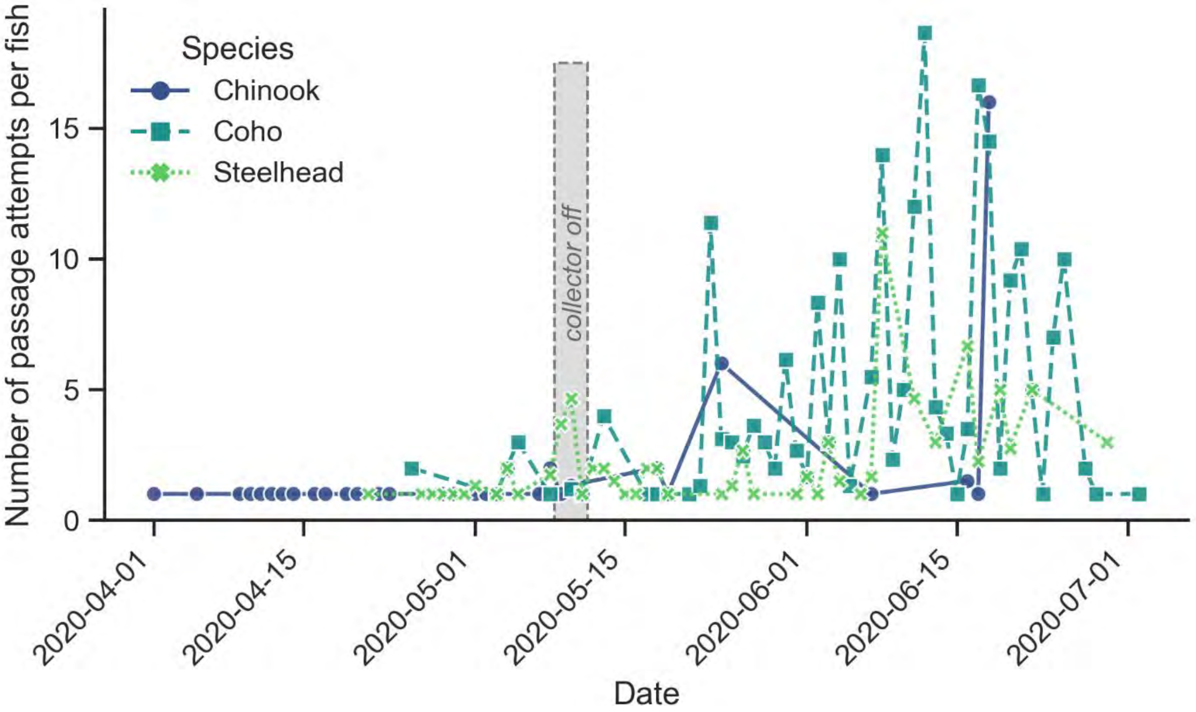


Figure 17. Average number of passage attempts per fish per day at the Swift floating surface collector during the 2020 season. Shaded box denotes period when the floating surface collector was not operational. This contrasts with Figure 16 which shows the number of individual fish making attempts per day.

3.4.2 *Diel Dynamics*

Study fish initiated passage attempts at the Swift FSC during all hours of the day, but were collected more frequently during the night or later afternoon (Figure 18). Particularly for Chinook, but consistently among all species, passage attempts that resulted in successful recapture were initiated from the evening through the early morning hours (approximately 18:00 to 06:00). Conversely, passage attempts that resulted in rejection of the collector (in either the primary or secondary channel) were initiated during the middle of the day. Human (worker) activity on the FSC tends to occur between 09:00 and 15:00, while daylight at the FSC is variable across the season but extends from 05:30 to 20:30 during May. Either or both factors may affect fish passage at the FSC.

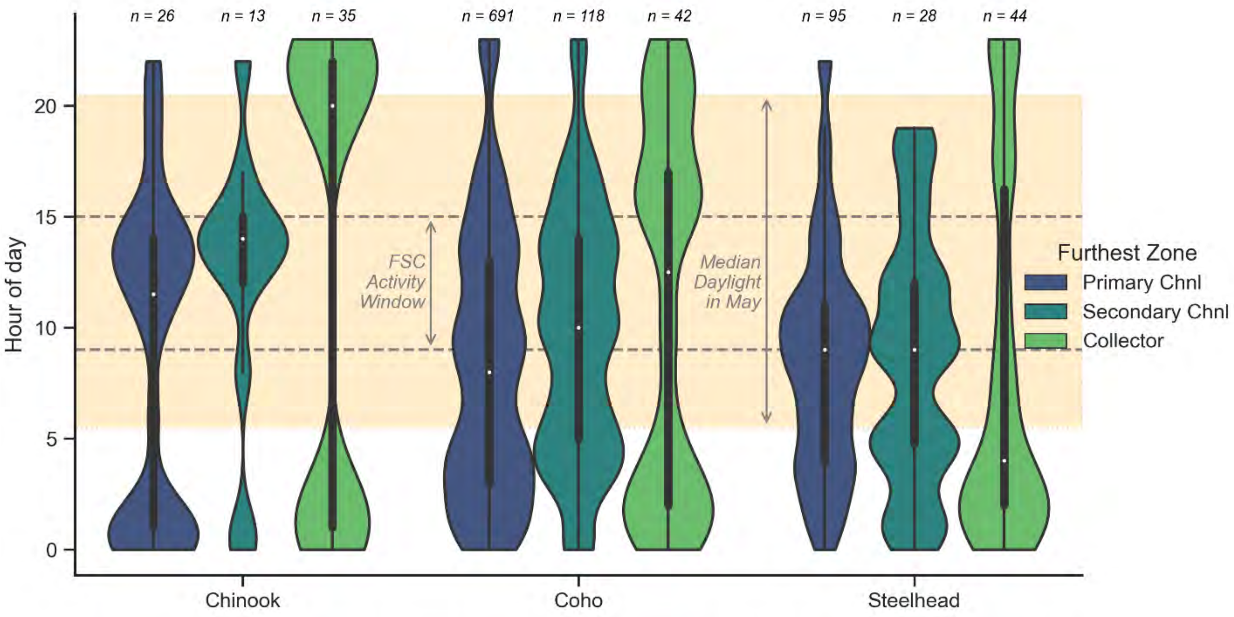


Figure 18. Diel patterns of Swift floating surface collector passage behavior during 2020, grouped by species and furthest zone reached during their final attempt (primary channel, secondary channel, or collector). Plot shows the diel distribution of the time during which fish initiated passage attempts within each categorical outcome. To faciliate visualizing trends and comparing groups, kernel density estimator bandwidths were all 0.2, and violin widths are all equal. See Figure 10 for explanation of violin symbology. Shaded orange overlay indicates approximate median sunlight hours in Cougar, Washington, during May 2020, and dashed horizontal lines indicate approximate time frame when workers may be present on the floating surface collector (09:00-15:00).

3.4.3 Fork Length

When considered across the entire group of study fish within each species, there was a modest but statistically significant effect of fork length on probability of recapture (Figure 19). Coho and steelhead that were recaptured at the FSC were significantly shorter than those that rejected the collector (*t*-test, $p < 0.05$); length of Chinook did not differ between fish that rejected the FSC and those that were recaptured.

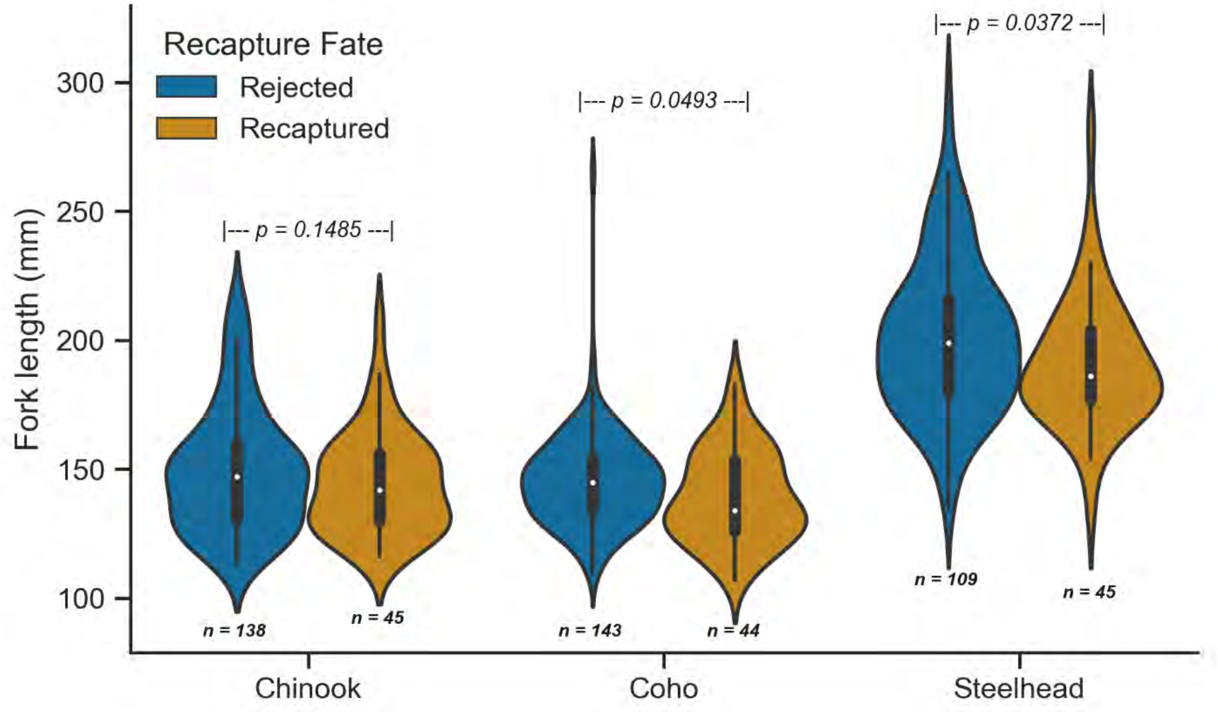


Figure 19. Comparison of fork length between study fish that were recaptured at the Swift floating surface collector during 2020 and those that rejected the Swift floating surface collector during 2020, grouped by species. All study fish are included in this plot. Scott's Rule (Scott 1992) was applied for kernel density bandwidth selection. To facilitate visual comparison among groups, violin widths are all equal. See Figure 10 for explanation of violin symbology. Sample size for each group is noted below each violin. *P*-values summarize results of *t*-tests of difference in length between rejected and recaptured fish, for each species.

3.4.3.1 Model Results

The recapture probability model was evaluated by plotting model predicted probability of recapture against significant model factors, to visualize the shape of each relationship and conceptualize the strength of each effect. This showed that probability of recapture has a negative relation to fork length. This effect is strongest among Coho, with steelhead and Chinook showing a weaker effect (Figure 20).

The probability of recapture was also plotted against time of day when each study fish initiated their final passage attempt (Figure 21). Similar to fork length, Coho exhibited the strongest model-predicted response, largely driven by many more unsuccessful attempts during the middle of the day. However, as visualized on Figure 18), Chinook and—to a lesser extent—steelhead both exhibited diel patterns in success of passage attempts.

Detailed recapture probability model results are available in APPENDIX A.

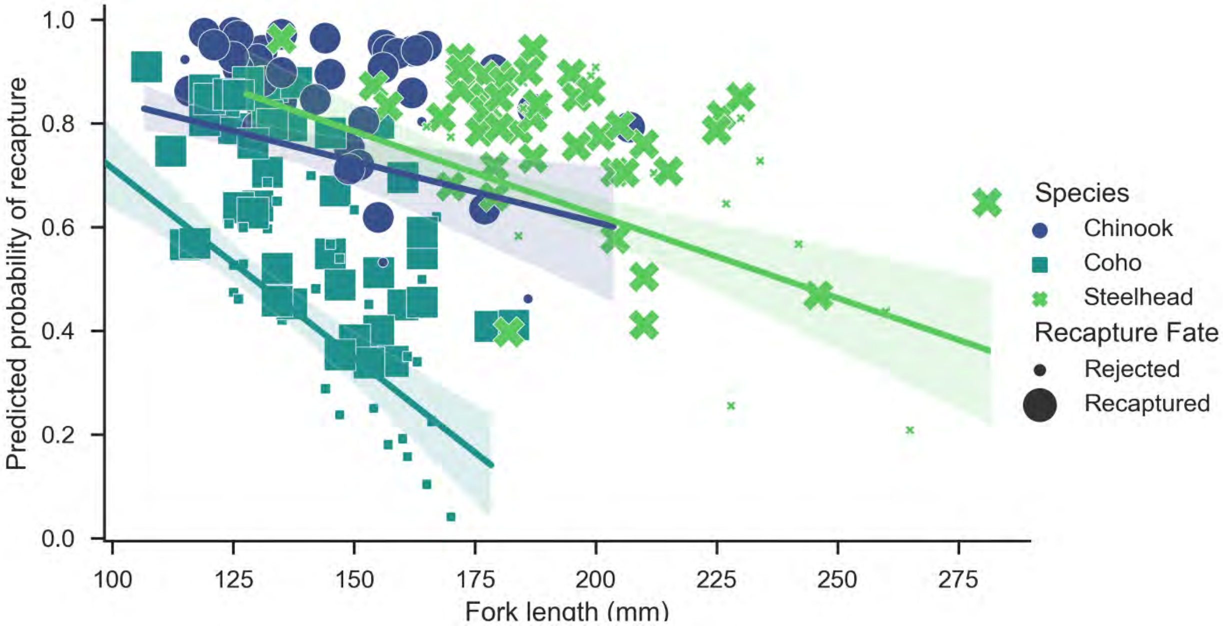


Figure 20. Model-predicted probability of recapture as a function of fork length. Marker shape and color represent species, while marker size represents recapture fate: large markers were truly recaptured, while small markers rejected the collector.

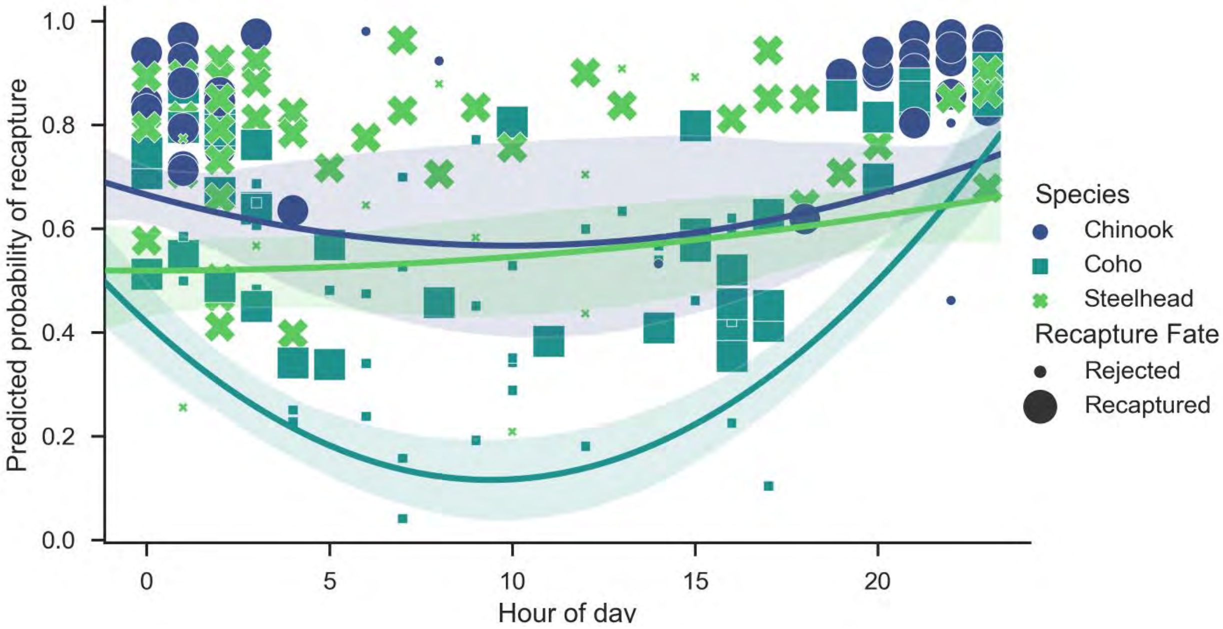


Figure 21. Model-predicted probability of recapture as a function of hour of day of passage attempt. Marker shape and color represent species, while marker size represents recapture fate: large markers were truly recaptured, while small markers rejected the collector.

3.5 Floating Surface Collector Outage Effects

During the mid-May FSC shutdown to repair damage caused by debris, 31 study fish attempted passage by entering the FSC: 5 Chinook, 7 Coho, and 19 steelhead. This group of fish was ultimately recaptured at a similar rate to the rest of the study fish (Figure 22). In total, 14 of these 31 (45%) were ultimately collected after the FSC was turned back on, and recapture rates for all species were similar to season-wide P_{CE} estimates (χ^2 for each species, $p \geq 0.9$).

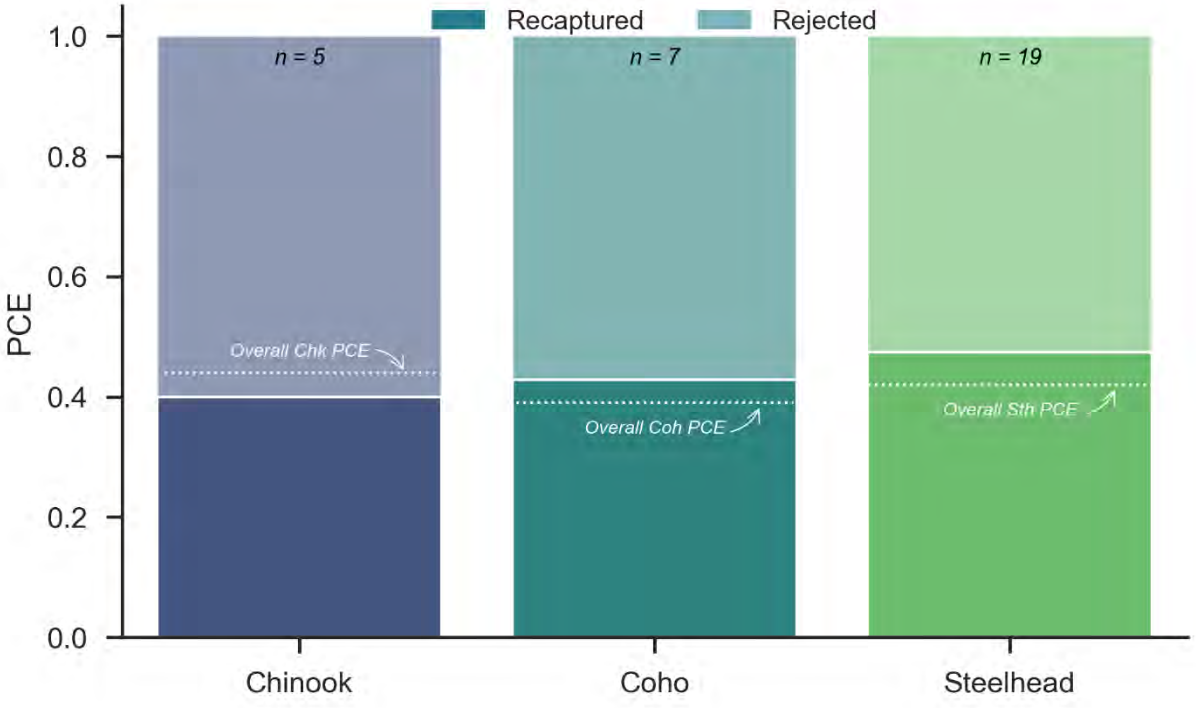


Figure 22. Effects of floating surface collector outage on fish passage.

3.6 Recapture Rates of Passive Integrated Transponder- and Dual-Tagged Fish

During the 2020 Study season, Chinook and steelhead tagged with both PIT and acoustic tags were recaptured at higher rates than fish tagged exclusively with PIT tags, while dual-tagged Coho were recaptured at a lower rate than PIT-only fish (Figure 23). Difference in recapture rate between PIT-only and dual-tagged Chinook and steelhead were not significant, but those for Coho were highly significant (χ^2, $p = 0.004$). Although PIT-only Coho included smaller fish than Coho that were dual-tagged, mean fork length was similar between the two groups (Figure 24).

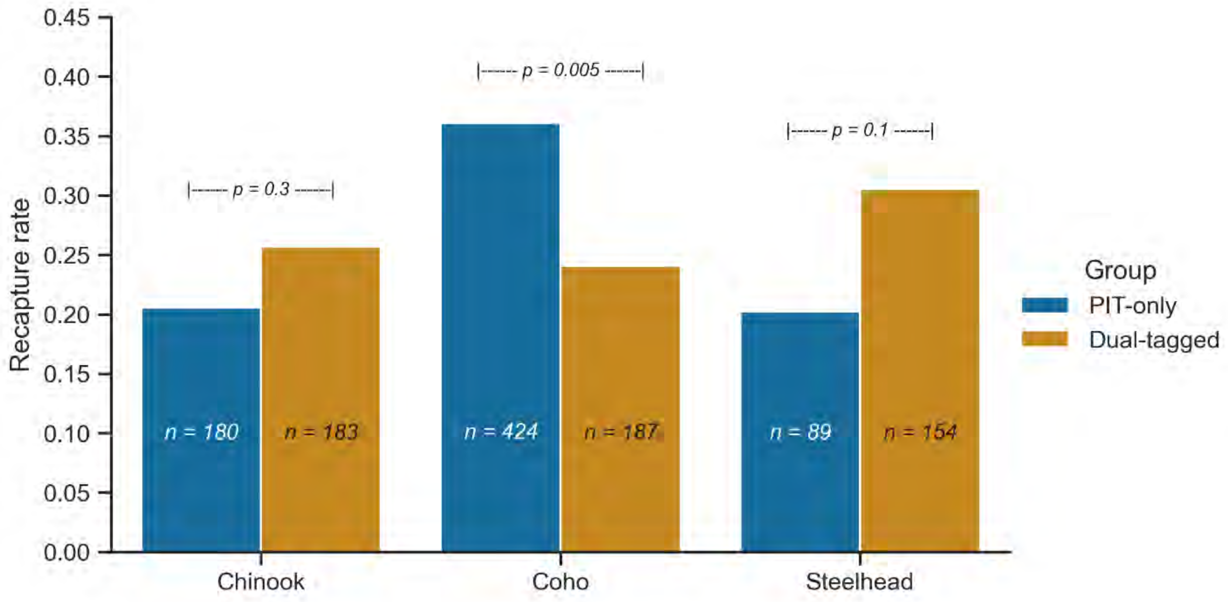


Figure 23. Swift floating surface collector 2020 recapture rates compared between dual-tagged and passive integrated transponder-only study fish, for each species. *P*-values summarize results of χ^2 tests for each species.

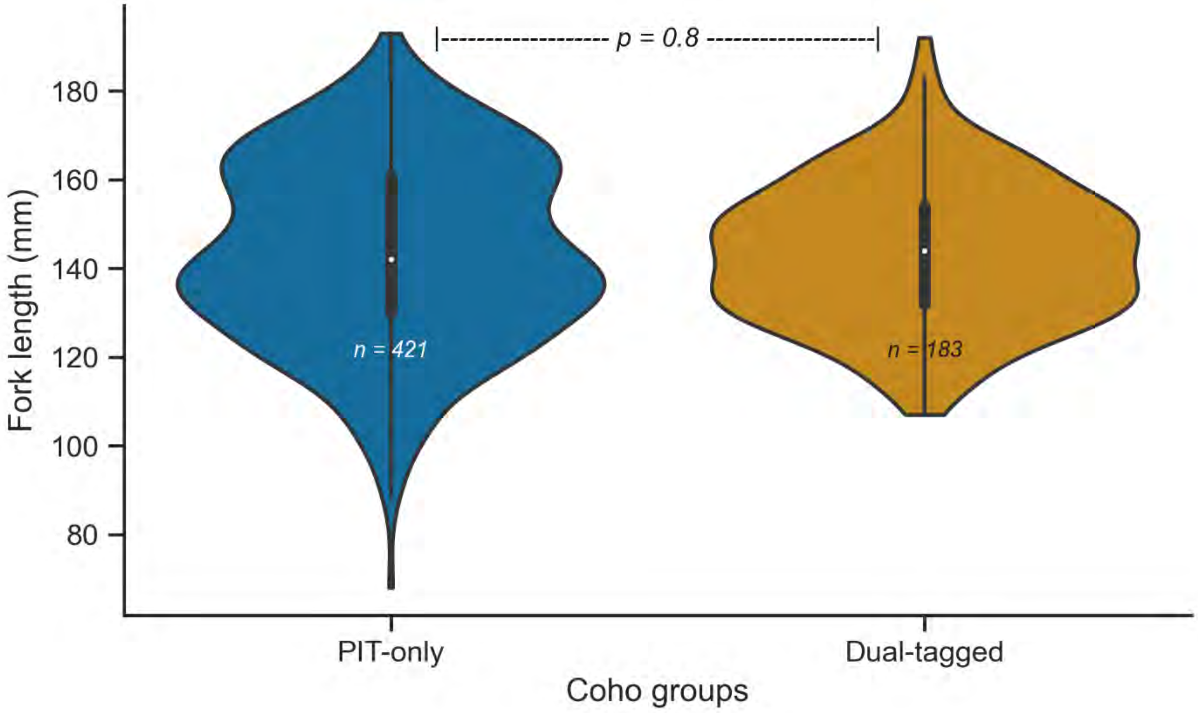


Figure 24. Comparison of fork length between passive integrated transponder-only and dual-tagged groups of Coho study fish. Scott's Rule (Scott 1992) was applied for kernel density bandwidth selection. To facilitate visual comparison among groups, violin widths are all equal. See Figure 10 for explanation of violin symbology. Sample size for each group is noted within each violin. *P*-value summarizes results of a *t*-test of difference in length between rejected and recaptured fish, for each species.

3.7 Delayed Migration

The 41 study fish from the 2019 study that were included in computation of performance metrics were detected outmigrating after the 2019 study (APPENDIX C). 12 Chinook, 24 Coho, and 5 steelhead were detected on PIT antennas in the FSC (SHP), at the WRP, or by hand-wanding conducted by PacifiCorp staff and contractors between October 2019 and October 2020 (Figure 25).

After initial tagging and release, Chinook that delayed outmigration were evenly split between 6 fish that outmigrated in the fall after release (2019), and 6 that outmigrated the following spring (2020). While most Coho that delayed migration (19 fish) outmigrated in the spring after release (2020), 2 fish delayed migration until the fall after release (2019), and another 3 fish outmigrated the next fall (2020). The 5 steelhead that delayed outmigration did so exclusively in the spring after release (2020). These counts of delayed migrants represent 8% of Chinook released in 2019 with active tags (32% of Chinook recaptured in 2019 with active tags), 10% of Coho released in 2019 (23% of Coho recaptured in 2019 with active tags), and 7% of steelhead released in 2019 (50% of steelhead recaptured in 2019 with active tags.

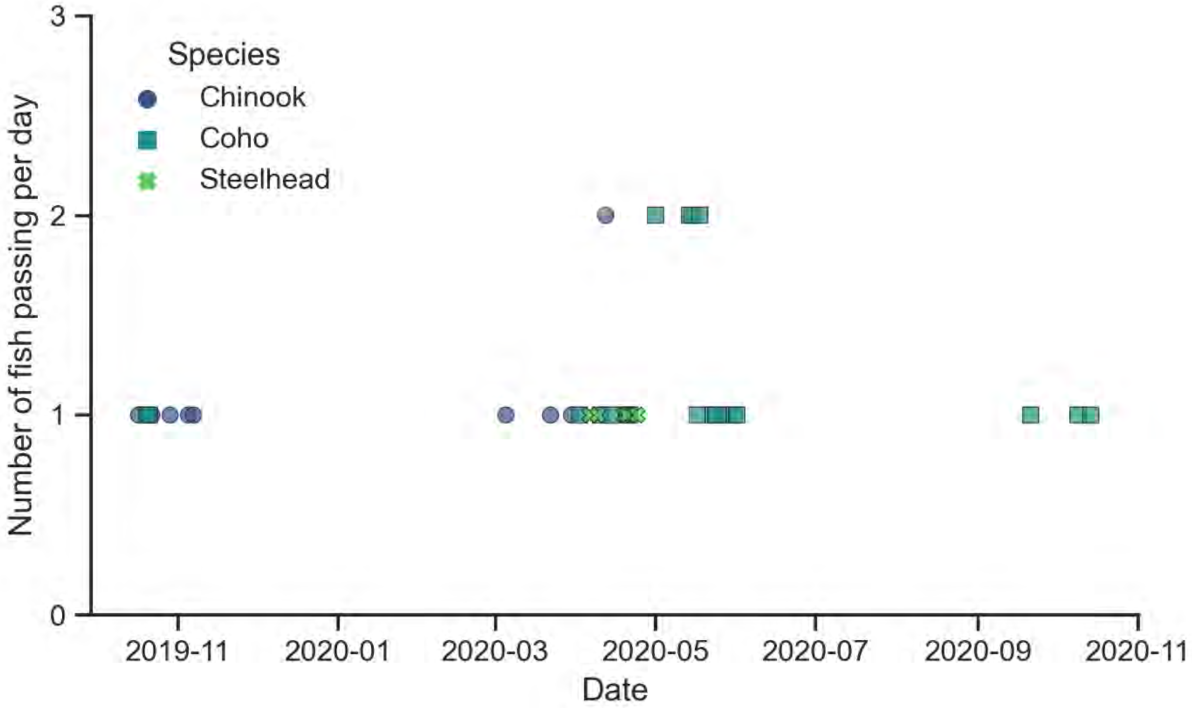


Figure 25. Daily counts of 2019 study fish detections on passive integrated transponder arrays at or below the Swift floating surface collector during Fall 2019 – Spring 2020.

The results of the hypothetical exercise of bounding the range of possible adjusted P_{CE} values (Section 2.7) indicate that adjusted 2019 P_{CE} values that account for delayed migration may have been as much as 28% (15 percentage points) below or 32% (9 percentage points) above unadjusted P_{CE} values reported in the 2019 report (Table 9). Provisionally adjusted 2020 P_{CE} values reflecting worst-case and best-case scenarios that assume identical rates of non-detection during the study period and of delayed migration as were reported for the 2019 study are presented in Table 10. Under these provisional scenarios, steelhead P_{CE} may be as high as 56% and Chinook P_{CE} may be as low as 31%.

Table 9. Hypothetical adjusted P_{CE} values for 2019 study fish under "best-case" and "worst-case" scenarios.

Species	Released in 2019	Detected in ZOI During 2019 Study	Collected at FSC During 2019 Study	Detected at FSC or WRP After 2019 Study	Never Detected on Acoustic Array or PIT antennas at FSC or WRP	Unadjusted 2019 P_{CE}	2019 $P_{CE-Adj-Worst}$	2019 $P_{CE-Adj-Best}$
Chinook Salmon	151	75	38	12	63	51%	36%	57%
Coho Salmon	250	167	106	24	75	63%	54%	68%
Steelhead	69	37	10	5	29	27%	23%	36%

Table 10. Provisionally adjusted P_{CE} values for 2020 study fish, under "best-case" and "worst-case" scenarios, assuming similar rates of delayed migration compared to 2019.

Species	Unadjusted 2020 P_{CE}	2020 $P_{CE-Adj-Worst}$	2020 $P_{CE-Adj-Best}$
Chinook Salmon	44%	31%	50%
Coho Salmon	39%	33%	42%
Steelhead	42%	35%	56%

4 Discussion

This section discusses the general results of the 2020 Study, compares the results among study years, and addresses principal questions related to the behavior and operation of the FSC.

4.1 Comparison of 2020 Reservoir Passage and Encounter Rate Estimates to Previous Years

In the 2020 Study, the encounter rate (P_{ZOI}) was defined as the proportion of released study fish that are detected within the ZOI. This differed from previous studies in which P_{ZOI} was calculated as transitions between two sub-reaches: P_{RES}, the proportion of released study fish that are detected at the entrance of the forebay upstream of the ZOI, and P_{ENC}, the proportion of fish in the forebay that locate the ZOI. P_{ZOI} in 2020 is equivalent to the product of P_{RES} and P_{ENC} computed in previous years (i.e., $P_{ZOI} = P_{RES} \times P_{ENC}$), and this expression was used to examine differences in P_{ZOI} among study years (Table 1).

In the 2020 Study, P_{ZOI} was highest for steelhead and was lowest for Chinook (Table 5). P_{ZOI} for Chinook in 2020 was similar to the previous two study years (2017 and 2019), but for Coho it was lower in 2020 by 12 percentage points than in 2017 (a 16% reduction) and by 20 percentage points than in 2019 (a 24% reduction). For steelhead, P_{ZOI} was higher in 2020 than in any year since 2015 and was 14 percentage points higher than in 2019 (a 24% increase). Potential mechanisms underlying observed performance in 2020 and changes over time are discussed in Sections 4.2 through 4.4.

4.2 Discussion of 2020 Collection Metrics and Comparison to Previous Years

In the 2020 Study, Swift FSC collection efficiency (P_{CE}) was below the performance standard of 95% for all species evaluated (90% CIs for P_{CE} do not extend beyond 95% for any species; Table 5). The total corrected P_{CE} estimate for study fish of all species was 42%; individual species estimates ranged from 39% for Coho Salmon to 44% for Chinook Salmon. This overall (all species) P_{CE} estimate for 2020 was the second highest of any observed in previous studies between 2013 and 2019 (Table 1). Similarly, the 2020 P_{CE} estimates for Chinook Salmon and Coho Salmon were the second highest observed in past studies where active tags (i.e., radio or acoustic telemetry tags) were used (Courter et al. 2013; Stroud et al. 2014; Reynolds et al. 2015; Caldwell et al. 2017; Anchor QEA 2018; Four Peaks 2020).

In the 2019 and 2020 studies, fish entering the collector as far as the NTS were evaluated using the P_{ENT} performance metric, which examines the proportion of study fish that moved downstream from the ZOI and entered the NTS. Overall, the corrected P_{ENT} estimate for all species in 2020 was 96%, meaning that almost all of the fish that found the ZOI also entered the NTS. These results were similar to observations in 2019 and suggest that the modifications made to the collector in 2018 and 2019 continue to be effective at encouraging fish to enter the collector. All three study species exhibited P_{ENT} values greater than 95% in 2020. P_{ENT} in 2020 was similar for Coho Salmon (95%) and steelhead (99%) compared to in 2019 when P_{ENT} for Coho was 97% and for steelhead was 98%. P_{ENT} for Chinook Salmon in 2020 (95%) was higher than in 2019 (78%). These results suggest that fish are entering the collector in sufficient numbers to achieve the P_{CE} target of 95%, and that rejection between the NTS and the FSC—rather than attraction or the ability to locate the FSC—is the primary bottleneck for achieving collection goals.

Although study fish appear to enter the NTS in sufficiently high numbers to achieve performance goals, less than half of these were collected in 2020. As in the 2019 study, the probability of collection after entering the NTS was evaluated using the P_{RET} performance metric. Overall, the corrected P_{RET} estimate for all species was 43%. This means that 57% of the fish that entered the FSC did not proceed on to collection. The species specific P_{RET} in 2020 was 47% for Chinook and 42% for both Coho Salmon and steelhead. Differences in P_{RET} between 2020 and 2019 are similar to differences observed for P_{CE}, with substantial increases observed for steelhead and decreases observed for Coho Salmon. Regardless of these differences, the conclusion presented from both studies is consistent: the rejection in the reach between the NTS and the FSC is the primary bottleneck to achieving the P_{CE} target of 95% for each species.

The FSC has undergone substantial modifications that appear to have improved P_{CE} since the 2017 study. Modifications include reducing operating noise by reprogramming flow pumps and adjusting dewatering screen baffles and increasing attraction velocity. These modifications appear to have increased collection efficiency for Chinook and Coho Salmon (Four Peaks 2020).

During the past year, the light conditions in the collection area have been modified in ways that could have changed passage collection efficiency. In 2019 it was noted that the metallic floor of the secondary screen was highly reflective and may have created a strong contrasting visual cue that could have elicited rejection behavior (Chris Karchesky, PacifiCorp, personal communication, 2019). This reflective condition was mitigated in 2020 by installing a cover that created shade and could have both reduced the previously identified reflective contrast or created a new shade effect. In the case of the latter, shadows created by the cover may have also elicited avoidance behavior (Kemp et al. 2005; Kemp and Williams 2008). More specifically, it is not clear how the lighting and shading changes influenced collection; previous research does indicate that lighting, flow, and smolt-size interact to influence smolt passage performance through downstream fish passage facilities (Kemp et al. 2005). Determining the impact of a change in lighting would require a study design that has adequate controls and replicates to parse out specific treatment effects (e.g., operate the FSC with the cover and without the cover for multiple “block” periods throughout the season).

However, changes in lighting may not be an important factor that reduced Coho Salmon P_{CE} in 2020. Recapture rates for PIT-tag only Coho were significantly higher than those for dual-tagged study fish (Figure 23), suggesting some underlying characteristic of the dual-tagged Coho (rather than the Coho run-at-large) may have contributed to decreased P_{CE} for the Coho study fish. Dual-tagged Coho were also disproportionately collected from early in the run (Figure 9), meaning that the dual-tagged fish may be less representative of the overall population, or may have biological differences associated with migration timing that also impact passage success. One such difference may be size. Dual-tagged Coho study fish were substantially smaller in 2020 than in 2019: mean fork length for Coho Salmon study fish decreased by more than 20% between 2019 and 2020. It is also possible that the physiological status and subsequent migratory behavior of the two groups differed because of environmental experience associated with different capture and release dates (Zydlewski et al. 2005)

Unfortunately, these two sample groups (PIT-tag only and dual-tagged fish) were not directly comparable, which confounds interpretation of the mechanisms underlying differences in passage success. Ideally the two groups would have been randomly subsampled from the same collection event to ensure 1) dual tagged fish do not systematically exclude similar individuals that were PIT tagged (although this may not be possible, given biological and regulatory concerns about tagging small fish) and 2) the size of all fish tagged on a given day accurately represents size of run-of-river fish passing on that date. This would have potentially reduced the effects of and interactions between release time, physiological status of smolts, or operational variability at the collector during expected recapture dates.

Instead, dual-tagged fish may have been selected in part based on their size (Mark Ferraiolo, PacifiCorp, personal communication, 11/20/2020), and if they were collected from different portions of the run, there may be additional important differences between smolt status or operational conditions experienced by these two groups. Further investigation into the differences between the PIT-tag only and the dual-tagged Coho Salmon samples in 2020 may help identify potential causes for lower than anticipated Coho Salmon P_{CE}.

Increases in steelhead P_{CE} observed in 2020 relative to 2019 bring P_{CE} estimates for steelhead closer to the benchmark set using S_{RES} in 2018. Natural variability in the steelhead run may help explain this. In 2019, the steelhead run contained a higher percentage of larger smolts than in other years, which may have negatively impacted steelhead P_{CE} in 2019 (Four Peaks 2020). Steelhead study fish were smaller in 2020 compared to 2019 (Figure 10)

4.3 Potential Reasons for Rejection in the Collection Channel

The 2020 Study estimated additional metrics (P_{CHAN} and P_{COL}) to describe behavior within the NTS and collection channel to further investigate the reasons for rejection in this reach. P_{CHAN} quantifies the transition probability from the NTS to the channel. Overall, P_{CHAN} was 74% for all species and ranged from 67% for steelhead to 82% for Coho Salmon. This indicates that more than half of the fish that entered the NTS progressed downstream and entered the collection channel to some extent (Figure 11).

The probability of collection after fish enter the collection channel is described with P_{COL}, which was 58% for all species and ranged from 51% for Coho Salmon to 66% for Chinook Salmon. The P_{CHAN} and P_{COL} results confirm that fish of all species are more likely to reject collection in the collection channel than in the NTS. Still, enough fish reject collection after only reaching the NTS to fall short of P_{CE} targets. This effect appeared greatest for Coho and least for steelhead.

Additional transition probabilities describing behavior within the collection channel (Table 7) suggest that once fish have entered the channel, the majority transition downstream from the primary channel to the secondary channel. This effect was most pronounced for Coho Salmon (all Coho that enter the collection channel proceed into the secondary channel) and least so for Chinook Salmon (88% proceed to the secondary channel). These results, combined with the finding that fish were present in the channel at all hours of the day (Figure 18) suggest that shadows created by the shade screen in 2020 did not discourage fish from moving downstream into the shaded portion of the channel. However, low detection efficiency in the collection channel subzones for Chinook Salmon (Table 8) impart additional uncertainty to this conclusion for that species.

To understand factors contributing to rejection within the collection channel more precisely, acoustic detection histories associated with fish passage attempts were analyzed. These efforts produced three insights. First, shorter fish appear to be recaptured more successfully than longer fish (Figure 19, Figure 20). This effect was strongest for Coho Salmon but was also present within Chinook Salmon and steelhead. This observation is consistent with findings of the 2019 study and may have more to do with the ability to volitionally reject as opposed to volitionally pass. The collection channel was designed to gradually increase flow velocity to a level (i.e., “capture velocity”) above which smolts are not expected to be able to escape. However, the observation that larger smolts were more likely to reject collection after entering the collection channel suggests that flow velocities within the FSC collection channel have an asymmetric impact on fish of different sizes. In general, the maximum swimming velocity for a larger fish is higher than for a smaller fish of the same species (Bainbridge 1958), so it follows that larger smolts may be able to more effectively escape entraining flows within the FSC if they experience conditions (e.g., hydraulics, light/shadows, noise) that initiate an avoidance response, while smaller fish are simply carried down the collector by the intake flow. Still, the overall effect of length on successful recapture was modest, and when considered across all study fish, the difference in length between fish that were recaptured and those that rejected was significant only for Coho (Figure 19).

Second, all species exhibited a pattern of increasing passage attempt activity through the study season (Figure 17). Juvenile salmonids are motivated to outmigrate by environmental cues that increase in intensity through the spring, such as day length, water temperature, and accumulated thermal experience (Sykes et al. 2009; Sykes and Shrimpton 2009; Stich et al. 2015). Most fish (54%) attempt passage only once, and almost all (95%) attempt 30 times or fewer (Figure 15). However, results from the 2020 Study indicate that, as the season progresses, all species of juvenile salmonids in Swift tend to undertake more passage attempts per species. It appears that if fish are not successfully recaptured, they will continue to attempt passage, as many as a hundred or more times. This tendency is encouraging from a management perspective, as it suggests that the combination of environmental factors, fish physiology, and FSC operations result in a relatively strong motivation to outmigrate through the FSC, despite the presence of some condition(s) within the channel that cues fish to reject.

The third and possibly most informative result for improving retention after fish enter the collection channel appears to be related to the time of day during which fish initiated the passage attempt. Although fish entered the collection channel and progressed as far as the secondary channel at all hours of the day (Figure 18), most successful passage attempts are initiated in the early morning before dawn or in the latter half of the afternoon (Figure 18, Figure 21). This effect of the time of day on passage success was strongest for Coho (Figure 21), but all three species appear to be more successful when attempting during evening and nighttime hours(Figure 18). This pattern may be an effect of diel patterns of environmental conditions such as daylight and temperature, or of activity levels on the FSC.

Other studies have found interactions between light levels and flow velocity. Haro et al. (1998) noted that downstream migrating juvenile Atlantic Salmon exhibited strong behavioral responses to accelerating flow fields within a weir entrance. At a “critical reaction point” within the weir, fish either continued to pass or swam rapidly upstream to avoid entrainment. Most smolts were able to burst swim upstream to avoid entrainment at velocities less than 2 meters per second; however, at very low light levels, smolts rarely swam upstream. Vowles et al. (2014) also observed avoidance behavior by Chinook Salmon smolts when they encountered velocity gradients in an experimental flume. Similar to Haro et al. (1998), lighting modulated the behavioral response, so that avoidance behavior increased when the flume was illuminated and decreased when it was dark.

Still, it is not clear to what extent light levels may have played a role in the observed diel patterns of passage attempt success, given that the probability of passage attempt success for Coho Salmon begins to increase in late afternoon. At that time of day during the study period, there are still several hours of daylight left at the latitude of Swift Reservoir (Figure 18) , but the collection channel tends to be shaded (Chris Karchesky, personal communication, 12/3/2020). It is possible that the angle of sunlight during these hours interacts with the newly installed shade screen to shade or filter light in the channel to the point that fish are encouraged to enter the collector. Additional data collection and analysis to understand light levels in the collection channel would be required to adequately test this hypothesis.

Human activity levels in and around the collector may provide an alternative explanation for these observed diel passage patterns. Salmonids are known to exhibit avoidance behavior when exposed to human or industrial activities that generate infrasonic "noise" at or below the threshold of human hearing (Popper and Carlson 1998; Bui et al. 2013). One hypothetical explanation for the observed diel pattern is that fish may tentatively explore the FSC at all hours, but when they do so during work hours (approximately 09:00 – 15:00), they experience acoustic conditions (e.g., loud noise) that lead them to reject.

Alternatively, fish attempting to enter the surface collector during the night and early mornings likely encounter quieter conditions, as there is little or no human activity occurring in the FSC. Based on the 2020 results, these "quiet" periods encompass most successful collections. Of the three species included in the 2020 Study, Coho appeared particularly active (Figure 17 and Figure 18): 78 Coho made 851 passage attempts, or 10.9 attempts per fish (six times more attempts than the 1.8 per Chinook and four times more attempts than the 2.8 per steelhead). This suggests Coho may have been highly motivated to outmigrate in 2020. However, Coho also appeared to encounter conditions within the channel that deterred them from successfully proceeding through the channel and into the collector during the morning and early afternoon (Figure 18). If loud work activity on the FSC during 2020 was particularly frequent (e.g., to address excessive debris loading), then this may have contributed to the strength of this diel pattern and to overall low collection efficiency for Coho in 2020. Debris loading in the collector in 2020 was considerably higher than in 2019, requiring substantially more maintenance activity in the collection channel, NTS, and forebay to clear debris (Chris Karchesky, Personal Communication, 11/23/2020). This additional activity in 2020 may have disturbed study fish that were attempting passage through the collection channel resulting in lower passage success during daylight hours than in 2019, when Coho and steelhead were collected more frequently during the day (Four Peaks 2020). This hypothesis may also explain the observed decrease in retention efficiency relative to 2019. Documenting levels of activity at the FSC more precisely would enable this hypothesis to be tested more rigorously.

4.4 Additional Considerations

In addition to annual performance metrics and scoped analyses, a suite of ancillary attributes were analyzed during the 2020 Study. These included the comparison of PIT-only and dual-tagged study fish, the effects of a collector outage on fish recapture, and documentation of the incidence and timing of delayed migration among 2019 study fish. In addition to these evaluations, possible implications of trap-naïvety on passage metrics were analyzed.

During mid-May, the FSC was turned off for 3 days to make repairs caused by extensive debris loading. During this outage, there was a spike in the number of steelhead that attempted passage (Figure 16), but these fish did not undertake appreciably more passage attempts per fish than during bracketing periods (Figure 17). It seems plausible that these fish may have been exploring the collector area, rather than being attracted to it, *per se*, and thus these "attempts" are more likely milling and "random walks" in the forebay. Importantly, this outage did not appear to detectably affect collection: fish that were detected within the collector during this outage were subsequently recaptured at similar rates compared to the overall sample of study fish (Figure 22).

Finally, delayed migration appears be occurring within populations of juvenile anadromous salmonids in Swift Reservoir (Figure 25). Delayed migrants constitute a noteworthy proportion of the release group in 2019. Counts of successfully recaptured delayed migrants represented over 10% of 2019 Chinook and

Coho recaptures. If these numbers are representative of natural variation in freshwater residency, the attainability of a 95% collection target should be critically evaluated. Alternatively, accounting for these behaviors through annual “corrections” in collection efficiency could provide an opportunity to more accurately characterize FSC performance. It may be worth undertaking additional analyses or studies to increase understanding of what drives delayed migration, and whether the tagging and handling associated with evaluating FSC performance increase the likelihood of juvenile salmonids delaying migration. Analyzing otoliths from adult returns may also provide some insight into the relative proportions of fish that spend more than 1 year in freshwater.

It also bears noting that fish included in the 2020 Study are not trap naïve. Previous studies at Swift found that juvenile salmonids initially collected from the Swift FSC (i.e., trap non-naïve fish) exhibited reduced FSC recapture rates compared to fish that were initially collected from upstream locations (i.e., trap naïve fish) (Caldwell et al. 2017). This effect likely derives from a combination of factors. First, handling and transporting juvenile fish is a stress that almost certainly imposes an energetic burden (Congleton et al. 2000). This burden includes the requirement to traverse Swift Reservoir a second time, as well the energetic costs that result from mounting the well-documented stress response associated with any fish handling (Mazeaud et al. 1977; Sumpter et al. 1986; Raby et al. 2015). Second, this stress response itself—separately from the energetic burden—may hinder successful outmigration (Midwood et al. 2016). Third, handling and transporting juvenile fish may bother them sufficiently to deter them from attempting passage through the FSC again, through a phenomenon known as aversive or “negative operant” conditioning (Popper and Carlson 1998; Richards et al. 2007; Bui et al. 2013). As a result, it may be worth evaluating the effects of trapping location, e.g., by comparing recapture rates between groups of PIT-tagged fish collected at the FSC and those collected upstream, especially if tagging and handling experience is found to influence the incidence of delayed migration.

5 Conclusions

- Entrance efficiency (P_{ENT}) was very high for all three species, indicating that, once in the ZOI, fish successfully enter the NTS.
- Retention efficiency (P_{RET}) was modest for all three species, indicating that, once in the NTS, more than half of all study fish reject the FSC.
- As a result of this low retention efficiency, collection efficiency (P_{CE}) was confidently below performance standards for all three species.
- It appears that, once fish reach the ZOI and subsequently the NTS, a large portion rejects between the NTS and primary channel. Then, once in the primary channel nearly all fish proceed to the secondary channel.
- More than one third of all fish that reach the secondary channel, however, reject the FSC before being collected. This suggests that multiple bottlenecks to successful collection exist within the FSC, including one between the NTS and the primary channel and another between the secondary channel and the entrance to the FSC.
- Smaller fish appear more likely to be recaptured, potentially as a result of an inability to physically reject once inside the channel.
- Passage attempts initiated between evening and early morning appear more successful than those initiated during the middle of the day, potentially a result of daylight and/or activity on the FSC.
- An FSC outage to address debris loading does not appear to have measurably affected fish passage, although a large number of steelhead attempted passage during this period.
- Recapture rates were similar among PIT-only and dual-tagged Chinook and steelhead but were significantly higher for PIT-only Coho.
- Similar to 2019, the 2020 sample of Coho study fish appears to have been collected disproportionately from the early part of the run.
- 2020 Coho study fish were significantly smaller than 2019 Coho study fish.
- A small but nontrivial number of 2019 study fish were detected outmigrating after completion of the 2019 study season.

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APPENDIX A Detailed Study Methods

A.1 Acoustic Telemetry Array

Overview

From 24 to 28 February 2020, Four Peaks Environmental Science & Data Solutions (Four Peaks) staff installed an acoustic telemetry array comprising 13 receivers in the Swift Dam forebay, plus a remote receiver within the floating surface collector (FSC) for confirming tag activation (2020 Swift Reservoir Floating Surface Collector Passage Evaluation [2020 Study] Figure 6). The 13 forebay receivers covered three zones: the zone of influence (ZOI), net transition structure (NTS), and the collection channel (CCH), which was further broken up in to the primary screen collection channel (primary channel) and the secondary screen collection channel (secondary channel). Each of these zones was monitored with a subarray of receivers: three autonomous receivers in the ZOI, two cabled receivers in the NTS, three cabled receivers in the primary channel, and five cabled receivers in the secondary channel. Receiver codes and the approximate depths of their hydrophones are provided in Appendix Table A.1. .

Appendix Table A.1. Acoustic receiver model and approximate depths of hydrophones associated with each receiver within the Swift floating surface collector acoustic telemetry array.

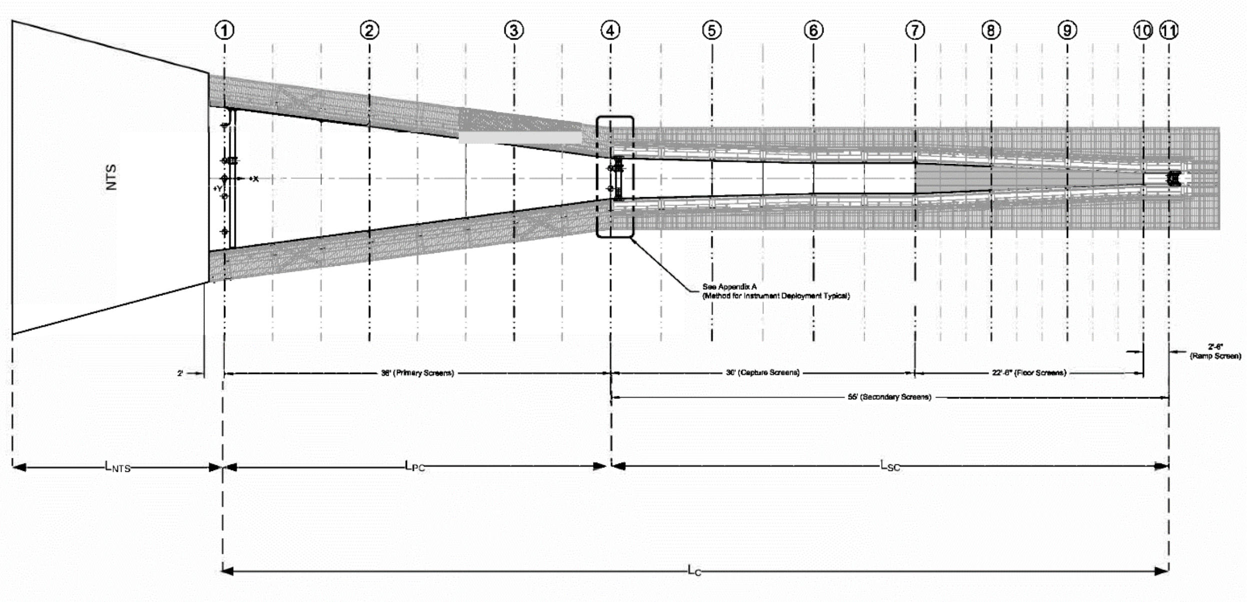
Zone	Receiver ID	Receiver Model	Approximate Hydrophone Depth
ZOI	ZOI-01	Autonomous SR3001	15 feet
ZOI	ZOI-02	Autonomous SR3001	15 feet
ZOI	ZOI-03	Autonomous SR3001	15 feet
NTS	NTS-01	Cabled SR3017	7 feet
NTS	NTS-02	Cabled SR3017	7 feet
Primary Channel	CCH-01	Cabled SR3017	5 feet
Primary Channel	CCH -02	Cabled SR3017	10 feet
Primary Channel	CCH -03	Cabled SR3017	6 feet
Secondary Channel	CCH -04	Cabled SR3017	5 feet
Secondary Channel	CCH -05	Cabled SR3017	3 feet
Secondary Channel	CCH -06	Cabled SR3017	2 feet
Secondary Channel	CCH -07	Cabled SR3017	2 feet
Secondary Channel	CCH -08	Cabled SR3017	2 feet
Secondary Channel	FSC Transfer Tank	Modified Mobile SR3000	*Not Applicable*

Context, Approach, and Design

Results from the Swift FSC 2019 evaluation (Four Peaks 2020) identified low retention efficiency as the main factor limiting FSC collection efficiency. During the 2019 study, fish appeared to enter the collection channel but then returned upstream instead of continuing to collection. Consequently, the acoustic array for the 2020 study was designed to focus on this area of interest, providing higher spatial resolution within the NTS and collection channel with coarser resolution in the ZOI.

Collection Channel Subarrays

The collection channel array was designed to identify areas within the collection channel where tagged fish hold or turnaround. This was accomplished by installing hydrophones within two subarrays within the channel, to distinguish zones associated with the upstream primary channel (the area bounded by cross sections 1 and 4 in Error! Reference source not found.) and downstream secondary channel (the area bounded by cross sections 4 and 10 in Error! Reference source not found.).



Appendix Figure A.1. Swift floating surface collector schematic diagram, showing plan (overhead) view of the collection channel, including primary screen and secondary screen zones.

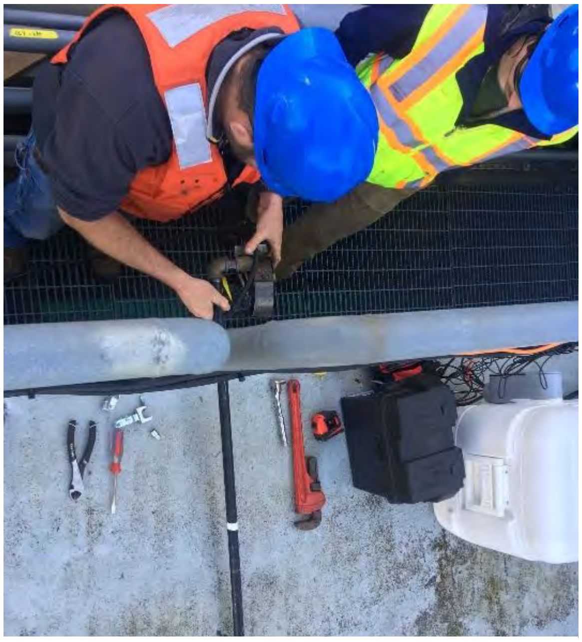
An array of eight shore-based, hydrophones cabled directly to acoustic receivers (Advanced Telemetry Systems [ATS] SR3017 Trident) was designed to provide comprehensive coverage of the channel with minimal exposure to noise and minimal prominence within the channel (2020 Study Figure 7).

For the primary channel subarray, three hydrophones were deployed on the port (north) side of the primary channel, which largely avoided excessive noise from high water velocities on the starboard (south) side, as determined during pre-study testing and the initial weeks of the study (Appendix A.3). Two of these hydrophones were deployed near the upstream end of the primary channel, to cover the vertical profile of this deep section. The third hydrophone was deployed near the boundary between the primary and secondary channels, for detecting fish as they transition from the primary to the secondary channel during their progression downstream toward the collector. For the secondary channel subarray, five hydrophones were evenly spaced in a sawtooth pattern along the port and starboard sides of the secondary channel, to optimize detection opportunities throughout this area.

Deployment of hydrophones in the high-velocity, acoustically challenging aquatic environment of the collection channel required careful consideration to achieve acceptable detection efficiency while minimizing the impact of equipment on fish passage and operations. Several deployment options were tested that did not involve direct placement of hydrophones within the collection channel, but on the sides of the channel, in the areas behind the dewatering screens (Error! Reference source not found.).

This technique kept the hydrophones out of high water velocities in the channel that create acoustically noisy conditions that could have made it difficult to detect tagged fish. Moreover, confined space means that deploying hydrophones and their mounts directly within the channel would result in reduced detection ranges for these receivers. Placing hydrophones directly within the channel could also affect fish movement or otherwise negatively influence retention and collection efficiency.

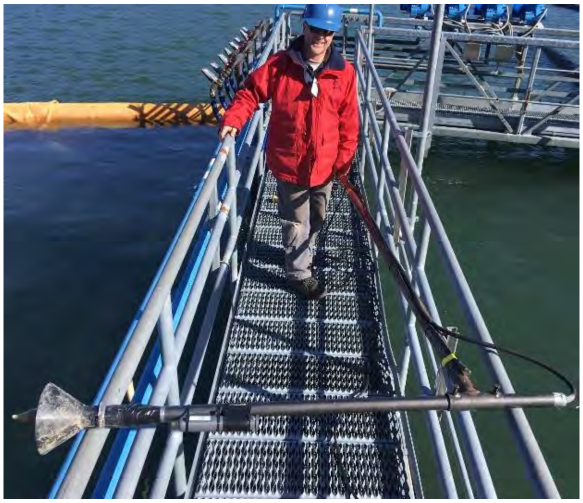
The receivers were deployed in the area along the sides of the collection channel, between the wedge wire dewatering screens and perforated plates. This is out of the direct in-channel flow paths and provides a desirable acoustic environment in which to deploy the hydrophones.


Appendix Figure A.2. Deployment of a collection channel hydrophone and mount, showing location behind the dewatering screens on the collection channel platform.

Mounts for hydrophones deployed in the primary and secondary channels were designed to meet the narrow gap tolerance between the wedge wire dewatering screens and the perforated plates along the walls of the primary and secondary channel and allow room for the hydrophone cable. A baffle to reduce flow noise and acoustic multipath noise was fitted into the hydrophone mount and the hydrophone attached inside the baffle. The mount was attached to three-quarter-inch (19 mm) steel pipe, lowered into the gap to the appropriate depth, then pressed against the wedge wire screen and pipe attached to the screen stiffener bars using beam clamps. The hydrophone cable was then routed to deck level and attached in position to avoid contact with the screen cleaning assembly.

Net Transition Structure and Zone of Influence

To detect tagged fish as they transition from the ZOI into the collection channel by way of the NTS, two additional SR3017 Trident receivers (one port, one starboard) were deployed along the sides of the NTS, near the mid-point of the NTS. The hydrophones for these receivers were mounted to a three-quarter-inch (19 mm) steel pipe using an assembly that was similar to the mounts described above for use in the collection channel (Error! Reference source not found.). This pipe was then passed through a 90° (three-socket) tee horizontally, to which a second length of three-quarter-inch (19 mm) steel pipe was attached vertically. This assembly was then lowered into position and the mount pressed against the outer wall of the NTS before being attached with beam clamps.


Appendix Figure A.3. Cabled hydrophone and pipe mount.

Appendix Figure A.4. Autonomous receivers deployed in the zone of influence, showing rope and shackles that held kettlebell weights.

To detect fish within the ZOI, three autonomous receivers (ATS SR3001 Trident) were deployed within the forebay. Two of these were located approximately 6 feet (2 m) in front of the NTS entrance. These receivers detected fish as they entered the ZOI and enabled estimation of the times when tagged fish entered the NTS. The third autonomous receiver was deployed 150 feet (46 m) upstream of the NTS entrance, along the guide net that extends from the mouth of the FSC east into the forebay, to detect fish entering the ZOI.

The autonomous receivers mounted off the front (upstream) end of the NTS were attached with ropes to aluminum poles and suspended 6 feet upstream from the NTS (**Error! Reference source not found.**). A 25-pound kettlebell was attached below the autonomous receiver to keep the receiver at the target depth. The autonomous receiver on the guide net was attached to the guide net with a rope and a shackle and a 10-pound kettlebell attached.

Monitoring the Fish Transfer Tank

Inside the FSC, a cabled hydrophone was placed in the fish transfer tank where fish recovered after tagging. The hydrophone was coupled with a modified mobile receiver (ATS SR3000) located immediately behind the tank. Data from this receiver were used to verify tag activation after tagging and prior to release.

Acoustic Reference Beacons

Ten 60-second ping rate acoustic reference beacons (ATS, Error! Reference source not found.**,** Appendix Table A.2) were deployed within the array. These beacons emit a known tag signal at the stated frequency (1 per minute) that can be used to verify the consistent operation of each hydrophone-receiver pair within the array. The beacon signals were also used to correct time-drift in the SR3000 receivers which enhanced zone presence estimates using time-of-arrival difference (TOAD) (2020 Study Section 2.2.3).

Appendix Figure A.5. ATS reference beacons attached to steel pipe for deployments in the NTS.

Appendix Table A.2. Beacon tag associations and locations across the deployment.

Beacon ID	Tag Code	Depth (feet)	Location
ZOI-01	G721F14A8	15	On receiver.
ZOI-02	G721F1BE9	15	On receiver.
ZOI-03	G721F27F4	15	On receiver.
NTS-01	G721F3EF5	6	On receiver.
NTS-02	G727DAA4E	6	On receiver.
B-1	G727DA9AC	6	Between CCH-02 and CCH-03 (port); 10.5 in. upstream of CCH-02 (looking starboard).
B-2	G727DB1F3	6	Between CCH-04 and CCH-01 (starboard); 23 feet upstream of CCH-01 (looking port).
B-3	G721F2077	2	Between CCH-06 and CCH-04 (starboard); 5 feet upstream of CCH-04 (looking port).
B-4	G727DADCD	2	Between CCH-05 and B-5 (port); 5 feet downstream of CCH-05 (looking starboard).
B-5	G727DD274	2	Between B-4 and CCH-07 (port); 8 feet downstream of CCH-07 (looking starboard).
B-6	G727DBEB2	1.5	Between CCH-06 and CCH-08 (starboard); 8 feet upstream of CCH-08 (looking port).

A.2 Array Testing Methods

Performance evaluations for equipment within the array and for data processing algorithms were conducted before and during the season, according to the following schedule (Appendix Table A.3.). Before deployment, field testing of the full system was conducted twice, to verify that deployment methods and assumptions were valid, and to ensure that resulting data were of sufficient quality to answer the project research questions. Testing within the collection channel included static monitoring of tags at fixed positions, as well as controlled tag drifts through the channel. The purpose of these tests was to determine if tags were detectable in this environment and to test positioning algorithms for identifying location and movement of acoustic tags through the channel.

Appendix Table A.3. Receiver array testing schedule.

Zone	Type	Dates	Notes
NTS	Static	27-Feb-20	Conducted during array deployment.
NTS	Drag	27-Feb-20	Conducted during array deployment.
ZOI	Static	27-Feb-20	Conducted during array deployment.
NTS	Drag	28-Feb-20	Conducted during array deployment.
ZOI	Drag	28-Feb-20	Conducted during array deployment.
NTS	Drag	12-Mar-20	
NTS	Drag	26-Mar-20	First study release.
NTS	Drag	2-Apr-20	Corresponded with final array deployment (moving CCH-01 and CCH-03)
NTS	Drag	1-May-20	

Drags and Holds

Field testing included a series of tag drags, floats, and holds, using two to six acoustic tags affixed at a range of depths to a length of cord that was buoyed at the top using a float and anchored at the bottom using a large shackle (test stringer, Error! Reference source not found.). The test stringer was deployed by boat within the

Appendix Figure A.6. Bottom portion of test tag stringer, showing two tags, stringer cord, and weight.

Appendix Figure A.7. Deploying test stringer by hand within the floating surface collector collection channel.

ZOI and by hand from the deck of the NTS (Error! Reference source not found.). The basic test protocol involved one person deploying the test stringer at a static location or across a transect, and a second person recording location details, start and end times, and other relevant metadata. In addition, a series of beacon tags were deployed within the array, to estimate idealized detection efficiency and provide basic quality assurance of the performance of each receiver. Test data obtained in this way were used to develop and validate computer algorithms that position fish within the arrays and subarrays.

During deployment, all receiver systems were tested as they were deployed, to verify function and to ensure that the hydrophone had direct “line-of-sight” with the environment it was monitoring. After deployment, once the collector was turned on, both static and drift testing was conducted using stringers of multiple test tags. Data were then processed and analyzed, to verify function of all receivers and test for detection efficiency and deployment positioning effectiveness. Additional static tag and tag drags tests were conducted in the ZOI to verify detection range and efficiency of the autonomous receivers and validate methods for positioning fish within the ZOI.

Detection Efficiency During Testing

Detection efficiency of acoustic receivers was evaluated prior to deployment and periodically during the study season to ensure that acoustically-tagged individuals would be properly detected in the ZOI, NTS, and collection channel. Detection efficiency was evaluated by determining the number of acoustic transmissions omitted from a stringer of test tags (“pings”) expected within a given time interval (based on a 3-second ping rate interval; 2020 Study Table 2) and then finding the number of pings detected on a group of receivers within a given zone. The ratio of these two counts provided the proportion of pings detected among a group of receivers and was used to quantify detection efficiency during deployment of the acoustic array. Detection efficiency values were then summarized by test ID, depth of the test tag, and location of the test within the particular area of interest.

During in-season reporting, detection efficiency was evaluated on a per receiver basis using a series of automated diagnostics that were performed during periodic receiver download trips (Appendix Table A.3). Diagnostic reports provided visualizations of the detection history of acoustic tags known to be part of the acoustic study (i.e., “study tags”) as well as beacon tags deployed within the acoustic array to provide a constant acoustic transmission on which to determine in-season detection efficiency. Diagnostics also enumerated the amount of detections heard by the receiver that were not associated with any known deployed acoustic tag and deemed noise, in order to understand the signal-to-noise ratio experienced by each acoustic receiver in the array. Visual diagnostics were reviewed following each receiver download to identify unusual tag detection histories or periods when receivers were potentially overloaded with background ambient noise.

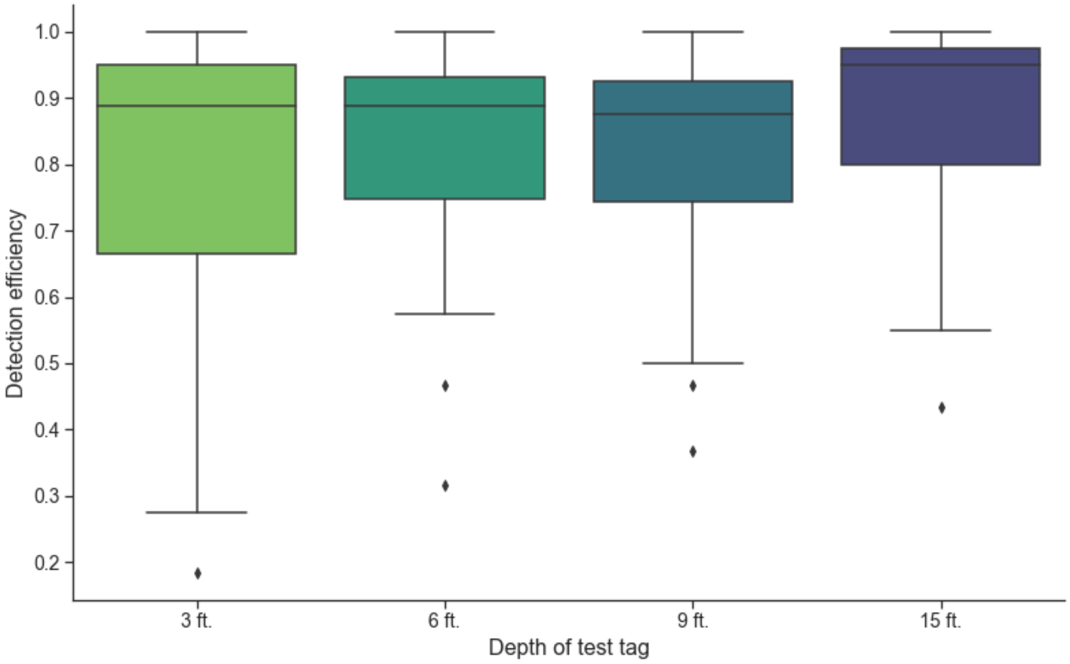
A.3 Array Testing Results

Pre-Season Array Testing Results

Pre-season array testing confirmed that the receivers were functioning properly and were detecting tags at acceptable ranges, providing ample detection ability for each zone. Results for the ZOI, NTS, and collection channel subarrays are discussed in the following subsections.

Zone of Influence

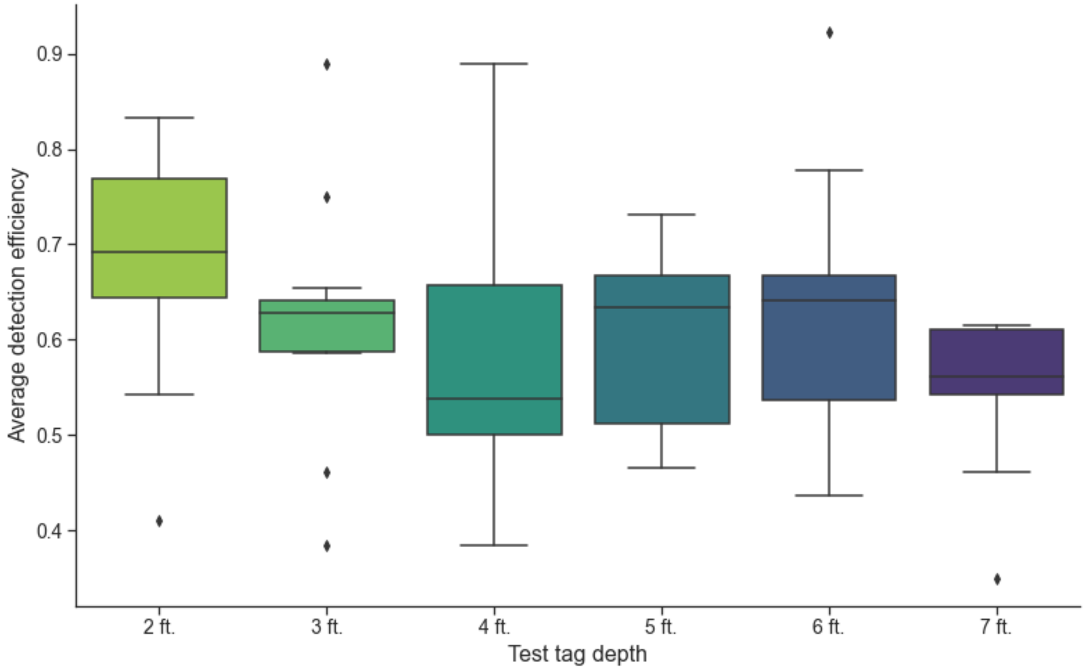
On 27 February, a series of tests were conducted that involved holding four tags spanning depths of 3-15 feet at a series of fixed locations in the ZOI. Results from these tests indicated that detection efficiency of the ZOI subarray was at least 90% across the range of depths tested (Appendix Figure A.8). The combined performance of all three receivers and the measure of redundancy provided by having two receivers monitoring the ZOI from the front of the collector (ZOI-02 and ZOI-03) provided ample coverage of the ZOI, even during short periods where individual receivers did not function optimally.



Appendix Figure A.8. Detection efficiency results from tag hold testing in the zone of influence on 27 February 2020. Boxplots show the distribution in detection efficiency for each test tag depth across multiple tests. Variability depicted is across multiple tests at each depth. Midline within each box indicates the median detection efficiency across all tests, ends of boxes indicate interquartile range (IQR, i.e., 25th – 75th percentile), thin "whiskers" extend to "Tukey's fences," 1.5*IQR beyond the IQR in each direction, and markers beyond the whiskers indicate outlier values.

Net Transition Structure and Collection Channel

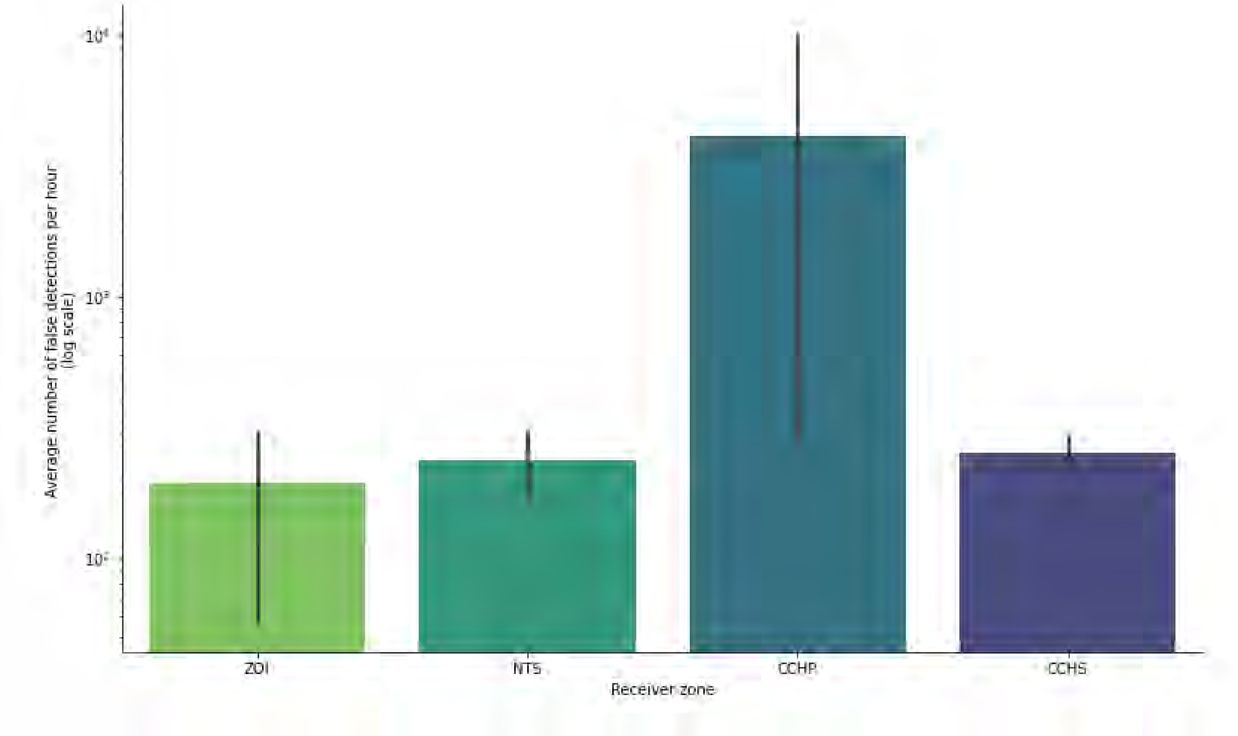
Test results in the NTS and collection channel suggested that the receivers within each zone were able to effectively detect individual tags moving through the NTS, primary channel, and secondary channel. Detection efficiency was 60-70% for tags at a variety of depths that were both floated downstream and dragged back upstream (Appendix Figure A.9). This means that between 6 and 7 of every 10 pings expected from each tag were detected by the receivers. Redundancy in the NTS and channel subarrays mitigated noise interference, achieving sufficient detection efficiency to track individuals moving and holding in these zones, despite high flow rates. Tag floats and drag tests also helped identify areas of high flow noise and provided context for formulating zone presence criteria (ZPC) for these areas.



Appendix Figure A.9. Detection efficiency results from tag drag testing in the net transition structure and collection channel on 12 March 2020. Boxplots show the distribution in detection efficiency for each test tag depth across multiple tests. Variability depicted is across multiple tests at each depth. Midline within each box indicates the median detection efficiency across all tests, ends of boxes indicate interquartile range (IQR, i.e., 25th – 75th percentile), thin "whiskers" extend to "Tukey's fences," 1.5*IQR beyond the IQR in each direction, and markers beyond the whiskers indicate outlier values.

In-Season Array Performance

The acoustic telemetry array was stable and performed as expected throughout the study period. The acoustic environment within the array differed among the subarrays covering each zone. Acoustic noise manifests itself on the acoustic receivers used for the study as detections of random tag codes, or false signals. In the ZOI, the acoustic environment was relatively quiet and there were few false signals in the data from the subarray. Noise levels increase moving towards the channel, peaking in the primary channel before dropping substantially in the secondary screen channel (Appendix Figure A.10). This is due largely to the structure of these zones, with the ZOI being more open and having a relatively low water velocity environment compared to the more confined areas in the NTS and collection channel with higher velocity.



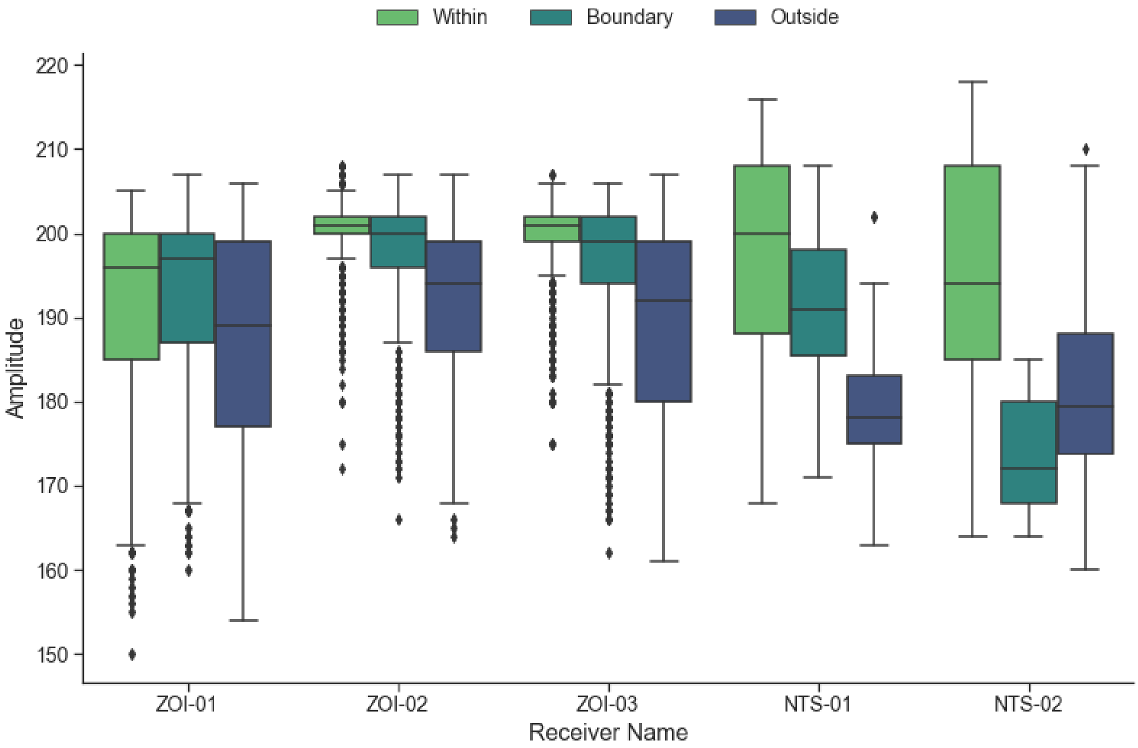
Appendix Figure A.10. Number of false detections by zone across the entire study period. Bar heights represent the amount of noise detections per hour across the entire study period. Error bars represent 95% bootstrapped confidence intervals for mean counts across receivers within each zone. Note that y-axis is log scale.

Despite high levels of ambient noise in the collection channel, continuous tag drags and diagnostic reports confirmed that study tags were detected regularly, indicating that tags could be detected despite the background noise in this zone. Receiver and acoustic diagnostic information retrieved with each data download indicated this detection ability was sustained within each zone throughout the season and kept the team informed of possible issues.

A.4 Zone Presence Criteria Development and Testing

After raw acoustic detection data were summarized into a filtered form, they were summarized to position fish within a given zone along the approach to collection (zone presence). This process included establishing, testing, and then iteratively adjusting a suite of ZPC that logically and quantitatively evaluate an acoustic signal to determine its location. ZPC were initially constructed by using acoustic data collected during pre-season tests outside the ZOI and within the NTS and the collection channel. After formulating the initial set of ZPC for each zone using these data, Four Peaks continued to evaluate the efficiency of criteria by using a combination of in-season acoustic data and continual tag drag tests performed throughout the season. This allowed the construction of a final set of ZPC that were used to inform presence-absence through the entire array across the entire study period, which was used to inform mark-recapture models.

Amplitude results from static testing suggested that, while median amplitude was higher and less variable on ZOI receivers compared to NTS receivers, some pings originating from the ZOI were detected at higher amplitude in the NTS (Appendix Figure A.11.). As such, final ZPC for the ZOI relied on time corrections over amplitude for resolving positions within the zone.



Appendix Figure A.11. Distributions in amplitude on zone of influence and net transition structure receivers from static testing in the zone of influence on 27 February 2020. Groups are broken up by the detecting receiver, and colors represent the location of the test relative to the zone of influence. Midline within each box indicates the median detection amplitude across all tests, ends of boxes indicate interquartile range (IQR, i.e., 25th – 75th percentile), thin "whiskers" extend to "Tukey's fences," 1.5*IQR beyond the IQR in each direction, and markers beyond the whiskers indicate outlier values.

The final set of ZPC used estimated positions along the channel calculated through a simplified TOAD analysis (Deng et al. 2011). This 1D positioning method approximates longitudinal location within the channel by comparing detection times of an acoustic tag signal (a ping) on multiple receivers. The method relies on grouping together detections across receivers for a single tag code (in intervals based on the ping rate interval [PRI]; 3 seconds for ATS SS400 tags, 2020 Study Section 3.2), and then ordering them chronologically to provide an understanding of where an individual is in the array. The order in which this detection occurs allows the estimation of the position of an individual within the acoustic array.

TOAD analyses for each tag were used in conjunction with other criteria to construct a presence-absence matrix across the entire array and throughout the study period. The final set of criteria used TOAD comparisons between each zone to position fish within the ZOI, NTS, primary channel, and secondary channel independently. Additionally, certain zone-specific criteria were used in the NTS, primary channel, and secondary channel, which allowed for identification of individuals within these areas in instances where there were sparse numbers of detections across receivers, using the position of certain receivers and amplitude filters. Once ZPC were established, it allowed the construction of a total presence-absence matrix for the entire array across the entire season, which was used to inform mark-recapture models.

The final set of zone presence time series was constructed by first time-correcting data off the ZOI receivers (Section A.7) and then constructing a data frame of individual pings for all tags detected across all receivers. The final set of zone-presence criteria were as follows:

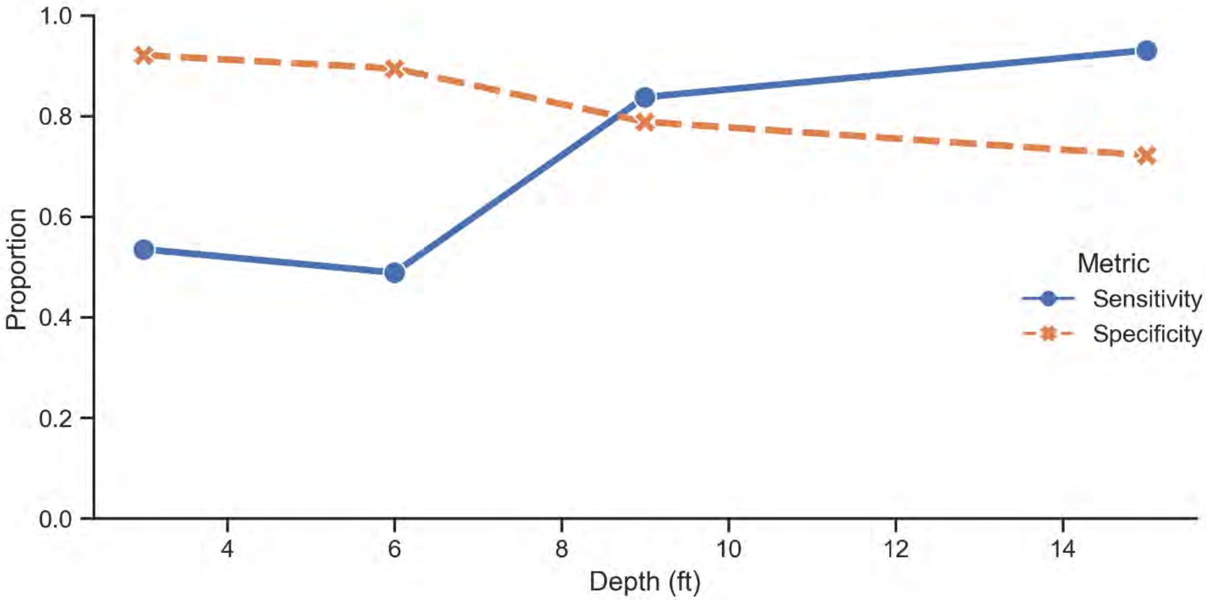
- An individual was considered within the ZOI if there was at least one ping satisfying one of the following criteria:
  - First detected on any ZOI receiver (ZOI-01, ZOI-02, or ZOI-03), and then subsequently detected on any other ZOI receiver
  - First detected on ZOI-02 or ZOI-03, and then subsequently detected on NTS-01 or NTS-02 with a time-of-arrival difference between the two detections greater than 0.0014 seconds
- An individual was considered within the NTS if there was at least one ping satisfying one of the following criteria:
  - First detected on any NTS receiver (NTS-01 or NTS-02), and then subsequently detected on any other NTS receiver
  - First detected on any NTS receiver (NTS-01 or NTS-02), and then subsequently detected on any receiver in the adjacent zones (ZOI-02, ZOI-03, CCH-01, CCH-02, or CCH-03)
  - First detected on CCH-01, and then next detected on any NTS receiver with an amplitude of 200 or greater
- An individual was considered within the primary channel if there was at least one ping satisfying one of the following criteria:
  - First detected on CCH-02 or CCH-03, and then subsequently detected on any primary channel receiver (CCH-01, CCH-02, or CCH-03)
  - First detected on CCH-02 or CCH-03, and then subsequently detected on any receiver in the adjacent zones (NTS-01, NTS-02, CCH-04, CCH-05, CCH-06, CCH-07, or CCH-08)
  - First detected on CCH-01, and then next detected on any downstream receiver (CCH-02, CCH-03, CCH-04, CCH-05, CCH-06, CCH-07, or CCH-08)
  - First detected on CCH-04, and then next detected on any upstream receiver (NTS-01, NTS-02, CCH-01, CCH-02, CCH-03)
- An individual was considered within the secondary channel if there was at least one ping satisfying one of the following criteria:
  - First detected on CCH-05, CCH-06, CCH-07, or CCH-08, and then subsequently detected on CCH-05, CCH-06, CCH-07, or CCH-08
  - First detected on CCH-05, CCH-06, CCH-07, or CCH-08, and then subsequently detected on any receiver in the primary channel (CCH-01, CCH-02, or CCH-03)
  - First detected on CCH-04, and then next detected on any downstream receiver (CCH-05, CCH-06, CCH-07, or CCH-08)
  - First detected on CCH-05 or CCH-07 with an amplitude of 210 or greater

These criteria were found to balance the high levels of acoustic noise present within the collection channel with the difficulty of detecting an individual as it moved towards the FSC, especially within the secondary channel. Zone positions were determined by selecting only those pings which resolved to be within a single zone; if a ping was resolved to be in more than one zone, it was considered indeterminate and was not assigned to either zone. Detections of fish on the ZOI and NTS receivers that did not meet any ZPC were labeled as being present within the forebay for diagnostic reasons, although these detections were not used to inform mark-recapture models. Zone presence time series for tags were used to inform mark-recapture models and subsequent behavioral analyses.

A.5 Zone Positioning Accuracy

Zone of Influence Positioning

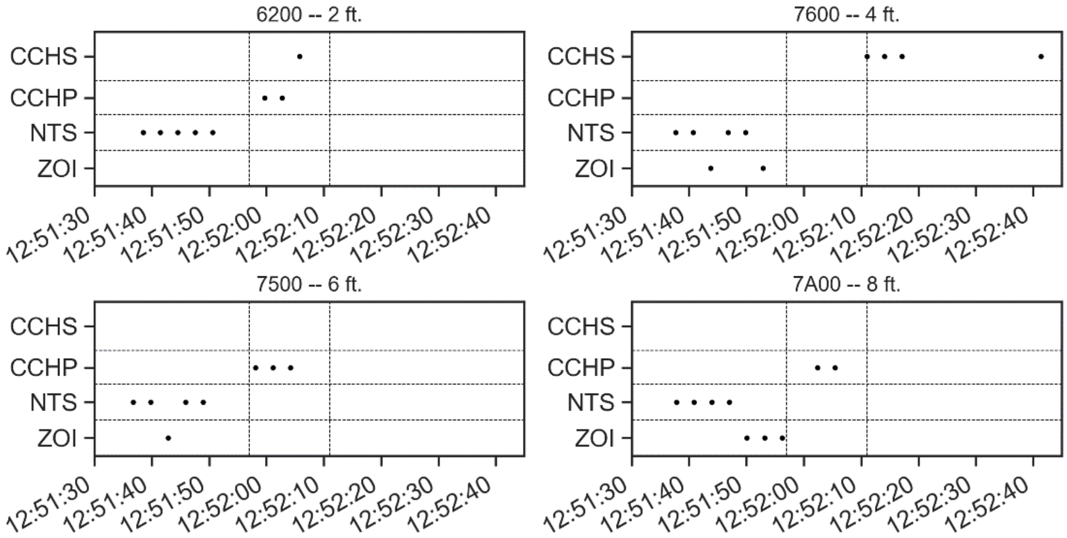
Static testing in the ZOI demonstrated that the zone presence processing code was able to correctly position tags within the ZOI. Accuracy of positioning tags within the ZOI (sensitivity) and of inferring that tags were *not* in the ZOI (specificity) were both high across tested depths but tended to decrease as tag depth increased (Appendix Figure A.12). Specificity and sensitivity appeared optimally balanced near 9-foot tag depth. The most common area where the zone of individual tags was mis-specified was at the transition of the ZOI to the NTS, where amplitude was an unreliable approximation of distance to each of these zones. To overcome this, ZOI receivers were time-corrected in order to use TOADs as a measure of zone presence.



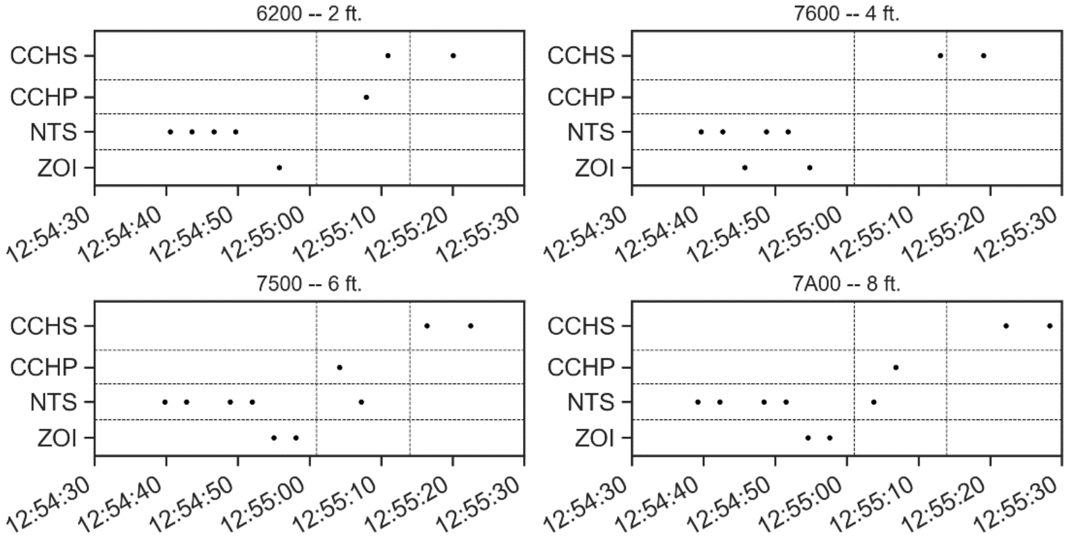
Appendix Figure A.12. Detection efficiency metrics associated with Swift floating surface collector zone of influence subarray testing on 27 February 2020.

Net Transition Structure and Channel Positioning

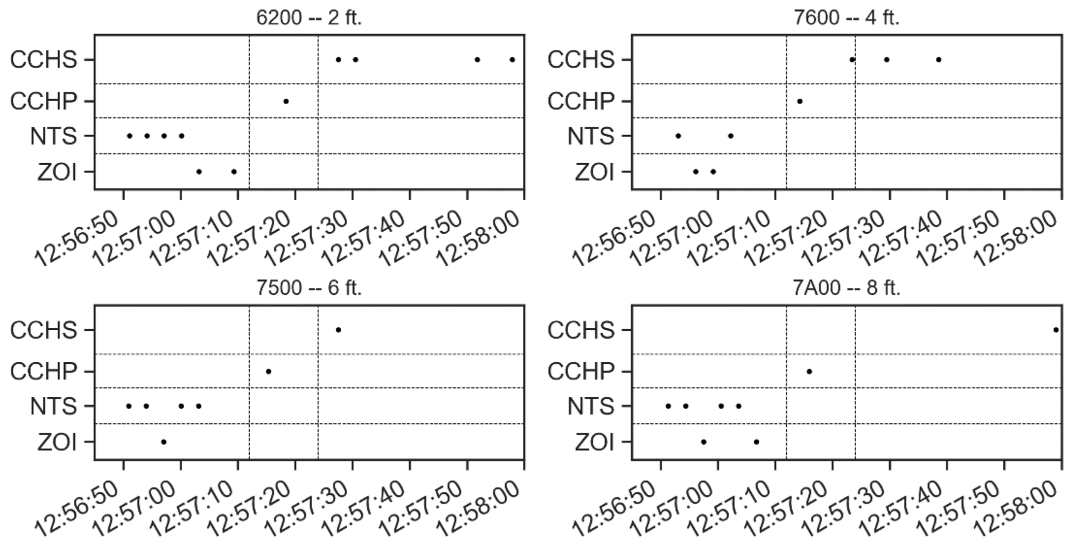
The zone presence processing code positioned tags within the NTS and channel with acceptable accuracy for the study. Plots of the computed zone presence versus the observed zone presence for test float data were used to validate the ZPC and confirm that the zone presence processor accurately positioned fish. Appendix Figure A.13 through Appendix Figure A.18**Error! Reference source not found.** show the ZPTS plots of four test tags deployed at 2-, 4-, 6-, and 8-foot depths during testing on 2 April 2020.



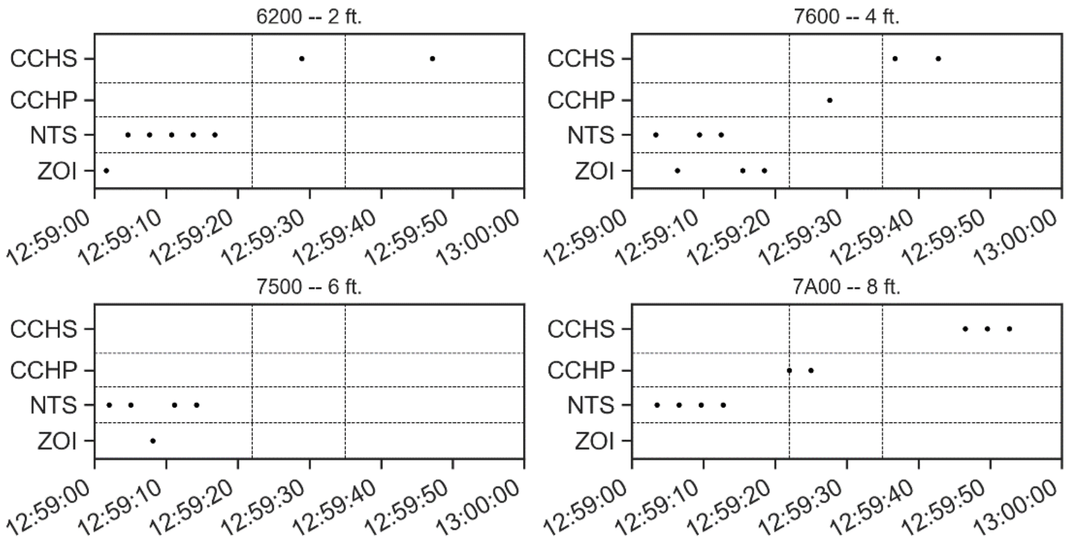
Appendix Figure A.13. Inferred and observed positions of four tags on the test stringer used for Float Test 5 within the Swift floating surface collector channel subarray on 02 April 2020. Horizontal lines indicate transitions between the zones each tag was positioned in based on acoustic data, while vertical lines indicate times of the observed transitions from zones during the test.



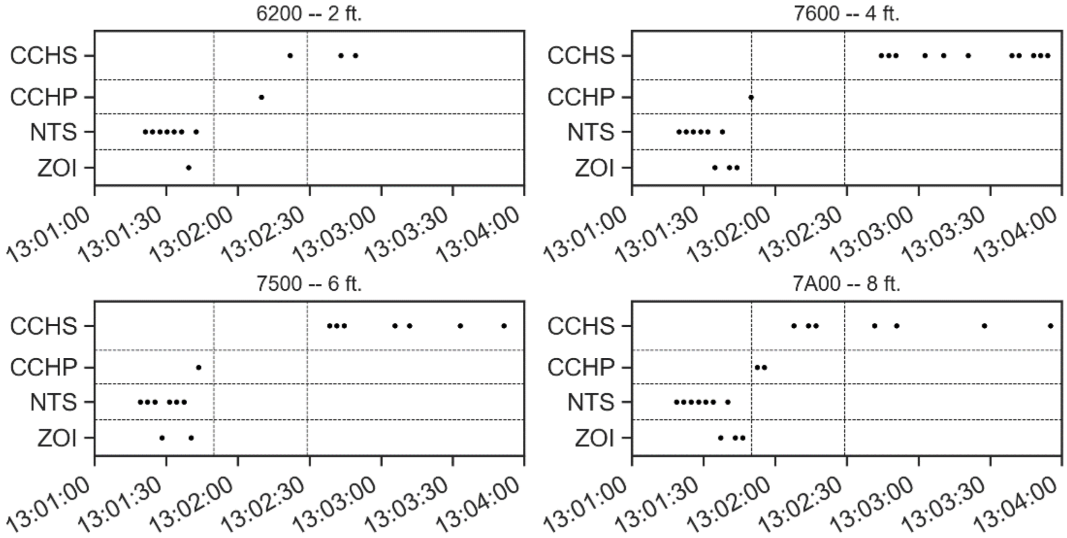
Appendix Figure A.14. Inferred and observed positions of four tags on the test stringer used for Float Test 7 within the Swift floating surface collector channel subarray on 02 April 2020. Horizontal lines indicate transitions between the zones each tag was positioned in based on acoustic data, while vertical lines indicate times of the observed transitions from zones during the test.



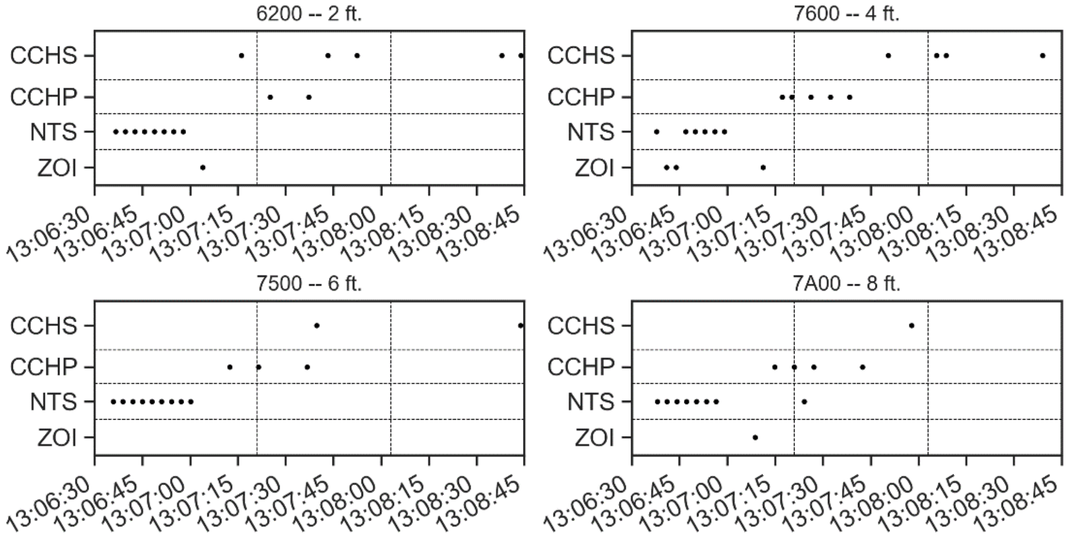
Appendix Figure A.15. Inferred and observed positions of four tags on the test stringer used for Float Test 9 within the Swift floating surface collector channel subarray on 02 April 2020. Horizontal lines indicate transitions between the zones each tag was positioned in based on acoustic data, while vertical lines indicate times of the observed transitions from zones during the test.



Appendix Figure A.16. Inferred and observed positions of four tags on the test stringer used for Float Test 11 within the Swift floating surface collector channel subarray on 02 April 2020. Horizontal lines indicate transitions between the zones each tag was positioned in based on acoustic data, while vertical lines indicate times of the observed transitions from zones during the test.



Appendix Figure A.17. Inferred and observed positions of four tags on the test stringer used for Float Test 13 within the Swift floating surface collector channel subarray on 02 April 2020. Horizontal lines indicate transitions between the zones each tag was positioned in based on acoustic data, while vertical lines indicate times of the observed transitions from zones during the test.



Appendix Figure A.18. Inferred and observed positions of four tags on the test stringer used for Float Test 15 within the Swift floating surface collector channel subarray on 02 April 2020. Horizontal lines indicate transitions between the zones each tag was positioned in based on acoustic data, while vertical lines indicate times of the observed transitions from zones during the test.

A.6 Fish Tagging, Receiver Data Download, and Array Maintenance Schedule

After initial receiver deployment during the week of 27 February 2020, data were downloaded from all receivers on as close to a bi-weekly schedule as possible (Appendix Table A.4). This schedule was partly dependent on weather, boat availability, and unanticipated receiver maintenance requirements. There were three classes of unanticipated issues occurring over the study period that required maintenance. The first set of issues were caused by strong flows occurring towards the back of the NTS and the beginning of the primary channel, which generated high amounts of ambient noise and generated vibrations in mechanical equipment in the area. This seemed to impact the primary channel receivers initially positioned on the starboard side of FSC (CCH-01 and CCH-03), causing low signal-to-noise ratios and at times overloading processors on the receivers, resulting in SD cards being corrupted and data having to be retrieved off the receiver using a HXD cable. Because of the high noise levels occurring in the initial deployment position, these receivers were both moved to the port-side of the FSC and to deeper depth (CCH-01 was moved on 26 March and CCH-03 was moved on 2 April). The second set of issues was due to battery cable wiring on the autonomous SR3001 receivers deployed in the ZOI. Wiring to the battery of these receivers appeared to be more fragile, and this caused several instances in which batteries on the receivers became disconnected and power was lost. Battery cables were replaced for ZOI-02 and ZOI-03 on 27 March, and cable failures were discovered two times after this date (on 16 April for ZOI-01 and on 15 May for ZOI-03). Separately, there was also a bad SD card discovered in ZOI-02 on 1 May. Redundancy in the array between ZOI and NTS receivers is believed to have mitigated the lapses in data caused by these issues. Finally, on 15 June, receivers that were housed in a cooler on the port-side of the FSC (CCH-03, CCH-05, CCH-07) lost power when a power cable to the cooler was unplugged from within the FSC. This caused a loss in data of 1.5 days prior to downloads on 15 June. A timeline of these issues and other activities occurring on the FSC is provided in Appendix Table A.4.

Appendix Table A.4. Receiver data download and maintenance schedule for the 2020 Swift Reservoir Floating Surface Collector Passage Evaluation.

Date	Event	Notes
02/28	Deployment, Array Testing and Receiver Download	Deployment took place from 02/24 to 02/28.
03/12	Array Testing	
03/18	Array Testing	
03/19	Study Release	
03/26	Array Testing and Receiver Download; Fry Bar PIT Array Reactivated	Battery cable broken on ZOI-01. Data lapse from 02/28 – 03/26. SD card corrupted on CCH-01. Receiver moved to port-side. Minor data lapse on 03/26.
03/27	Study Release; Array Maintenance	Battery replacement on ZOI-02, ZOI-03; data lapse 03/26 – 03/27.
04/02	Array Testing and Receiver Download	CCH-01 moved slightly and positioned to deeper depth. CCH-03 moved to port-side and to deeper depth.
04/03	Study Release	
04/06	Fry Bar PIT Array Deactivated	
04/10	Study Release	
04/16	Study Release; Receiver Download	Battery cable broken on ZOI-01. Data lapse from 04/02 – 04/16.
04/24	Study Release	
04/26	Secondary Channel Shading Installed	Shade net installed above channel.
04/30	Study Release	
05/01	Receiver Download	SD card corrupted on ZOI-02. Data lapse from 04/16 – 05/01.
05/04	Fry Bar PIT Array Reactivated	
05/08	Study Release; Collector Turned Off	FSC shut-off due to high debris loading.

Date	Event	Notes
05/11	Collector Turned On	
05/12	Study Release; Additional Secondary Channel Shading	Additional shading installed over secondary channel.
05/15	Receiver Download	Battery cable broken on ZOI-03. Data lapse from 05/01 – 05/13.
05/22	Study Release; Additional Secondary Channel Shading	Additional shading installed over secondary channel.
05/28	Study Release and Receiver Download	
06/15	Receiver Download	Power failure on CCH-03, CCH-05 and CCH-07. Data lapse from 06/13 – 06/15.
06/29	Receiver Download	SD card corrupted on CCH-01. Data lapse from 06/27 – 06/29.
07/17	Receiver Download and Demobilization	

A.7 Zone of Influence and Net Transition Structure Time Correction

ZPC rely in part on TOAD analysis for position estimations, so it was necessary to synchronize internal clocks across the acoustic array. Because the three SR3001 autonomous node receivers in the ZOI do not have the capacity for time synchronization, detections of reference beacons strategically deployed throughout the collection channel and the ZOI enabled post-hoc time corrections that allowed synchronization to be carried out.

Additionally, it was determined in the study season that the internal clock associated with NTS-02 was also having trouble synchronizing, and as such time correction was required for that receiver as well. As a result, the time on NTS-02 would periodically become misaligned by 1 second from the cabled (SR3017) receivers. To correct for this time offset, detections of the reference beacon on NTS-01 were used to resynchronize the offset times from NTS-02. Briefly, reference beacon detection times were compared among the datasets from the two NTS receivers, noting differences in time-of-arrival for individual reference beacon pings, as follows. The reference beacon pinged every minute. Therefore, when the TOAD for the beacon was approximately 1 second between the two NTS receivers, the detection times for all data within the minute of the beacon detection was corrected by 1 second on NTS-02.

The autonomous (SR3001) receivers used in the ZOI subarray lack internal GPS chips to facilitate time synchronization. Instead, each receiver has multiple internal clocks, including a more and a less precise clock, each of which consume more and less battery, respectively. To maximize battery life, the priority clock is generally the low precision, high efficiency clock. At midnight on each day, the more precise clock, which uses more battery, is used to apply a correction to the less precise (but more battery efficient) clock that is used to timestamp detections. As a result, the clocks on these receivers drift continuously and linearly over the course of each day before the internal time correction is applied.

To account for this punctuated drift that occurred throughout the entire season, detection times for all three autonomous ZOI receivers were corrected as follows. As with the NTS receivers, time corrections were made using TOAD from reference beacon detections. Since these time drifts were from a continuous clock drift rather than a periodic 1-second offset, measured positions for the acoustic receivers were accounted for, to correct for actual detection time differences of the reference beacon signals.

The autonomous receivers were then iteratively time synchronized, as follows. Briefly, the difference between the stamp of the beacon detection on the receiver to be corrected and the reference receiver was regressed against the correct time for the reference receiver. Next, TOAD was calculated using known receiver distances and approximate speed of sound in water for the relevant water temperature.

The resulting regression equation was then used to correct for the time drift of the receiver data being time corrected and this time was offset by the known TOAD.

The reference beacon used for synchronization of each receiver pair was the beacon that was most frequently detected on both receivers. First, detections from the NTS-02 reference beacon were used to synchronize ZOI-02 to NTS-02. Then, using shared detections of the ZOI-03 reference beacon, ZOI-03 was time synchronized to the corrected data from ZOI-02. Finally, using shared detections of the ZOI-01 beacon, ZOI-01 was time synchronized to ZOI-03. The time corrections where then verified between all receivers to confirm that time corrections resulted in accurate positioning.

A.8 Performance Metrics Computation

The estimation of survival and detection probabilities happens concurrently within a multinomial mark-recapture framework, in which zonal detection probabilities are estimated based on apparent missed "detections" (i.e., the number of individuals positioned within a zone that were not positioned within the previous zone), and then survival probabilities are estimated based on these detection probabilities. The logit link function was used in the construction of all mark-recapture models, as this is the most commonly used function associated with a binary outcome ("present" or "absent").

The modelling framework had the following assumptions:

1. The PIT-array within the collector has 100% detection efficiency (p=1).
2. All fish act independently.
3. Survival probabilities are the same for all individuals between sampling occasions.
4. Detection probability is the same for all individuals at each sampling occasion.
5. There is no unaccounted tag loss or handling mortality.
6. The study area is constant throughout the season.

We note that assumption (1) is required in order to correctly partition survival probability and detection probability within the final reach, from the collection channel into the collector. However, it was noted that over the course of the study the PIT antenna within the collector was off for two periods of time (from the beginning of the study to 26 March and from 6 April to 4 May; Appendix A.4). During this time, Meridian employees conducted hand-wanding of individuals that were held within the collector to supplement any individuals missed entering the collector. Additionally, data from PIT-antennas at the Woodland Release Ponds was queried from PTAGIS to determine if any individuals were put into the ponds that were not previously detected via the FSC PIT antenna or through hand-wanding. Nevertheless, it is possible that individuals were not detected from any of these sources and were ultimately collected. To account for these individuals, Four Peaks analyzed acoustic signatures within the NTS and collection channel that appeared to correspond with collection, and updated the zone-presence results of these individuals to indicate they were mostly likely collected. As such, mark-recapture results are robust to this assumption.

Survival through the FSC was partitioned into four parameters representing survival through reaches defined by our zones:

1. Between the release location and the ZOI (p_{ZOI})
2. Between ZOI and the NTS (p_{ENT})
3. Between the NTS and the collection channel (p_{CHAN})
4. Between the collection channel and the collector (p_{COL})

This yields a multinomial likelihood with $2^4 = 16$ possible capture histories representing zone positioning results. The survival probabilities estimated in the mark-recapture model provided estimates to the reported project metrics of the encounter rate (p_{ZOI}), the entrance efficiency (p_{ENT}) and the channel efficiency (p_{CHAN}), as well as the unreported metric p_{COL} representing survival from the collection channel to the collector.

These survival probabilities were then used to further calculate collection efficiency and retention efficiency; here collection efficiency p_{CE} is estimated as:

$$p_{CE} = p_{ENT} \cdot p_{CHAN} \cdot p_{COL}$$

with the associated variance term estimated via the Delta Method (Seber 1982):

$$\begin{gathered} Var(\widehat{p_{CE}}) = \widehat{p_{CHAN}}^2\, \widehat{p_{COL}}^2 Var(\widehat{p_{ENT}}) + \widehat{p_{ENT}}^2\, \widehat{p_{COL}}^2 Var(\widehat{p_{CHAN}}\,) + \widehat{p_{ENT}}^2 \widehat{p_{CHAN}}^2 Var(\widehat{p_{COL}}) + \\ 2\widehat{p_{CE}} \cdot (\widehat{p_{ENT}} Cov(\widehat{p_{CHAN}}\,, \widehat{p_{COL}}) + \widehat{p_{CHAN}}\, Cov(\widehat{p_{ENT}}, \widehat{p_{COL}}) + \widehat{p_{COL}} Cov(\widehat{p_{ENT}}, \widehat{p_{CHAN}}\,)) \end{gathered}$$

Similarly, retention efficiency p_{RET} is estimated as:

$$p_{RET} = p_{CHAN} \cdot p_{COL}$$

with the associated variance term:

$$Var(\widehat{p_{RET}}) = \widehat{p_{COL}}^2 Var(\widehat{p_{CHAN}}\,) + \widehat{p_{CHAN}}^2 Var(\widehat{p_{COL}}) + \widehat{p_{CE}} \cdot Cov(\widehat{p_{CHAN}}\,, \widehat{p_{COL}})$$

A.9 Passage Attempt Filtering Criteria

After acoustic detections of dual-tagged study fish were grouped into passage attempts, time series plots depicting the sequence of zone presence for each fish were developed. These plots were then evaluated along with a set of logical criteria to filter the attempt dataset and remove apparent attempts that may not represent true passage attempts. The logical criteria were:

1. Attempt duration must be longer than 10 seconds.
    a. What was observed?

       13% of the apparent attempts were less than 10 seconds in duration.

    b. Why are these attempts not valid?

       These very short attempts likely reflect spurious detections from fish holding in the forebay or near the entrance to the receiver, not FSC passage attempts.

    c. Why is this a problem for analyses?

       Retaining very short duration attempts hinders interpretation of visualizations, reduces statistical power of analyses by introducing noise, and introduces systematic bias (e.g., towards conclusions that unsuccessful attempts are short duration).

    d. How were these treated?

       Apparent attempts less than 10 seconds in duration were removed.

2. If collected, fish must have been detected on the sorting bar PIT array or collection flumes.
    a. What was observed?

       FSC PIT antennas were not operational for periods of the 2020 study season (2020 Study Figure 4).

    b. Why are these attempts not valid?

       Fish collected during these periods do not have an accurate record of the time of collection, and thus the true duration of these attempts is not known with confidence.

    c. Why is this a problem for analyses?

       Including these attempts introduces errors and systematic bias to analyses of the effect on successful passage related to attempt duration.

    d. How were these treated?

       Attempts associated with fish that were collected at the FSC but only PIT detected using hand wanding were omitted.

3. Time series plot must resemble active fish behavior.
    a. What was observed?

       Preliminary visual evaluation of time series plots showed patterns difficult to reconcile with true fish behaviors (e.g., excessive duration of apparent station holding).

    b. Why are these attempts not valid?

       These detection histories likely reflect spurious noise detections, fish holding station near zone boundaries, detections from intermittently failing acoustic tags, and other activity not associated with passage attempts.

    c. Why is this a problem for analyses?

       Including these attempts masks true patterns associated with volitionally swimming juvenile fish tagged with functional acoustic tags.

    d. How were these treated?

       Apparent attempts with anomalous or unexplainable patterns were omitted.

A.10 Statistical Modeling and Analysis Methods

A multipronged approach was used to model recapture probability that included balancing the dataset by resampling, eliminating insignificant model factors by recursive feature elimination, and then parameterizing and testing a statistical model using machine learning (ML) and a classic generalized linear model fit using a logit link (“logistic regression”). All modeling tasks were completed within Python, using the functions contained within the SciKit-Learn library (Pedregosa et al. 2011).

First, the dataset was filtered to include only study fish that satisfied the following three criteria:

1. Tagged with PIT and acoustic tags
2. Contained live acoustic tags at the time of attempted passage
3. Attempted passage while the FSC was functioning

This filtering process left 179 individuals (41 Chinook, 78 Coho, and 60 steelhead), for which the number of passage attempts were tallied. Most of these fish (54%) attempted passage only once, and 95% attempted less than 30 times, with a small number of outlier fish attempting dozens of times (2020 Study Figure 15).

For each fish within this filtered set, the associated dataset of passage attempts was further filtered to retain only the last attempt. This approach admittedly discards information associated with all but the final attempt for each fish. However, some of this information was retained by including for each fish a count of the number of attempts. This approach offers a compromise solution to retain the most information possible while focusing on outcomes for individuals, rather than analyzing individual behaviors.

A “parent” candidate model was constructed to include the following factors hypothesized to affect passage outcome (i.e., recapture or rejection):

- Number of attempts
- Species
- Fish length
- Fish mass
- Release date
- Date of initiation of passage attempt
- Hour of initiation of passage attempt
- Days at large

Fish mass was not measured for every fish but was highly correlated with length, so was dropped from the model after initial data exploration.

Then, the synthetic minority over-sampling technique (SMOTE) was applied to rebalance the dataset and overcome predictive limitations associated with an “imbalanced” dataset (Chawla et al. 2002). Imbalance refers to unequal representation of successful and unsuccessful outcomes (i.e., recapture and rejection for our purposes), and can lead to inappropriate predictions and poor performance by a model. SMOTE randomly resamples the dataset by under-sampling the majority class (here, fish that rejected the collector) and over-sampling the minority class (here, fish that were successfully recaptured) using synthetic examples introduced by joining nearest neighbors.

Next, recursive feature elimination, an iterative form of “remove-one” backward model selection, was applied to eliminate potentially uninformative model parameters (Kuhn and Johnson 2013). Days at large appeared to be relatively unimportant, while fish length appeared to be highly important, but no factors were ultimately dropped.

A ML-based “train/test split” methodology was then applied to parameterize a logistic regression model (Dreiseitl and Ohno-Machado 2002; Vabalas et al. 2019; Pawluszek-Filipiak and Borkowski 2020). Various train/test split model runs were evaluated, including 80/20, 75/25, 70/30, 50/50, and 25/75. Results from model runs employing a 20-50% training split were qualitatively similar. The best balance of predictive accuracy between positive and negative outcomes was observed with a 70/30 train/test split (receiver operating characteristic [ROC] curve area under the curve [AUC] = 0.74), so results from that run are reported here.

For comparison, a classic logistic regression was also fit to the balanced dataset. Results were qualitatively similar to the ML approach described above, with slightly less model support for the importance of length (although still significant).

For simplicity, results presented in the body of this report focus on the balanced ML model run using a 30/70 train/test split.

A series of Wald tests for model coefficients (Diggle et al. 1996, Draper and Smith 1998), was implemented using the wald.test function within the aod package for analysis of over dispersed data (Lesnoff and Lancelot 2012), within program R (R Core Team 2020).

For univariate factors of interest, statistical comparisons among groups were tested using Welch's *t*-tests, Tukey's honestly significant difference tests, or χ^2 tests, depending on the metric and number of groups being compared. Tests were conducted in Python, using the Stats package of functions within the Scientific Computing in Python (SciPy) library (Virtanen et al. 2020), and in program R (R Core Team 2020), using base R functions.

A.11 Model Validation

Data summarizing the model and its performance are provided in Appendix Table A.5., and data summarizing evaluation of individual model parameters are provided in Appendix Table A.6. Modeling results indicated that species, length, and time of day of passage attempt were all statistically significant factors that affect success of recapture (Wald tests, $p < 0.05$).

Appendix Table A.5. Model performance overview.

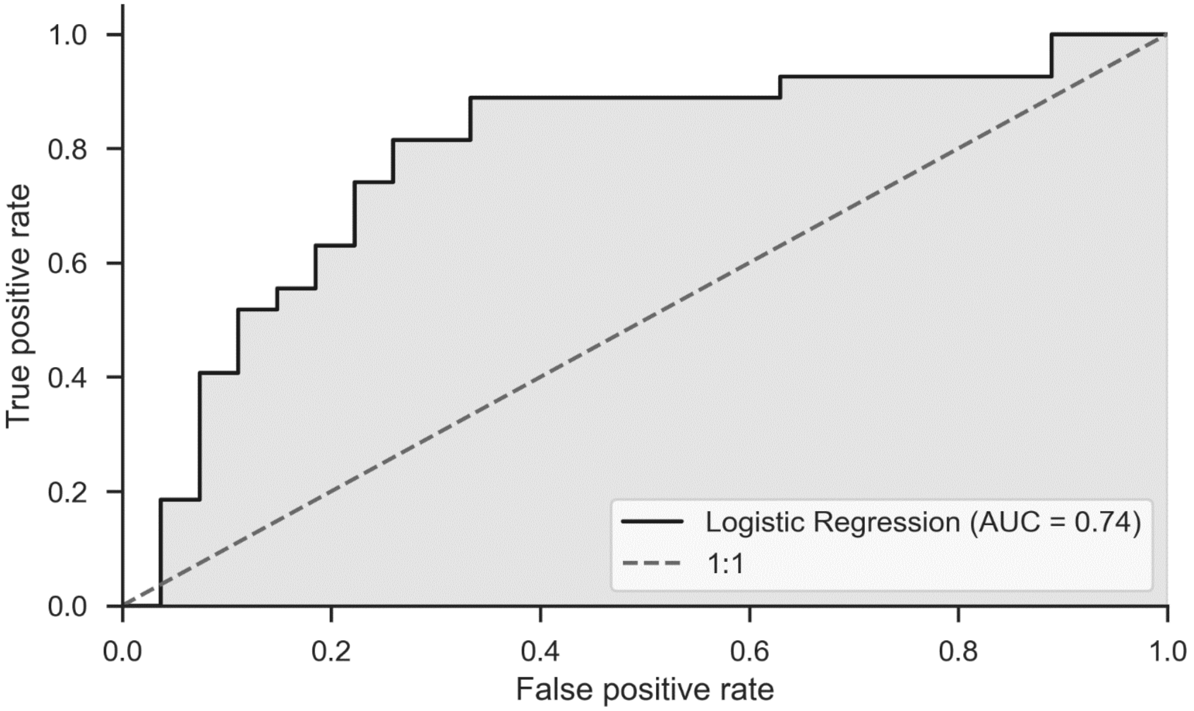
Parameter	Value
Model	Logit
Dependent Variable	collected_tag
Date of Run	2020-10-16
No. Observations	180[a]
Df Model	8
Df Residuals	171
Converged	1.0000
No. Iterations:	7.0000
Pseudo R-squared	0.259
AIC	202.8285
BIC	231.5651
Log-Likelihood	-92.414
LL-Null	-124.77
LLR p-value	5.5210e-11
Scale	1.0000

Note:
a. Reflect SMOTE balanced dataset

Appendix Table A.6. Model parameter evaluation summary.

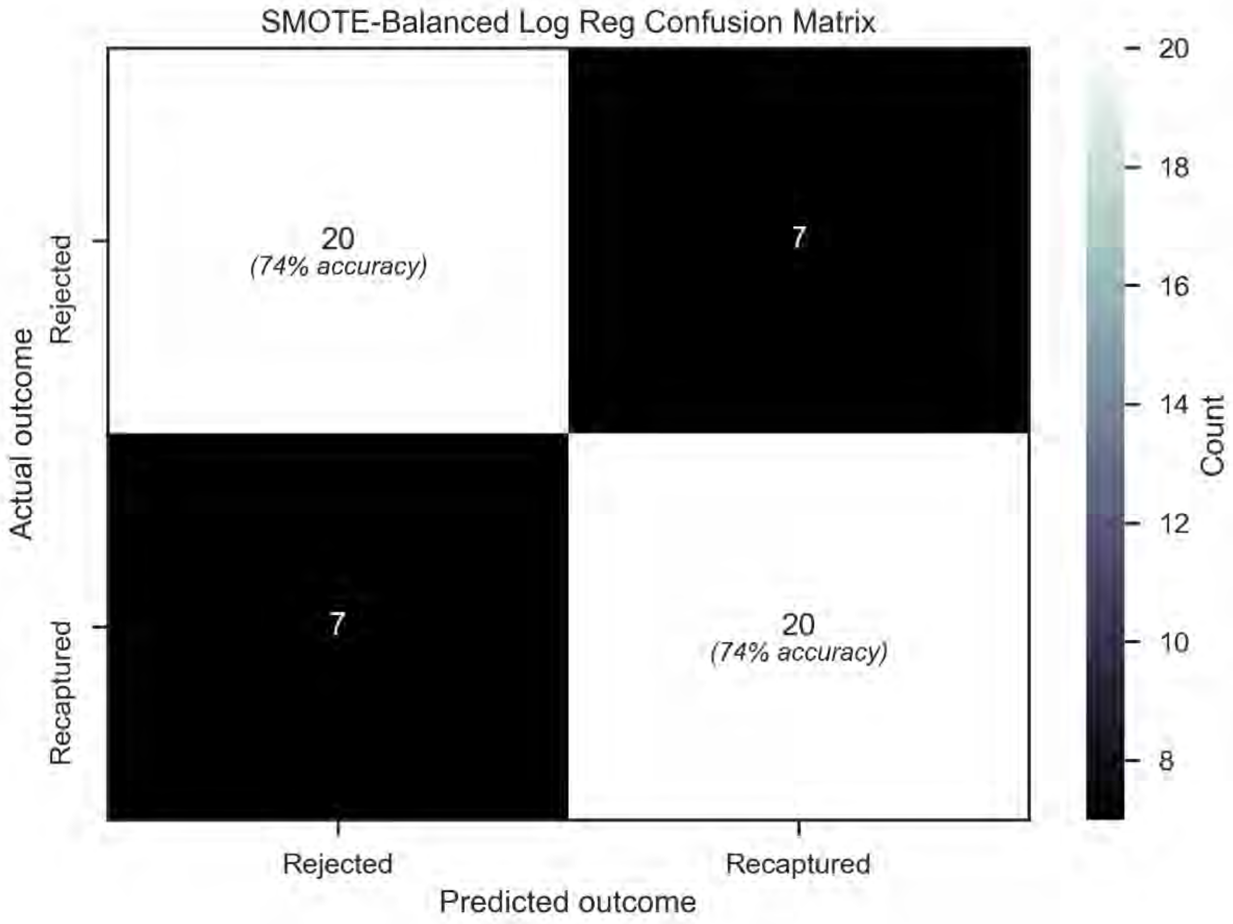
	Coef.	Std.Err	z	P>|z|	[0.025	0.975]
Attempts	-0.0206	0.0166	-1.2423	0.2141	-0.0532	0.0119
Chinook	4.2575	1.2312	3.4579	***0.0005***	1.8443	6.6708
Coho	2.4372	1.3563	1.7969	0.0724	-0.2212	5.0956
Steelhead	4.3408	1.5616	2.7797	***0.0054***	1.2801	7.4015
Len_mm	-0.0253	0.0080	-3.1718	***0.0015***	-0.0409	-0.0097
Release_date_ord	-1.4622	0.8416	-1.7373	0.0823	-3.1118	0.1874
Start_date_ord	1.4743	0.8401	1.7550	0.0793	-0.1722	3.1207
Start_time	0.0877	0.0443	1.9787	***0.0479***	0.0008	0.1746
Days_at_large	-1.5227	0.8403	-1.8122	0.0700	-3.1697	0.1242

Performance of the SMOTE-balanced 70/30 train/test split ML predictive model was evaluated by plotting the ROC curve relating true and false positives predicted on the test split of the dataset (Appendix Figure A.19.). The model had an ROC curve that diverged markedly from the 1:1 reference line, with an AUC of 0.74, indicating relatively reliable performance. If false and true positives increase at similar rates—visualized by an ROC curve that remains close to (or below) a 1:1 reference line—model predictions are unreliable. The further the ROC curve is away from (above) the 1:1 line, the more reliable (i.e., accurate) the model predictions. AUC for an ROC plot is an established method to quantify the ability of a model to predict true positives and negatives: ROC AUC = 0.5 would essentially parallel the 1:1 line and offer weak predictive accuracy, while ROC AUC = 1.0 would perform flawlessly.



Appendix Figure A.19. Receiver operating characteristic curve for synthetic minority over-sampling technique-balanced 70/30 train/test split machine learning predictive model.

Model accuracy is summarized in terms of true positive and negative classification of passage outcome for individuals within the 54 fish test group, compared to false positive and negative classifications, using a confusion matrix (Appendix Figure A.20.). Our model was reasonably accurate, and this accuracy was equal for predicting true positives and true negatives (74% in both cases) within the test split of the dataset.



Appendix Figure A.20. Confusion matrix for synthetic minority over-sampling technique-balanced 70/30 train/test machine learning predictive model.

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APPENDIX B Zonal Presence-Absence Matrix

The following table provides a presence-absence matrix of all 524 acoustically-tagged individuals in the study (note that three individuals at the bottom of the table were released without corresponding acoustic information.) This matrix was constructed by performing in-season estimates of zone presence of individuals from available acoustic data, and iteratively updating the zones at one point occupied by an individual at any point in the study. As such, presence in any given zone (indicated by a 1 value) is presented regardless of when the individual occupied the zone. Columns for the zone of influence, net transition structure, and collection channel were used as detection histories to fit mark-recapture models.

Appendix Table B.1. Presence-absence matrix of all study tags released in the 2020 study. 4-digit acoustic tag codes and passive integrated transponder-tag codes are displayed. Zone columns are shown for the zone of influence (ZOI), net transition structure (NTS), primary channel (CCHP), secondary channel (CCHS), and the collection channel as a whole (CCH). "0" indicates no presence in the zone over the course of the entire study (based on zone presence criteria), while "1" indicates a presence at least once at some point of the study.

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Coho	Unknown	0074	3DD.003D5C2B12	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	00F7	3DD.003D5C2D06	2020-03-27 08:10:00	1	1	0	0	0	0	
Steelhead	Winter	0106	3DD.003D91E7A9	2020-05-28 10:30:00	1	1	0	0	0	0	
Chinook	Spring	013A	3DD.003D5C1BA4	2020-03-19 11:45:00	0	0	0	0	0	0	
Coho	Unknown	021B	3DD.003D91CA27	2020-05-12 09:48:38	1	1	0	0	0	1	2020-05-19 21:50:23
Coho	Unknown	027B	3DD.003D91CEA4	2020-05-12 09:58:22	1	1	1	1	1	0	
Steelhead	Winter	029D	3DD.003D91CA3A	2020-05-08 08:25:00	1	1	1	1	1	1	2020-05-13 18:14:45
Coho	Unknown	03F4	3DD.003D59C8EE	2020-05-22 09:30:00	1	1	1	0	1	0	
Coho	Unknown	040D	3DD.003D91CA00	2020-05-12 09:36:37	1	1	0	0	0	0	
Steelhead	Winter	041D	3DD.003D5C226A	2020-04-16 09:05:00	1	1	0	0	0	0	
Chinook	Spring	04D7	3DD.003D5C227A	2020-04-16 09:05:00	1	1	0	0	0	0	
Steelhead	Winter	05FE	3DD.003D5C2B0C	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	0710	3DD.003D5C2B20	2020-04-24 10:40:00	1	1	0	0	0	0	
Chinook	Spring	080E	3DD.003D5C225A	2020-04-16 09:05:00	1	1	0	0	0	0	
Coho	Unknown	08F9	3DD.003D91CC5F	2020-04-30 10:30:00	1	0	0	0	0	0	
Coho	Unknown	0A65	3DD.003D91CA2B	2020-05-08 08:25:00	1	1	1	1	1	0	
Steelhead	Winter	0AA4	3DD.003D91E776	2020-05-28 10:30:00	0	0	0	0	0	0	
Coho	Unknown	0AC6	3DD.003D59C931	2020-05-22 09:30:00	1	1	1	1	1	1	2020-06-20 04:55:13
Chinook	Spring	0AE5	3DD.003D5C2292	2020-04-10 10:50:00	0	0	0	0	0	0	
Coho	Unknown	0AEA	3DD.003D91C9FE	2020-05-08 08:25:00	0	0	0	0	0	0	
Chinook	Spring	0B0E	3DD.003D5C2D1C	2020-04-03 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	0B37	3DD.003D91CC9E	2020-04-30 10:30:00	1	1	1	0	1	0	
Chinook	Spring	0CA9	3DD.003D5C224C	2020-04-16 09:05:00	0	0	0	0	0	0	
Steelhead	Winter	0D49	3DD.003D91E74E	2020-05-28 10:30:00	1	1	0	0	0	0	
Coho	Unknown	0D55	3DD.003D91CEEF	2020-05-12 09:58:49	1	1	1	1	1	1	2020-06-20 05:33:15

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Steelhead	Winter	0E39	3DD.003D91CA44	2020-05-08 08:25:00	1	1	1	1	1	1	2020-05-12 16:22:56
Coho	Unknown	0E3A	3DD.003D91CC5A	2020-04-30 10:30:00	0	0	0	0	0	0	
Chinook	Spring	0E7A	3DD.003D5C1B68	2020-03-19 11:45:00	1	1	0	1	1	1	2020-04-16 22:44:20
Chinook	Spring	0F20	3DD.003D5C229D	2020-04-16 09:05:00	0	0	0	0	0	0	
Steelhead	Winter	0F4A	3DD.003D91C9FB	2020-05-08 08:25:00	1	1	0	0	0	1	2020-05-15 23:11:42
Coho	Unknown	0F8E	3DD.003D91CEA7	2020-05-12 10:00:59	1	1	1	0	1	1	2020-05-21 23:43:51
Coho	Unknown	0FC7	3DD.003D91CA2F	2020-05-12 09:47:50	0	0	0	0	0	0	
Coho	Unknown	1060	3DD.003D5C2B43	2020-04-24 10:40:00	1	0	0	0	0	0	
Chinook	Spring	10B1	3DD.003D5C2275	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	10FC	3DD.003D5C2D2C	2020-04-03 10:30:00	0	0	0	0	0	0	
Chinook	Spring	1255	3DD.003D5C2D0C	2020-03-27 08:10:00	1	1	0	0	0	1	2020-06-20 05:36:10
Steelhead	Winter	126D	3DD.003D91E7A5	2020-05-28 10:30:00	1	1	1	1	1	1	2020-06-29 02:01:45
Chinook	Spring	1389	3DD.003D5C2264	2020-04-16 09:05:00	0	0	0	0	0	0	
Chinook	Spring	13C6	3DD.003D5C2B2A	2020-04-24 10:40:00	1	0	0	0	0	0	
Coho	Unknown	144F	3DD.003D59C903	2020-05-22 09:30:00	1	1	0	0	0	0	
Steelhead	Winter	148B	3DD.003D91E78A	2020-05-28 10:30:00	1	1	1	1	1	1	2020-06-17 17:26:56
Coho	Unknown	1550	3DD.003D59C8FB	2020-05-22 09:30:00	1	1	0	0	0	0	
Steelhead	Winter	155F	3DD.003D91CC92	2020-04-30 10:30:00	1	1	1	1	1	1	2020-04-30 17:01:33
Chinook	Spring	15AE	3DD.003D5C22A2	2020-04-16 09:05:00	0	0	0	0	0	0	
Coho	Unknown	166E	3DD.003D91CEF2	2020-05-12 09:59:15	1	1	0	0	0	0	
Coho	Unknown	16AB	3DD.003D59C8E0	2020-05-22 09:30:00	0	0	0	0	0	0	
Coho	Unknown	16AD	3DD.003D91CA09	2020-05-08 08:25:00	0	0	0	0	0	0	
Steelhead	Winter	16F9	3DD.003D91CA31	2020-05-08 08:25:00	1	1	1	1	1	0	
Chinook	Spring	172B	3DD.003D5C1B7C	2020-03-19 11:45:00	1	1	1	1	1	1	2020-04-12 23:45:54
Coho	Unknown	1814	3DD.003D91CC97	2020-04-30 10:30:00	0	0	0	0	0	0	
Chinook	Spring	189D	3DD.003D5C2D36	2020-04-03 10:30:00	1	1	0	0	0	1	2020-04-13 01:15:43
Steelhead	Winter	1990	3DD.003D5C2AF8	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	1997	3DD.003D91CEFF	2020-05-12 10:00:05	1	1	1	1	1	1	2020-05-22 11:00:25
Chinook	Spring	1A06	3DD.003D5C2CE5	2020-03-27 08:10:00	0	0	0	0	0	0	
Coho	Unknown	1A92	3DD.003D91CA19	2020-05-12 09:52:08	0	0	0	0	0	0	
Steelhead	Winter	1AC9	3DD.003D91CCA4	2020-04-30 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	1C7A	3DD.003D5C224E	2020-04-16 09:05:00	1	1	0	1	1	1	2020-04-29 02:44:51
Steelhead	Winter	1C89	3DD.003D5C2B33	2020-04-24 10:40:00	1	1	1	0	1	1	2020-05-25 10:19:16
Chinook	Spring	1CED	3DD.003D5C2AF1	2020-04-24 10:40:00	1	1	0	1	1	1	2020-06-17 01:37:27
Steelhead	Winter	1D8A	3DD.003D91CC7D	2020-04-30 10:30:00	1	1	0	0	0	0	
Chinook	Spring	2065	3DD.003D5C2D27	2020-03-27 08:10:00	1	1	1	0	1	1	2020-04-17 00:40:54
Coho	Unknown	20B8	3DD.003D91CC81	2020-04-30 10:30:00	1	1	0	1	1	1	2020-05-18 02:27:35
Coho	Unknown	22B3	3DD.003D59C8DC	2020-05-22 09:30:00	1	1	0	0	0	1	2020-05-24 19:33:15

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Chinook	Spring	230E	3DD.003C010FC8	2020-03-19 11:45:00	1	1	0	0	0	0	
Coho	Unknown	2323	3DD.003D59C8FC	2020-05-22 09:30:00	1	1	0	0	0	0	
Steelhead	Winter	23C1	3DD.003D5C2B39	2020-04-24 10:40:00	1	1	1	1	1	1	2020-04-27 01:28:35
Chinook	Spring	23DA	3DD.003D5C1B52	2020-03-19 11:45:00	1	1	0	0	0	0	
Steelhead	Winter	24B1	3DD.003D91E79B	2020-05-28 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	25AD	3DD.003D91E7A7	2020-05-28 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	25B7	3DD.003D91CC4D	2020-04-30 10:30:00	1	1	1	1	1	0	
Coho	Unknown	262F	3DD.003D5C22AA	2020-04-16 09:05:00	1	1	1	0	1	0	
Steelhead	Winter	2687	3DD.003D91E786	2020-05-28 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	26E4	3DD.003D5C2B19	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	2717	3DD.003D5C2D39	2020-03-27 08:10:00	1	1	0	0	0	0	
Coho	Unknown	2730	3DD.003D5C2260	2020-04-16 09:05:00	0	0	0	0	0	0	
Chinook	Spring	2766	3DD.003D5C2D2A	2020-04-03 10:30:00	1	1	1	1	1	1	2020-05-18 19:02:38
Coho	Unknown	27A0	3DD.003D59C90F	2020-05-22 09:30:00	1	0	0	0	0	0	
Chinook	Spring	27CB	3DD.003D5C1B75	2020-03-19 11:45:00	0	0	0	0	0	0	
Steelhead	Winter	2829	3DD.003D91E79D	2020-05-28 10:30:00	1	1	0	0	0	0	
Chinook	Spring	28CA	3DD.003D5C1B54	2020-03-19 11:45:00	1	1	1	0	1	0	
Steelhead	Winter	28D2	3DD.003D91E74F	2020-05-28 10:30:00	0	0	0	0	0	0	
Coho	Unknown	2A1D	3DD.003D59C8FF	2020-05-22 09:30:00	1	1	1	1	1	0	
Coho	Unknown	2A8B	3DD.003D5C2253	2020-04-16 09:05:00	1	1	0	0	0	0	
Chinook	Spring	2A8E	3DD.003D5C1B66	2020-03-19 11:45:00	1	1	0	0	0	1	2020-05-19 02:45:51
Chinook	Spring	2AD4	3DD.003D5C2B14	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	2B2D	3DD.003D91CA45	2020-05-12 09:38:37	1	1	1	1	1	0	
Chinook	Spring	2B6E	3DD.003D5C2279	2020-04-16 09:05:00	1	1	0	0	0	0	
Steelhead	Winter	2B78	3DD.003D91CA51	2020-05-08 08:25:00	1	1	1	1	1	0	
Steelhead	Winter	2B9A	3DD.003D91E7A3	2020-05-28 10:30:00	1	1	0	0	0	0	
Coho	Unknown	2C82	3DD.003D5C2B25	2020-04-24 10:40:00	0	0	0	0	0	0	
Steelhead	Winter	2E73	3DD.003D91E7A4	2020-05-28 10:30:00	1	1	0	1	1	1	2020-06-06 03:22:54
Steelhead	Winter	2E92	3DD.003D91CCA7	2020-04-30 10:30:00	1	1	0	0	0	0	
Coho	Unknown	2F6C	3DD.003D5C2B07	2020-04-24 10:40:00	1	1	1	1	1	1	2020-05-26 01:05:08
Steelhead	Winter	3179	3DD.003D5C2272	2020-04-16 09:05:00	1	1	0	0	0	0	
Coho	Unknown	319A	3DD.003D5C2B2D	2020-04-24 10:40:00	0	0	0	0	0	0	
Steelhead	Winter	31DF	3DD.003D91E7A6	2020-05-28 10:30:00	1	1	0	0	0	0	
Chinook	Spring	3200	3DD.003D5C228F	2020-04-16 09:05:00	1	1	1	1	1	1	2020-04-29 10:59:11
Coho	Unknown	326E	3DD.003D59C8E9	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	329F	3DD.003D5C2CF4	2020-04-03 10:30:00	1	1	0	1	1	0	
Steelhead	Winter	32C0	3DD.003D91CA3F	2020-05-08 08:25:00	1	1	1	0	1	0	
Coho	Unknown	333E	3DD.003D59C914	2020-05-22 09:30:00	1	1	1	1	1	1	2020-06-02 03:08:07

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Chinook	Spring	333F	3DD.003D5C1B6F	2020-03-19 11:45:00	1	1	0	0	0	1	2020-03-27 17:53:19
Coho	Unknown	3423	3DD.003D91CA48	2020-05-08 08:25:00	0	1	0	0	0	0	
Coho	Unknown	3596	3DD.003D91CC7C	2020-04-30 10:30:00	1	1	1	0	1	0	
Coho	Unknown	3676	3DD.003D91CA0F	2020-05-12 09:49:02	0	0	0	0	0	0	
Steelhead	Winter	3751	3DD.003D91E77F	2020-05-28 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	3756	3DD.003D91E7A0	2020-05-28 10:30:00	1	1	1	1	1	0	
Coho	Unknown	3776	3DD.003D59C8E2	2020-05-22 09:30:00	1	1	0	0	0	0	
Chinook	Spring	382E	3DD.003D5C2B0B	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	382F	3DD.003D5C22A8	2020-04-16 09:05:00	0	0	0	0	0	0	
Steelhead	Winter	38B7	3DD.003D91CA07	2020-05-08 08:25:00	1	1	1	1	1	1	2020-05-13 07:02:52
Coho	Unknown	3912	3DD.003D5C2B1E	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	391B	3DD.003D91CA29	2020-05-08 08:25:00	1	1	0	0	0	0	
Coho	Unknown	3B3B	3DD.003D91CC77	2020-04-30 10:30:00	1	1	1	1	1	0	
Coho	Unknown	3BD3	3DD.003D5C2B1D	2020-04-24 10:40:00	1	1	1	1	1	1	2020-05-26 03:24:33
Chinook	Spring	3C3E	3DD.003D5C22AE	2020-04-10 10:50:00	1	1	0	0	0	0	
Coho	Unknown	3D92	3DD.003D91CA14	2020-05-12 09:46:10	0	0	0	0	0	0	
Coho	Unknown	3D96	3DD.003D59C917	2020-05-22 09:30:00	1	1	1	1	1	0	
Steelhead	Winter	3D9C	3DD.003D91E75D	2020-05-28 10:30:00	1	1	0	0	0	0	
Chinook	Spring	3DC5	3DD.003D5C2CF0	2020-04-03 10:30:00	1	1	0	0	0	0	
Coho	Unknown	3DD0	3DD.003D91CA55	2020-05-08 08:25:00	1	1	1	1	1	0	
Steelhead	Winter	3DF8	3DD.003D91CC8E	2020-04-30 10:30:00	1	1	1	1	1	1	2020-05-04 02:15:47
Chinook	Spring	3EC4	3DD.003D5C2251	2020-04-16 09:05:00	0	0	0	0	0	0	
Coho	Unknown	3F60	3DD.003D91CC5B	2020-04-30 10:30:00	1	1	1	1	1	0	
Coho	Unknown	3F9D	3DD.003D91CA16	2020-05-12 09:41:11	1	1	0	1	1	1	2020-06-03 15:10:51
Chinook	Spring	40B3	3DD.003D5C2257	2020-04-16 09:05:00	0	0	0	0	0	0	
Coho	Unknown	4160	3DD.003D59C8E6	2020-05-22 09:30:00	1	1	1	1	1	1	2020-06-17 17:19:41
Chinook	Spring	418E	3DD.003D5C2265	2020-04-16 09:05:00	0	0	0	0	0	1	2020-06-16 10:11:56
Coho	Unknown	4196	3DD.003D91CC51	2020-04-30 10:30:00	0	0	0	0	0	0	
Chinook	Spring	41E0	3DD.003D5C2CE1	2020-03-27 08:10:00	1	1	1	0	1	0	
Coho	Unknown	4254	3DD.003D91CC58	2020-04-30 10:30:00	1	1	1	1	1	1	2020-06-18 17:04:59
Steelhead	Winter	4272	3DD.003D91CC69	2020-04-30 10:30:00	1	1	1	1	1	0	
Steelhead	Winter	4273	3DD.003D5C2B21	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	42AA	3DD.003D91CA36	2020-05-12 09:40:16	1	1	1	1	1	0	
Coho	Unknown	439A	3DD.003D91CCAE	2020-04-30 10:30:00	1	1	1	1	1	1	2020-05-05 02:51:19
Coho	Unknown	4451	3DD.003D91CA1A	2020-05-12 09:34:27	0	0	0	0	0	0	
Steelhead	Winter	449B	3DD.003D91CC8B	2020-04-30 10:30:00	1	1	1	0	1	1	2020-06-02 05:50:21
Coho	Unknown	45BA	3DD.003D91C9F5	2020-05-08 08:25:00	1	0	0	0	0	0	
Chinook	Spring	4636	3DD.003D5C2CF1	2020-03-27 08:10:00	1	1	1	0	1	1	2020-04-09 22:34:45

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Chinook	Spring	46CE	3DD.003D5C2B0E	2020-04-24 10:40:00	1	1	1	0	1	1	2020-06-17 01:27:22
Chinook	Spring	46DB	3DD.003D5C2CFC	2020-04-03 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	4766	3DD.003D91CC6B	2020-04-30 10:30:00	1	1	1	0	1	1	2020-05-08 02:35:29
Steelhead	Winter	47A9	3DD.003D5C226B	2020-04-16 09:05:00	1	1	0	0	0	0	
Coho	Unknown	47D9	3DD.003D5C2AFF	2020-04-24 10:40:00	1	1	1	1	1	0	
Coho	Unknown	482B	3DD.003D91CEF4	2020-05-12 09:55:37	1	1	1	0	1	1	2020-05-24 02:44:30
Coho	Unknown	483F	3DD.003D59C8D6	2020-05-22 09:30:00	1	1	0	0	0	0	
Chinook	Spring	4881	3DD.003D5C226C	2020-04-16 09:05:00	1	1	1	0	1	0	
Chinook	Spring	495D	3DD.003D5C228B	2020-04-10 10:50:00	0	0	0	0	0	0	
Steelhead	Winter	49B6	3DD.003D91CA39	2020-05-08 08:25:00	0	0	0	0	0	0	
Coho	Unknown	4C35	3DD.003D59C915	2020-05-22 09:30:00	1	1	1	1	1	1	2020-06-21 06:16:16
Chinook	Spring	4CCB	3DD.003D5C2282	2020-04-16 09:05:00	1	1	0	1	1	1	2020-05-07 01:33:41
Steelhead	Winter	4D03	3DD.003D5C2268	2020-04-16 09:05:00	1	1	1	0	1	1	2020-04-29 01:18:24
Coho	Unknown	4D92	3DD.003D91CA41	2020-05-12 09:43:41	0	0	0	0	0	0	
Chinook	Spring	4D9D	3DD.003D5C226D	2020-04-16 09:05:00	0	0	0	0	0	0	
Steelhead	Winter	4E49	3DD.003D91CCA8	2020-04-30 10:30:00	0	0	0	0	0	1	2020-05-05 00:55:44
Coho	Unknown	4E7E	3DD.003D91CA3C	2020-05-08 08:25:00	1	1	1	1	1	0	
Coho	Unknown	4FD0	3DD.003D91CA12	2020-05-12 09:53:52	1	0	1	1	1	1	2020-05-19 01:09:33
Steelhead	Winter	5005	3DD.003D91CC4B	2020-04-30 10:30:00	1	1	1	1	1	0	
Chinook	Spring	512D	3DD.003D91CA1E	2020-05-08 08:25:00	0	0	0	0	0	0	
Chinook	Spring	51DE	3DD.003D5C1BA1	2020-03-19 11:45:00	1	1	0	0	0	0	
Steelhead	Winter	5410	3DD.003D91E78E	2020-05-28 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	5439	3DD.003D91E76A	2020-05-28 10:30:00	0	0	0	0	0	0	
Chinook	Spring	5484	3DD.003D5C2B35	2020-04-24 10:40:00	1	0	0	0	0	0	
Chinook	Spring	55A2	3DD.003D5C2250	2020-04-16 09:05:00	0	0	0	0	0	0	
Coho	Unknown	55A5	3DD.003D91CA0E	2020-05-12 09:53:21	0	0	0	0	0	0	
Steelhead	Winter	56B3	3DD.003D91CC55	2020-04-30 10:30:00	1	1	0	0	0	0	
Chinook	Spring	56B7	3DD.003D91CA22	2020-05-08 08:25:00	0	0	0	0	0	0	
Steelhead	Winter	5786	3DD.003D91E78B	2020-05-28 10:30:00	0	0	0	0	0	0	
Coho	Unknown	5870	3DD.003D59C8E4	2020-05-22 09:30:00	1	1	1	1	1	1	2020-06-24 08:46:40
Steelhead	Winter	588D	3DD.003D91CC7B	2020-04-30 10:30:00	1	1	0	0	0	0	
Coho	Unknown	58EB	3DD.003D91CC9C	2020-04-30 10:30:00	1	1	1	1	1	1	2020-06-08 16:36:21
Coho	Unknown	5939	3DD.003D91CA2C	2020-05-12 09:38:14	1	1	1	1	1	1	2020-06-05 00:19:53
Chinook	Spring	5945	3DD.003D91CA03	2020-05-08 08:25:00	0	0	0	0	0	0	
Steelhead	Winter	5971	3DD.003D91E7A8	2020-05-28 10:30:00	0	0	0	0	0	0	
Chinook	Spring	59FF	3DD.003D5C1B47	2020-03-19 11:45:00	0	0	0	0	0	0	
Chinook	Spring	5A7C	3DD.003D5C2289	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	5A85	3DD.003D5C2B34	2020-04-24 10:40:00	0	0	0	0	0	0	

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Chinook	Spring	5AF2	3DD.003D5C2CE9	2020-04-03 10:30:00	1	1	0	0	0	1	2020-04-14 14:28:21
Steelhead	Winter	5B2D	3DD.003D91CA49	2020-05-08 08:25:00	1	1	1	1	1	1	2020-06-07 23:34:57
Steelhead	Winter	5B4F	3DD.003D91E759	2020-05-28 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	5C7E	3DD.003D91E7AA	2020-05-28 10:30:00	1	1	0	0	0	0	
Coho	Unknown	5CC5	3DD.003D91CA20	2020-05-12 09:39:53	1	1	1	1	1	0	
Coho	Unknown	5D54	3DD.003D91CCA3	2020-04-30 10:30:00	1	1	0	0	0	0	
Chinook	Spring	5D78	3DD.003D5C2254	2020-04-16 09:05:00	1	1	0	0	0	1	2020-06-14 00:42:32
Steelhead	Winter	5D90	3DD.003D91E77C	2020-05-28 10:30:00	1	1	1	1	1	1	2020-06-19 08:34:48
Steelhead	Winter	5D93	3DD.003D59C8F7	2020-05-22 09:30:00	1	1	1	1	1	1	2020-06-22 03:07:02
Coho	Unknown	5E99	3DD.003D91CC90	2020-04-30 10:30:00	1	1	1	1	1	0	
Steelhead	Winter	5EDD	3DD.003D5C2AF9	2020-04-24 10:40:00	1	1	0	0	0	1	2020-05-03 22:06:16
Steelhead	Winter	5F23	3DD.003D91CCA6	2020-04-30 10:30:00	1	1	1	0	1	1	2020-05-15 13:58:26
Chinook	Spring	5F82	3DD.003D5C224B	2020-04-10 10:50:00	0	0	0	0	0	0	
Coho	Unknown	601B	3DD.003D5C2B00	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	608A	3DD.003D5C2D1E	2020-03-27 08:10:00	0	0	0	0	0	0	
Chinook	Spring	60F2	3DD.003D5C2D11	2020-04-03 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	6115	3DD.003D91E74A	2020-05-28 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	613C	3DD.003D5C2B24	2020-04-24 10:40:00	0	0	0	0	0	0	
Steelhead	Winter	61BE	3DD.003D91CA1D	2020-05-08 08:25:00	1	1	1	0	1	0	
Chinook	Spring	62E7	3DD.003D5C2267	2020-04-16 09:05:00	1	1	1	1	1	1	2020-05-02 23:32:25
Coho	Unknown	6300	3DD.003D91CA3D	2020-05-08 08:25:00	1	1	0	0	0	0	
Steelhead	Winter	6323	3DD.003D91CA40	2020-05-08 08:25:00	0	0	0	0	0	0	
Steelhead	Winter	6338	3DD.003D91CC4E	2020-04-30 10:30:00	1	1	1	0	1	0	
Steelhead	Winter	636B	3DD.003D91CA02	2020-05-08 08:25:00	1	1	1	1	1	1	2020-06-11 04:30:31
Steelhead	Winter	63C2	3DD.003D91E757	2020-05-28 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	63D7	3DD.003D91E794	2020-05-28 10:30:00	1	1	0	0	0	0	
Coho	Unknown	6409	3DD.003D91CEB0	2020-05-12 10:00:31	0	0	0	0	0	0	
Steelhead	Winter	6502	3DD.003D91E773	2020-05-28 10:30:00	0	0	0	0	0	0	
Coho	Unknown	683D	3DD.003D91C9F7	2020-05-08 08:25:00	1	1	1	0	1	0	
Coho	Unknown	68D2	3DD.003D5C2AF7	2020-04-24 10:40:00	1	1	0	0	0	0	
Coho	Unknown	694B	3DD.003D5C2B40	2020-04-24 10:40:00	1	1	1	1	1	1	2020-06-03 02:40:41
Steelhead	Winter	694C	3DD.003D91E76D	2020-05-28 10:30:00	0	0	0	0	0	0	
Coho	Unknown	6A1F	3DD.003D91CC78	2020-04-30 10:30:00	1	1	1	0	1	1	2020-05-03 02:25:51
Coho	Unknown	6A52	3DD.003D91C9F8	2020-05-12 09:41:33	1	1	1	1	1	0	
Coho	Unknown	6A55	3DD.003D91CC5C	2020-04-30 10:30:00	1	1	0	0	0	0	
Coho	Unknown	6C57	3DD.003D59C8F1	2020-05-22 09:30:00	1	0	0	1	1	1	2020-05-24 21:02:42
Coho	Unknown	6CAC	3DD.003D91CA08	2020-05-08 08:25:00	1	1	0	0	0	0	
Steelhead	Winter	6CC2	3DD.003D91E796	2020-05-28 10:30:00	0	0	0	0	0	0	

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Steelhead	Winter	6CCF	3DD.003D91CC73	2020-04-30 10:30:00	1	1	1	0	1	0	
Coho	Unknown	6D88	3DD.003D91CA01	2020-05-08 08:25:00	1	1	0	0	0	0	
Steelhead	Winter	6D93	3DD.003D59C918	2020-05-22 09:30:00	1	1	0	0	0	0	
Steelhead	Winter	6D97	3DD.003D59C916	2020-05-22 09:30:00	1	1	0	0	0	0	
Chinook	Spring	6DD2	3DD.003D5C2277	2020-04-10 10:50:00	0	0	0	0	0	0	
Coho	Unknown	6DE0	3DD.003D59C924	2020-05-22 09:30:00	0	0	0	0	0	1	2020-06-12 22:55:58
Chinook	Spring	6E21	3DD.003D5C2D1D	2020-03-27 08:10:00	1	1	0	0	0	1	2020-06-14 22:45:00
Chinook	Spring	6F50	3DD.003D5C22AD	2020-04-16 09:05:00	1	0	0	0	0	0	
Coho	Unknown	702F	3DD.003D91CEBF	2020-05-12 10:01:48	0	0	0	0	0	0	
Chinook	Spring	70D2	3DD.003D5C2D0E	2020-04-03 10:30:00	1	1	1	1	1	1	2020-04-11 21:41:34
Steelhead	Winter	70EF	3DD.003D91E789	2020-05-28 10:30:00	1	1	1	1	1	1	2020-06-07 00:31:17
Chinook	Spring	7291	3DD.003D5C2CE3	2020-04-03 10:30:00	1	1	0	0	0	0	
Coho	Unknown	72E6	3DD.003D59C8E1	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	730B	3DD.003D5C2CDC	2020-04-03 10:30:00	0	0	0	0	0	0	
Coho	Unknown	732A	3DD.003D91CEAF	2020-05-12 09:57:59	1	1	0	0	0	0	
Steelhead	Winter	7332	3DD.003D91CC4C	2020-04-30 10:30:00	0	0	0	0	0	0	
Chinook	Spring	735F	3DD.003D5C2270	2020-04-10 10:50:00	1	1	1	1	1	1	2020-05-01 20:09:52
Steelhead	Winter	7393	3DD.003D91CCAC	2020-04-30 10:30:00	0	0	0	0	0	0	
Coho	Unknown	73B9	3DD.003D91CCAB	2020-04-30 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	74C4	3DD.003D91CC7A	2020-04-30 10:30:00	1	1	1	0	1	0	
Coho	Unknown	7543	3DD.003D5C2B03	2020-04-24 10:40:00	0	0	0	0	0	0	
Steelhead	Winter	76E5	3DD.003D91CA4E	2020-05-08 08:25:00	1	1	0	0	0	0	
Coho	Unknown	7716	3DD.003D59C90C	2020-05-22 09:30:00	1	1	1	1	1	1	2020-05-24 20:55:35
Coho	Unknown	776A	3DD.003D91CA3B	2020-05-12 09:45:45	0	0	0	0	0	0	
Steelhead	Winter	7894	3DD.003D5C2B3A	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	7A67	3DD.003D5C227C	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	7A68	3DD.003D5C228C	2020-04-16 09:05:00	0	0	0	0	0	0	
Coho	Unknown	7AA3	3DD.003D59C8DE	2020-05-22 09:30:00	0	0	0	0	0	0	
Coho	Unknown	7AE5	3DD.003D5C2AEA	2020-04-24 10:40:00	1	1	1	1	1	0	
Coho	Unknown	7B43	3DD.003D59C92C	2020-05-22 09:30:00	1	1	1	1	1	0	
Coho	Unknown	7B64	3DD.003D91CEF8	2020-05-12 10:03:10	0	0	0	0	0	0	
Coho	Unknown	7BCD	3DD.003D91C9FD	2020-05-08 08:25:00	1	1	1	1	1	0	
Coho	Unknown	7C17	3DD.003D5C2AF3	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	7C30	3DD.003D5C2D22	2020-03-27 08:10:00	0	0	0	0	0	0	
Coho	Unknown	7C57	3DD.003D59C907	2020-05-22 09:30:00	0	0	0	0	0	0	
Coho	Unknown	7CF6	3DD.003D59C8EC	2020-05-22 09:30:00	1	1	1	0	1	1	2020-06-24 16:05:07
Coho	Unknown	7F0D	3DD.003D59C912	2020-05-22 09:30:00	0	0	0	0	0	0	
Steelhead	Winter	7FA2	3DD.003D91E77D	2020-05-28 10:30:00	0	0	0	0	0	0	

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Coho	Unknown	8038	3DD.003D5C2AE7	2020-04-24 10:40:00	1	1	0	0	0	0	
Steelhead	Winter	8066	3DD.003D91CA13	2020-05-08 08:25:00	1	1	0	0	0	0	
Coho	Unknown	80A3	3DD.003D5C22A6	2020-04-16 09:05:00	1	1	1	1	1	1	2020-05-12 15:23:00
Coho	Unknown	80FD	3DD.003D59C921	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	8157	3DD.003D5C1B7F	2020-03-19 11:45:00	1	1	1	0	1	0	
Steelhead	Winter	82B3	3DD.003D91E749	2020-05-28 10:30:00	1	1	1	1	1	1	2020-06-04 12:16:31
Chinook	Spring	832A	3DD.003D91CA28	2020-05-08 08:25:00	1	1	1	0	1	0	
Chinook	Spring	8385	3DD.003D5C2D09	2020-03-27 08:10:00	1	1	0	1	1	0	
Coho	Unknown	8386	3DD.003D91CA1F	2020-05-08 08:25:00	1	1	1	0	1	0	
Coho	Unknown	83AE	3DD.003D5C2B01	2020-04-24 10:40:00	1	1	1	0	1	1	2020-04-25 01:33:49
Chinook	Spring	849F	3DD.003D5C2AE6	2020-04-24 10:40:00	1	0	0	0	0	0	
Steelhead	Winter	84A5	3DD.003D91E765	2020-05-28 10:30:00	0	0	0	0	0	0	
Chinook	Spring	84AD	3DD.003D5C228A	2020-04-16 09:05:00	1	1	0	0	0	0	
Chinook	Spring	8505	3DD.003D5C2D37	2020-04-03 10:30:00	0	0	0	0	0	0	
Chinook	Spring	8525	3DD.003D5C22AB	2020-04-16 09:05:00	0	0	0	0	0	0	
Coho	Unknown	857A	3DD.003D59C8F5	2020-05-22 09:30:00	1	1	1	1	1	1	2020-05-25 15:26:26
Steelhead	Winter	85A6	3DD.003D91E748	2020-05-28 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	86C6	3DD.003D91CA50	2020-05-08 08:25:00	1	1	0	0	0	0	
Coho	Unknown	89A2	3DD.003D59C911	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	89A4	3DD.003D5C2D2B	2020-04-03 10:30:00	1	1	1	0	1	1	2020-04-19 22:00:43
Chinook	Spring	89BF	3DD.003D5C227B	2020-04-16 09:05:00	1	1	1	0	1	0	
Steelhead	Winter	89EB	3DD.003D91C9F4	2020-05-08 08:25:00	0	0	0	0	0	0	
Chinook	Spring	8B08	3DD.003D5C2271	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	8B26	3DD.003D5C22A5	2020-04-10 10:50:00	1	1	0	0	0	0	
Coho	Unknown	8B34	3DD.003D91CA53	2020-05-12 09:52:32	1	0	0	0	0	0	
Coho	Unknown	8B3C	3DD.003D91CA33	2020-05-12 09:50:58	1	1	1	1	1	0	
Coho	Unknown	8B59	3DD.003D59C8F6	2020-05-22 09:30:00	1	1	1	1	1	0	
Coho	Unknown	8B8B	3DD.003D91CC68	2020-04-30 10:30:00	1	1	1	1	1	1	2020-05-26 20:03:26
Chinook	Spring	8B96	3DD.003D5C227E	2020-04-16 09:05:00	1	1	1	0	1	1	2020-04-23 01:55:59
Coho	Unknown	8C2E	3DD.003D91CF03	2020-05-12 10:03:36	1	1	1	1	1	1	2020-05-24 23:01:48
Steelhead	Winter	8C7B	3DD.003D5C2AFD	2020-04-24 10:40:00	1	1	1	0	1	0	
Steelhead	Winter	8C84	3DD.003D91CC94	2020-04-30 10:30:00	1	1	1	1	1	1	2020-06-02 04:10:38
Steelhead	Winter	8CC6	3DD.003D91CC85	2020-04-30 10:30:00	0	0	0	0	0	1	2020-05-05 03:49:08
Chinook	Spring	8D2F	3DD.003D5C2CFF	2020-03-27 08:10:00	1	1	0	0	0	1	2020-06-02 22:26:41
Chinook	Spring	8E0A	3DD.003D5C226F	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	8E49	3DD.003D5C2290	2020-04-10 10:50:00	0	0	0	0	0	0	
Steelhead	Winter	8EB1	3DD.003D5C2B2B	2020-04-24 10:40:00	1	1	1	1	1	0	
Steelhead	Winter	8F02	3DD.003D91E783	2020-05-28 10:30:00	1	1	1	1	1	0	

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Chinook	Spring	8F3A	3DD.003D5C2D25	2020-03-27 08:10:00	1	1	0	1	1	0	
Steelhead	Winter	8FA8	3DD.003D91E770	2020-05-28 10:30:00	1	1	0	0	0	0	
Chinook	Spring	8FB9	3DD.003D5C2CEF	2020-03-27 08:10:00	1	1	0	0	0	0	
Coho	Unknown	8FF4	3DD.003D59C904	2020-05-22 09:30:00	1	1	1	1	1	0	
Chinook	Spring	9005	3DD.003D5C2B17	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	9027	3DD.003D5C2D02	2020-03-27 08:10:00	0	0	0	0	0	0	
Steelhead	Winter	90D2	3DD.003D91E77B	2020-05-28 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	91C1	3DD.003D5C2B11	2020-04-24 10:40:00	1	1	1	1	1	0	
Chinook	Spring	91C2	3DD.003D5C2D08	2020-04-03 10:30:00	1	1	0	0	0	0	
Coho	Unknown	91D9	3DD.003D59C8FD	2020-05-22 09:30:00	1	1	1	0	1	0	
Steelhead	Winter	91E5	3DD.003D59C92E	2020-05-22 09:30:00	1	1	1	0	1	0	
Steelhead	Winter	92DF	3DD.003D91E769	2020-05-28 10:30:00	1	1	1	0	1	1	2020-06-20 02:28:55
Steelhead	Winter	9335	3DD.003D91CCA0	2020-04-30 10:30:00	1	1	1	1	1	1	2020-05-08 00:11:18
Coho	Unknown	9371	3DD.003D59C91A	2020-05-22 09:30:00	1	1	0	0	0	0	
Chinook	Spring	9443	3DD.003D5C2296	2020-04-16 09:05:00	0	0	0	0	0	0	
Chinook	Spring	94CA	3DD.003D5C2D29	2020-04-03 10:30:00	0	0	0	0	0	0	
Chinook	Spring	9524	3DD.003D5C2D04	2020-03-27 08:10:00	1	1	0	0	0	0	
Chinook	Spring	9616	3DD.003D5C2B23	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	9637	3DD.003D91CA47	2020-05-12 09:44:35	0	0	0	0	0	0	
Coho	Unknown	9667	3DD.003D5C2B13	2020-04-24 10:40:00	0	0	0	0	0	0	
Steelhead	Winter	973C	3DD.003D91E79F	2020-05-28 10:30:00	1	0	0	0	0	0	
Steelhead	Winter	976C	3DD.003D91CA4F	2020-05-08 08:25:00	0	0	0	0	0	0	
Coho	Unknown	9878	3DD.003D91CA32	2020-05-08 08:25:00	0	0	0	0	0	0	
Chinook	Spring	98D3	3DD.003D5C2D21	2020-03-27 08:10:00	1	1	1	0	1	1	2020-04-11 20:18:10
Chinook	Spring	98F5	3DD.003D5C2CEC	2020-04-03 10:30:00	1	1	1	1	1	1	2020-04-13 00:08:04
Chinook	Spring	995F	3DD.003D5C2D0A	2020-03-27 08:10:00	1	1	0	0	0	0	
Chinook	Spring	9977	3DD.003D5C2D24	2020-04-03 10:30:00	1	1	0	0	0	1	2020-04-22 23:28:28
Steelhead	Winter	99DC	3DD.003D91CC98	2020-04-30 10:30:00	1	1	1	0	1	1	2020-05-24 19:52:53
Chinook	Spring	99F2	3DD.003D5C2B09	2020-04-24 10:40:00	1	1	0	0	0	0	
Coho	Unknown	9A0F	3DD.003D91CEC0	2020-05-12 09:55:45	0	0	0	0	0	0	
Chinook	Spring	9A3F	3DD.003D5C229B	2020-04-16 09:05:00	0	0	0	0	0	0	
Coho	Unknown	9D3E	3DD.003D91C9FC	2020-05-12 09:37:50	1	1	1	1	1	0	
Chinook	Spring	9D4A	3DD.003D91CA34	2020-05-08 08:25:00	1	1	1	1	1	1	2020-06-18 18:24:14
Steelhead	Winter	9DC7	3DD.003D91E797	2020-05-28 10:30:00	1	1	1	1	1	0	
Coho	Unknown	9EB1	3DD.003D91CA4C	2020-05-12 09:52:54	0	0	0	0	0	0	
Coho	Unknown	9ECD	3DD.003D59C8EA	2020-05-22 09:30:00	1	1	0	0	0	0	
Coho	Unknown	9F80	3DD.003D91C9FF	2020-05-12 09:48:13	0	0	0	0	0	0	
Coho	Unknown	9F8C	3DD.003D91CC80	2020-04-30 10:30:00	1	1	1	0	1	0	

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Chinook	Spring	9FF7	3DD.003D5C2B32	2020-04-24 10:40:00	1	0	0	0	0	0	
Steelhead	Winter	A09E	3DD.003D59C8D7	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	A0EC	3DD.003D5C2B26	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	A10B	3DD.003D5C2D17	2020-04-03 10:30:00	1	1	0	0	0	0	
Chinook	Spring	A161	3DD.003D5C2CF2	2020-04-03 10:30:00	1	1	0	0	0	1	2020-05-03 23:32:06
Steelhead	Winter	A1A0	3DD.003D91E778	2020-05-28 10:30:00	0	0	0	0	0	0	
Coho	Unknown	A230	3DD.003D91CEFD	2020-05-12 10:02:12	0	0	0	0	0	0	
Chinook	Spring	A2BC	3DD.003D5C2288	2020-04-16 09:05:00	0	0	0	0	0	0	
Steelhead	Winter	A360	3DD.003D91E75B	2020-05-28 10:30:00	1	1	1	1	1	1	2020-06-02 07:09:47
Coho	Unknown	A44D	3DD.003D91CEC3	2020-05-12 10:01:27	1	1	0	0	0	0	
Coho	Unknown	A481	3DD.003D91CA23	2020-05-12 09:37:26	0	0	0	0	0	0	
Chinook	Spring	A4C7	3DD.003D5C2B1A	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	A4F5	3DD.003D91CEC8	2020-05-12 09:56:31	1	0	0	0	0	1	2020-05-24 23:39:16
Chinook	Spring	A556	3DD.003D5C225E	2020-04-16 09:05:00	1	1	0	0	0	0	
Steelhead	Winter	A57C	3DD.003D91CA56	2020-05-08 08:25:00	1	1	1	1	1	1	2020-05-18 03:05:55
Chinook	Spring	A5A9	3DD.003D5C2263	2020-04-16 09:05:00	0	0	0	0	0	0	
Steelhead	Winter	A610	3DD.003D91CC89	2020-04-30 10:30:00	1	1	1	1	1	1	2020-05-18 06:37:53
Coho	Unknown	A63E	3DD.003D91CEA9	2020-05-12 09:57:21	0	0	0	0	0	0	
Chinook	Spring	A654	3DD.003D5C22A0	2020-04-10 10:50:00	0	0	0	0	0	0	
Steelhead	Winter	A6E6	3DD.003D91E784	2020-05-28 10:30:00	0	0	0	0	0	0	
Chinook	Spring	A752	3DD.003D5C2D2F	2020-04-03 10:30:00	1	1	0	0	0	1	2020-04-20 01:38:22
Coho	Unknown	A8CF	3DD.003D91CA05	2020-05-12 09:44:03	0	0	0	0	0	0	
Chinook	Spring	A8E9	3DD.003D5C2294	2020-04-10 10:50:00	1	1	0	0	0	1	2020-06-20 01:16:01
Coho	Unknown	A963	3DD.003D91CA2A	2020-05-12 09:51:47	0	0	0	0	0	0	
Steelhead	Winter	A98D	3DD.003D91E79A	2020-05-28 10:30:00	0	0	0	0	0	0	
Chinook	Spring	AAF0	3DD.003D5C2276	2020-04-16 09:05:00	0	0	0	0	0	0	
Chinook	Spring	AB01	3DD.003D5C2D26	2020-04-03 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	ABCF	3DD.003D91E774	2020-05-28 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	ABFB	3DD.003D91CC9D	2020-04-30 10:30:00	1	1	1	1	1	1	2020-05-05 00:37:24
Chinook	Spring	ACC0	3DD.003D5C2280	2020-04-10 10:50:00	0	0	0	0	0	0	
Steelhead	Winter	ADF2	3DD.003D59C8F0	2020-05-22 09:30:00	0	0	0	0	0	0	
Coho	Unknown	AE0D	3DD.003D5C2295	2020-04-16 09:05:00	1	1	0	0	0	1	2020-06-12 06:26:10
Chinook	Spring	AE19	3DD.003D91CA4D	2020-05-08 08:25:00	1	1	0	0	0	0	
Chinook	Spring	AE39	3DD.003D5C2281	2020-04-10 10:50:00	0	0	0	0	0	0	
Coho	Unknown	AE64	3DD.003D91CA21	2020-05-12 09:50:33	1	1	1	0	1	0	
Steelhead	Winter	AF05	3DD.003D91E788	2020-05-28 10:30:00	1	1	0	0	0	0	
Coho	Unknown	B011	3DD.003D91CC9B	2020-04-30 10:30:00	0	0	0	0	0	0	
Chinook	Spring	B04C	3DD.003D5C2278	2020-04-16 09:05:00	0	0	0	0	0	0	

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Coho	Unknown	B069	3DD.003D59C8E7	2020-05-22 09:30:00	1	1	0	0	0	0	
Coho	Unknown	B0B7	3DD.003D91CEF7	2020-05-12 09:56:08	0	0	0	0	0	0	
Coho	Unknown	B161	3DD.003D91CA3E	2020-05-12 09:51:23	0	0	0	0	0	0	
Coho	Unknown	B175	3DD.003D91CED8	2020-05-12 10:02:38	1	0	0	0	0	0	
Coho	Unknown	B187	3DD.003D91CA0D	2020-05-12 09:41:58	0	0	0	0	0	0	
Steelhead	Winter	B2DA	3DD.003D91E792	2020-05-28 10:30:00	1	1	1	1	1	1	2020-06-11 23:18:52
Chinook	Spring	B31A	3DD.003D5C2D28	2020-03-27 08:10:00	1	1	0	0	0	0	
Coho	Unknown	B347	3DD.003D91CA4B	2020-05-12 09:46:38	0	0	0	0	0	0	
Chinook	Spring	B394	3DD.003D5C2D30	2020-04-03 10:30:00	1	1	0	0	0	1	2020-04-14 23:47:54
Coho	Unknown	B3A1	3DD.003D59C90E	2020-05-22 09:30:00	1	1	1	1	1	1	2020-06-04 17:32:28
Steelhead	Winter	B400	3DD.003D59C901	2020-05-22 09:30:00	1	1	0	0	0	1	2020-05-27 05:01:05
Chinook	Spring	B41D	3DD.003D5C226E	2020-04-16 09:05:00	1	0	0	0	0	0	
Coho	Unknown	B4CA	3DD.003D91CEC6	2020-05-12 09:56:55	0	0	0	0	0	0	
Steelhead	Winter	B50A	3DD.003D91E7A2	2020-05-28 10:30:00	1	1	1	1	1	1	2020-06-01 02:43:35
Coho	Unknown	B539	3DD.003D59C913	2020-05-22 09:30:00	0	0	0	0	0	0	
Steelhead	Winter	B551	3DD.003D91E78C	2020-05-28 10:30:00	0	0	0	0	0	0	
Chinook	Spring	B5B9	3DD.003D5C2D03	2020-03-27 08:10:00	1	1	0	0	0	1	2020-06-30 05:12:27
Chinook	Spring	B5ED	3DD.003D5C2D31	2020-04-03 10:30:00	0	0	0	0	0	0	
Chinook	Spring	B60B	3DD.003D5C2D2D	2020-04-03 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	B61F	3DD.003D91E787	2020-05-28 10:30:00	0	0	0	0	0	0	
Coho	Unknown	B6DC	3DD.003D91CA0C	2020-05-08 08:25:00	1	1	1	1	1	0	
Coho	Unknown	B774	3DD.003D59C8F4	2020-05-22 09:30:00	0	0	0	0	0	0	
Coho	Unknown	B787	3DD.003D59C909	2020-05-22 09:30:00	1	1	1	1	1	0	
Chinook	Spring	B793	3DD.003D5C2CE0	2020-04-03 10:30:00	0	0	0	0	0	0	
Chinook	Spring	B7D1	3DD.003D5C2299	2020-04-10 10:50:00	1	1	0	0	0	1	2020-06-07 21:10:14
Coho	Unknown	B830	3DD.003D5C2B3D	2020-04-24 10:40:00	0	0	0	0	0	0	
Steelhead	Winter	B870	3DD.003D91E76B	2020-05-28 10:30:00	0	0	0	0	0	0	
Chinook	Spring	B973	3DD.003D5C2266	2020-04-10 10:50:00	0	0	0	0	0	0	
Coho	Unknown	BA1D	3DD.003D59C90A	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	BA42	3DD.003D5C2AF5	2020-04-24 10:40:00	0	0	0	0	0	0	
Steelhead	Winter	BA5C	3DD.003D5C2261	2020-04-16 09:05:00	1	1	0	1	1	1	2020-04-21 00:55:09
Chinook	Spring	BC35	3DD.003D5C2285	2020-04-10 10:50:00	1	1	1	0	1	1	2020-05-24 02:25:57
Coho	Unknown	BC7B	3DD.003D91CA24	2020-05-12 09:40:40	0	0	0	0	0	0	
Steelhead	Winter	BC98	3DD.003D91CA42	2020-05-08 08:25:00	1	1	0	0	0	0	
Steelhead	Winter	BD16	3DD.003D91CC72	2020-04-30 10:30:00	0	0	0	0	0	0	
Chinook	Spring	BDCF	3DD.003D5C22A4	2020-04-16 09:05:00	0	0	0	0	0	0	
Coho	Unknown	BE88	3DD.003D91CA52	2020-05-12 09:54:17	0	0	0	0	0	0	
Coho	Unknown	BE9D	3DD.003D59C8ED	2020-05-22 09:30:00	1	1	1	1	1	0	

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Steelhead	Winter	BF49	3DD.003D91E74D	2020-05-28 10:30:00	1	1	0	0	0	0	
Coho	Unknown	BF4A	3DD.003D91CA4A	2020-05-12 09:39:01	0	0	0	0	0	0	
Chinook	Spring	BFDF	3DD.003D5C2286	2020-04-10 10:50:00	1	1	1	0	1	1	2020-04-28 21:50:58
Chinook	Spring	C088	3DD.003D5C2D20	2020-03-27 08:10:00	1	1	0	0	0	1	2020-04-01 23:36:32
Steelhead	Winter	C0FE	3DD.003D91CA1B	2020-05-08 08:25:00	1	1	1	0	1	0	
Chinook	Spring	C101	3DD.003D91CA43	2020-05-08 08:25:00	1	1	1	0	1	0	
Steelhead	Winter	C26B	3DD.003D91E75C	2020-05-28 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	C2E5	3DD.003D5C2287	2020-04-16 09:05:00	1	1	0	1	1	0	
Steelhead	Winter	C330	3DD.003D59C90D	2020-05-22 09:30:00	1	1	1	1	1	1	2020-05-25 23:44:12
Chinook	Spring	C3B8	3DD.003D5C2D1F	2020-03-27 08:10:00	1	1	0	1	1	1	2020-04-12 23:53:22
Steelhead	Winter	C418	3DD.003D91CC62	2020-04-30 10:30:00	1	1	1	1	1	1	2020-05-01 03:40:37
Coho	Unknown	C562	3DD.003D91CA2E	2020-05-08 08:25:00	0	0	0	0	0	0	
Steelhead	Winter	C64E	3DD.003D91C9F3	2020-05-08 08:25:00	1	1	1	1	1	1	2020-05-13 20:05:06
Chinook	Spring	C679	3DD.003D5C228E	2020-04-10 10:50:00	0	0	0	0	0	0	
Steelhead	Winter	C691	3DD.003D91E767	2020-05-28 10:30:00	0	0	0	0	0	0	
Chinook	Spring	C6C5	3DD.003D5C1B51	2020-03-19 11:45:00	1	1	1	1	1	1	2020-05-24 01:34:02
Coho	Unknown	C75D	3DD.003D91CC6A	2020-04-30 10:30:00	1	1	1	1	1	0	
Chinook	Spring	C87A	3DD.003D5C2258	2020-04-16 09:05:00	1	1	0	0	0	0	
Coho	Unknown	C9BD	3DD.003D59C8E5	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	CA3D	3DD.003D5C1B8E	2020-03-19 11:45:00	0	0	0	0	0	0	
Coho	Unknown	CA48	3DD.003D91C9F9	2020-05-12 09:39:23	0	0	0	0	0	0	
Coho	Unknown	CACB	3DD.003D59C8D9	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	CADA	3DD.003D5C2CED	2020-03-27 08:10:00	1	1	1	0	1	1	2020-04-29 04:00:58
Coho	Unknown	CB7C	3DD.003D59C92A	2020-05-22 09:30:00	1	0	0	1	1	1	2020-05-26 21:24:03
Chinook	Spring	CC23	3DD.003D5C1B80	2020-03-19 11:45:00	1	1	1	1	1	1	2020-04-10 03:04:57
Chinook	Spring	CC7E	3DD.003D5C2D19	2020-03-27 08:10:00	1	1	1	0	1	1	2020-04-05 22:50:32
Chinook	Spring	CC80	3DD.003D91C9FA	2020-05-08 08:25:00	0	0	0	0	0	0	
Steelhead	Winter	CC92	3DD.003D91CC8A	2020-04-30 10:30:00	1	1	0	0	0	0	
Coho	Unknown	CD40	3DD.003D91CC99	2020-04-30 10:30:00	1	1	1	1	1	1	2020-05-17 03:07:28
Chinook	Spring	CD43	3DD.003D5C2293	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	CDA4	3DD.003D91CA0A	2020-05-08 08:25:00	1	1	0	0	0	0	
Coho	Unknown	CE47	3DD.003D5C2B1B	2020-04-24 10:40:00	1	1	1	1	1	1	2020-06-04 16:39:55
Chinook	Spring	CE56	3DD.003D5C2D01	2020-04-03 10:30:00	0	0	0	0	0	0	
Chinook	Spring	CE5C	3DD.003D5C2252	2020-04-16 09:05:00	1	1	1	0	1	0	
Chinook	Spring	CEAE	3DD.003D91CA2D	2020-05-08 08:25:00	1	1	0	0	0	0	
Chinook	Spring	D06B	3DD.003D5C225D	2020-04-16 09:05:00	1	1	0	0	0	0	
Coho	Unknown	D090	3DD.003D59C8D8	2020-05-22 09:30:00	1	1	0	0	0	0	
Coho	Unknown	D0AE	3DD.003D59C8FA	2020-05-22 09:30:00	1	1	1	1	1	1	2020-06-24 16:05:17

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Coho	Unknown	D1E4	3DD.003D5C2262	2020-04-16 09:05:00	1	1	0	0	0	0	
Chinook	Spring	D2C5	3DD.003D5C2D12	2020-04-03 10:30:00	0	0	0	0	0	0	
Coho	Unknown	D323	3DD.003D91CC53	2020-04-30 10:30:00	1	1	1	1	1	1	2020-06-12 11:23:23
Steelhead	Winter	D384	3DD.003D91E799	2020-05-28 10:30:00	1	1	0	0	0	0	
Coho	Unknown	D3AA	3DD.003D91CA46	2020-05-12 09:37:00	0	0	0	0	0	0	
Coho	Unknown	D3D0	3DD.003D5C2B37	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	D4EC	3DD.003D91CA25	2020-05-08 08:25:00	0	0	0	0	0	0	
Chinook	Spring	D4F4	3DD.003D5C1B96	2020-03-19 11:45:00	1	1	0	0	0	1	2020-04-28 21:52:34
Steelhead	Winter	D5B1	3DD.003D91E779	2020-05-28 10:30:00	1	0	0	0	0	0	
Coho	Unknown	D5D7	3DD.003D91CA1C	2020-05-12 09:43:18	0	0	0	0	0	0	
Chinook	Spring	D626	3DD.003D5C2CF7	2020-03-27 08:10:00	0	0	0	0	0	0	
Chinook	Spring	D70D	3DD.003D5C2CE8	2020-03-27 08:10:00	1	1	0	0	0	0	
Steelhead	Winter	D729	3DD.003D91E761	2020-05-28 10:30:00	1	1	1	0	1	0	
Steelhead	Winter	D753	3DD.003D91CC8F	2020-04-30 10:30:00	1	1	1	0	1	0	
Coho	Unknown	D7BC	3DD.003D59C91F	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	D7F9	3DD.003D5C229F	2020-04-16 09:05:00	0	0	0	0	0	0	
Steelhead	Winter	D86E	3DD.003D91CA10	2020-05-08 08:25:00	1	1	0	0	0	0	
Chinook	Spring	D8D9	3DD.003D5C2259	2020-04-10 10:50:00	1	1	0	0	0	0	
Steelhead	Winter	D8F0	3DD.003D5C22A9	2020-04-16 09:05:00	1	1	1	0	1	1	2020-05-16 02:19:22
Chinook	Spring	D9CF	3DD.003D5C2B31	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	DA1B	3DD.003D91CA17	2020-05-12 09:47:29	1	1	0	0	0	1	2020-05-22 00:59:48
Chinook	Spring	DAA4	3DD.003D5C2CDD	2020-03-27 08:10:00	1	1	1	1	1	1	2020-04-22 02:33:21
Steelhead	Winter	DAF6	3DD.003D91CA0B	2020-05-08 08:25:00	1	1	0	0	0	0	
Coho	Unknown	DBF2	3DD.003D91CC88	2020-04-30 10:30:00	1	1	1	1	1	1	2020-06-01 03:59:56
Steelhead	Winter	DC50	3DD.003D91E790	2020-05-28 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	DC72	3DD.003D91E758	2020-05-28 10:30:00	1	1	0	0	0	0	
Chinook	Spring	DD67	3DD.003D5C2CFB	2020-04-03 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	DD93	3DD.003D91CC5D	2020-04-30 10:30:00	1	1	0	0	0	0	
Steelhead	Winter	DDB7	3DD.003D5C2B02	2020-04-24 10:40:00	1	1	1	0	1	1	2020-04-28 01:15:28
Chinook	Spring	DE36	3DD.003D5C229A	2020-04-16 09:05:00	0	0	0	0	0	0	
Chinook	Spring	DE4B	3DD.003D5C228D	2020-04-10 10:50:00	0	0	0	0	0	0	
Coho	Unknown	DE85	3DD.003D91CC76	2020-04-30 10:30:00	1	0	0	0	0	1	2020-05-03 21:41:01
Chinook	Spring	DF23	3DD.003D5C2CF6	2020-03-27 08:10:00	1	1	0	0	0	1	2020-06-10 23:14:04
Chinook	Spring	DFAB	3DD.003D5C225F	2020-04-16 09:05:00	1	1	0	1	1	0	
Chinook	Spring	E097	3DD.003D5C2CE4	2020-03-27 08:10:00	1	1	0	0	0	1	2020-04-11 00:52:10
Steelhead	Winter	E0C0	3DD.003D91CA54	2020-05-08 08:25:00	1	1	1	1	1	1	2020-05-31 02:01:46
Chinook	Spring	E1C9	3DD.003D5C22AC	2020-04-16 09:05:00	1	0	0	0	0	0	
Steelhead	Winter	E1EB	3DD.003D91CA06	2020-05-08 08:25:00	1	1	1	0	1	1	2020-05-15 23:51:25

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Coho	Unknown	E1F1	3DD.003D59C91E	2020-05-22 09:30:00	1	0	0	0	0	0	
Coho	Unknown	E2BF	3DD.003D59C8DD	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	E2CD	3DD.003D5C1B6B	2020-03-19 11:45:00	0	0	0	0	0	0	
Chinook	Spring	E2F7	3DD.003D5C1B55	2020-03-19 11:45:00	1	1	0	0	0	0	
Steelhead	Winter	E383	3DD.003D91E79C	2020-05-28 10:30:00	1	1	0	0	0	0	
Chinook	Spring	E398	3DD.003D91CA04	2020-05-08 08:25:00	0	0	0	0	0	0	
Coho	Unknown	E3C0	3DD.003D91CEC9	2020-05-12 09:59:37	1	1	0	1	1	1	2020-05-30 00:51:54
Coho	Unknown	E3F6	3DD.003D5C2B16	2020-04-24 10:40:00	0	0	0	0	0	0	
Coho	Unknown	E47B	3DD.003D91C9F6	2020-05-12 09:47:00	0	0	0	0	0	0	
Coho	Unknown	E4EA	3DD.003D91CA26	2020-05-08 08:25:00	1	1	1	1	1	0	
Coho	Unknown	E5E9	3DD.003D59C8F9	2020-05-22 09:30:00	0	0	0	0	0	0	
Steelhead	Winter	E852	3DD.003D91CA18	2020-05-08 08:25:00	1	1	0	1	1	1	2020-05-19 09:24:56
Coho	Unknown	E952	3DD.003D59C928	2020-05-22 09:30:00	0	0	0	0	0	0	
Chinook	Spring	EBD2	3DD.003D5C2269	2020-04-16 09:05:00	1	1	0	0	0	0	
Steelhead	Winter	ECBC	3DD.003D91CA11	2020-05-08 08:25:00	1	1	0	0	0	0	
Chinook	Spring	ECF7	3DD.003D5C1B9E	2020-03-19 11:45:00	1	1	1	1	1	0	
Chinook	Spring	ED18	3DD.003D5C2273	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	ED83	3DD.003D5C2274	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	EE83	3DD.003D5C1B97	2020-03-19 11:45:00	0	0	0	0	0	1	2020-06-13 01:14:25
Chinook	Spring	EE9C	3DD.003D5C2D16	2020-04-03 10:30:00	0	0	0	0	0	0	
Coho	Unknown	EF06	3DD.003D91CA30	2020-05-12 09:42:30	1	1	1	1	1	1	2020-06-03 14:58:13
Coho	Unknown	F084	3DD.003D59C900	2020-05-22 09:30:00	1	1	1	1	1	0	
Chinook	Spring	F35C	3DD.003D5C2B0F	2020-04-24 10:40:00	0	0	0	0	0	0	
Chinook	Spring	F367	3DD.003D5C22A1	2020-04-10 10:50:00	1	1	0	0	0	0	
Steelhead	Winter	F3CD	3DD.003D5C2B3C	2020-04-24 10:40:00	1	1	1	1	1	0	
Chinook	Spring	F3D7	3DD.003D5C224F	2020-04-10 10:50:00	0	0	0	0	0	0	
Chinook	Spring	F3E2	3DD.003D5C2284	2020-04-16 09:05:00	1	1	0	0	0	0	
Steelhead	Winter	F414	3DD.003D91E7A1	2020-05-28 10:30:00	0	0	0	0	0	0	
Coho	Unknown	F41E	3DD.003D5C2B29	2020-04-24 10:40:00	1	1	1	1	1	1	2020-06-20 15:03:03
Steelhead	Winter	F434	3DD.003D91CC59	2020-04-30 10:30:00	1	1	0	0	0	1	2020-06-03 00:50:33
Chinook	Spring	F516	3DD.003D5C22A7	2020-04-16 09:05:00	1	1	0	0	0	0	
Coho	Unknown	F520	3DD.003D91CCAD	2020-04-30 10:30:00	1	0	0	0	0	0	
Chinook	Spring	F53E	3DD.003D5C2291	2020-04-10 10:50:00	1	1	0	0	0	0	
Steelhead	Winter	F566	3DD.003D5C2AFB	2020-04-24 10:40:00	1	1	1	1	1	1	2020-05-02 13:47:13
Chinook	Spring	F5A4	3DD.003D5C2255	2020-04-16 09:05:00	1	1	0	0	0	1	2020-04-16 20:46:56
Coho	Unknown	F6A1	3DD.003D91CA15	2020-05-08 08:25:00	1	1	1	1	1	0	
Steelhead	Winter	F753	3DD.003D91E777	2020-05-28 10:30:00	0	0	0	0	0	0	
Steelhead	Winter	F784	3DD.003D5C224D	2020-04-16 09:05:00	1	1	1	1	1	0	

Species	Run	Acoustic Tag	PIT Tag	Release Date-Time	ZOI	NTS	CCHP	CCHS	CCH	Collected	Collection Date-Time
Coho	Unknown	F807	3DD.003D91CA38	2020-05-12 09:49:24	1	1	1	1	1	0	
Chinook	Spring	F8A6	3DD.003D5C2D15	2020-03-27 08:10:00	1	1	0	0	0	0	
Steelhead	Winter	--	3DD.003D91CC93	2020-04-28 17:36:00	1	1	0	0	0	0	
Coho	Unknown	--	3DD.003D91CC8C	2020-04-28 17:36:00	0	0	0	0	0	0	
Coho	Unknown	--	3DD.003D91CC65	2020-04-28 17:36:00	0	0	0	0	0	0	

APPENDIX C Delayed Migrants from 2019

Passive integrated transponder-tag detections for 41 study fish from 2019 that displayed evidence of delayed migration are provided below. Individuals considered are those that were included in computation of performance metrics for the 2019 study and were subsequently detected on the Swift FSC antenna, the Woodland Release Pond antenna, or hand-wanded within the FSC between 22 July 2019 and 15 October 2020.

Appendix Table C.1. Passive integrated transponder (PIT)-tag detection summaries for 2019 study fish exhibiting delayed migration.

Species	Acoustic Tag	PIT Tag	Release Date-Time	Collection Date-Time
Coho	041D	3DD.003D5C1CF9	2019-05-22 11:30:00	2020-05-15 08:32:03
Coho	04D7	3DD.003D5C1D0C	2019-05-22 11:30:00	2020-04-20 01:20:55
Coho	126D	3DD.003D59C8B5	2019-05-21 11:00:00	2020-04-02 18:47:29
Coho	16AD	3DD.003D59C87B	2019-05-21 11:00:00	2020-04-10 13:37:36
Coho	1814	3DD.003D5C21C6	2019-05-17 13:30:00	2020-05-15 17:03:20
Steelhead	22B3	3DD.003D59C6F6	2019-05-30 12:00:00	2020-04-24 01:33:16
Chinook	23C1	3DD.003D5C1FD5	2019-03-26 11:31:08	2020-04-12 03:02:46
Chinook	28CA	3DD.003D5C2AA6	2019-06-26 09:04:53	2020-03-22 18:43:05
Coho	28E6	3DD.003D5C1D33	2019-05-22 11:30:00	2020-04-21 04:14:30
Coho	333F	3DD.003D5C1CE2	2019-05-22 11:30:00	2020-10-09 07:41:43
Coho	4E7E	3DD.003D59C89D	2019-05-21 11:00:00	2019-10-20 21:37:01
Coho	512D	3DD.003D5C1D19	2019-05-22 11:30:00	2020-05-18 07:02:53
Coho	6115	3DD.003D5C1D35	2019-05-22 11:30:00	2020-05-31 08:50:52
Coho	6D88	3DD.003D5C1D1C	2019-05-22 11:30:00	2020-05-18 22:20:29
Coho	7B18	3DD.003D5C21E3	2019-05-17 13:30:00	2020-09-21 07:40:13
Chinook	7BCD	3DD.003D5C29EE	2019-04-10 13:00:00	2020-03-30 19:26:10
Chinook	8386	3DD.003D5C2AAD	2019-06-26 09:04:17	2020-04-20 04:08:01
Chinook	857A	3DD.003D5C2A11	2019-04-10 13:00:00	2019-10-21 06:04:33
Chinook	85A6	3DD.003D5C2ACF	2019-06-26 09:03:49	2019-10-22 05:29:59
Coho	86C6	3DD.003D5C2C64	2019-05-15 11:00:00	2020-05-23 16:28:24
Chinook	8CC6	3DD.003D5C27B9	2019-05-09 12:00:00	2020-04-12 04:07:37
Steelhead	8E49	3DD.003D59CC90	2019-05-09 12:00:00	2020-04-20 13:56:10
Coho	8EB1	3DD.003D5C2C6E	2019-05-15 11:00:00	2020-05-17 13:16:08
Steelhead	9335	3DD.003D59CC78	2019-05-01 13:00:00	2020-04-09 21:16:18
Coho	A2BC	3DD.003D59CCB1	2019-05-09 12:00:00	2020-10-14 10:29:01
Chinook	A4C7	3DD.003D5C29EA	2019-04-19 09:30:00	2019-10-29 06:31:18
Coho	AFE6	3DD.003D5C2C25	2019-05-15 11:00:00	2020-05-01 10:11:12
Coho	BA42	3DD.003D5C2C49	2019-05-15 11:00:00	2020-05-27 11:40:47
Coho	BA5C	3DD.003D5C2C27	2019-05-15 11:00:00	2020-05-14 10:41:40
Steelhead	BC27	3DD.003D5C2C52	2019-05-15 11:00:00	2020-04-06 00:28:53
Coho	C691	3DD.003D5C29E6	2019-04-19 09:30:00	2020-04-14 16:10:47
Coho	D0AE	3DD.003D5C27A8	2019-05-09 12:00:00	2020-05-24 18:47:50
Coho	D101	3DD.003D5C2C42	2019-05-15 11:00:00	2020-05-14 12:42:20
Coho	D729	3DD.003D5C23E8	2019-05-15 11:00:00	2019-10-21 22:56:35
Steelhead	DAA4	3DD.003D59CCAB	2019-05-01 13:00:00	2020-04-25 14:56:11
Coho	DF25	3DD.003D5C2430	2019-05-15 11:00:00	2020-05-01 08:24:35
Chinook	E1EB	3DD.003D59CCA8	2019-05-01 13:00:00	2019-11-07 04:05:37
Chinook	E852	3DD.003D59CC8E	2019-04-19 09:30:00	2019-11-05 01:15:32
Chinook	F3CD	3DD.003BC96385	2019-04-02 00:13:00	2019-10-17 23:48:26
Coho	F516	3DD.003D5C2194	2019-05-17 13:30:00	2020-06-01 01:39:43
Chinook	F53E	3DD.003D5C2C44	2019-05-15 11:00:00	2020-03-05 10:33:40

APPENDIX D Summary of Previous and Current Results

Appendix Table D.1. Summary of results from Swift floating surface collector collection efficiency studies conducted between 2013 and 2020.

Study Attributes						Detection Numbers (Total)			Detection Estimates (Total)[1]			
Year	Study Type	Capture Location	Release Location	Species	Release Numbers	Detected Forebay	Detected ZOI	Captured at FSC	P_{ZOI} Estimate	P_{ENT} Estimate	P_{RET} Estimate	P_{CE} Estimate
2013	Radio Telemetry	FSC	<3.1 miles east of FSC	Chinook Salmon	58	NA	46	0	79%	NA	NA	0%
				Coho Salmon	82	NA	44	6	54%	NA	NA	6%
				Steelhead	NA	NA	NA	NA	NA	NA	NA	NA
2014	Radio Telemetry	FSC	2 miles east of FSC	Chinook Salmon	20	NA	3	0	15%	NA	NA	0%
				Coho Salmon	157	NA	31	9	20%	NA	NA	29%
				Steelhead	16	NA	4	1	25%	NA	NA	25%
2015	Dual PIT/ Acoustic Telemetry	Eagle Cliff Rotary Screw Trap/Hook and Line	Swift Forest Camp Boat Launch	Chinook Salmon	14	9	6	0	28%	NA	NA	0%
				Coho Salmon	139	126	110	13	72%	NA	NA	12%
				Steelhead	47	43	43	8	84%	NA	NA	19%
2016	Dual PIT/ Acoustic Telemetry	FSC and Eagle Cliff Rotary Screw Trap	Swift Forest Camp Boat Launch	Chinook Salmon	3	1	1	0	11%	NA	NA	0%
				Coho Salmon	156	140	98	30	56%	NA	NA	31%
				Steelhead	40	28	17	4	30%	NA	NA	24%
2017	Dual PIT/ Acoustic Telemetry	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	108	75	62	7	57%	47%	24 %	11%
				Coho Salmon	232	184	164	46	74%	65%	41%	27%
				Steelhead	180	117	107	21	59%	48.6	40%	20%
2018	PIT	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	396	--	--	94	--	NA	NA	24%[2]
				Coho Salmon	484	--	--	191	--	NA	NA	40%[2]
				Steelhead	278	--	--	136	--	NA	NA	49%[2]
2019	Dual PIT/Acoustic Telemetry	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	155	88	75	42	54%	78%	65%	51%
				Coho Salmon	300	175	167	156	82%	98%	65%	64%
				Steelhead	70	40	37	11	58%	97%	28%	27%
2020	Dual PIT/Acoustic Telemetry	FSC	Swift Forest Camp Boat Launch	Chinook Salmon	183	--	104	47	58%	95%	47%	44%
				Coho Salmon	185	--	112	45	62%	95%	42%	39%
				Steelhead	153	--	110	47	73%	99%	42%	42%

Notes:

Source: Courter et al. 2013; Stroud et al. 2014; Reynolds et al. 2015; Caldwell et al. 2017; Anchor QEA 2018; PacifiCorp and Cowlitz County PUD 2019; Four Peaks 2020

1. For 2013 through 2017, seasonal performance metrics have been corrected for array detection efficiency.
2. In 2018, survival probability through reservoir (SRES) was used as a surrogate for collection efficiency.

-- = not calculated

NA = not applicable

APPENDIX D

SPAWN TIMING, DISTRIBUTION AND ABUNDANCE OF TRANSPORTED FISHES – 2020 FINAL REPORT

Environmental Sciences
Regulatory Planning
Project Management

Memorandum

To: Erik Lesko, PacifiCorp, Chris Karchesky, PacifiCorp

From: Jason Shappart, Senior Fisheries Scientist

Date: Draft – February 28, 2021

Re: NF Lewis River upstream of Swift Dam – 2020 Salmon Spawning Survey Results

Introduction

Coho Salmon spawning surveys were conducted from October 1, 2020 through December 31, 2020 by Meridian Environmental, Inc. (Meridian) through contract with PacifiCorp. Per Objective 15 of the Monitoring and Evaluation Plan (PacifiCorp and Cowlitz PUD 2017), surveys were conducted to provide the basis for estimating the spawner abundance, timing, and distribution of transported adult anadromous fish in the North Fork (NF) Lewis River upstream of Swift Dam. Due to the low number of adult female spring Chinook transported upstream in 2020, spawning surveys specifically for spring Chinook in September were not included in PacifiCorp's 2020 authorized scope of work. However, observations of spring Chinook made during the Coho spawning surveys are reported.

The original spawning survey sample design was developed in 2012. All known stream habitat potentially accessible to transported anadromous fish upstream of Swift Dam was divided into discrete approximately 0.3-mile-long reaches, and approximately 33 percent of all available reaches were drawn into three randomly-stratified yearly survey panels. The year-1 panel of survey reaches was visited for the first time in 2012, year-2 panel in 2013, and year-3 panel in 2014. In 2020, the year-3 panel received its third visit since first being surveyed in 2014 and resurveyed in 2017. This memorandum summarizes salmon spawning survey results for the year-3 panel conducted from October 1, 2020 to December 31, 2020. The 2014 and 2017 results are also provided and discussed, where possible, to illustrate potential changes in transported anadromous fish spawn timing, distribution and abundance over time.

Survey Conditions

The USGS North Fork Lewis River above Muddy River gage[1] approximates general flow patterns relative to median conditions throughout the NF Lewis River basin during the survey season (Figure 1). Daily mean flows in 2020 were generally below daily median flows from September through December. However, notable spikes occurred in mid-October, November, and late-December. Flows over about 1,000 cfs (Lewis River above Muddy River gage) are considered unsafe for conducting spawning surveys via kayak on the upper NF Lewis River mainstem and visibility is also generally greatly reduced. Flows were generally well below 1,000 cfs during the survey season, which allowed for several kayak surveys to be conducted. Flows over about 600 cfs generally limit surveys by foot

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[1] https://waterdata.usgs.gov/nwis/uv?site_no=14216000

(due to deep and swift wading conditions) in the Muddy River watershed, which occurred during most of November 2020. In addition, seasonally locked gates limit access to the upper Muddy River watershed beginning in early-November. Small tributary streams within the year-3 panel (surveyed in 2020) were either totally dry or too low to allow upstream migration of spawning salmon until the second half of October, including reservoir tributaries such as S15, S20, Range, and Drift creeks, and many of the small tributaries throughout the upper basin (Pepper, Spencer, M1, M2, P1, and P10 creeks). Many of these streams returned to low flows after the mid-October storm event, until flows rose again in early-November.

Flow patterns in 2017 were similar to those in 2020; however, baseflows were somewhat higher than in 2020 and flow spikes were substantially larger in 2017 (spikes up to 10,000 cfs) compared to 2020 (spikes generally below 2,000 cfs), see Figure 1. The low level of Swift Reservoir limited launching a boat to conduct reservoir tributary surveys during November and December of 2017. Mechanical problems with PacifiCorp's boat also limited reservoir tributary surveys in 2017. Meridian did not conduct surveys in 2014 (surveys were conducted by WDFW and PacifiCorp). However, flows were substantially lower than median daily stream flow conditions from September through mid-October, which likely hindered fish access to small streams (similar to 2020). However, flows after October 31 rose and remained generally well above 1,000 cfs through December 2014, which likely substantially hindered survey access and visibility compared to 2020 conditions. Overall, flows in 2020 were substantially lower and flow spikes were very minor compared to 2017 and 2014, which likely resulted in much higher redd detection probability in 2020.

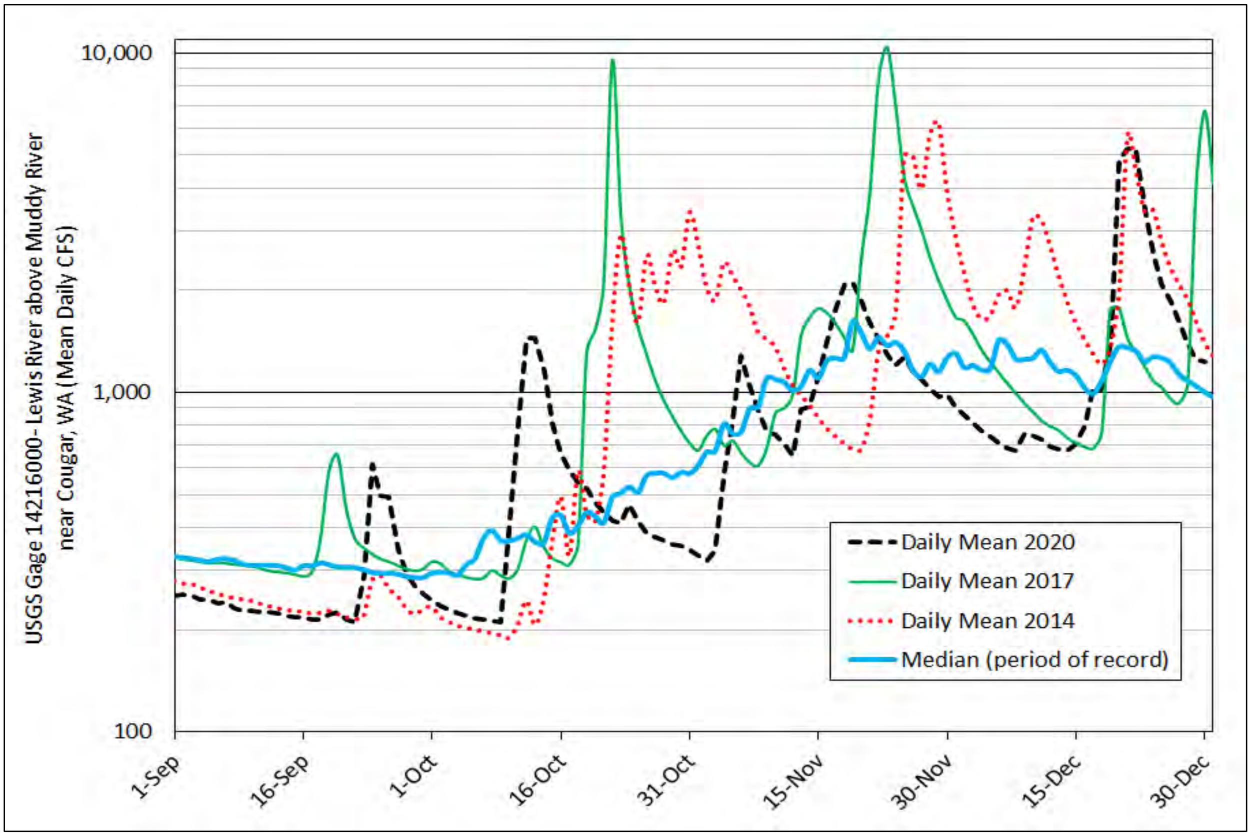

Figure 1. USGS North Fork Lewis River above Muddy River Gage mean daily flow (cfs) September through December (2020, 2017, 2014).

Methods

Field survey methods followed those described in the revised monitoring and evaluation plan (PacifiCorp and Cowlitz PUD 2017) with no deviations. Note that in 2020 all surveys were conducted by Meridian biologists. In 2017, surveys were conducted by the same Meridian biologist crew as well as PacifiCorp biologists. In 2014 the mainstem NF Lewis River mainstem was surveyed by PacifiCorp biologists, but all other surveys were conducted by Washington Department of Fish and Wildlife crews.

Results

Spring Chinook and Coho Transported Upstream

A total of 56 adult female Chinook were transported upstream to spawn through December 31, 2020. All of the spring Chinook were transported upstream by the end of July 2020. A total of 430 adult female spring Chinook were transported upstream to spawn during 2017. Due to low returns, no spring Chinook were transported upstream during the 2014 spawning season.

A total of 4,909 adult female Coho were transported upstream to spawn through December 31, 2020, and of these 4,865 could have potentially been observed during the survey period (i.e., transported upstream prior to the last survey). A total of 3,281 (2017) and 4,217 (2014) adult female Coho were available for observation during the survey time period of each year. Most of the adult female Coho transported upstream in 2020 were early-Coho (86 percent) and nearly 80 percent were transported by mid-October. In 2017, only 53 percent were early-Coho and less than 50 percent of all Coho were transported upstream by mid-October (Figure 2). Only early-Coho were transported upstream in 2014 and all were transported upstream by mid-October (Figure 2).

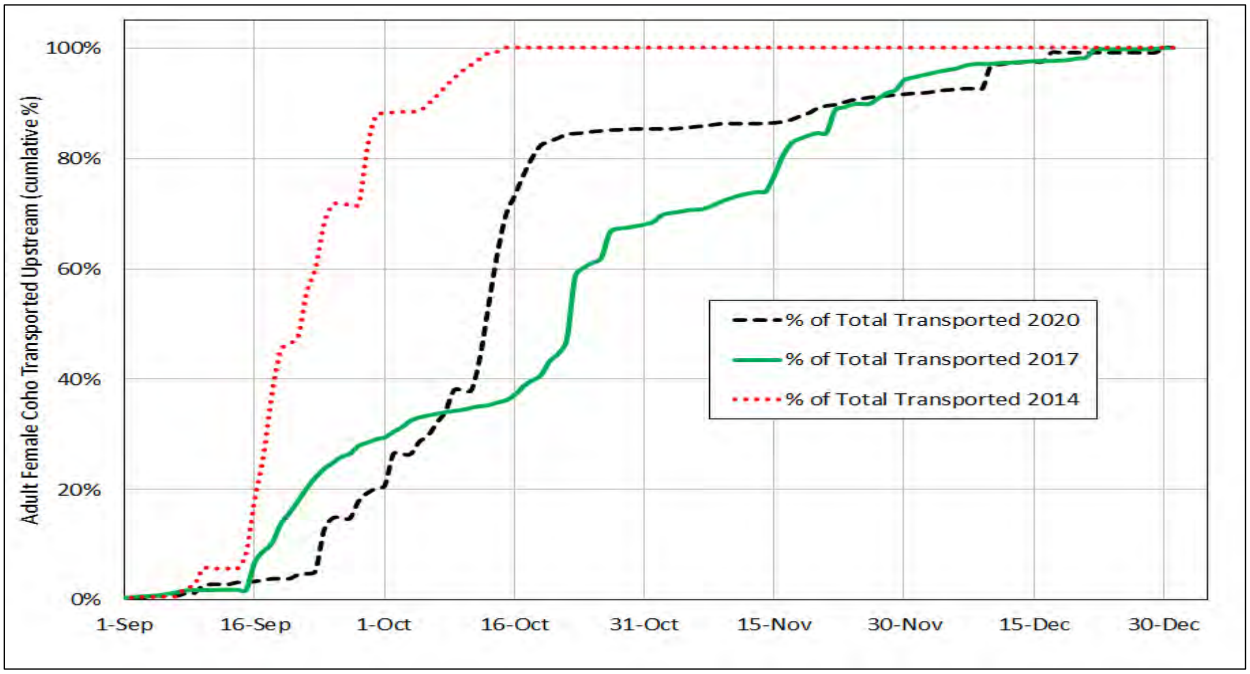

Figure 2. Percent of total adult female Coho transported upstream per day through December 31 each year (2020, 2017, 2014).

Spring Chinook Observations

The entire mainstem of Pine Creek and approximately the lower 1.5 miles of P8 Creek (tributary to Pine Creek) were surveyed by foot every week from September through October 2020 for Bull Trout spawning surveys. No spring Chinook or potential spring Chinook redds were observed in Pine Creek during this time period. This is consistent with all prior years' results. No spring Chinook or potential Chinook redds have been observed in Pine Creek during any of the prior spawning survey years when spring Chinook have been transported upstream of Swift Dam. Rush Creek was also surveyed weekly in September and October of 2020 for Bull Trout surveys and no spring Chinook were observed. One female spring Chinook spawned-out carcass was observed in the NF Lewis River mainstem on October 10, 2020 in a deep bedrock pool just below Curly Creek bridge. No potential spring Chinook redds were identified during the October through December 2020 Coho spawning surveys. Due to the low number of adult Chinook transported upstream in 2020 and the lack of specific Spring Chinook spawning surveys, no further comparison to 2017 spring Chinook spawning survey results is possible.

Coho Redd Counts

A total of 791 Coho redds were counted during the 2020 survey season within the year-3 panel of survey reaches (Table 2), of which 28 (3.5 percent) were determined to be new redds superimposed on redds previously counted. Most redds (84 percent) were counted in the NF Lewis River and Muddy River watersheds, and nearly the same number of redds were counted within each watershed (Table 2). The NF Lewis River mainstem, Clear Creek, and the Muddy River mainstem had particularly high Coho redd counts (Table 2). Drift Creek (Swift Reservoir tributary) also had a relatively high total Coho redd count (Table 2). In some smaller streams, such as Spencer Creek, all potential spawning gravel patches within the survey reach contained at least one redd. Only 4 redds were counted in the Pine Creek watershed, all in P8 Creek, within the year-3 panel of survey reaches (Table 2). However, while conducting Bull Trout spawning surveys in October, 48 Coho redds were observed in the lower half of the mainstem of Pine Creek (outside the year-3 survey panel), which are not included in Table 2 (see discussion section for further details).

A total of 140 Coho redds were counted during the 2017 survey season, and 74 percent were counted within the NF Lewis River and Muddy River watersheds. Similar to 2020, the NF Lewis River mainstem, Clear Creek, and the Muddy River mainstem had the highest Coho redd counts in 2017, and relatively few redds (5 total) were counted in the Pine Creek watershed (Table 2).

A total of 282 Coho redds were counted during the 2014 survey season, the highest annual count prior to the 2020 survey, and 81 percent were counted within the NF Lewis River and Muddy River watersheds. However, more redds were counted in Swift Reservoir tributaries than the Muddy River watershed in 2014 (Table 2). A total of 67 percent of all Coho redds were counted in the NF Lewis River mainstem, and the remainder were more evenly distributed throughout several streams such as Clear Creek, the Muddy River mainstem, Little Creek, Drift Creek and S15 Creek. Similar to 2020 and 2017, relatively few Coho redds (3 total) were counted in the Pine Creek watershed in 2014.

Though total redd counts differ between years, the overall distribution and number of occupied reaches was similar; 51 percent (2020), 44 percent (2017), and 49 percent (2014) of surveyed reaches were occupied by live or dead Coho, or Coho redds (Table 2).

Table 2. Coho spawning survey summary results (year-3 survey panel; 2020, 2017, 2014).

	2020 Coho Surveys								2017 Coho Surveys				2014 Coho Surveys				
	# Reaches in Panel	% Reaches Surveyed Total	% Reaches Surveyed Oct	% Reaches Surveyed Nov	% Reaches Surveyed Dec	# of Redds	# Coho (live + dead)	% Surveyed Reaches Occupied[d]	% Reaches Surveyed	# of Redds	# Coho (live + dead)	% Surveyed Reaches Occupied[d]	# Reaches in Panel	% Reaches Surveyed Total	# of Redds	# Coho (live + dead)	% Surveyed Reaches Occupied[d]
Muddy River Watershed	39	79%	79%	26%	33%	332	160	45%	79%	35	36	31%	37	84%	41	110	48%
Clear Creek[a,e]	13	46%	46%	46%	46%	181	122	100%	46%	20	28	83%	13	62%	20	40	100%
Clearwater Creek[e,f]	5	80%	80%	0%	0%	13	12	25%	80%	3	1	40%	5	80%	4	8	50%
Muddy River Mainstem[e]	12	100%	100%	33%	50%	138	24	50%	100%	12	7	25%	12	100%	17	62	50%
Smith Creek[e]	7	100%	100%	0%	0%	0	2	14%	100%	0	0	0%	7	100%	0	0	0%
M1 Creek[e]	1	100%	100%	0%	0%	0	0	0%	100%	0	0	0%	added in 2016				
M2 Creek	1	100%	100%	0%	100%	0	0	0%	100%	0	0	0%	added in 2016				
NF Lewis Watershed	21	90%	90%	90%	90%	333	443	95%	95%	68	266	79%	20	95%	188	103	79%
Big Creek[c]	1	0%	0%	0%	0%	0	0	0%	0%	0	0	0%	1	0%	0	0	0%
Little Creek	1	100%	100%	100%	100%	33	16	100%	100%	4	18	100%	1	100%	20	61	100%
Pepper Creek	1	100%	100%	100%	100%	0	0	0%	100%	0	0	0%	added in 2016				
Rush Creek	2	50%	50%	50%	50%	1	0	100%	100%	6	1	100%	2	100%	3	3	50%
Spencer Creek	1	100%	100%	100%	100%	20	10	100%	100%	3	2	100%	1	100%	5	8	100%
NF Lewis River Mainstem	15	100%	100%	100%	100%	279	417	100%	100%	55	245	80%	15	100%	160	31[b]	80%
Pine Creek Watershed	17	100%	100%	53%	82%	4	0	6%	100%	5	2	19%	17	100%	3	0	6%
P1 Creek	2	100%	100%	0%	100%	0	0	0%	100%	0	0	0%	2	100%	0	0	0%
P8 Creek[e]	5	100%	100%	100%	40%	4	0	20%	100%	1	0	20%	5	100%	3	0	20%
P10 Creek	1	100%	100%	100%	100%	0	0	0%	100%	3	0	100%	1	100%	0	0	0%
Pine Creek Mainstem	9	100%	100%	33%	100%	0	0	0%	100%	1	2	13%	9	100%	0	0	0%
Swift Reservoir Watershed	7	100%	100%	71%	71%	122	71	71%	57%	32	48	80%	6	83%	50	159	80%
Drift Creek	3	100%	100%	100%	100%	108	29	100%	67%	20	25	100%	3	100%	27	96	67%
Range Creek	1	100%	100%	0%	0%	0	5	100%	0%	0	0	0%	1	100%	6	14	100%
S15 Creek	2	100%	100%	50%	50%	14	37	50%	50%	9	8	100%	2	50%	17	49	100%
S20 Creek	1	100%	100%	100%	100%	0	0	0%	100%	3	15	100%	added in 2016				
Grand Total	84	88%	88%	51%	61%	791	674	51%	86%	140	352	44%	80	90%	282	372	49%

[a] Seven of thirteen reaches were not accessible by foot due to steep inaccessible canyon slopes in all survey years.

[b] Coho carcasses only; live Coho were not reported by the PacifiCorp survey crew for the NF Lewis River mainstem surveys.

[c] Not logistically feasible to access by foot.

[d] A reach was determined to be occupied if a live Coho, Coho carcass, or Coho redd was counted within the reach.

[e] Seasonally closed roads and snow limit access to reaches in November and December in all survey years.

[f] The most upstream reach is not logistically feasible to survey in one day.

Spawn Timing

New Coho redds were observed on the first survey on October 1, 2020 (Table 3) in Clear Creek, and by October 8 many redds were counted in the NF Lewis River mainstem. The last new redds counted were in the NF Lewis River mainstem on December 29, 2020 (Table 3). The survey data suggests that Coho began spawning sometime before October 1 and continued spawning through December 2020 and likely into January 2021. In 2020, 85 percent of female Coho were transported upstream and 80 percent of the total redds were counted by November 3 (Figure 3). Spawn timing during 2020 was similar to that observed during 2017 when both early- and late-Coho were transported upstream in both years (Table 3). However, in 2017, 90 percent of all redds were counted by November 7 although only 71 percent of female Coho had been transported upstream. Note that in 2014 spawn timing was not observed to extend into December, though little survey effort was expended in December and only early-Coho were transported upstream (Figure 5).

Table 3. Key spawn timing observations (2020, 2017, 2014).

Coho Spawn Timing Parameter	2020	2017	2014
1st new redd observed	Oct 1	Oct 11	Oct 6
1st occupied redd observed	Oct 8	Oct 14	Unknown[a]
1st carcass observed	Oct 16	Oct 14	Oct 13
Last carcass observed	Dec 29	Dec 20	Nov 24
Last new redd observed	Dec 29	Dec 21[b]	Nov 20[c]

[a] The WDFW and PacifiCorp data summary is insufficient to determine for 2014

[b] High flows limited surveys the last week of December in 2017.

[c] Very limited survey effort occurred after Nov 22 and no surveys were conducted after Dec 6 in 2014.

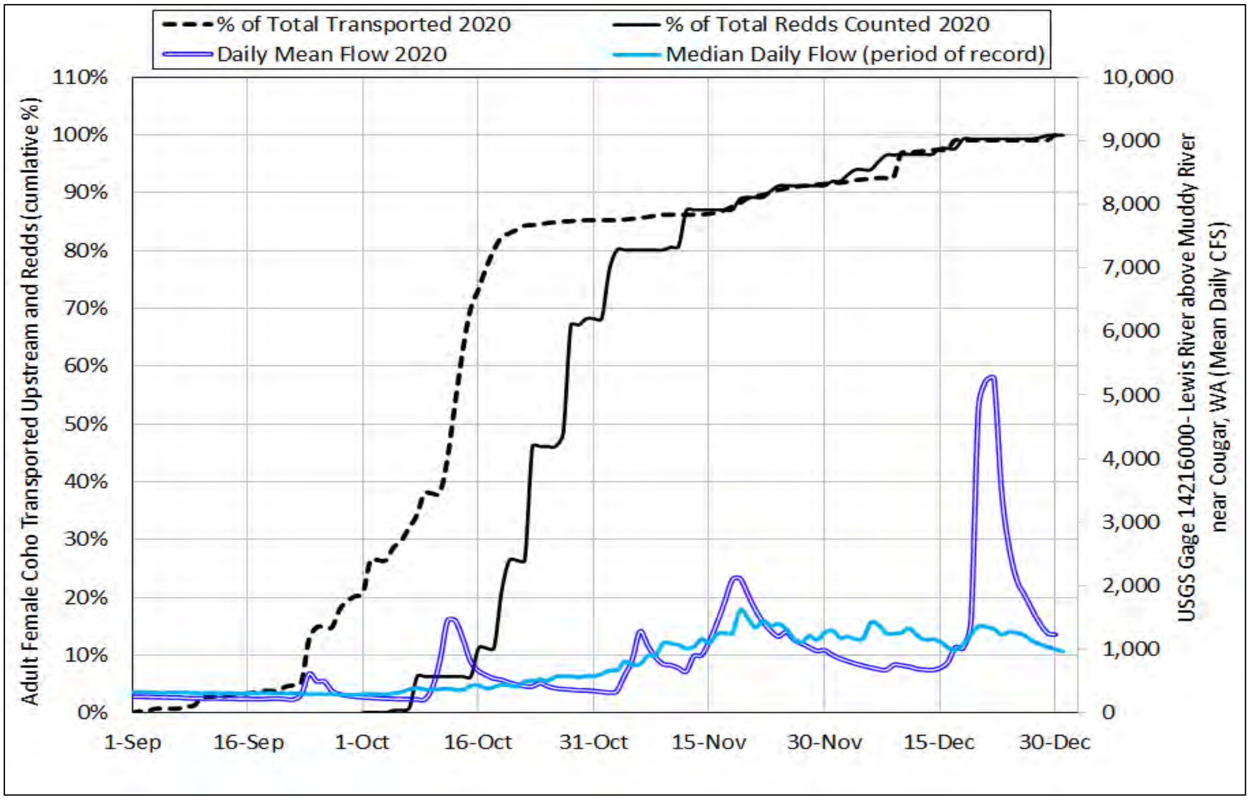

Figure 3. Coho redd count vs. adult female Coho transport timing vs flow (2020).

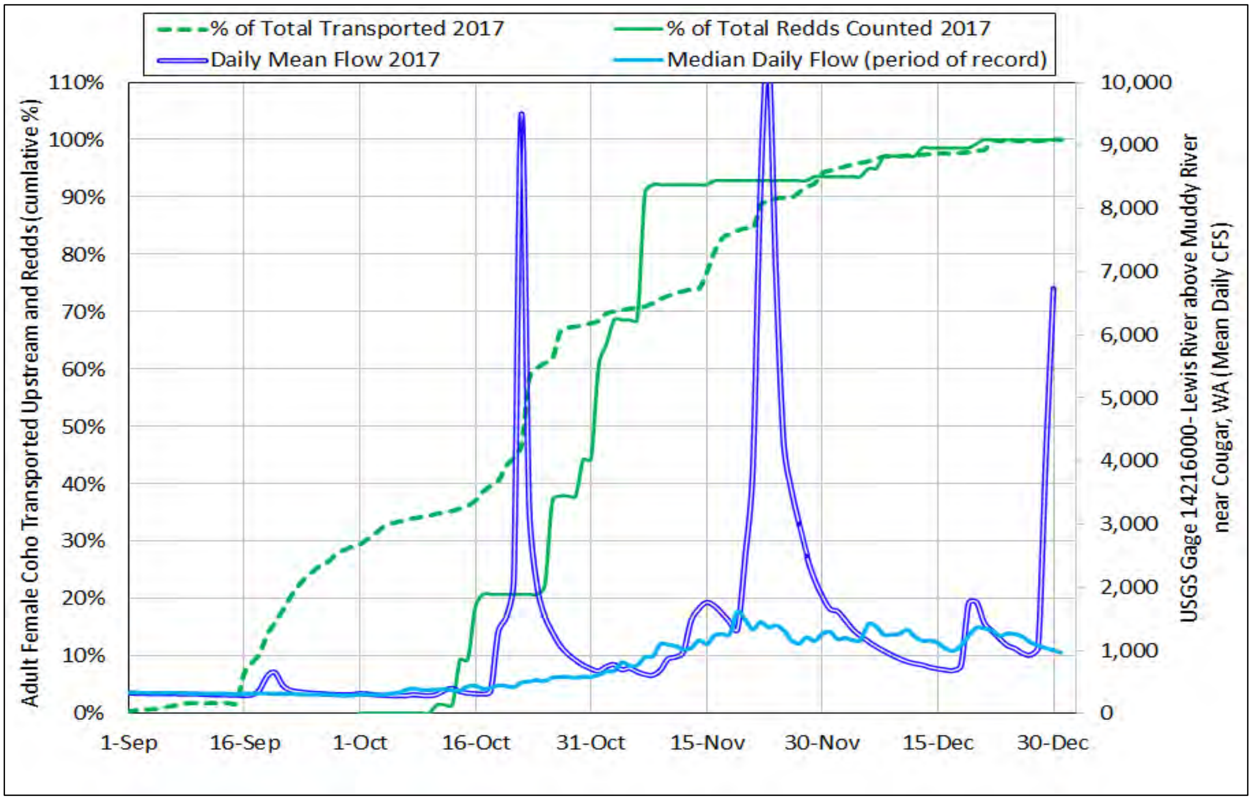

Figure 4. Coho redd count vs. adult female Coho transport timing vs flow (2017).

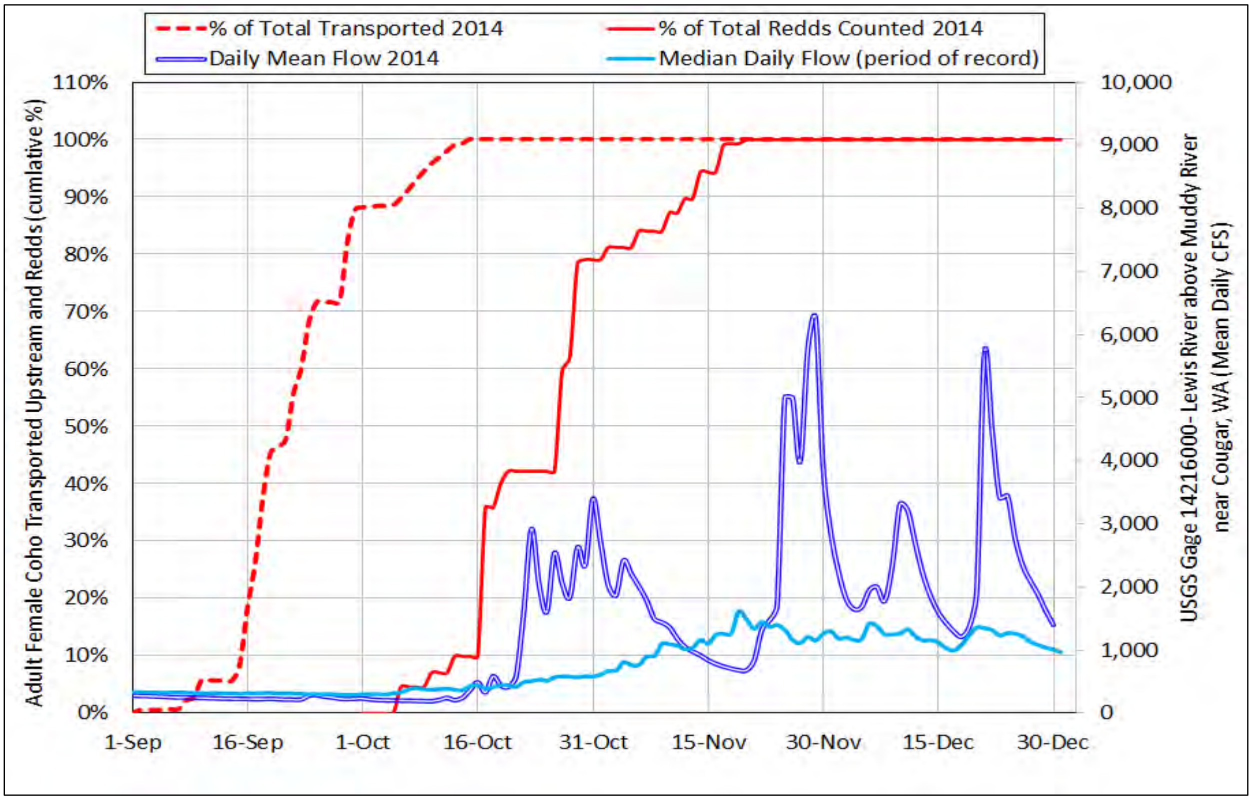

Figure 5. Coho redd count vs. adult female Coho transport timing vs flow (2014).

Estimate of Total Redds

Redd counts were used to make estimates of total redds by watershed (Starcevich 2021). Total Coho redd estimates incorporating a redd detection probability of 0.3 to 0.6, as specified in PacifiCorp and Cowlitz PUD (2017) are presented in Table 4 for 2020, 2017, and 2014. Total redd estimates are much larger than in 2017 and 2014, and even the lower bounds of the 2020 total redd estimate is greater than the upper bounds of the prior estimates. It is suspected that the actual detection probability in 2020 (due to excellent survey conditions when most of the Coho were spawning in October) is higher than assumed in the analysis of 0.3 to 0.6.

Table 4. Total Coho redd estimates (2020, 2017, 2014).

	2020 Total Redd Estimate (% total)	2020 95% CI	2017 Total Redd Estimate (% total)	2017 95% CI	2014 Total Redd Estimate[a] (% total)	2014 95% CI
Muddy River Watershed	3,240 (53%)	1,526 to 5,454	336 (29%)	116 to 622	401 (19%)	189 to 674
NF Lewis River Watershed	2,163 (35%)	1,145 to 3,542	465 (39%)	175 to 846	1,305 (62%)	379 to 2,504
Pine Creek Watershed[b]	29 (1%)	0 to 71	37 (3%)	6 to 72	22 (1%)	0 to 50
Swift Reservoir Watershed	696 (11%)	249 to 1,301	339 (29%)	190 to 534	382 (18%)	152 to 649
Grand Total	6,128	3,662 to 9,515	1,178	702 to 1,886	2,110	985 to 3,617
Total Female Coho[b]	4,865		3,281		4,217	

[a] 2014 data re-analyzed in 2017 to incorporate current sample frame and redd detection probability (Starcevich 2018).
[b] Does not include 48 Coho redds counted in Pine Creek during Bull Trout surveys (outside reaches scheduled for 2020 surveys).
[b] Total adult female Coho transported upstream of Swift Dam that could have potentially been observed during the survey period.

Estimate of Proportion of Transported Female Coho that Spawned

Using the adjusted estimate of total redds based on the range of assumed detection probability and assuming one spawning female per redd, yields an estimate of 1.26 (bootstrap 95 percent confidence interval of 0.75 to 1.96) as the proportion of transported female Coho that spawned in 2020 (Starcevich 2021), which is the highest of all estimates made over the 7-year period (Table 5). Proportions of 1.0 (or greater) suggest that all transported females spawned (assuming 1 redd per female). Proportions substantially greater than 1.0 indicate that actual detection probabilities are higher than assumed and/or that female Coho may build more than 1 redd on average.

Table 5. Estimates of the proportion of spawning Coho females by year.

	Estimated Proportion of Spawning Female Coho	95% Confidence Interval
2020	1.26	0.75 to 1.96
2019	0.54	0.26 to 0.91
2018	0.61	0.33 to 0.98
2017	0.34[a]	0.20 to 0.54
2016	0.69	0.25 to 1.20
2015	No Estimate[b]	
2014	0.50	0.23 to 0.86

[a] Likely substantially underestimated due to survey limitations in areas known to be heavily used by Coho for spawning in November and December. NF Lewis River mainstem surveys were limited due to high flows and Swift Reservoir tributary surveys were limited due to low reservoir conditions, which precluded boat access. Closed gates limited access to the upper Muddy River watershed. Very high flow events likely scoured redds between surveys in October and November.

[b] High water and unsurveyable conditions persisted throughout the spawning season precluding estimates.

Discussion and Conclusions

Due to excellent survey conditions present after the majority of Coho were transported upstream in October, it is suspected that the actual redd detection probability in 2020 was much greater than the range assumed in the analysis (0.3 to 0.6), which probably results in an over estimation of total redds and spawning success. However, even the lower bounds of the 2020 estimate of the proportion of transported females that actually spawned (0.75) is still higher than the actual estimate for all other years since 2014 (Table 5). Overall, the redd counts and estimates of spawning success suggest that most (if not all) adult female Coho transported upstream during 2020 spawned.

Early-Coho are transported upstream from late-August into October, while late-Coho are transported upstream primarily in November and December, and sometimes into January. Flows are usually low in October making for generally excellent survey conditions and likely relatively high detection probability, such as in 2020. When late-Coho are transported upstream after October, flows are generally much higher limiting survey access and visibility, and seasonally closed gates and/or snow limit access to a substantial portion of survey reaches, which ultimately likely results in much lower detection probability for redds made by late spawning Coho such as in 2017. However, even when only early-Coho are transported upstream, in unusually wet years such as 2015, detection probability can still be substantially reduced by limiting visibility and/or safe access to streams for the majority of the survey season. This spawning survey design was originally developed to quantify early-Coho and spring Chinook spawning. The decision to transport late-Coho upstream in substantial numbers was not contemplated in this survey design. Surveys to quantify late-Coho spawning abundance, timing, and distribution will likely always be somewhat problematic due to inherent survey limitations that occur during the late-Coho spawning time as described previously.

Considering all of the spawning survey information and observations since 2012, and by comparing 2020, 2017, and 2014 surveys of the same year-3 survey panel of reaches, it appears that the fluctuation in the estimated proportion of transported adult female Coho that spawn each year (Table 5) is likely as much a function of fluctuating detection probability between years than actual variation in spawning success. The only indication that spawning success may be reduced in some years is the observation that some Coho (to an unknown degree) elect to spawn in the Swift Reservoir drawdown zone. Drawdown zone spawning appears to occur in some years when low stream flow and low reservoir conditions occur during the onset of the Coho spawn time. Though not specifically quantified, some Coho were observed spawning in the drawdown zones of reservoir tributaries and the mainstem NF Lewis River in 2019. Stream flows in 2019 were the lowest during the Coho spawning season and the Swift Reservoir level was 15 to 20 feet lower (due to drought) than any other year since the fish passage program began in 2012. The spawning survey sample frame only covers the stream network of available habitat upstream of the Swift Reservoir full pool elevation. Therefore, an assumption inherent to the sample design is that if Coho spawn below the full pool elevation within the drawdown zone, these redds are not counted, and therefore are treated as unsuccessful spawning events.

Bull Trout surveys were conducted in 2020 during September and October and the entire length of the mainstem of Pine Creek was surveyed weekly. During Bull Trout surveys, a total of 48 Coho redds were counted in October in the lower half of Pine Creek, which were located outside of the reaches scheduled for Coho spawning surveys in 2020. Incorporating these redds into the analysis only slightly changes the total redd estimate (increase of 1.4 percent) and female spawning success estimate (increase of 1.6 percent). However, the total Pine Creek watershed redd estimate increases from 29 (see Table 4) to 133 (95 percent confidence interval of 31 to 248) (Starcevich 2021).

No lower Pine Creek reaches were included in the year-3 panel of Coho spawning survey reaches, suggesting that the allocation of Pine Creek reaches may not be spatially-balanced within each revisit year (Starcevich 2021). Lower Pine Creek reaches are disproportionately allocated to the year-1 panel (Starcevich 2021). The initial spatial balance of the survey draw (originally completed in 2012) may have been confounded by the closely aligned upper tributaries in the Pine Creek system, such as P8 Creek (Starcevich 2021). A reallocation of the Pine Creek segments to survey panels may be appropriate so that a subsample of the lower reaches of Pine Creek are surveyed every year, especially given that these reaches seem to be disproportionately used by Coho for spawning in some years, such as observed in 2020 (Starcevich 2021).

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