Final

WILLAMETTE VALLEY FISH PASSAGE MONITORING VIA ROTARY SCREW TRAPS

Annual Report

Prepared for

US Army Corps of Engineers

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Acronyms and Abbreviations

Big Cliff	Big Cliff Dam
BiOp	Willamette Project Biological Opinion
BY	Brood Year
Cougar Dam HOR	Cougar Dam Head of Reservoir
Dexter	Dexter Dam Tailrace
EAS	Environmental Assessment Services, LLC
ESA	Endangered Species Act
Fall Creek HOR	Fall Creek Head of Reservoir
Fall Creek TR	Fall Creek Dam Tailrace
Foster HOR	Foster Dam Head of Reservoir – South Santiam River
Green Peter TR	Green Peter Tailrace – Middle Santiam River
Lookout Dam HOR	Lookout Dam Head of Reservoir
Lookout Dam TR	Lookout Dam Tailrace
NMFS	National Marine Fisheries Service
ODFW	Oregon Department of Fish and Wildlife
PIT	Passive Integrated Transponder
RO	Regulating Outlet
RPA	Reasonable and Prudent Alternative
RST	Rotary screw traps
TE	Trapping Efficiency
USACE	U.S. Army Corps of Engineers
UWR	Upper Willamette River
VIE	Visible Implant Elastomer
WVP	Willamette Valley Project

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Rotary Screw Trap Program Annual Report

Introduction

The U.S. Army Corps of Engineers (USACE) operates 13 dams in the largest five Willamette River tributaries for flood risk management, irrigation, recreation, and hydropower. Major habitat blockages of Upper Willamette River (UWR) Chinook Salmon and Winter Steelhead resulted from dam construction circa 1952 from Big Cliff and Detroit dams on the North Santiam River, Cougar Dam on the McKenzie River, Hills Creek Dam and Dexter/Lookout Point Dam on the Middle Fork Willamette River, and circa 1967 from Green Peter Dam on the Middle Santiam River (NMFS 2008c). High-head, flood risk management dams in Oregon's Willamette River basin are operated much differently than the run of river projects on the Columbia and Snake Rivers. Willamette basin dams are in tributaries rather than on the mainstem, and many have no upstream or downstream fish passage facilities (Myers et al. 2006; NMFS 2008). The National Marine Fisheries Service (NMFS) worked with the USACE, the U.S. Bureau of Reclamation, and the Bonneville Power administration to evaluate the impact of the Willamette Valley Project (WVP) on the Endangered Species Act (ESA) listed salmon and trout by developing the 2008 Willamette Project Biological Opinion (BiOp; NMFS 2008). In the BiOp, NMFS identified a Reasonable and Prudent Alternative (RPA) that set forth specific actions the Action Agencies could implement to satisfy their legal obligations under the ESA to "…avoid the likelihood of jeopardizing the continued existence of the ESA listed species or the destruction or adverse modification of their designated critical habitat." (NMFS, 2008)

In 2018, the Action Agencies reinitiated ESA consultation with NMFS on the effects of the WVP to ESA-listed species and their critical habitat. In 2020, the USACE, BPA, and NMFS identified and agreed to implement a suite of interim measures, in addition to the measures in the RPA, to benefit ESA-listed salmonids in the Willamette until the reinitiated consultation is completed. Broadly, the interim measures were intended to improve water quality and downstream passage of juvenile salmonids.

In September 2021, the U.S. District Court for the District of Oregon issued an Interim Injunction Order directing the USACE to implement certain interim injunctive measures to improve fish passage and water quality at several WVP dam sites to benefit UWR spring Chinook salmon and winter steelhead. These interim injunctive measures replaced some of the prior interim measures and continued others. This study, in conjunction with other efforts, evaluated the biological effects of these measures that were implemented starting in fall 2021 on downstream passage of emigrating juvenile Chinook salmon (e.g., timing, size at migration, and natural production).

Rotary screw traps (RST) were used in accordance to established methods (Keefer et al. 2012, 2013; Romer et al. 2013–2016) to aid and understand the effects of downstream fish passage through the reservoirs and dams in rivers upstream of Foster, Cougar, Fall Creek, and Lookout Point reservoirs, and in the tailraces of Big Cliff, Green Peter, Cougar, Fall Creek, Dexter, Lookout and Hills Creek dams.

These traps were used to carry out the objectives of the project, which include the collection of length/weight data of natural origin juvenile salmonids passing through WVP reservoirs, migration timing, evaluating juvenile salmonids for presence of injuries, gathering information on relative abundance of incidental fish species, and assessing post-collection mortality. At sites where trapping efficiency trials provided sufficiently robust results, an objective of the RSTs was to estimate the abundance of out-migrating juvenile salmonids.

This report contains a summary and analysis of the field study implemented by Environmental Assessment Services, LLC (EAS) under contract with the USACE for RST sampling efforts starting in fall 2021 through December 31, 2022.

Additional RST sampling was conducted by Cramer Fish Sciences at certain sites through November 2021 to meet interim injunctive measure requirements (Cramer Fish Sciences 2023) and the Corps at Fall Creek Tailrace through winter 2022.

Methods

Rotary Screw Traps and Sampling Sites

An RST consists of a cone with interior baffles that use the flow of the water to rotate the cone and funnel fish to a live well supported on a pontoon system. RSTs are commonly built in two sizes denominated by the size of the cone's upriver opening diameter, either a 5-foot or 8-foot opening. Traps are connected to a highline cable that spans the river or river section that is being sampled and is anchored to fixed point on either side. A block is set on the highline for the dropper to the trap to attach. A loop line running through two blocks at either anchor point is then connected to the highline block to allow for trap position adjustments along the highline. Perpendicular adjustments are achieved by changing the length of the dropper line(s) to the trap. A labelled image of an RST is provided in Appendix F. Traps are set in the river thalweg or in positions likely to capture juvenile fish as they travel downstream through the sampling area. Traps were accessed either by wading or with inflatable kayaks. The RSTs used for sampling were manufactured by E.G. Solutions. EAS used a combination of RSTs provided by USACE and procured additional RSTs as necessary to perform sampling tasks. EAS staff made minor repairs throughout the season to ensure that traps sampled efficiently and safely.

RSTs were operated at 11 locations in the southern Willamette River watershed: Big Cliff Dam, Green Peter Dam Tailrace – Middle Santiam River, Foster Dam Head of Reservoir- South Santiam River, Cougar Dam, Cougar Head of Reservoir, Fall Creek Dam Tailrace, Fall Creek Head of Reservoir, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point Head of Reservoir, and Hills Creek Dam. Trap deployment locations at each of these sites were placed as close to historical sampling locations as possible. For sites where environmental conditions no longer allowed for a trap to sample in a historic location, an alternative site was selected in an area that allowed for safe sampling while maximizing the traps capture efficiency. Below is the list of sites where traps were operated:

- At Big Cliff Dam, a single 8-foot RST operated in the tailrace from December 1, 2021, to February 15, 2022. The trap did not sample again until March 15, 2022, and continued sampling through December 31, 2022.
- At the Green Peter Dam Tailrace – Middle Santiam River, a single 8-foot RST operated from March 3, 2022, to May 12, 2022, when it had to be removed due to damage incurred to the south bank anchor after a high flow event.
- A 5-foot trap operated at the Foster Dam Head of Reservoir- South Santiam River site from March 16, 2022, to June 30, 2022, and resumed sampling for a second period on September 9, 2022, to November 30, 2022.
- Three RSTs were deployed in the Cougar Dam Tailrace, two 8-foot RSTs in the Powerhouse channel and one 5-foot RST in the Regulation Outlet (RO) channel, and operated from December 1, 2021, through December 31, 2022.
- At the Cougar Head of Reservoir site, a single 5-foot RST was deployed in the South Fork McKenzie River from March 8, 2022, to June 30, 2022, and then resumed sampling again on September 16, 2022, to November 30, 2022.
- An 8-foot RST was used to sample the RO channel of Fall Creek Dam by EAS from March 15, 2022, to July 15, 2022, and again from October 15, 2022, through December 31, 2022.
- A single 8-foot RST was utilized at the Fall Creek Head of Reservoir site from January 14, 2022, to May 31, 2022.
- A 5-foot RST was deployed in the Dexter Dam Tailrace and sampled from March 7, 2022, through December 31, 2022.
- Three 8-foot RSTs were operated below Lookout Dam, two in the Powerhouse channel and one in the Spill channel, from March 15, 2022, through December 31, 2022.

- A 5-foot RST operated at the Lookout Head of Reservoir site in the Middle Fork Willamette River from March 7, 2022, through December 31, 2022.
- One 8-foot RST and one 5-foot RST operated in the Powerhouse and RO channels of Hills Creek Dam, respectively, from October 15, 2021, to March 01, 2022, and again from September 15, 2022, through December 31, 2022.

Maps showing trap deployment locations for each site can be found Appendix A. Sampling at various sites had to be stopped for short periods of time due to damage and environmental conditions. A summary table of these outages by site is shown in Appendix B. Information on trap installation and sampling periods by site are provided in Table 1.

Table 1. Rotary screw trap locations, installation dates, and sampling periods.

Big Cliff Dam	12/01/2022[1]	11/30/2021 – 02/15/2022
Big Cliff Dam	12/01/2022[1]	03/15/2022 – 10/15/2022
Big Cliff Dam	12/01/2022[1]	10/16/2022 – 12/15/2022
Big Cliff Dam	12/01/2022[1]	12/16/2022 – 12/31/2022
Green Peter Tailrace- Middle Santiam River	03/02/2022[2]	03/01/2022 – 05/12/2022
Foster Dam Head of Reservoir- South Santiam River	03/16/2022[2]	03/01/2022 – 06/30/2022
Foster Dam Head of Reservoir- South Santiam River	09/02/2022	09/02/2022 – 11/30/2022
Cougar Dam PH	12/01/2021[1]	11/30/2021 – 11/30/2022
Cougar Dam PH	12/01/2021[1]	12/01/2022 – 12/31/2022
Cougar Dam RO	12/01/2021[1]	11/30/2021 – 11/30/2022
Cougar Dam RO	12/01/2021[1]	12/01/2022 – 12/31/2022
Cougar Dam Head of Reservoir	03/07/2022[2]	03/01/2022 – 06/30/2022
Cougar Dam Head of Reservoir	09/16/2022[3]	09/01/2022 – 11/30/2022
Fall Creek Dam	03/15/2022[1]	03/15/2022 – 05/30/2022
Fall Creek Dam	03/15/2022[1]	05/31/2022 – 07/15/2022
Fall Creek Dam	03/15/2022[1]	10/15/2022 – 12/31/2022
Fall Creek Head of Reservoir	01/11/2022[3]	01/02/2022 – 05/31/2022
Dexter Dam Tailrace	03/03/2022	03/07/2022 – 12/16/2022
Dexter Dam Tailrace	03/03/2022	12/17/2022 – 12/31/2022
Lookout Point Dam	03/15/2022[1]	03/15/2022 – 07/31/2022
Lookout Point Dam	03/15/2022[1]	08/01/2022 – 10/17/2022
Lookout Point Dam	03/15/2022[1]	10/18/2022 – 12/31/2022
Lookout Point Head of Reservoir	03/06/2022[2]	03/07/2022 – 12/16/2022
Lookout Point Head of Reservoir	03/06/2022[2]	12/17/2022 – 12/31/2022
Hills Creek Dam PH	10/12/2021	10/15/2021 – 03/01/2022
Hills Creek Dam PH	09/15/2022	09/15/2022 – 11/15/2022
Hills Creek Dam PH	09/15/2022	11/16/2022 – 12/31/2022
Hills Creek Dam RO	10/12/2021	10/15/2021 – 03/01/2022
Hills Creek Dam RO	09/15/2022	09/15/2022 – 11/15/2022
Hills Creek Dam RO	09/15/2022	11/16/2022 – 12/31/2022

[1] Trap was installed and sampling prior to EAS monitoring.
[2] Initiation of sampling delayed until trap was delivered by manufacturer.
[3] Initiation of sampling delayed due to weather/environmental conditions.

Data Collection

Fish Collection, Trap and Environmental Metrics

RSTs were checked once per day unless conditions necessitated additional checks for fish or trap safety. Upon arrival at a trap site, crews collected data on cone rotation speed (time for three full cone rotations), rotation count from last check to current check, water temperature at trap, and time of fish collection. Additional environmental data was collected from U.S. Geological Survey gages and USACE dam operations data and included inflow, outflow by route, water temperature, and dissolved oxygen concentration where available. Fish were removed from trap live wells and transported to a safe work-up location. Fish were then anesthetized using a prepared Tricaine methanesulfonate solution (Syndel USA Tricaine-S) that was buffered with sodium bicarbonate (Aldon Corporation Sodium Bicarbonate) to neutralize the pH. Fish were anesthetized in small groups in aerated anesthetic baths made from the prepared Tricaine solution and river water. Aerated recovery tanks were set up with river water and stress coat (API Stress Coat) to allow for fish recuperation after handling. Additionally, water temperature of the anesthetic bath and recovery tanks were monitored and replaced if temperature increased 2°C. Non-target fish species were identified at the time of capture, enumerated, assigned a condition code (unharmed, injured, or dead), and released back into the river. Target species were transported to a safe work-up location for further processing. At sites located in the Santiam basin, all unmarked juvenile O. mykiss were treated and reported as winter steelhead.

Biological Data and Tagging

Biological data was collected for each target fish we captured. At sites where winter steelhead were target fish, all juvenile O. mykiss captured were treated as targets, as it is not possible to accurately distinguish between resident rainbow trout and anadromous steelhead trout. Data collected included species, fork length to the nearest millimeter, weight to the nearest 0.1-gram, fish condition, injuries, and assessment of presence of tags or other marks. A list of injury codes used for assessments is provided in Table 2. In addition to the injury codes listed, we also enumerated the number of adult gravid female copepods (*Salmincola californeinsis*) by attachment location (branchial cavity or fins) and assigned a value to the level of gas bubble disease observed in fish (1 to 4). Scales were collected from fish larger than 50 mm in fork length, and fin clips for future DNA analysis were collected from fish larger than 45 mm in fork length. Scales and fin clips were collected from a subset of fish meeting size criteria at below dam sites and were collected from nearly all fish meeting these criteria at head of reservoir sites. All fish with a fork length of 65 mm or larger, not being placed into a 24-hour hold study, were PIT tagged and released. All PIT-tag data was uploaded into PTAGIS. Appendix C contains information on PIT tags and tag files. At the Cougar Dam Head of Reservoir and Lookout Point Head of Reservoir sites, fish smaller than 65 mm and larger than 35 mm were marked with visible implant elastomer. Photos of species encountered and injuries were collected throughout the sampling periods and are provided in Appendix D. A summary of data collected by site is provided in Table 3.

Table 2. List of injury codes and abbreviations for injury assessments.

Live fish with no external injuries	NXI
Mortality with no external injuries	MUNK
Descaling < 20%	DS<2
Descaling > 20%	DS>2
Bloated	BLO
Bloody eye (hemorrhage)	EYB
Bleeding from vent	BVT
Fin blood vessels broken	FVB
Gas Bubble Disease (fin ray/eye inclusions)	GBD
Pop eye (eye popping out of head)	POP
Head injury	HIN
Opercle Damage	OPD
Body injury (tears, scrapes, mechanical damage)	TEA
Bruising (any part of body)	BRU
Hole behind pectoral fin	HBP
Head only	HO
Body only	BO
Head barely connected	HBO
Fin damage	FID
Predation marks (vertical claw or teeth marks)	PRD
Copepods (on gills or fins)	COP
BKD (distended abdomen)	BKD
Fungus	FUN

Table 3. Summary of data collected at each RST site

Big Cliff Dam	Yes- Hatchery Fish	Spring Chinook and O. mykiss	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes- on fish not included in 24-hr holds.	No
Green Peter Dam Tailrace- Middle Santiam	Yes- Hatchery Fish	Spring Chinook and O. mykiss	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes- on fish not included in 24-hr holds.	No
Foster Dam Head of Reservoir- South Santiam	Yes- Run of River Fish, Hatchery Fish in Fall	Spring Chinook and O. mykiss	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	No	Yes	No
Cougar Dam Tailrace	Yes- Hatchery Fish	Spring Chinook	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes- on fish not included in 24-hr holds.	No
Cougar Dam Head of Reservoir	Yes- Hatchery Fish	Spring Chinook	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	No	Yes	Yes

Fall Creek Dam	Yes- Hatchery Fish	Spring Chinook	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes	No
Fall Creek Head of Reservoir	Yes- Run of River	Spring Chinook	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	No	Yes	No
Dexter Dam Tailrace	Yes- Hatchery Fish	Spring Chinook	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes- on fish not included in 24-hr holds.	No
Lookout Dam Tailrace	Yes- Hatchery Fish	Spring Chinook	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes- on fish not included in 24-hr holds.	No
Lookout Point Head of Reservoir	Yes- Hatchery Fish	Spring Chinook	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	No	Yes	Yes
Hills Creek Dam	Yes- Hatchery Fish	Spring Chinook	Yes- weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes- on fish not included in 24-hr holds.	No

Trapping Efficiency Trials and Approach

Approach

Due to limited hatchery fish availability and inconsistent catch of run of river fish for use in mark recapture studies for trapping efficiency, we used a flow-based approach to evaluate the efficiency of each trap. Flow categories were assigned for each trap that were tailored to the specific location and range of conditions the trap could operate in. Multiple trials with marked hatchery fish were conducted across the range of flows in a category and pooled together to calculate weekly estimates for each specific location based on the flows occurring during that time period. When sufficient numbers of run of river fish were available, captured fish were marked with a caudal clip that alternated weekly between the lower or upper lobe and released upstream of the trap. We also tracked trials based on size of hatchery fish used. This allowed us to evaluate differences in capture efficiency by flow, fish size, and origin. Using this approach, we can also use historical data to supplement our efficiency calculations and continue to add to data in subsequent years as more trials are performed.

Trapping Efficiency Trials

Hatchery Fish. Due to environmental conditions and fish availability, we were unable to test each site to the extent we had planned. We performed trapping efficiency trials with large groups of marked hatchery fish at Big Cliff Dam, Green Peter Dam Tailrace – Middle Santiam River, Foster Dam Head of Reservoir-South Santiam River, Cougar Dam, Cougar Head of Reservoir, Fall Creek Dam Tailrace, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point Head of Reservoir, and Hills Creek Dam. In order to utilize trapping efficiencies from hatchery fish to calculate run of river passage, we have to assume that hatchery fish and run of river fish have the same probability of being captured in an RST. When possible, we performed run of river fish trials to interrogate this assumption. All hatchery fish utilized in trapping efficiency trials were adipose clipped at minimum. Additional fin clips and Bismarck brown dye were utilized at sites to differentiate fish by release location and route. Fifty fish from each trial had their fork length measured to the nearest millimeter, weighed to nearest 0.1 grams, and had injury assessments performed prior to release. Hatchery fish were collected either from ODFW hatcheries or from Oregon State University's Smith Farms fish facility. Water temperature and dissolved oxygen levels were continuously monitored during fish

transportation and corrected as necessary. Upon arrival to the release site, river water was slowly mixed into transport and marking tanks at the release site to acclimate fish to the site before work-up and final release. Fish were then anesthetized and marked in small batches and placed into a large tank of river water treated with stress coat to fully recover. Once recovered, fish were released in small groups across the channel being tested to discourage schooling behavior. Fish were released approximately 500 meters above the trap, or as far upstream as possible at below dam sites. Marked fish recaptured within one week of release were considered as recaptured fish regarding the trap's efficiency. Those captured outside of the one-week period were not included in the efficiency calculation.

Run of River Fish. Run of river fish were captured, marked, and released upstream of the trapping sites to assess the capture efficiency of the trap. These run of river trials only occurred at sites where hatchery fish were not allowed for release and at locations when sufficient numbers of natural origin fish were captured to allow for trials to be performed. For the Fall Creek Head of Reservoir site 2022 sampling period, run of river trapping efficiency trials were the only type of trapping efficiency trial we could perform as our permits did not allow us to utilize hatchery fish at this site. Run of river trials were utilized at the Foster Dam Head of Reservoir - South Santiam River and Cougar Dam sites to supplement the hatchery fish trials and allow us to compare between hatchery and run of river capture efficiencies. At the Cougar Dam site, run of river trapping efficiency trials were performed when sufficient numbers of natural origin fish were being collected weekly to allow for enough fish to be released so that at least five recaptures would occur. For fish used in trials, data was collected on captured fish as normal, fish were then tagged and marked with a caudal clip that alternated weekly between the lower or upper lobe and then were released approximately 500 meters upstream of the trap. Marked fish recaptured within one week of release were considered as recaptured fish regarding the trap's efficiency. Those captured outside of the one-week period were not included in the efficiency calculation. A summary of trap efficiency trials performed at each site is provided in subsequent results and discussion sections.

24 Hour Post-Capture Holding Trials

At Big Cliff Dam, Green Peter Dam Tailrace, Cougar Dam, Fall Creek Dam Tailrace, Dexter Dam Tailrace, Lookout Dam Tailrace, and Hills Creek Dam, the first 60 natural origin juvenile Chinook (or steelhead where applicable) were held for 24 hours to assess post-capture or delayed mortality. Biological data was collected on captured fish per normal protocol as described in the Biological Data and Tagging section. Fish placed in the hold trial were not PIT tagged or VIE marked to not bias the delayed mortality study. After work-up and recovery, the first 60 run of river fish captured each week were placed into a holding tank. Where applicable, fish passing through a regulating outlet or spill route were prioritized for hold. At most sites, hold tanks were created using perforated buckets that were attached to the traps so that fish could be held in low densities (less than 0.22 kg of fish per 3.8 L of water) in the river. At Cougar Dam, two large holding tanks were set up with constant water inflow from the river. Fish were held within these tanks in perforated buckets to allow for fish sorting by size and route. After the 24-hour holding period, live fish were enumerated and released at their capture site. Mortalities were enumerated and processed for injury/biological data again. It is important to note that a control was not included in the hold trials. Other groups that have performed similar studies in the basin observed high mortality rates of wild juvenile Chinook after being captured (Herron et al. 2018). Mortality rates from this study reflect the combined effects of previous fish health conditions at the time of passage, passage effects, handling, and holding at the trap site.

Data Analysis

Passage Estimates

Catch Evaluations. Where possible, daily catch rates were standardized to 24-hour sampling intervals based on trap start and stop times (time between trap checks). At Cougar Powerhouse, Cougar regulating outlet, and Hills Creek Powerhouse raw daily catch numbers were used. At those three locations, operations frequently cycled within 24 hours (i.e., the RO cycles regularly during a fish passage operation, but the trap samples the entirety of the operation between checks) and resulted in discrete flow time windows the traps sampled between checks. Due to RST operations in these situations, standardization of catch was not necessary, and an alternative equation was used. Refer to equations detailed below. Operations cycled at other sites, such as Big Cliff, but those traps were in the tailrace and experienced continuous flow, allowing

us to standardize catch to 24-hour periods. Across all sites, traps were fished a total of 3,679 start/stop times with an average duration of 23.98 hours between checks (st dev. 3.1 hours). Trap sampling time between checks ranged from 0.25 and 53 hours. In almost all instances (>99%) traps were fished overnight, but due to logistics trap checks occurred at various times the following day. This resulted in sampling duration that included overnight effort ranging from approximately 12 to 34 hours. Most checks (91%) occurred between 19 and 28 hours. In a few instances (n<15) traps were not fished overnight, typically during high flows due to safety/debris clogging issues classified as weather event checks. Any weather event trap check <2 hours (n<10) were excluded from analysis. In a few instances (n<10) traps were fished two nights because it was impossible to reach trap sites due to extreme weather (e.g., Ice storm in December 2022). Additionally, data was excluded (<2% n<60) from further analysis if a trap was not functioning upon arrival, typically due to debris clogging. Adjusted daily catch was calculated with the following equation:

$$c_{adj} = c^*\{(T_e-T_s)/24\}$$

where

c_{adj} = Daily catch adjusted to 24 hours
c = number of fish captured between traps start and stop
T_s = Daily trap start time
T_e = Trap check time the following day.

Weekly catch was calculated from the standardized daily catch rates.

$$c_w = \sum c_{adj} *(7/D_f)$$
or
$$c_w = \sum c *(7/D_f)$$

where

c_w = Adjusted weekly catch
$\sum c_{adj}$ = Weekly sum of adjusted daily catch
$\sum c$ = Weekly sum of raw catch at locations that had discrete flows
D_f = Days fished in a week.

Abundance Estimates of Out-Migrating Target Species

Building on the previous work in the area conducted by Keefer et al. 2013, Romer et al. (2012–2017), and Cramer 2022. We calculated trap capture efficiency by marking hatchery Chinook for each trap efficiency trail. Fish were released upstream ~500 m from the trap, or as far upstream as possible below dam sites. Fish for trap efficiency releases were uniquely marked for each trial individually or in combination with PIT-tags, fin clips (adipose, vent right or left, and caudal upper or lower), Bismarck brown staining. Unique marking was especially important for sites (e.g., Hills Creek RO) where captured fish could have traveled from two routes to the trap or when second trials occurred within the recapture window of a week. Recaptured fish were recorded, and weekly abundance estimates made based on the hatchery trap efficiency trials for each trap. Weekly abundance estimates for outmigration were calculated by using equations modified from Romer et al. (2016).

$$N_{mf} = c_w / e_{mf}$$
and
$$e_m = r/m.$$

where

N_{mf} = weekly estimated out-migrants, based on flow levels (Low, medium, and high) where possible.
C_w = Adjusted weekly catch

e_m = average measured trap efficiency, based on flow levels (Low, medium, and high) where possible.
R = number of recaptured marked fish
m = number of marked fish released.

One novel difference from previous work in this area is that we attempt to account for flow rates. Water flow has been shown to be the dominant factor affecting trap efficiency in multiple RST out-migrating juvenile salmonid studies (Chang and Gallinat 2004; Dambacher 1991; Rayton et al. 2006; Volkhardt et al. 2007; Voss and Poytress 2020). Determining trap efficacy is problematic and likely a large source of error with RST research in this area, especially at sites with wide and/or deep flow channels (e.g., below Lookout Dam). Ideally run of River TE trials would be conducted weekly, but previous work in the area has shown that releasing enough RST captured fish to obtain the minimum of five recaptures to calculate TE is problematic at most locations. Unfortunately, it is unrealistic to perform weekly trials at sites with hatchery fish as there are not enough fish available for this purpose.

Flow rates are likely a major factor in trap efficiency, but the response appears to be on a site-by-site basis. Details about specific TE trials are reported in the results section. For most sites too few successful TE trials (total trials, at specific flow rates, or not enough recaptures) were conducted in 2022 to model TE in relation to flows. In those instances, all TE trials were pooled if trials had enough capture returns. There appear to be linear trends at some sites, but at this time not enough trials have been conducted (particularly at high flows) to model the data. At Cougar RO, a highly channelized location, the TE appears to be unaffected by flow, but more trials are needed at flows above 2000 CFS to confirm. Additionally, we theorize trap efficiency functionally changes at different flow rates for Big Cliff and Lookout HOR similar to Dambacher (1991, 2023). For example, the performance of the trap at Big Cliff Tailrace appears to change depending on flow rate, and roughly corresponds to low (<2 k CFS), medium (<2-4 k CFS), and high flows (>4 k CFS). Therefore, we believe that by pooling TE trails, possibly including historical studies if sampling methodology overlaps, we will be able to build a model overtime that can predict TE based on flow rates. This would reduce the overall number of required TEs and decrease error estimates.

Confidence intervals were calculated at alpha 0.05 level based on the TE trials for each flow range (when possible).

$$N_{95} = c_w / e_{95}$$
and
$$e_{95} = e_m (\alpha * s * n)$$

where

N_{95} = Estimated 95% weekly CI for out-migrants, based TE trials at flow levels (Low, medium, and high) where possible.
C_w = Adjusted weekly catch

e_m = Average measured trap efficiency, based on flow levels (Low, medium, and high) where possible.
E_{95} = Upper and lower 95% TE CI, based on TE trials at flow levels (Low, medium, and high) where possible.
A = 0.05 level of significance
s = Standard deviation of trap efficiency trials for a given site, route, and flow rate
n= Number of trap efficiency trials for a given site, route, and flow rate

If a trap was stopped for a period of one week or more due to low flow preventing the trap from spinning, the cone being raised due to dangerously high flows/debris volume, or a requested non-sampling period weekly passage was not estimated. If trap efficiency criteria were not met (5 TE fish recaptures per release) for a particular site, those trials were not used for any calculations.

Brood Year

A subset of scales collected from juvenile Chinook (and O. mykiss in Santiam basin sites) were mounted and read to determine age of collected fish. Scales were read for at least 10% of the total catch for each site. Scale readers were provided with samples identified with a unique identification number, location of capture, and date of capture. Fish length and size were not included so as to not bias the reader. Each sample was read by two individuals, independently. For samples with conflicting ages based on independent scale reads, a third read was performed by another reader. Additionally, a random subset of samples were read a third time to confirm age determinations. Fish age was then correlated back to individual fish using the unique identification number and used to determine brood year (BY) for size class of fish throughout the year.

Trapping Injuries

To account for injuries associated with handling and capture in a RST, injury data was collected on hatchery fish being released for trapping efficiency trials before release and after capture. Injury rates by type pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. The proportional change was then applied as a correction factor to observed injuries on target fish to provide better clarity on injuries likely incurred from passage instead of RST capture and handling.

Results

Big Cliff Dam

EAS began monitoring the single 8-foot RST in the Big Cliff Dam on December 1, 2021. The trap sampled 355 days during the period from December 1, 2021, to the end of 2022. The trap did not sample from February 16, 2022, to March 15, 2022, while passage measures were not being implemented. There were two additional sampling outages that resulted from high flows that occurred from May 5, 2022, to May 13, 2022, and from June 12, 2022, to June 14, 2022. Additional information regarding sampling outages at this site can be found in Appendix B.

Target Catch and Passage Timing

The trap captured 1255 juvenile Chinook salmon and 107 juvenile O. mykiss. It is assumed that O. mykiss captured at this site are primarily comprised of resident rainbow trout since steelhead are not transported to spawn above Detroit Reservoir. However, due to the difficulty in distinguishing between resident trout and anadromous steelhead, all unmarked O. mykiss were treated as target fish and reported as such. Peak passage of juvenile Chinook salmon exiting Big Cliff Dam occurred in July 2022 (n= 526, 41.9% of total Chinook), with other significant passage events occurring in April 2022 (n= 292, 23.3%) and October-November 2022 (n= 143, 11.4%) (Figure 1). Peak passage for juvenile O. mykiss occurred November-December 2022 (n= 25, 23.4%), with another significant passage event occurring in July 2022 (n= 23, 21.5%) (Figure 2).

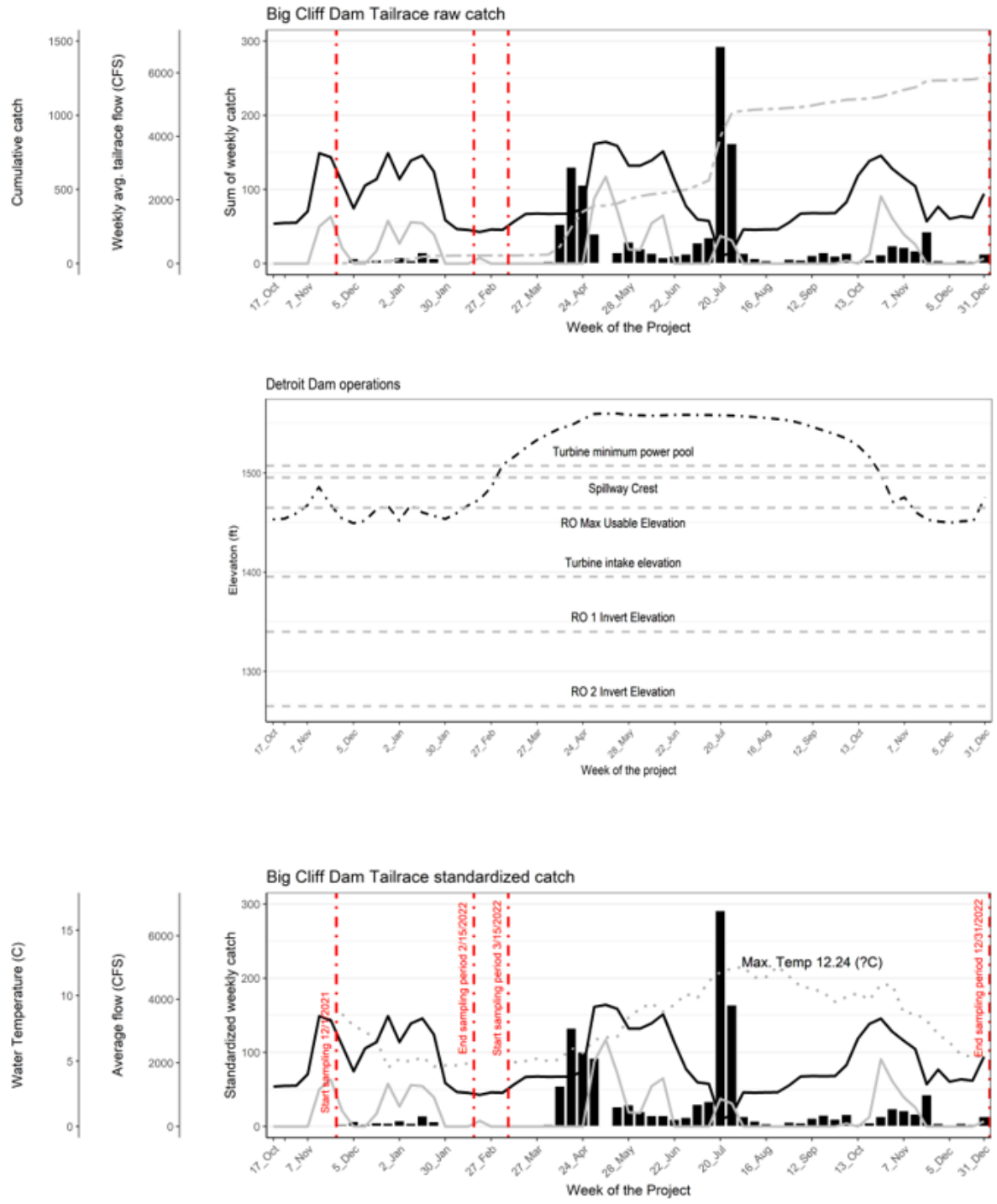

Figure 1. Raw catch (top panel), Detroit Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Big Cliff Dam with spill (black line), powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) for December 1, 2021, through the end of 2022.

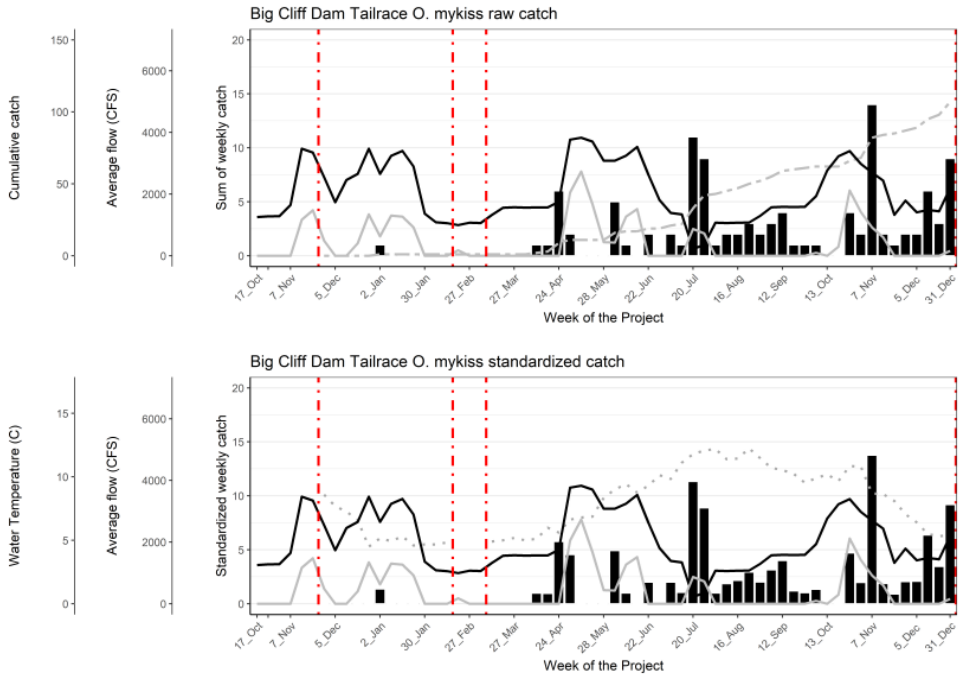

Figure 2. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile O. mykiss at Big Cliff Dam with spill (black line), powerhouse outflow (gray line), stream temperature (gray dots), and cumulative catch (gray dot dash line) December 1, 2021, through the end of 2022.

Chinook catch consisted of two BY classes, BY 2020 and BY 2021. Brood year 2020 Chinook were the dominant age class captured from the initiation of sampling through May 2022. The peak migration of yearling BY 2020 fish occurred in April. The average fork length of BY 2020 fish captured in the spring period was 165.2 mm (n=290, min: 100 mm, max: 260 mm, median: 160 mm) and the average weight was 46.6 g (n=290, min: 8.4 g, max: 180.6 g, median: 38.1 g). The first BY 2021 fry captured at the Big Cliff Dam trap occurred on April 29, 2022. Catch from June 2022 to the end of the year was primarily comprised of BY 2021 sub-yearlings. However, age verification from scale samples shows a significant number of smaller BY 2020 yearlings passing the trap during this period. Due to this overlap in passage timing and size at age, we were unable to reliably assign a BY category from length-frequency analysis (Figure 3). The average fork length of juvenile Chinook captured from May through the end of 2022 was 137.1 mm (n=897, min: 31 mm, max: 283 mm, median: 131 mm) and the average weight was 32.7 g (n=897, min: 0.1 g, max: 264 g, median: 26.2 g). This overlap is likely due to differing growth rates resulting from differences in stream and reservoir rearing habitats and the variable length of time individuals reared in the reservoir. Previous studies in Detroit Reservoir show high growth rates for reservoir reared Chinook with many sub-yearlings captured in the reservoir displaying fork lengths greater than 150 mm in the latter months of the year (Monzyk et al. 2015). Our findings are consistent with these observations and suggest that large sub-yearling Chinook captured in the trap are likely fish that spent a majority of their time rearing in Detroit Reservoir. Peak passage timing of juvenile Chinook through Big Cliff Dam is similar to passage observed in 2021 (Cramer 2022) and 2016 (Romer et al. 2017). However, these peak passage observations differed from earlier monitoring efforts conducted by Romer et al. (2015, 2016).

Peak migration periods from studies in 2014 and 2015 generally occurred in November and December, a time period when we observed a relatively small pulse of juvenile Chinook. Peak passage of Chinook at Big Cliff Dam coincided with surface spill operations in late July and early August. We observed a slight increase in catch prior to this spill event which suggests that fish arrived at Big Cliff Dam prior to spill initiation and passed through the Powerhouse. It appears that a similar situation may have occurred with the spring passage event in April and May as well as during the fall outmigration period. Peak passage in July appears to relate with Detroit surface spill operations that occurred from late April through June

(Figure 4). Downstream movement of tagged fish in Big Cliff Reservoir suggest that fish typically take between 11 and 23 days to navigate from the Detroit Dam Tailrace to the forebay of Big Cliff Dam (Beeman and Adams 2015). Assuming these migration rates for fish to reach the forebay of Big Cliff Dam from the Detroit Tailrace, it is reasonable to assume that fish captured during our peak catch in July passed Detroit during the spring surface spill operations. Results from studies by Cramer Fish Sciences (2022) also support these findings. RO spill operations at Detroit during October and November also show a trend to increased catch below Big Cliff if the same assumptions on travel timing through Big Cliff Reservoir are applied. However, discharge through the turbines was also elevated at this time and could contribute to the increased catch observation. The only period of increased catch that does not correlate as strongly with spill operations as the other periods is during April and early May. Surface spill operations at Detroit did not start in earnest until April 24, 2022, at which point most of the fish for this period had already passed Big Cliff Dam (n=186, 63.7%). However, a high flow event prevented the screw trap from sampling in early May at a period when it is likely that many fish were migrating.

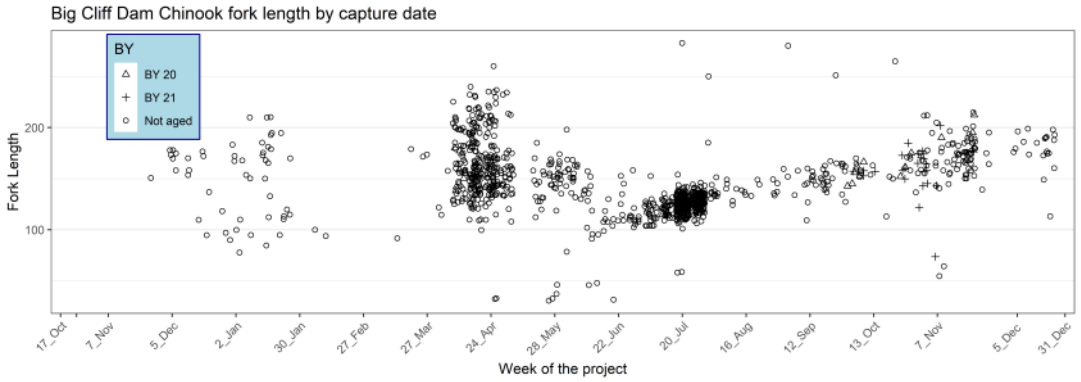

Figure 3. Length-frequency of juvenile Chinook salmon at the Big Cliff Dam Tailrace site from December 1, 2021, to December 31, 2022.

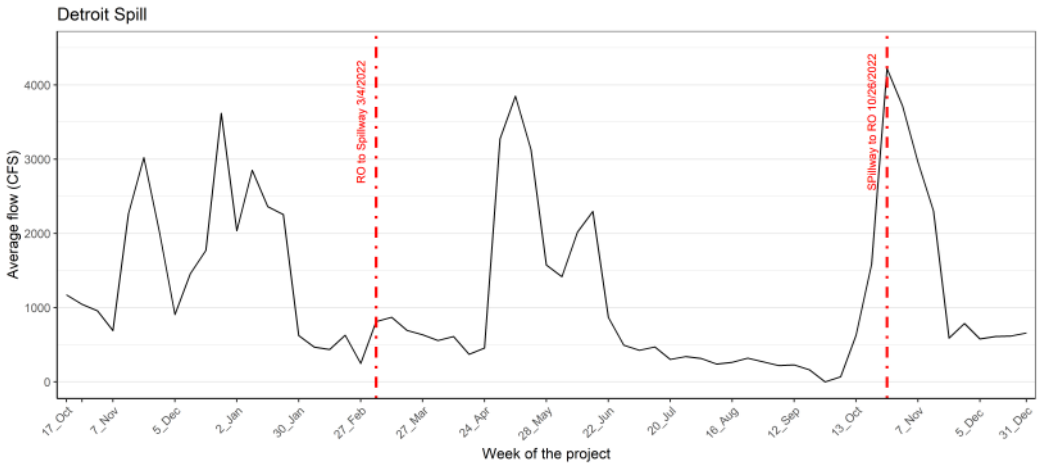

Figure 4. Detroit spill operations from the initiation of sampling at Big Cliff through 2022.

Trapping Efficiency Trials

A total of 13 trapping efficiency trials occurred using hatchery reared Chinook salmon in the Big Cliff Dam Tailrace. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 4. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled. Trapping efficiencies ranged from 2.1% to 12.0%. Using trapping efficiencies by flow category, we estimate that 23,617 (95% CI: 18,854 to 32,245) juvenile Chinook passed the trapping site in 2022 (Figure 5).

Table 4. Summary table of marked hatchery Chinook releases at Big Cliff Dam for trapping efficiency.

Big Cliff Dam Tailrace	12/22/2021	3,010	997	39	3.9%
Big Cliff Dam Tailrace	5/25/2022	3,055	995	21	2.1%
Big Cliff Dam Tailrace	8/9/2022	1,060	1000	92	9.2%
Big Cliff Dam Tailrace	9/30/2022	1,580	995	48	4.8%
Big Cliff Dam Tailrace	10/13/2022	2,820	500	15	3.0%
Big Cliff Dam Tailrace	10/24/2022	5,520	535	25	4.7%
Big Cliff Dam Tailrace	11/2/2022	5,450	949	40	4.2%
Big Cliff Dam Tailrace	11/16/2022	2,650	509	15	2.9%
Big Cliff Dam Tailrace	12/14/2022	1,380	502	60	12.0%
Big Cliff Dam Tailrace	12/19/2022	1,330	1010	92	9.1%
Big Cliff Dam Tailrace	12/21/2022	1,350	1014	33	3.3%
Big Cliff Dam Tailrace	12/27/2022	1,520	704	47	6.7%
Big Cliff Dam Tailrace	12/29/2022	1,470	452	22	4.9%

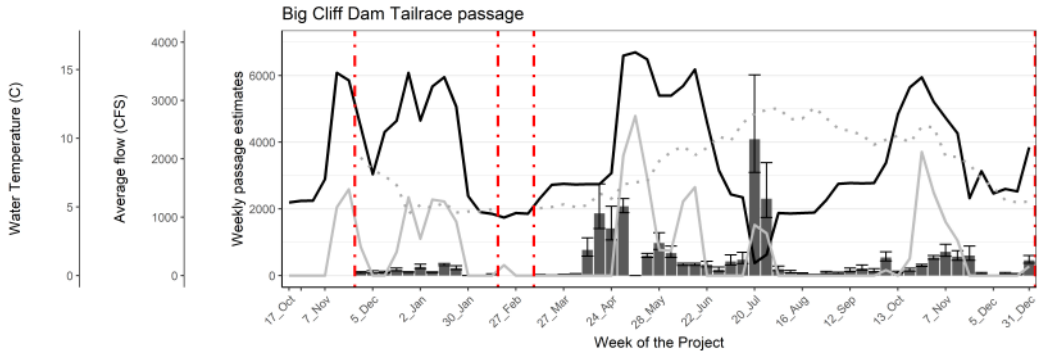

Figure 5. Passage estimates with 95% confidence for juvenile Chinook salmon at Big Cliff Dam with spill (black line) and powerhouse (gray line) outflow, and stream temperature (gray dots) for December 1, 2021, through the end of 2022.

Injury Data

A total of 1,209 (96.3% of total Chinook catch) juvenile Chinook and 58 (54.2% of total O. mykiss catch) juvenile O. mykiss displayed at least one of the injury code conditions, other than copepods (COP), listed in Table 2. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. This was then applied as a correction factor to provide more clarity to injury resulting from passage. The most common injuries associated with trap capture include descaling less than 20% and fin damage while the most common injuries associated with passage include descaling less than 20%, descaling greater than 20%, operculum damage and fin damage (Table 5). We also observed 49 Chinook and 7 O. mykiss with evidence of gas bubble disease. Observations of gas bubble disease coincided with spill operations at Big Cliff Dam (Figure 6). However, it is likely that observations of gas bubble disease are higher for RST captured fish than those that are not captured in an RST as these fish are often captured and held in areas of higher dissolved gas. 974 juvenile Chinook salmon and 27 juvenile O. mykiss were infected with copepods at time of capture (Figure 7). Copepod presence on captured Chinook salmon shows a positive correlation with the size of fish similar to observations made by previous studies (Cramer 2022, Monzyk et al. 2015). This is likely a correlation between time spent rearing in the reservoir rather than the size of the

fish. Monzyk et al. also noted that O. mykiss were infected with copepods at a much lower rate than Chinook, a trend we also observed in O. mykiss captured at the Big Cliff site. 162 Chinook (12.9 %) and 6 O. mykiss (5.6%) were dead at time of capture. The highest mortality rate observed for juvenile Chinook occurred in April and May when 111 dead Chinook were captured, 28.6% of the Chinook captured during this time.

Table 5. Injuries for target and trapping efficiency Chinook at Big Cliff Dam.

NXI	152	61	-14.3%	47	54
MUNK	0	0	0.0%	0	0
DS<2	253	439	37.1%	783	493
DS>2	3	20	3.1%	289	280
BLO	0	5	0.9%	9	9
EYB	1	7	1.1%	88	87
BVT	0	1	0.2%	41	41
FVB	0	4	0.7%	82	81
GBD	0	5	0.9%	49	49
POP	0	1	0.2%	15	15
HIN	1	2	0.2%	80	80
OPD	13	19	1.3%	157	155
TEA	2	4	0.4%	42	42
BRU	0	1	0.2%	82	82
HBP	0	0	0.0%	8	8
HO	0	0	0.0%	5	5
BO	0	0	0.0%	12	12
HBO	0	0	0.0%	5	5
FID	171	420	47.3%	667	351
PRD	0	0	0.0%	4	4
COP	0	6	1.1%	974	963
BKD	1	0	-0.2%	1	1
FUN	0	0	0.0%	5	5

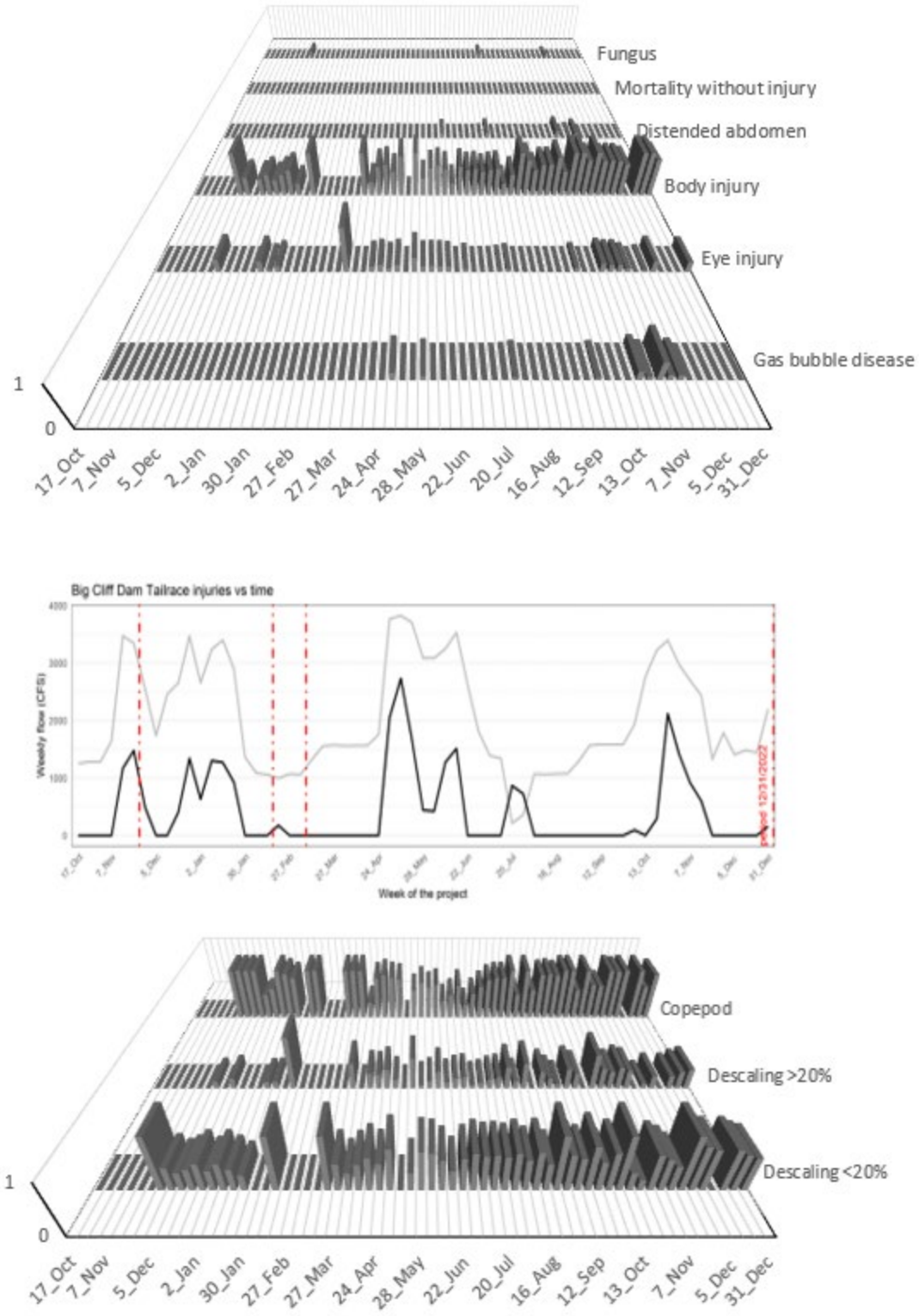

Figure 6. Injury rate of captured Chinook below Big Cliff Dam displaying proportion of fish with injuries by type (top panel) and descaling injuries and copepod presence (bottom panel). The middle panel shows spill (black line) and powerhouse flow (gray line) at Big Cliff Dam.

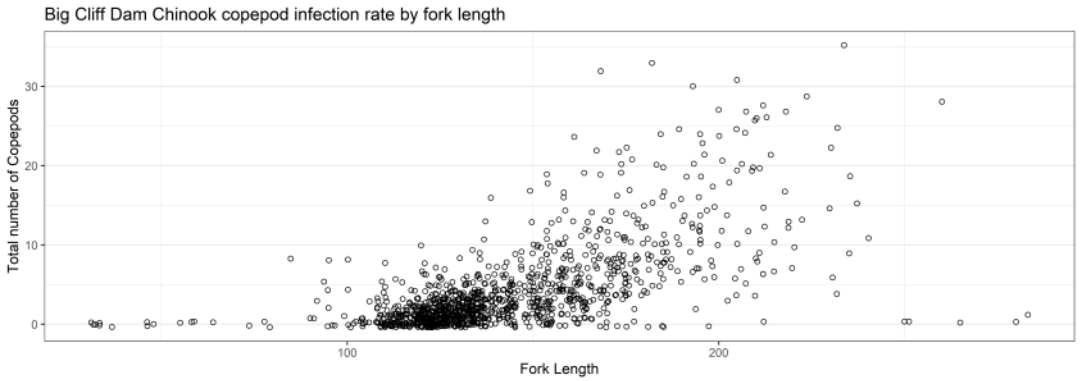

Figure 7. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon below Big Cliff Dam.

24-Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook and O. mykiss captured in the Big Cliff Dam Tailrace to assess delayed mortality potentially from dam passage, collection, or holding. The first fish entered the trial in March. A total of 545 fish—473 Chinook and 72 O. mykiss—was held in 2022 (Table 6). A total of 60 fish died during hold (11%), 54 of the 473 Chinook (11.4%) and 6 of the 72 O. mykiss (8.3%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 33.3%.

Table 6. Summary of 24-hour hold trials for fish captured in the RST at the Big Cliff Dam Tailrace site.

3/16/22 – 3/31/22	Chinook	*2*	*2*	*0.0%*
4/1/22 – 4/15/22	Chinook	*40*	*2*	*95.0%*
6/1/22 – 6/15/22	Chinook	*22*	*0*	*100.0%*
6/1/22 – 6/15/22	O. mykiss	*3*	*0*	*100.0%*
6/16/22 – 6/30/22	Chinook	*21*	*0*	*100.0%*
7/1/22 – 7/15/22	Chinook	*58*	*4*	*93.1%*
7/1/22 – 7/15/22	O. mykiss	*3*	*1*	*66.7%*
7/16/22 – 7/31/22	Chinook	*129*	*26*	*79.8%*
7/16/22 – 7/31/22	O. mykiss	*2*	*0*	*100.0%*
8/1/22 – 8/15/22	Chinook	*19*	*0*	*100.0%*
8/1/22 – 8/15/22	O. mykiss	*3*	*0*	*100.0%*
8/16/22 – 8/31/22	Chinook	*7*	*0*	*100.0%*
8/16/22 – 8/31/22	O. mykiss	*5*	*0*	*100.0%*
9/1/22 – 9/15/22	Chinook	*10*	*1*	*90.0%*
9/1/22 – 9/15/22	O. mykiss	*7*	*0*	*100.0%*
9/16/22 – 9/30/22	Chinook	*24*	*2*	*91.7%*
9/16/22 – 9/30/22	O. mykiss	*2*	*1*	*50.0%*
10/1/22 – 10/15/22	Chinook	*18*	*3*	*83.3%*
10/1/22 – 10/15/22	O. mykiss	*2*	*0*	*100.0%*
10/16/22 – 10/31/22	Chinook	*21*	*4*	*81.0%*
10/16/22 – 10/31/22	O. mykiss	*5*	*0*	*100.0%*
11/1/22 – 11/15/22	Chinook	*27*	*5*	*81.5%*
11/1/22 – 11/15/22	O. mykiss	*16*	*3*	*81.3%*
11/16/22 – 11/30/22	Chinook	*56*	*5*	*91.1%*

12/1/22 – 12/15/22	Chinook	*5*	*0*	*100.0%*
12/1/22 – 12/15/22	O. mykiss	*8*	*0*	*100.0%*
12/16/22 – 12/31/22	Chinook	*14*	*0*	*100.0%*
12/16/22 – 12/31/22	O. mykiss	*14*	*1*	*92.9%*

PIT Tagged fish and Downstream Detections

A total of 555 fish was PIT tagged at the Big Cliff Dam site in 2022, 543 juvenile Chinook and 9 juvenile O. mykiss. 1 tagged Chinook was redetected at downstream sites. Table 7 shows a summary of redetected tags with their tag date, tag site, redetection date, and redetection site. A summary of all tagged fish can be found in Appendix C.

Table 7. Summary of PIT tag redetections at downstream arrays for fish tagged at the Big Cliff Dam site.

3DD.003E1BC840	5/3/2022	Big Cliff Dam	5/8/2022	TWX – Estuary Towed Array (Exp.)

Willamette Valley Project Marked Fish Release Recaptures

In November of 2021, approximately 1,000 ad and caudal clipped juvenile Chinook salmon were released in Detroit Reservoir at Mongold boat launch. We did not capture any of these fish during our sampling efforts in 2021 or 2022.

Non-Target Capture Data

We captured 4,575 non-target fish in addition to natural origin juvenile Chinook and O. mykiss (Table 8). Clipped Chinook reported as non-targets are fish released for trapping efficiency purposes that were encountered seven or more days after their initial release.

Table 8. Summary of non-target species captured at the Big Cliff Dam RST site.

Bass	1	1
Bluegill	2,683	125
Bullhead catfish	8	1
Chinook (adult)	2	3
Chinook (clipped)	16	0
Cutthroat	4	0
Dace	1	1
Kokanee	201	70
Kokanee (clipped)	18	1
O. mykiss (clipped)	7	3
Pumpkinseed	1,621	29
Unknown	4	1
Mountain whitefish	8	3
Sculpin	1	0
Totals	**4,575**	**238**

Green Peter Dam Tailrace – Middle Santiam River

EAS began monitoring a single 8-foot RST in the Green Peter Dam Tailrace on March 2, 2022. The trap sampled 54 days in 2022. The trap did not sample from April 2, 2022, to April 13, 2022, due to high debris loads associated with initiation of spill. A high flow event occurred in early May that resulted in rapid and unanticipated increase in flow at the sampling site. During this increase, the primary south shore anchor point was damaged. The trap was removed from sampling on May 7, 2022, for the rest of the year. Plans to redesign the south shore anchor and reinstall the RST in 2023 are in progress. Additional details regarding trap sampling outages can be found in Appendix B.

Target Catch and Passage Timing

The trap captured 0 naturally produced juvenile Chinook salmon and 6 juvenile O. mykiss (Figure 8). O. mykiss at this site are likely progeny of resident trout. However, all juvenile O. mykiss at this site were treated as target fish. The O. mykiss captured consisted of two-year old (n=5, 8.3.3%), and three-year old (n=1, 16.7%) fish (Figure 9). The average fork length of the two-year old fish was 192.4 mm (min: 175 mm, max: 216 mm, median: 193 mm) and the average weight was 65.3 g (min: 46.2 g, max: 94.1 g, median: 63.4 g). The one three-year old fish had a fork length of 320 mm and weighed 316.1 g. During sampling, the trap also captured 3 radio-tagged Chinook associated with another study in Green Peter Dam Tailrace. All O. mykiss were captured in late April prior to the initiation of surface spill.

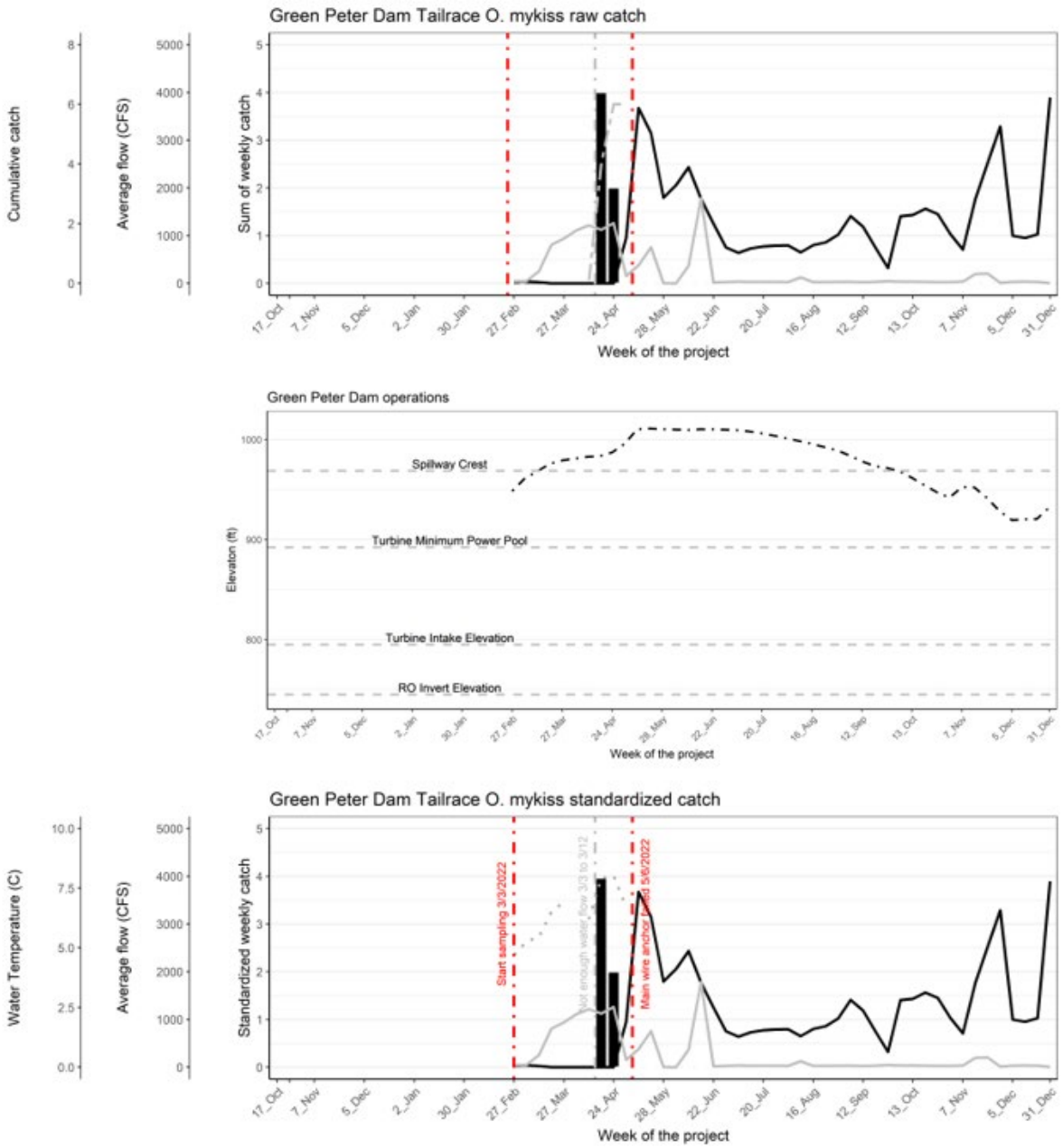

Figure 8. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile O. mykiss at Green Peter Dam Tailrace with spill (black line) and powerhouse (gray line) outflow for 2022.

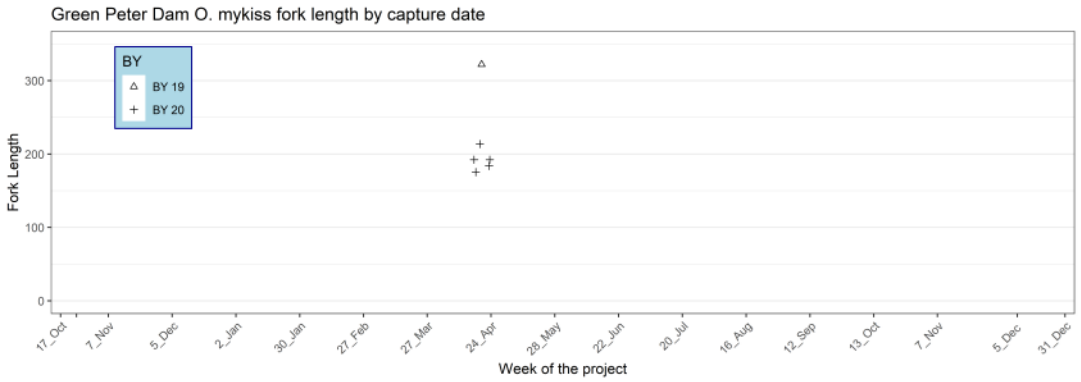

Figure 9. Age length-frequency for captured natural origin O. mykiss at the Green Peter Dam Tailrace site.

Trapping Efficiency Trials

A total of two trapping efficiency trials occurred using hatchery reared Chinook salmon in the Green Peter Dam Tailrace. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 9. Trapping efficiencies ranged from 0.6% to 1.7%. Due to high debris loads in early April and the damage to the south shore anchor, we were unable to perform as many trials as we had planned. Future trials will be needed to create sufficient data for passage estimates.

Table 9. Summary table of marked hatchery Chinook releases in the Green Peter Dam Tailrace for trapping efficiency.

Green Peter Dam Tailrace-Spill	3/29/2022	970	643	4	0.6%
Green Peter Dam Tailrace-Spill	4/30/2022	1,310	518	9	1.7%

Injury Data

A total of six juvenile O. mykiss displayed at least one of the injury code conditions listed in Table 10. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type both pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. Data from TE recaptures show that injuries observed on fish were not a result of RST capture at this site. The most common injuries observed on juvenile O. mykiss at this site include gas bubble disease (n=5, 2 at level 1, 1 at level 2, 1 at level 3, and 1 at level 4), fin damage (n=4), and bruising (n=4). All O. mykiss were alive at time of capture. It is likely that observations of gas bubble disease are higher for RST captured fish than those that are not captured in an RST as these fish are often captured and held in areas of higher dissolved gas. Due to the low capture numbers of target fish during sampling, RST captured kokanee were examined for injury. A total of 125 kokanee was captured and 118 (94.4%) displayed at least one of the injury code conditions listed. 61 kokanee were dead at the time of capture (48.8%). A summary of injury type by species is included in Table 10.

Table 10. Percentage of O. mykiss and Kokanee displaying injury by type at Green Peter Dam Tailrace RST site.

NXI	0%	5.6%
MUNK	0%	0.8%
DS<2	50%	31.2%
DS>2	33.3%	44%
BLO	0%	0.8%
EYB	16.6%	38.4%
BVT	0%	3.2%
FVB	0%	7.2%
GBD	83.3%	49.6%
POP	0%	15.2%
HIN	16.7%	26.4%
OPD	16.7%	39.2%
TEA	0%	11.2%
BRU	66.7%	12%
HBP	0%	0%
HO	0%	0%
BO	0%	0.8%
HBO	0%	8.8%
FID	66.7%	59.2%
PRD	0%	0%
COP	16.7%	1.6%
BKD	0%	1.6%
FUN	0%	0%

24 Hour Hold Trials

24 hour hold trials were performed on natural origin juvenile Chinook and O. mykiss captured in the Green Peter Dam Tailrace to assess delayed mortality resulting from dam passage. The first fish entered hold in April. All 6 O. mykiss that were captured at the Green Peter Dam Tailrace site were placed in a 24 hour hold (Table 11). All six fish died during hold (100%).

Table 11. Summary of 24-hour hold trials for fish captured in the RST at the Green Peter Dam Tailrace site.

4/15/2022 – 4/30/2022	O. mykiss	6	6	0.0%

PIT Tagged fish and Downstream Detections

No fish were PIT tagged at the Green Peter Dam Tailrace site by EAS in 2022. The trap did capture three radio and PIT tagged fish involved in another study at this site. A summary including tag numbers, observation date, and site can be found in Appendix C.

Non-Target Capture Data

229 non-target fish were captured in addition to natural origin juvenile O. mykiss in the Green Peter Dam Tailrace RST (Table 12). The most common species captured were bluegill and kokanee.

Table 12. Summary of non-target fish capture at the Green Peter Dam Tailrace RST.

Bluegill	86	59
Kokanee	125	61
Smallmouth bass	1	0
Sucker	2	2
O. mykiss (clipped)	4	2
Unknown	11	11
Totals	**229**	**135**

Foster Dam Head of Reservoir – South Santiam River

A single 5-foot RST was deployed in the South Santiam River above Foster Reservoir on March 7, 2022. The trap sampled a total of 183 days in 2022. Of note, this trap did not sample from July 1, 2022, to September 2, 2022. Additional sampling outages that resulted from high flows and debris are listed in Appendix B.

Target Catch and Passage Timing

A total of 128 juvenile Chinook salmon and 224 juvenile O. mykiss was captured in 2022. Peak passage of juvenile Chinook salmon entering Foster Reservoir occurred during two time periods, spring and fall. Peak spring passage of juvenile Chinook occurred in March (n= 45, 35.2%) and fall passage occurred in October and November (n=62, 48.4%) (Figure 10). Brood year 2020 and 2021 Chinook were captured at the trap during both migration periods (Figure 11). Spring passage timing of yearling Chinook was similar to previous studies occurring during March and April (Romer et al. 2015). However, the first Chinook fry was captured on March 20th, later in the spring than was observed previously. Romer et al. (2015) captured the most sub-yearling Chinook in January and February. They also noted that fry emergence in the South Santiam above Foster Reservoir in 2015 was earlier than other basins and that the fish they captured late in the spring were significantly larger than their counterparts in other areas. It is likely that we missed Chinook fry passing through the trap site prior to the initiation of sampling. The average length of BY 20 Chinook caught during the spring period was 124.4 mm (n=5, min: 108 mm, max: 138 mm, median: 127 mm) and the average weight was 21.9 g (min: 14.2 g, max: 27.5 g, median: 23.5 g). The average length of BY 2021 Chinook captured in the spring was 39.7 mm (n=61, min: 31 mm, max: 80 mm, median: 35 mm). Chinook catch in the fall was comprised of both BY 2020 and BY 2021 fish. Scale age analysis shows significant overlap when relating fork length to age at this time. Previous data collected at this site strongly suggests that a majority of our fall capture are BY 2021 fish, despite some of the overlap we observed (Romer et al. 2012–2015). The average fork length of juvenile Chinook captured from September through December was 104.5 mm (n=62, min: 81 mm, max: 161 mm, median: 142.5 mm) and the average weight was 13.7 g (min: 5.3 g, max: 94.0 g, median: 30.8 g).

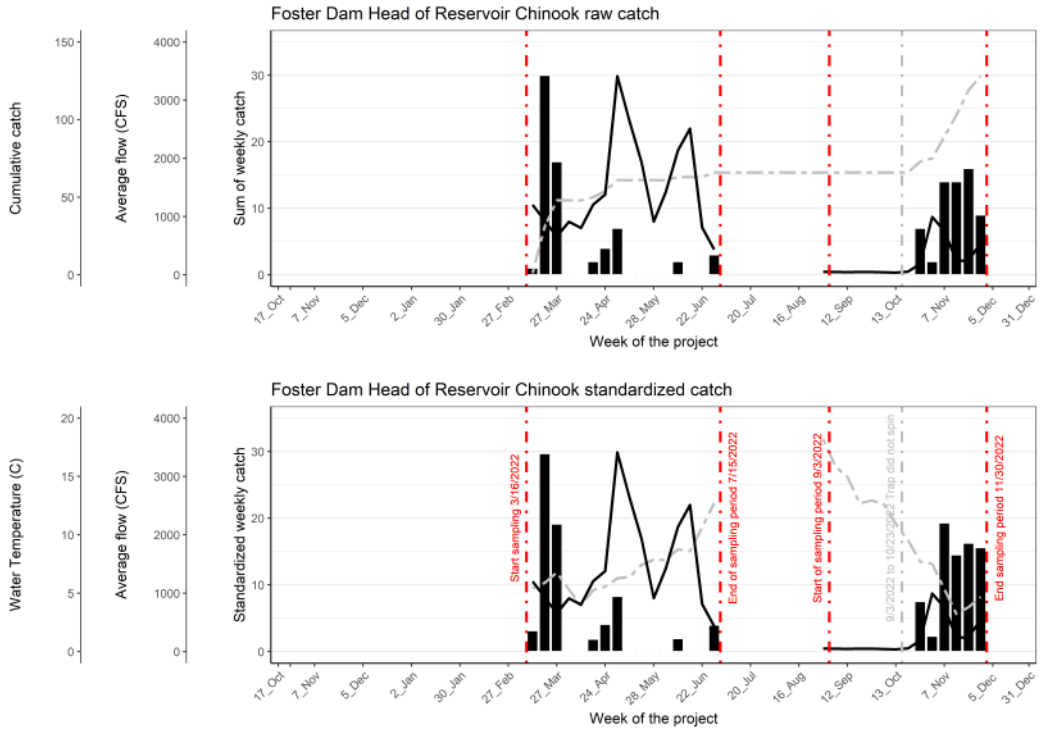

Figure 10. shows raw catch (top panel) and standardized catch (bottom panel) overlayed with flow (black line) and stream temperature (gray dot dash line) for juvenile Chinook at the Foster Dam Head of Reservoir site for 2022.

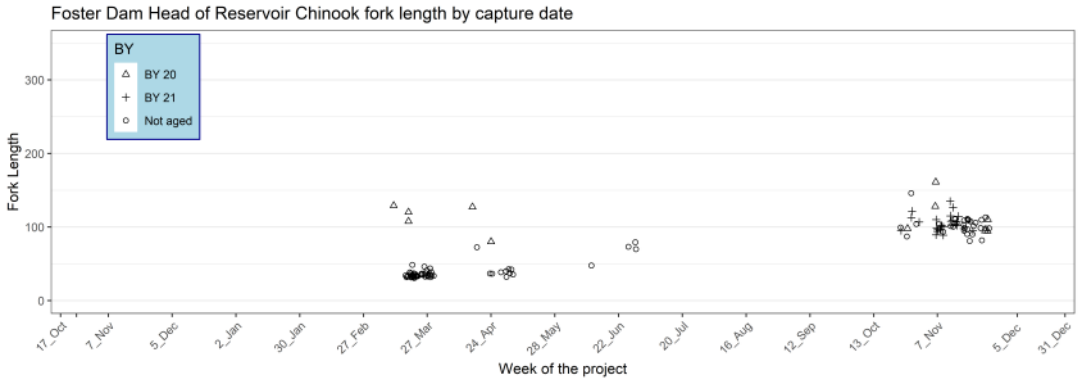

Figure 11. Shows length-frequency analysis for juvenile Chinook at the Foster Dam Head of Reservoir site for 2022.

Sub-yearling O. mykiss spring passage timing peaked in late April with fish migrating through June (Figure 12.). This timing is considerably earlier than previous studies observed in the basin (Romer et al. 2010–2016). Fry capture in March and April could potentially be progeny of a reservoir stock of rainbow trout or that of cutthroat trout. Due to the size of collected fry, crews were unable to distinguish between these possibilities and thus treated all captured trout fry as potential winter steelhead. The average fork length of sub-yearlings captured during the spring sampling period was 35.5 mm (n=32, min: 28 mm, max: 65 mm, median: 35 mm). During the spring passage period, we also observed age 1 (BY 2021) and age 2 O. mykiss (BY 2020) (Figure 13). These groups passed the trap from late March through the end of May. The average fork length of age 1 fish was 110.5 mm (n=16, min: 88 mm, max 132 mm, median: 111 mm) with an average weight of 15.4 g (min: 7.7 g, max: 30.9 g, median: 13.4 g). Age 2 fish had an average fork length of 172.3 mm (n=42, min: 141 mm, max: 213 mm, median: 170 mm) and an average weight of 50.0 g (min: 27.7 g,

max: 75.3 g, median: 50.0 g). Passage timing and size of age 1 and 2 O. mykiss closely resemble observations from catch in this basin in previous studies (Romer et al. 2012–2015). O. mykiss capture during the fall period consisted of age 0 and age 1 fish. Fall passage occurred in late October and November and was associated with streamflow. The average fork length of age 0 O. mykiss was 88.2 mm (n=65, min: 68 mm, max: 117 mm, median: 85 mm) with an average weight of 8.7 g (min: 3.9 g, max: 21.6 g, median: 7.6 g). The average fork length of age 1 O. mykiss was 148.1 mm (n=68, min: 125 mm, max: 205 mm, median: 145 mm) and an average weight of 33.4 g (min: 19.4 g, max: 87.2 g, median: 31.7 g). One age 2 fish was also captured that had a fork length of 266 mm and weighed 164.0 g. The timing of passage and fish size at age are similar to those seen in previous years at this site.

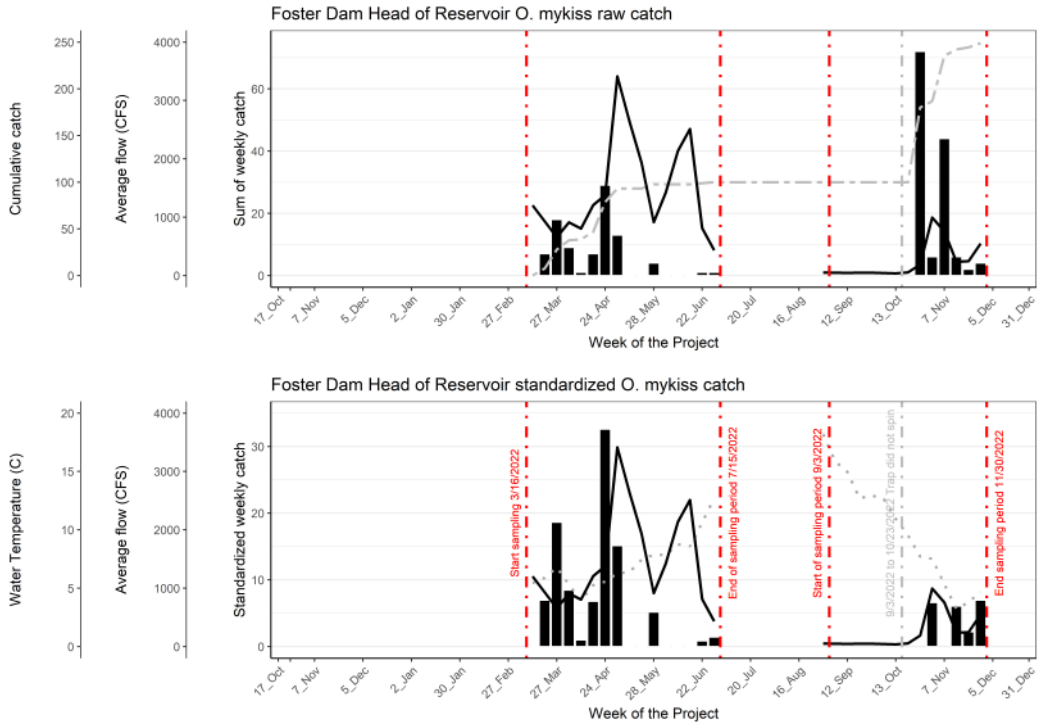

Figure 12. Shows raw (top panel) and weekly standardized (bottom panel) catch of juvenile O. mykiss overlayed with flow (black line) and stream temperature (gray dotted line) at the Foster Dam Head of Reservoir site for 2022.

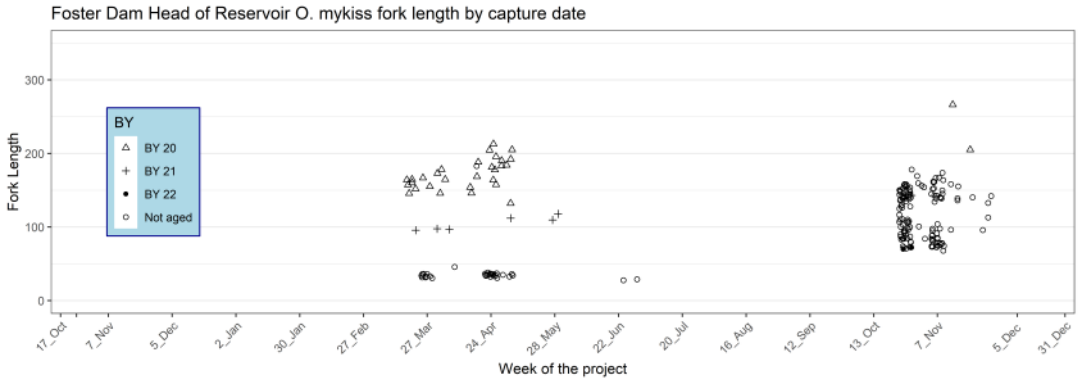

Figure 13. Shows length-frequency analysis by brood year for juvenile O. mykiss at the Foster Dam Head of Reservoir site for 2022.

Trapping Efficiency Trials

A total of six trapping efficiency trials occurred using hatchery reared Chinook salmon in the South Santiam River above Foster Reservoir. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 13. Trapping efficiencies ranged from 0% to 26.1%. Due to permit restrictions on the release of hatchery Chinook above Foster Reservoir on the South Santiam River during our spring sampling period, we were unable to perform trials with hatchery fish until the fall period. One efficiency trial performed during low flow did not yield any recaptures. This is likely due to the slow rotation speed of the trap at this flow level allowing fish to easily avoid the trap. Using trapping efficiencies by flow category, we estimate that 1,054 (95% CI: 689 to 2,238) juvenile Chinook passed the trapping site in 2022 (Figure 14).

Table 13. Summary table of marked hatchery Chinook releases at the Foster Dam Head of Reservoir site for trapping efficiency.

Foster Dam Head of Reservoir	9/29/2022	51	1,063	0	0%
Foster Dam Head of Reservoir	10/25/2022	211	821	116	14.1%
Foster Dam Head of Reservoir	11/1/2022	261	1,006	263	26.1%
Foster Dam Head of Reservoir	11/9/2022	560	1,007	68	6.8%
Foster Dam Head of Reservoir	11/15/2022	240	1,009	55	5.5%
Foster Dam Head of Reservoir	11/22/2022	165	933	163	17.5%

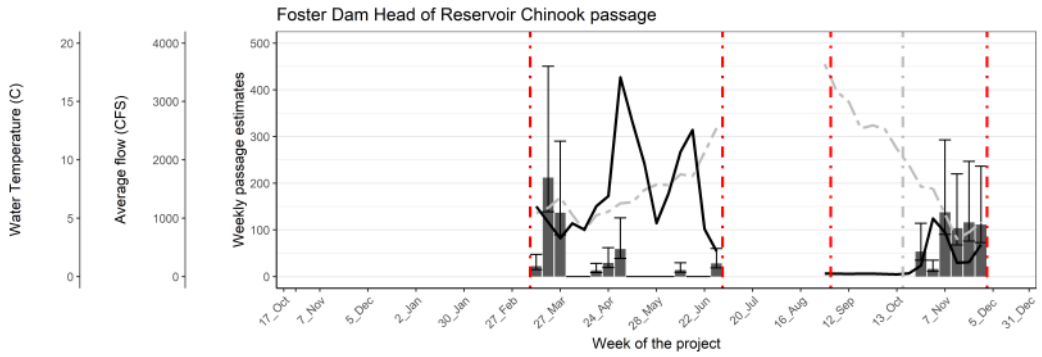

Figure 14. Weekly passage estimates of juvenile Chinook with 95% confidence intervals overlayed with flow (black line) and stream temperature (gray dot dash line) for sampling periods in 2022.

Injury Data

A total of 54 (41.4%) juvenile Chinook and 105 (46.9%) juvenile O. mykiss displayed at least one of the injury code conditions listed in Table 2. The most common injuries observed at this site include descaling less than 20% and fin damage. These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. Table 14 provides a summary of injuries observed on Chinook and O. mykiss at the Foster Dam Head of Reservoir site.

Table 14. Summary of injuries observed on juvenile Chinook and O. mykiss at the Foster Dam Head of Reservoir RST site.

NXI	56.3%	53.1%
MUNK	0.0%	0.0%
DS<2	41.4%	30.8%
DS>2	0.0%	0.0%
BLO	0.0%	0.0%
EYB	0.8%	0.4%
BVT	0.0%	0.0%
FVB	0.0%	0.4%
GBD	0.0%	0.0%
POP	0.0%	0.4%
HIN	0.0%	0.4%
OPD	0.0%	0.9%
TEA	0.05	0.4%
BRU	0.0%	1.3%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	21.9%	28.6%
PRD	0.0%	0.9%
COP	1.6%	0.9%
BKD	0.0%	0.0%
FUN	0.0%	0.9%

PIT Tagged fish and Downstream Detections

A total of 73 juvenile Chinook and 192 Juvenile O. mykiss was PIT tagged and released at the Foster Dam Head of Reservoir site in 2022. Of these, 26 fish were recaptured at the tagging site. These were fish transported and released upstream for the purpose of conducting run of river trapping efficiency trials. 1 tagged O. mykiss was redetected downstream at the Lebanon Dam North Ladder site, 17 days after release at the RST site. Table 15 shows a summary of the fish detected at downstream sites. Information regarding the redetections at the RST and other sites can be found in Appendix C.

Table 15. Summary of PIT tagged fish downstream redetections for the Foster Dam Head of Reservoir site in 2022.

3DD.003BEE167B	10/25/2022	Foster Dam Head of Reservoir – South Santiam River	11/11/2022	LD2 - Lebanon Dam North Ladder

Non-Target Capture Data

We captured 433 non-target fish in addition to natural origin juvenile Chinook and O. mykiss at the Foster Dam Head of Reservoir site (Table 16). Dace and Cutthroat trout were the most encountered non-target species.

Table 16. Summary of non-target fish capture at the Foster Dam Head of Reservoir- South Santiam River site.

Dace	382	11
Sculpin	2	1
Northern Pikeminnow	10	0
Largescale Sucker	6	1
Cutthroat	28	0
Brook Lamprey	1	0
Unknown	4	0
Totals	**433**	**13**

Cougar Dam

EAS began monitoring the three traps (two 8-foot RSTs in the Powerhouse channel and one 5-foot RST in the RO channel) below Cougar Dam on December 1, 2021. The Powerhouse traps sampled 307 days during the period from December 1, 2021, through December 31, 2022. The traps did not sample from July 29, 2022, to August 2, 2022, due to excessively high debris loads. There was an additional sampling outage from September 11, 2022, through September 12, 2022, that resulted from safety concerns regarding the Cedar Creek fire. The cones were raised to the non-sampling position on October 8, 2022, due to low flows creating conditions that prevented the cones from lowering into sampling position. They were unable to sample again until December 30, 2022. The RO channel trap sampled 394 days during the period from December 1, 2021, through December 31, 2022. The only period the RO RST was unable to sample when the RO was operating was from September 11, 2022, through September 12, 2022, due to safety concerns regarding the Cedar Creek fire. Additional information regarding sampling outages at this site can be found in Appendix B.

Target Catch and Passage Timing

A total of 2,996 juvenile Chinook was captured at the Cougar Dam Tailrace from December 1, 2021, through 2022. Total catch for 2022 was 2,972 fish. A total of 1,193 Chinook was captured in the Powerhouse traps (39.8% of total catch) (Figure 15) and 1,803 in the RO trap (60.2% of total catch) (Figure 16). Peak passage through the Powerhouse occurred February through May (n= 735, 61.6% of total Powerhouse catch). Another pulse of fish were captured in September and October (n= 321, 26.9% of total Powerhouse catch). Peak passage through the RO channel was similar to that observed in the Powerhouse with spring passage occurring February through May (n= 344, 19.1% of total RO catch), and fall passage occurring in October and November (n= 1,393, 77.3% of total RO capture). Total capture at Cougar Dam for the spring period was 1,079 Chinook (36.0% of total catch) and total catch for the fall period (September through November) was 1,714 Chinook (57.3% of total catch). The total catch for 2022 is similar to catch from previous studies. Extrapolated catch from 2021 sampling was 2,732 fish (Cramer, 2022) and the range of catch from ODFW RST sampling in 2011 through 2016 was 1,317 to 4,566. Our total capture for 2022 is consistent with these observations.

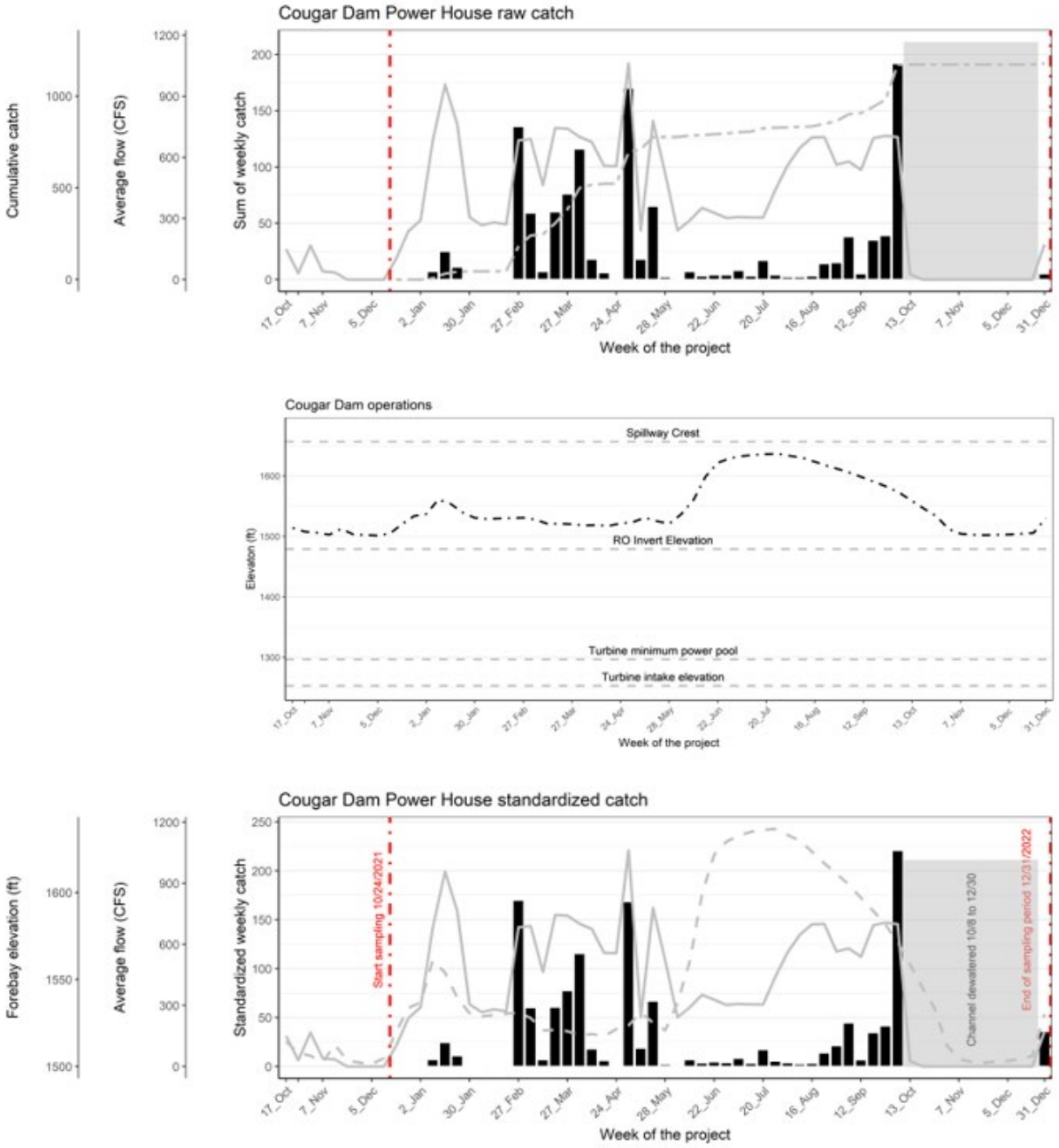

Figure 15. Raw (top panel) catch overlayed with powerhouse outflow (gray line) and cumulative catch (gray dash dot line). Middle panel displaying forebay elevation (black dot dash line) and intake elevations. Weekly standardized (bottom panel) catch overlayed with powerhouse outflow (gray line) and forebay elevation (gray dashed line) for the powerhouse traps at Cougar Dam from December 1, 2021, through December 31, 2022.

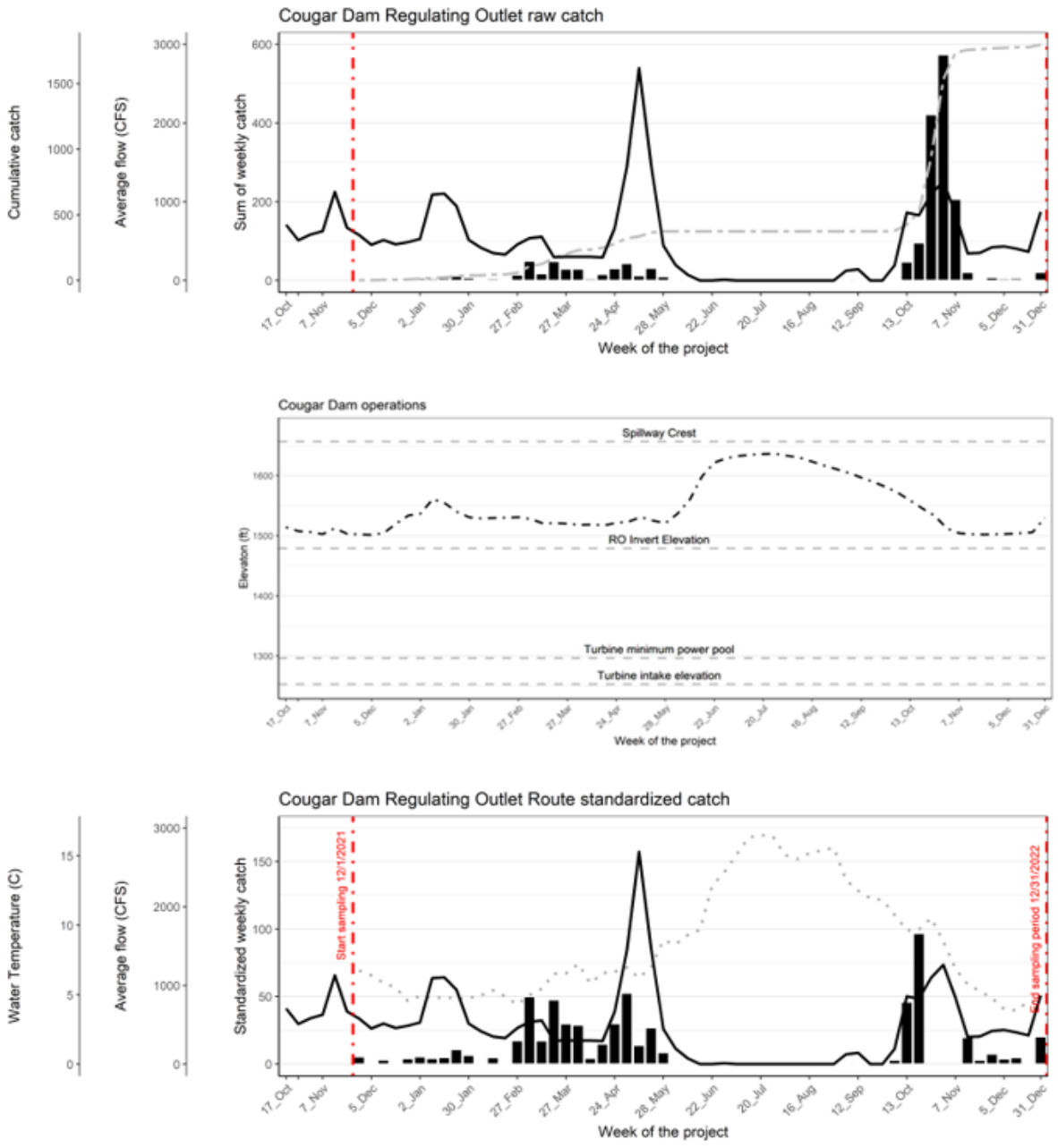

Figure 16. Raw (top panel) catch overlayed with regulating outlet outflow (black line) and cumulative catch (gray dash dot line). Middle panel displays forebay elevation (black dash dot line) and intake elevations. Weekly standardized (bottom panel) catch overlayed with regulating outlet outflow (black line) and water temperature (gray dot line) for the RO trap at Cougar Dam.

Chinook catch at Cougar Dam consisted of two BY classes, BY 2020 and BY 2021. Brood year 2020 Chinook were captured from the initiation of sampling through 2022. The peak migration of yearling BY 2020 fish occurred in April. The average fork length of BY 2020 fish captured in the spring period was 165.2 mm (n=290, min: 100 mm, max: 260 mm, median: 160 mm) and the average weight was 46.6 g (n=290, min: 8.4 g, max: 180.6 g, median: 38.1 g). The first BY 2021 fry captured at the Cougar Dam Tailrace occurred on March 5, 2022. The average fork length of BY 21 fish captured March through June was 38.4 mm (n=408, min: 27 mm, max: 64 mm, median: 37 mm). Catch from July 2022 to the end of the year was primarily comprised of BY 2021 sub-yearlings. However, age verification from scale samples shows a

significant number of smaller BY 2020 yearlings passing the trap during this period. Due to this overlap in passage timing and size at age, we were unable to reliably assign a BY category from length-frequency analysis (Figure 17). The average fork length of juvenile Chinook captured from July through the end of 2022 was 142.9 mm (n=1,802, min: 53 mm, max: 247 mm, median: 144 mm) and the average weight was 33.9 g (min: 1.2 g, max: 99.0 g, median: 31.9 g). This overlap is likely due to differing growth rates resulting from differences in stream and reservoir rearing habitats and the variable length of time individuals reared in the reservoir, similar to what has been observed in other basins. Previous studies in Cougar Reservoir show high growth rates for reservoir reared Chinook, compared to their stream reared counterparts, with most sub-yearlings captured in the reservoir displaying fork lengths greater than 100 mm in the latter months of the year (Monzyk et al. 2015; Hansen 2017). Our findings are consistent with these observations and suggest that large sub-yearlings captured in the trap are likely fish that spent a majority of their time rearing in Cougar Reservoir.

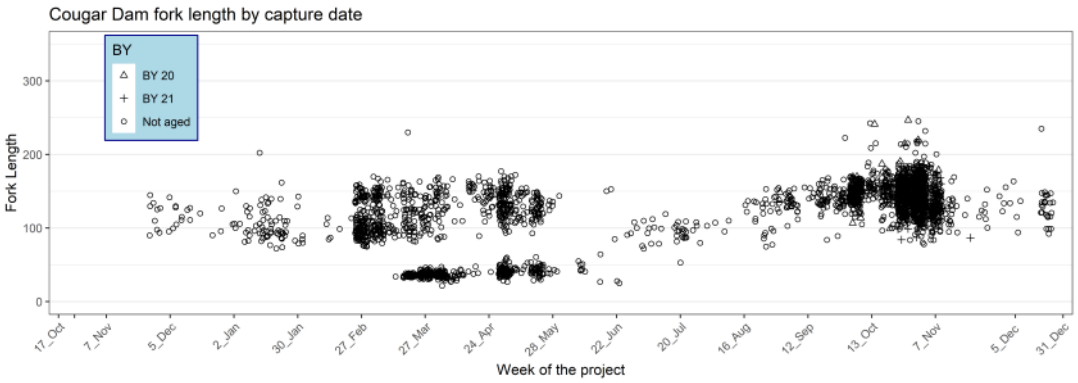

Figure 17. Length-frequency age analysis for juvenile Chinook captured below Cougar Dam in 2022.

Trapping Efficiency Trials

A total of 12 trapping efficiency trials occurred using hatchery reared Chinook salmon below Cougar Dam, eight in the RO channel and four in the Powerhouse channel. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 17. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled. Trapping efficiencies ranged from 1.6% to 12.8% in the RO channel and from 3.1% to 27.7% in the Powerhouse channel. We estimate that 24,956 (95% CI: 19,095 to 36,007) Chinook passed through the RO and 7,912 (95% CI: 4,743 to 23,823) passed through the Powerhouse from December 1, 2021, through 2022 (Figure 18). Total passage for this period at Cougar Dam is estimated to be 32,868 (95% CI: 23,838 to 59,830) juvenile Chinook.

Table 17. Summary table of marked hatchery Chinook releases at Big Cliff Dam for trapping efficiency.

Cougar Dam Powerhouse Channel	1/19/2022	405	997	37	3.7%
Cougar Dam Regulating Outlet Channel	1/19/2022	410	995	26	2.6%
Cougar Dam Powerhouse Channel	4/20/2022	357	1,000	67	6.7%
Cougar Dam Regulating Outlet Channel	4/20/2022	378	995	16	1.6%
Cougar Dam Regulating Outlet Channel	5/15/2022	987	500	64	12.8%
Cougar Dam Powerhouse Channel	7/19/2022	495	535	148	27.7%

Cougar Dam Powerhouse Channel	8/11/2022	501	949	29	3.1%
Cougar Dam Regulating Outlet Channel	10/14/2022	442	509	49	9.6%
Cougar Dam Regulating Outlet Channel	12/13/2022	506	502	42	8.4%
Cougar Dam Regulating Outlet Channel	12/15/2022	1,015	1,010	56	5.5%
Cougar Dam Regulating Outlet Channel	12/20/2022	500	1,014	61	6.0%
Cougar Dam Regulating Outlet Channel	12/28/2022	443	704	14	2.0%

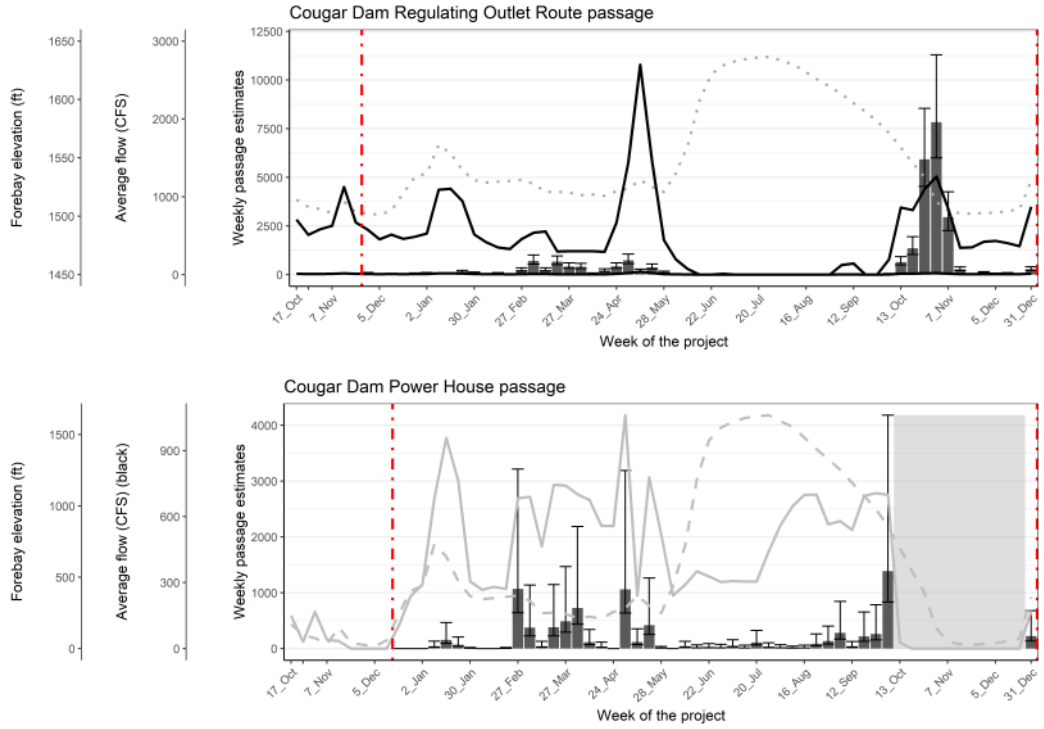

Figure 18. Shows estimated passage for the RO and Powerhouse routes (top panel and bottom panel, respectively) at Cougar Dam overlayed with powerhouse outflow (gray line), RO outflow (black line), and forebay elevation (gray dashed line).

Injury Data

A total of 2,568 juvenile Chinook displayed at least one of the injury code conditions listed in Table 18 (1,775 juvenile Chinook captured in the RO trap and 793 juvenile Chinook captured in the Powerhouse traps). To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. This was then applied as a correction factor to provide more clarity to injury resulting from passage. The most common injuries associated with trap capture include descaling less than 20% and fin damage while the most common injuries associated with passage include descaling less than 20%, descaling greater than 20%, operculum damage, and fin damage. It is likely that observations of gas bubble disease are higher for RST captured fish than those that are not captured in an RST as these fish are often captured and held

in areas of higher dissolved gas. Tables 19 and 20 show injuries observed on Chinook by route of passage. The proportion of fish displaying injuries by type over the sample period is shown in Figure 19. A total of 2,185 juvenile Chinook salmon was infected with copepods at time of capture (Figure 20). Copepod presence on captured Chinook salmon shows a positive correlation with the size of fish similar to observations made by previous studies (Cramer 2022; Monzyk et al. 2015). This is likely an association between time spent rearing in the reservoir rather than the size of the fish.

Table 18. Summary of injuries for trapping efficiency fish, observed injuries on natural origin Chinook, and corrected injuries for Chinook at the Cougar Dam Powerhouse RSTs.

NXI	42	26	-12.2%	400	449
MUNK	0	2	0.7%	10	10
DS<2	1	146	49.0%	517	264
DS>2	0	33	11.2%	121	107
BLO	0	1	0.3%	5	5
EYB	0	2	0.7%	33	33
BVT	0	1	0.3%	34	34
FVB	0	2	0.7%	63	63
GBD	0	0	0.0%	4	4
POP	0	2	0.7%	4	4
HIN	0	2	0.7%	21	21
OPD	3	10	1.9%	53	52
TEA	1	0	-0.5%	30	30
BRU	0	0	0.0%	27	27
HBP	0	0	0.0%	2	2
HO	0	0	0.0%	2	2
BO	0	0	0.0%	5	5
HBO	0	0	0.0%	0	0
FID	77	229	39.1%	311	189
PRD	0	0	0.0%	0	0
COP	0	7	2.4%	573	559
BKD	0	0	0.0%	0	0
FUN	0	0	0.0%	3	3

Table 19. Summary of injuries for trapping efficiency fish, observed injuries on natural origin Chinook, and corrected injuries for Chinook at the Cougar Dam RO RST.

NXI	151	28	-36.1%	28	38
MUNK	0	0	0.0%	0	0
DS<2	116	298	41.7%	1,065	621
DS>2	0	49	12.3%	560	491
BLO	5	6	0.1%	30	30
EYB	0	23	5.8%	240	226
BVT	0	3	0.8%	54	54
FVB	0	6	1.5%	151	149
GBD	0	6	1.5%	430	424
POP	0	2	0.5%	13	13
HIN	0	14	3.5%	80	77
OPD	4	12	1.9%	237	233
TEA	0	6	1.5%	38	37
BRU	0	7	1.8%	126	124
HBP	0	2	0.5%	31	31
HO	0	0	0.0%	0	0
BO	0	0	0.0%	2	2
HBO	0	0	0.0%	3	3
FID	97	368	64.7%	1,170	412
PRD	0	0	0.0%	3	3
COP	0	52	13.1%	1,612	1,401
BKD	0	0	0.0%	3	3
FUN	0	0	0.0%	11	11

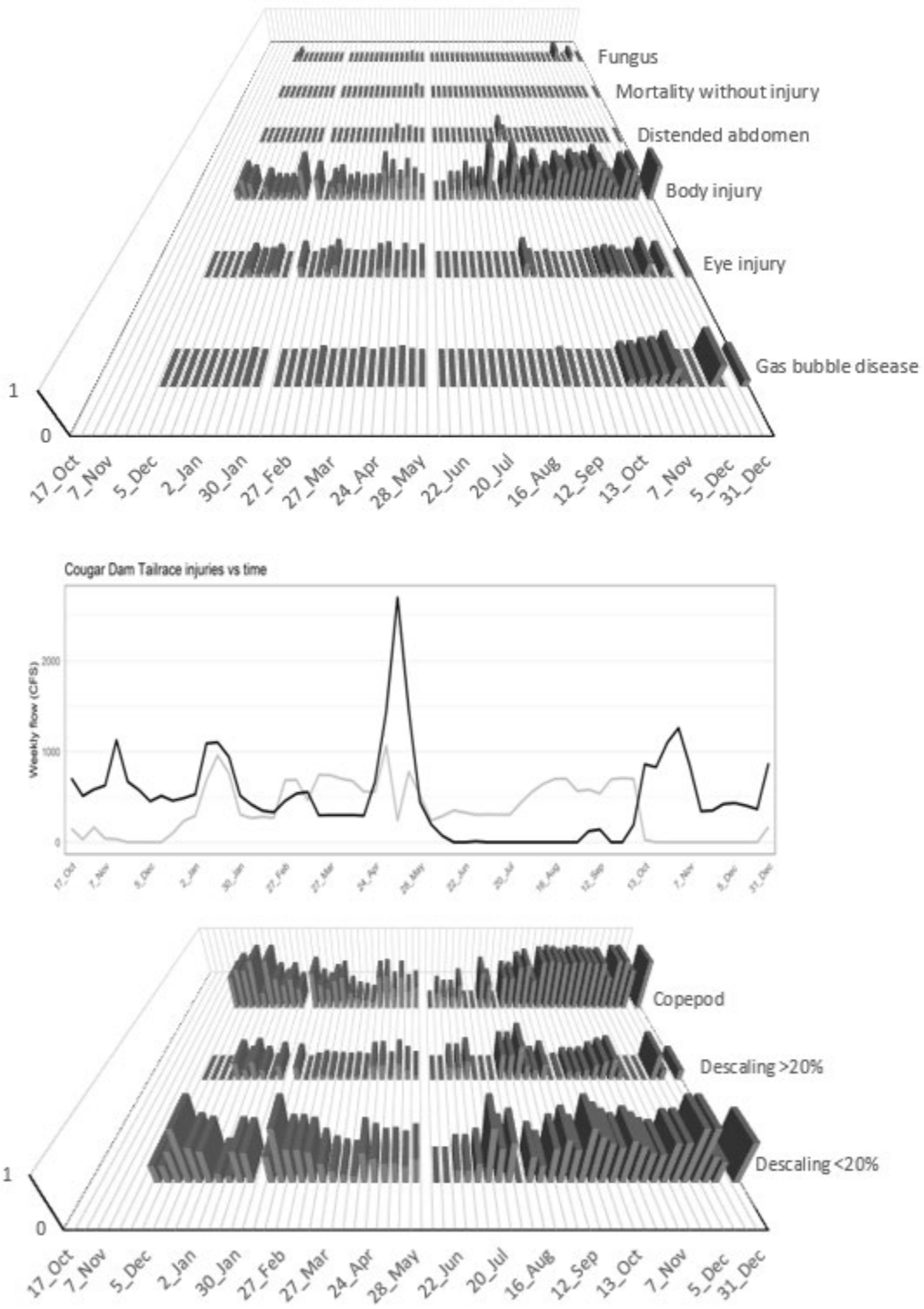

Figure 19. Proportion of captured juvenile Chinook displaying injuries by type (top panel), operations data from Cougar Dam showing cfs of spill (black line) and powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook displaying descaling and copepod injuries (bottom panel).

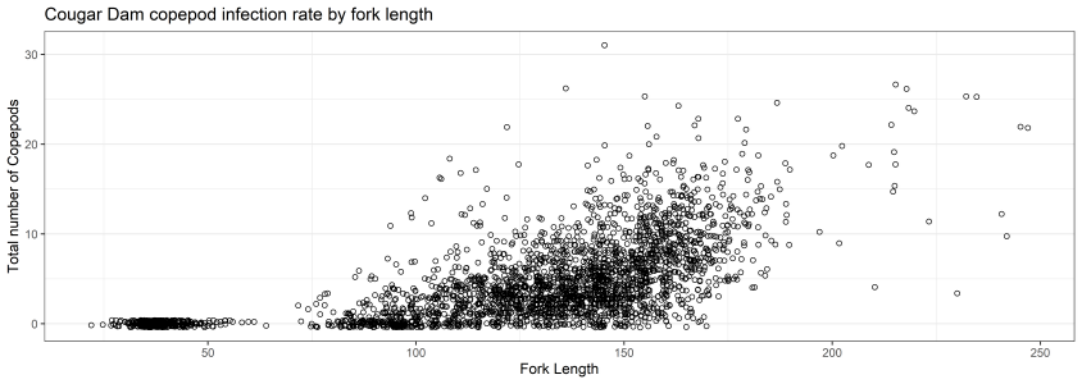

Figure 20. Copepod presence vs fork length on juvenile Chinook captured at Cougar Dam.

24 Hour Hold Trials

24 hour hold trials were performed on natural origin juvenile Chinook captured at Cougar Dam to assess delayed mortality resulting from dam passage. The first fish entered hold in December 2021. A total of 1,219 fish—635 from the RO and 584 from the Powerhouse—was held (Table 20). A total of 86 fish died during hold (7.1%), 60 of the RO Chinook (9.4%) and 26 of the Powerhouse Chinook (4.5%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 20.0%.

Table 20. Summary of 24-hour hold trials for fish captured in the RSTs at the Cougar Dam site.

12/1/21 – 12/15/21	RO	8	0	100%
12/16/21 – 12/31/21	RO	1	0	100%
1/1/22 – 1/15/22	RO	8	0	100%
1/1/22 – 1/15/22	PH	5	0	100%
1/16/22 – 1/31/22	RO	18	0	100%
1/16/22 – 1/31/22	PH	31	0	100%
2/1/22 – 2/15/22	RO	4	0	100%
2/1/22 – 2/15/22	PH	1	0	100%
2/16/22 – 2/28/22	RO	5	0	100%
2/16/22 – 2/28/22	PH	1	0	100%
3/1/22 – 3/15/22	RO	36	2	94.4%
3/1/22 – 3/15/22	PH	80	1	98.8%
3/16/22 – 3/31/22	RO	83	2	97.6%
3/16/22 – 3/31/22	PH	26	0	100%
4/1/22 – 4/15/22	RO	33	1	97.0%
4/1/22 – 4/15/22	PH	60	0	100%
4/16/22 – 4/30/22	RO	36	1	97.2%
4/16/22 – 4/30/22	PH	5	0	100%
5/1/22 – 5/15/22	RO	43	1	97.7%
5/1/22 – 5/15/22	PH	91	4	95.6%
5/16/22 – 5/31/22	RO	22	2	90.9%
5/16/22 – 5/31/22	PH	55	1	98.2%
6/1/22 – 6/15/22	PH	8	0	100%
6/16/22 – 6/30/22	PH	9	1	88.9%
7/1/22 – 7/15/22	PH	10	1	90.0%
7/16/22 – 7/31/22	PH	21	1	95.2%

8/1/22 – 8/15/22	PH	4	0	100%
8/16/22 – 8/31/22	PH	9	1	88.9%
9/1/22 – 9/15/22	PH	38	2	94.7%
9/16/22 – 9/30/22	PH	55	3	94.5%
10/1/22 – 10/15/22	RO	40	7	82.5%
10/1/22 – 10/15/22	PH	71	11	84.5%
10/16/22 – 10/31/22	RO	180	36	80.0%
11/1/22 – 11/15/22	RO	67	4	94.0%
11/16/22 – 11/30/22	RO	23	1	95.7%
12/1/22 – 12/15/22	RO	9	1	88.9%
12/16/22 – 12/31/22	RO	19	2	89.4%
12/16/22 – 12/31/22	PH	4	0	100

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 1,369 juvenile Chinook was PIT tagged and released at the Cougar Dam sites in 2022. Of these, 43 fish were recaptured at the tagging site. These were fish transported and released upstream for the purpose of conducting run of river trapping efficiency trials. As of February 1, 2023, two tags were redetected downstream by the estuary towed array, 46 days after tagging for one fish and 14 days after initial tagging and release for the other. As of February 1, 2023, data from the ODFW PIT array at Cougar Dam has not been uploaded to PTAGIS. Table 21 shows a summary of the fish detected downstream sites. Information regarding the redetections at the RST site can be found in Appendix C.

Table 21. Summary of redetections of fish PIT tagged at the Cougar Dam sites.

3DD.003E1BC7D6	4/11/2022	Cougar Dam	5/27/2022	TWX - Estuary Towed Array (Exp.)
3DD.003E1BC80A	5/10/2022	Cougar Dam	5/24/2022	TWX - Estuary Towed Array (Exp.)

Non-Target Capture Data

A total of 3,294 non-target fish was captured at the Cougar Dam sites. A summary of species and catch is provided below in Table 22. The most commonly captured non-target species were dace, O. mykiss, and sculpin. Information regarding captured Bull Trout is provided in Appendix C.

Table 22. Summary of non-target fish capture for the Cougar Dam RSTs from December 1, 2021, through 2022.

Brook lamprey	3	0
Bluegill	2	0
Bull Trout	1	0
Chinook (AD clipped)	46	14
Chinook (adult)	1	0
Crappie	1	1
Cutthroat	75	3
Dace	2,502	8
Largescale sucker	55	0
Mountain whitefish	52	3
Northern Pikeminnow	2	0
O. mykiss	319	3
Sculpin	207	4
Smallmouth bass	3	0
Spotted bass	4	0
Unknown	21	2
Totals	**3,294**	**38**

Cougar Dam Head of Reservoir

Monitoring of a single 5-foot RST in the South Fork McKenzie River above Cougar Reservoir began on March 7, 2022. The trap sampled 164 days in 2022. The trap was not sampled from July 1, 2022, to September 16, 2022. Additional sampling outages that resulted from high flows and snow events blocking access are listed in Appendix C.

Target Catch and Passage Timing

The trap captured 710 juvenile Chinook salmon. Peak passage of juvenile Chinook salmon entering Cougar Reservoir occurred in March and April (n= 329, 46.3%). This timing is consistent with data from previous studies (Romer et al. 2016). Figure 21 shows raw and standardized catch overlayed with flow at the Cougar Dam Head of Reservoir site. Chinook catch consisted of two BY classes, BY 2021 (n= 676, 95.2%) and BY 2020 (n= 34, 4.8%). Brood year 2021 Chinook were the dominant age class captured at this site throughout the year (Figure 22). The first BY 2021 fry captured at the trap occurred on March 10, three days after the start of sampling. The first BY 2020 yearling was also captured on March 10. Yearling catch continued through April suggesting that most BY 2020 fish had migrated to the reservoir prior to the summer months. BY 2020 had an average fork length of 91.6 mm (n= 34, min: 64 mm, max: 150 mm, median: 76 mm) and an average weight of 7.7 g (n=34, min: 3.2 g, max: 14.2 g, median: 8.2 g). Brood year 2021 catch during the spring sampling period had an average fork length of 39 mm (n=542, min: 27 mm, max: 77 mm, median: 37 mm). Since BY 2021 fry and BY 2020 yearlings were captured so close to the initiation of sampling, it is likely that some early migrants from both BYs were missed prior to sampling. Chinook passage during the fall monitoring period appeared to be more influenced by streamflow than timing. Catch during this period was comprised of BY 2021 sub-yearlings. The average fork length of juvenile Chinook captured from September through December was 78.6 mm (n=134, min: 60 mm, max: 99 mm, median: 78 mm) and the average weight was 5.46 g (n=134, min: 1.8 g, max: 11.2 g, median: 5.3 g).

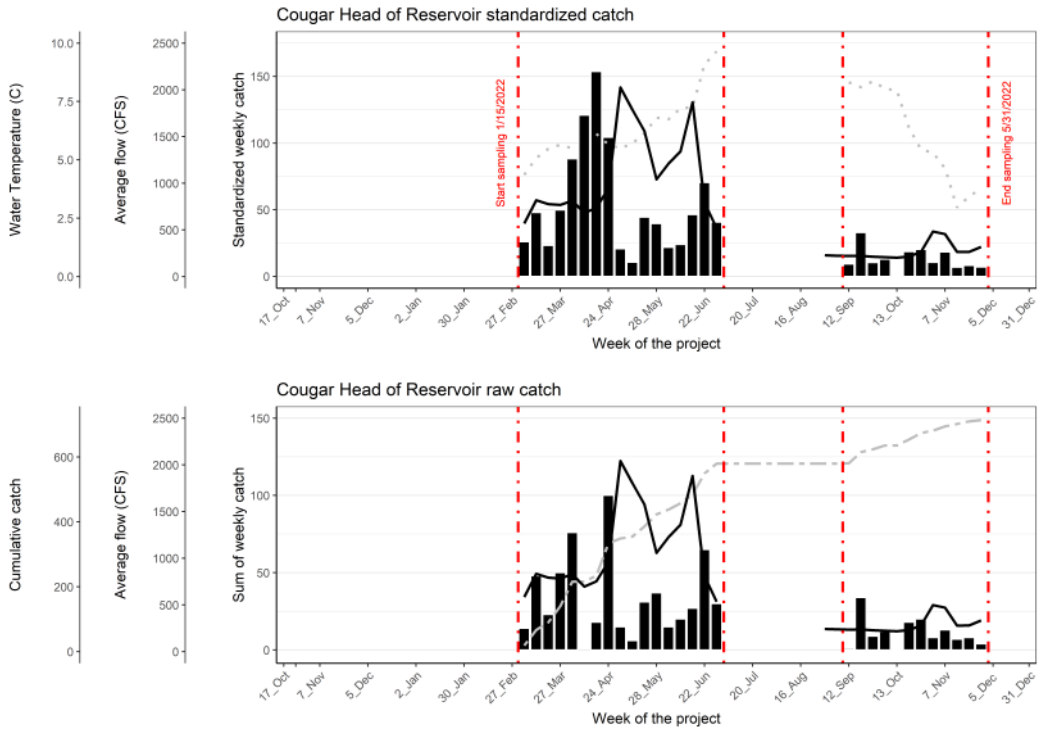

Figure 21. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Cougar Dam Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), and water temperature (gray dots) for 2022.

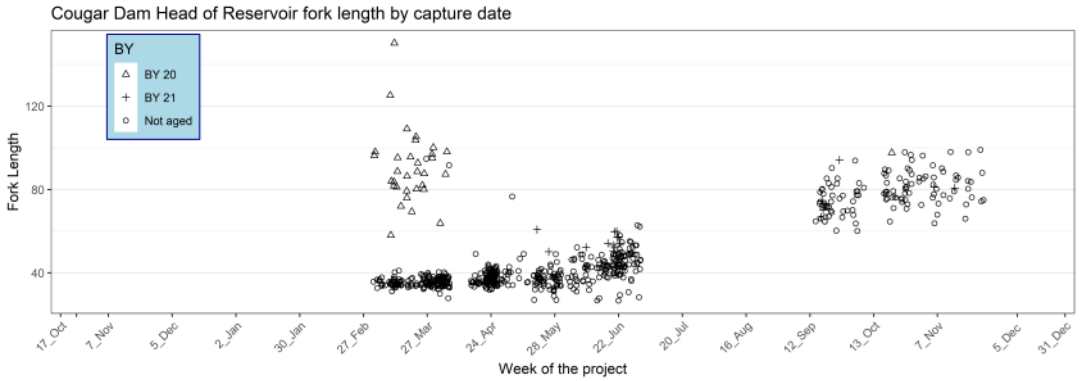

Figure 22. Length-frequency of juvenile Chinook salmon by brood year at the Cougar Dam Head of Reservoir site.

Trapping Efficiency Trials

A total of nine trapping efficiency trials occurred using hatchery reared Chinook salmon at the Cougar Dam Head of Reservoir site. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 23. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled. Trapping efficiencies ranged from 1.4% to 10.2%. We estimate that 18,952(95% CI: 14,462 to 27,482) juvenile Chinook migrated past our trap into Cougar Reservoir during the March to June and September to November sampling periods (Figure 23). This estimate is likely low due to sampling outages during high flows. For some of these events we could not produce a passage estimate until the trap resumed sampling. Additionally, previous work has found that some Chinook migrate into the reservoir during the summer months (Romer et al. 2012–2016), a period when our trap was not sampling.

Table 23. Summary table of marked hatchery Chinook releases at the Cougar Dam Head of Reservoir site for trapping efficiency.

Cougar Dam Head of Reservoir	3/18/2022	774	806	40	5.0%
Cougar Dam Head of Reservoir	5/19/2022	1,385	498	23	4.6%
Cougar Dam Head of Reservoir	6/23/2022	711	486	7	1.4%
Cougar Dam Head of Reservoir	9/22/2022	225	551	56	10.2%
Cougar Dam Head of Reservoir	10/5/2022	207	608	47	7.7%
Cougar Dam Head of Reservoir	11/10/2022	340	704	33	4.7%
Cougar Dam Head of Reservoir	11/16/2022	259	719	28	3.9%
Cougar Dam Head of Reservoir	11/23/2022	292	752	48	6.4%
Cougar Dam Head of Reservoir	11/29/2022	295	620	48	7.7%

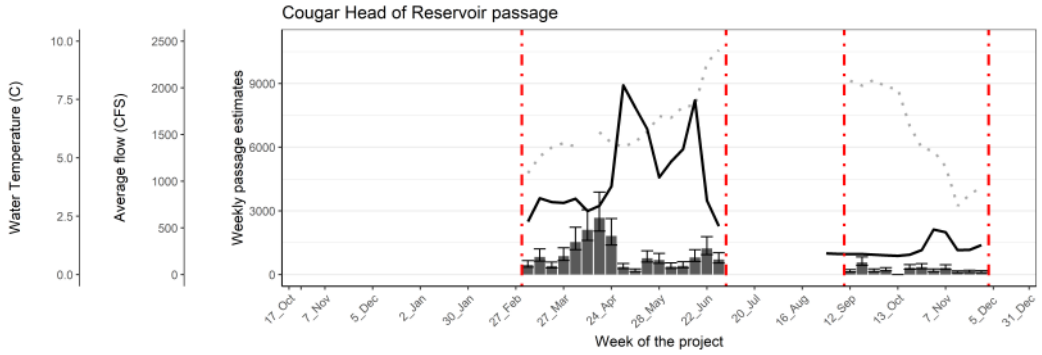

Figure 23. Passage estimates with 95% confidence for juvenile Chinook salmon at the Cougar Dam Head of Reservoir site with streamflow (black line) and stream temperature (gray dots) for the 2022 sampling period.

Injury Data

A total of 137 juvenile Chinook displayed at least one of the injury code conditions listed in Table 24. The most common injuries observed at this site include descaling less than 20% and fin damage. These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. There were 13 mortalities likely resulting from high debris in the trap.

Table 24. Percentage of juvenile Chinook displaying injury by type at the Cougar Head of Reservoir RST site.

NXI	80.4%
MUNK	0.4%
DS<2	13.1%
DS>2	0.6%
BLO	0.0%
EYB	0.0%
BVT	0.0%
FVB	0.1%
GBD	0.0%
POP	0.1%
HIN	1.0%
OPD	1.1%
TEA	0.8%
BRU	0.1%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	7.9%
PRD	0.4%
COP	1.4%
BKD	0.0%
FUN	0.1%

PIT Tagged/VIE Marked fish and Downstream Detections

A total of 156 fish was PIT tagged and 33 were VIE marked at Cougar Dam Head of Reservoir site in 2022. VIE marking was implemented on June 25, 2022. Additionally, 3,223 hatchery Chinook salmon were ad clipped, PIT tagged, and released above the trap site for the purpose of conducting trapping efficiency trials. 197 PIT tagged Chinook were recaptured at the Cougar Dam Head of Reservoir site in 2022. The 38 PIT tagged fish that were released at the trapping site were redetected at the Cougar Dam RST sites. The average time between release and redetection at Cougar Dam Tailrace was 31 days (min: 4, max: 87, median: 32). Table 25 shows a summary of redetected tags as of February 1, 2023, with their tag date, tag site, redetection date, and redetection site. As of February 1, 2023, data from the ODFW PIT arrays at Cougar Dam has not been available on PTAGIS. See Appendix C for information regarding tags redetected at the Cougar Dam Head of Reservoir site.

Table 25. Summary of PIT tag redetections at downstream arrays for fish tagged at the Cougar Dam Head of Reservoir site.

9/21/2022	Cougar Dam Head of Reservoir	10/31/2022	Cougar Dam
9/22/2022	Cougar Dam Head of Reservoir	10/28/2022	Cougar Dam
9/22/2022	Cougar Dam Head of Reservoir	10/31/2022	Cougar Dam
9/22/2022	Cougar Dam Head of Reservoir	11/12/2022	Cougar Dam

9/22/2022	Cougar Dam Head of Reservoir	10/26/2022	Cougar Dam
9/22/2022	Cougar Dam Head of Reservoir	10/31/2022	Cougar Dam
9/22/2022	Cougar Dam Head of Reservoir	10/26/2022	Cougar Dam
9/22/2022	Cougar Dam Head of Reservoir	10/28/2022	Cougar Dam
9/22/2022	Cougar Dam Head of Reservoir	10/29/2022	Cougar Dam
9/22/2022	Cougar Dam Head of Reservoir	10/28/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	11/2/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	11/5/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	12/31/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	11/5/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	10/29/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	11/5/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	10/27/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	11/5/2022	Cougar Dam
10/5/2022	Cougar Dam Head of Reservoir	11/2/2022	Cougar Dam
10/23/2022	Cougar Dam Head of Reservoir	10/27/2022	Cougar Dam
11/10/2022	Cougar Dam Head of Reservoir	12/26/2022	Cougar Dam
11/10/2022	Cougar Dam Head of Reservoir	12/28/2022	Cougar Dam
11/10/2022	Cougar Dam Head of Reservoir	12/30/2022	Cougar Dam
11/10/2022	Cougar Dam Head of Reservoir	11/22/2022	Cougar Dam
11/16/2022	Cougar Dam Head of Reservoir	12/30/2022	Cougar Dam
11/16/2022	Cougar Dam Head of Reservoir	11/30/2022	Cougar Dam
11/16/2022	Cougar Dam Head of Reservoir	12/14/2022	Cougar Dam
11/16/2022	Cougar Dam Head of Reservoir	12/28/2022	Cougar Dam
11/23/2022	Cougar Dam Head of Reservoir	11/29/2022	Cougar Dam
11/23/2022	Cougar Dam Head of Reservoir	12/30/2022	Cougar Dam
11/23/2022	Cougar Dam Head of Reservoir	12/28/2022	Cougar Dam

11/23/2022	Cougar Dam Head of Reservoir	12/31/2022	Cougar Dam
11/23/2022	Cougar Dam Head of Reservoir	12/5/2022	Cougar Dam
11/23/2022	Cougar Dam Head of Reservoir	11/30/2022	Cougar Dam
11/23/2022	Cougar Dam Head of Reservoir	11/30/2022	Cougar Dam
11/29/2022	Cougar Dam Head of Reservoir	12/30/2022	Cougar Dam
11/29/2022	Cougar Dam Head of Reservoir	12/5/2022	Cougar Dam
11/29/2022	Cougar Dam Head of Reservoir	12/28/2022	Cougar Dam

Non-Target Capture Data

We captured 443 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught are provided in Table 26. The most commonly captured non-target species were rainbow trout and cutthroat trout. Additionally, our trap captured 11 Bull Trout. All Bull Trout were measured and scanned for PIT tags. All information gathered, and the one collected carcass, were provided to ODFW. Date, fork length, and PIT tag information on captured Bull Trout is provided in Appendix C.

Table 26. Summary of non-target species capture at the Cougar Dam Head of Reservoir RST site for 2022.

Bull Trout	11	1
Cutthroat Trout	44	1
Dace	8	0
Sculpin	5	1
O. mykiss	341	3
Mountain Whitefish	24	0
Northern Pikeminnow	1	0
Unknown	9	0
Totals	**443**	**6**

Fall Creek Dam Tailrace and Fall Creek Head of Reservoir

EAS began monitoring the single 8-foot RST in the RO channel of Fall Creek Dam on March 15, 2022. Prior to EAS operating the RST at Fall Creek Dam, RST sampling was performed by the Corps. Results from Corps sampling is reported in the respective Corps biannual reports. The trap sampled 173 days in 2022. The trap did not sample from July 15, 2022, to October 15, 2022. Additionally, the trap was unable to sample in any capacity from December 5, 2022, through December 31, 2022. This outage was due to river bed movement from reservoir drawdown that filled the RO channel with sediment to the point that the cone could not be lowered to the sampling position.

The trap at the Fall Creek Head of Reservoir site was installed on January 11, 2022, and began sampling on January 14, 2022, once flows and debris receded to a level deemed safe for sampling. The trap sampled 131 days in 2022. Additional information regarding trap sample dates and outages can be found in Appendix B.

Target Catch and Passage Timing

The trap in the Regulating Outlet Channel below Fall Creek Dam captured 1 juvenile Chinook salmon during sampling in 2022. The juvenile Chinook salmon was captured on October 23, 2022 (Figure 24). Scale samples show that this fish was part of BY 2020 (n=1, FL= 230 mm, wt.=141.1 g) (Figure 25).

The trap at Fall Creek Head of Reservoir captured 7 juvenile Chinook salmon (Figure 26). Scale samples show that fish captured at this site consisted of BY 2020 (n=6) and 2019 (n=1) (Figure 27). BY 2020 had an average fork length of 128.3 mm (n= 6, min: 119 mm, max: 139 mm, median: 128.5 mm) and an average weight of 23.6 g (n=6, min: 16.1 g, max: 31.2 g, median: 21.9 g). The one BY 2019 fish captured had a fork length of 255 mm and a weight of 108.5 g. Capture of all Chinook at this site occurred in the last two weeks of March. Absence of BY 2021 catch above and below Fall Creek Reservoir suggests a year-class failure occurred. Capture of yearling fish in the spring period above Fall Creek Reservoir usually accounted for about 1% of total catch for the site annually (Keefer et al. 2012). Observations of age 1+ fish only occurred below the reservoir by previous groups. The BY 2019 fish we captured is likely a fish that reared in the reservoir before venturing above into Fall Creek where it was captured. Prior study above Fall Creek Reservoir found that most fish migrated into the reservoir December through the early summer months. The below dam site saw sub-yearlings exiting from December through February, and yearlings in November through February (Keefer et al. 2012).

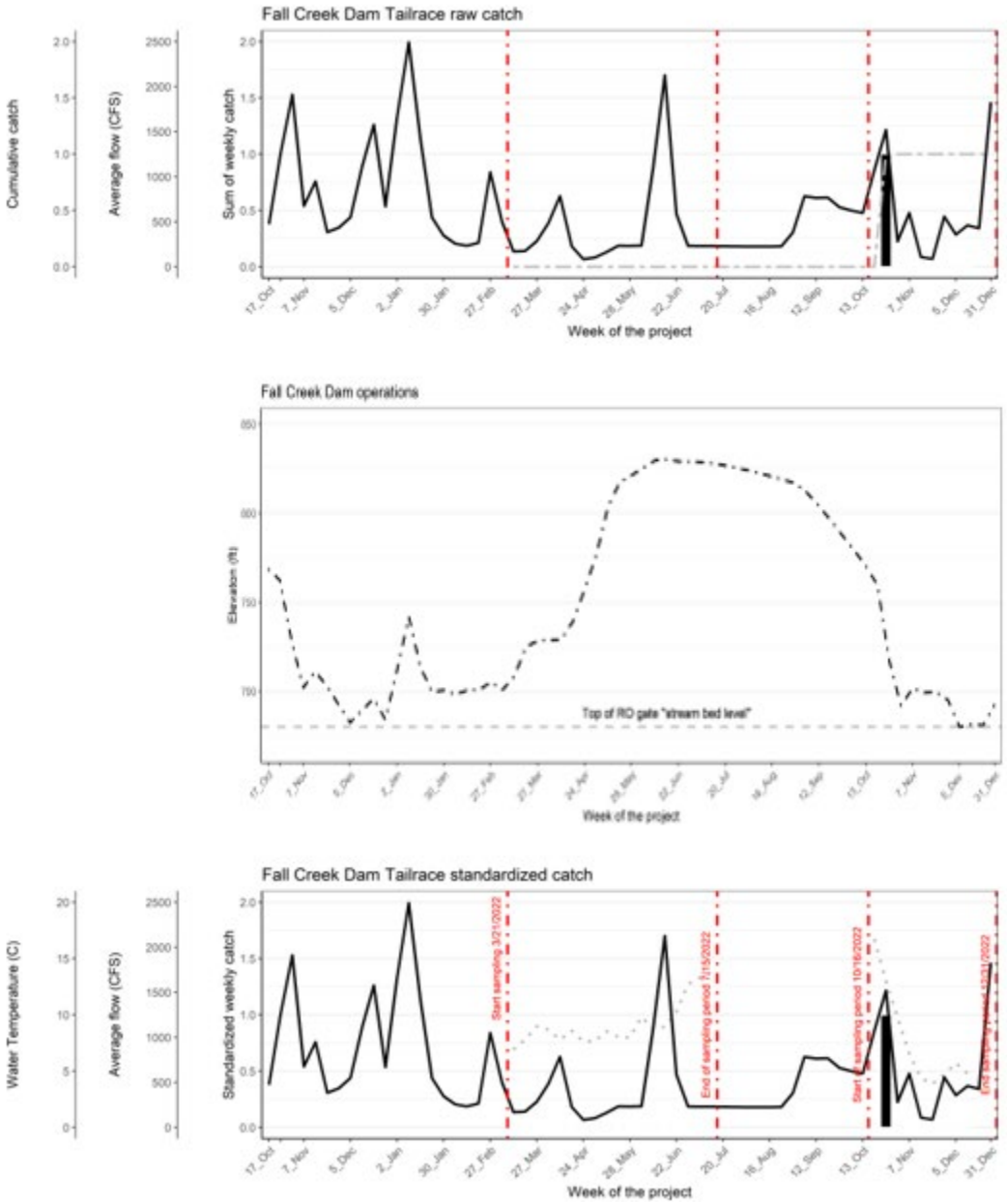

Figure 24. Raw catch (top panel), Fall Creek Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Fall Creek Dam Tailrace site with RO flow (black line), forebay elevation (black dot dash line, intake elevations (gray dash line), cumulative catch (gray dot dash line), and stream temperature (gray dots) for 2022.

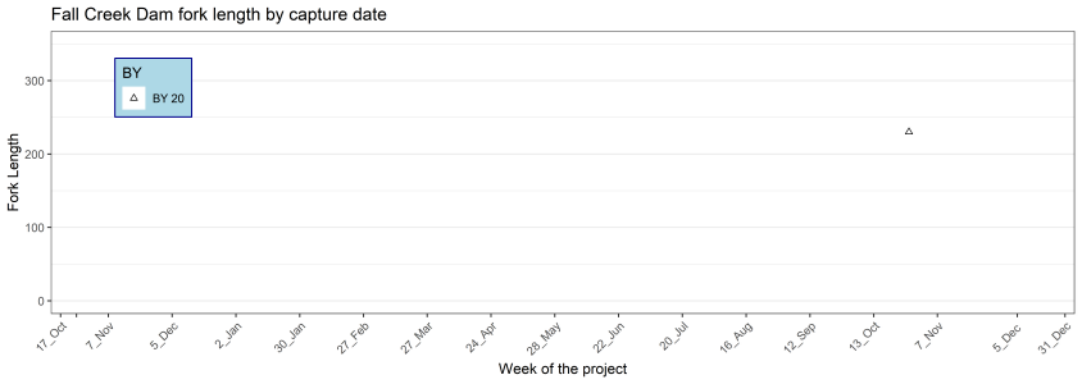

Figure 25. Length-frequency of juvenile Chinook salmon at the Fall Creek Dam Tailrace site.

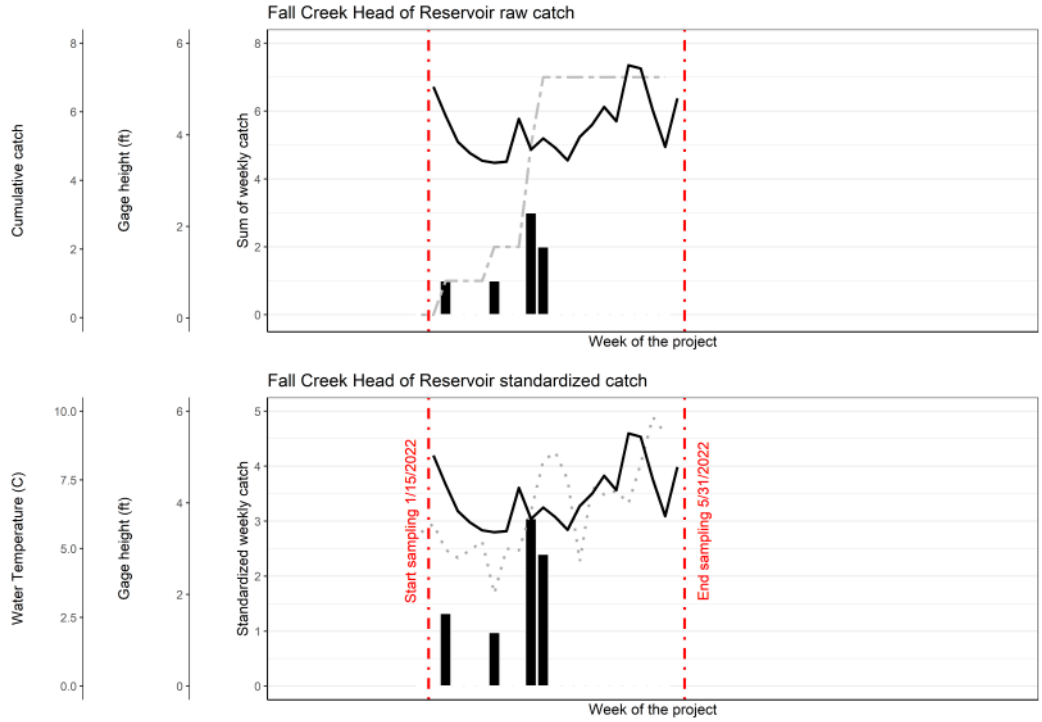

Figure 26. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Fall Creek Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), and stream temperature (gray dots) for 2022.

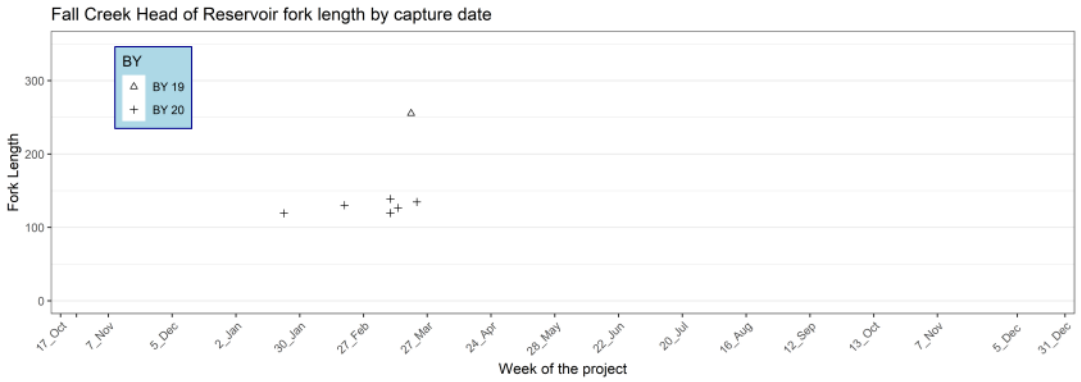

Figure 27. Length-frequency of juvenile Chinook salmon by brood year at the Fall Creek Head of Reservoir site.

Trapping Efficiency Trials

A total of three trapping efficiency trials occurred using hatchery reared Chinook salmon in the RO channel of Fall Creek Dam. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 27. Trapping efficiencies ranged from 0% to 2.1%. Due to strict limitations on the availability of hatchery Chinook from Middle Fork Willamette brood stocks and low catch rate of natural origin fish at this site, we were unable to perform enough trap efficiency trials to allow for passage estimates in 2022. Efficiency trials performed during low flow did not yield any recaptures. This is likely due to the slow rotation speed of the trap at these flow levels allowing fish to easily avoid the trap.

Table 27. Summary table of marked hatchery Chinook releases at Fall Creek Dam Tailrace for trapping efficiency.

Fall Creek Dam Regulating Outlet	06/08/2022	957	517	11	2.1%
Fall Creek Dam Regulating Outlet	06/30/2022	231	513	0	0
Fall Creek Dam Regulating Outlet	07/13/2022	228	498	0	0

In 2022, no hatchery origin fish were permitted for release at the Fall Creek Head of Reservoir site. Due to the low capture rate of natural origin fish, we were unable to perform run of river trap efficiency trials at this site. With insufficient trapping efficiency data and very low catch numbers, we are unable to calculate a passage estimate for 2022 at the Fall Creek sites.

Injury Data

The one juvenile Chinook captured at the Fall Creek Dam Tailrace site displayed descaling greater than 20%, bruising, and fin damage. This fish also had copepods present in the branchial cavity. Figure 28 shows total number of observed copepods versus fork length for the captured fish.

Of the seven fish captured at the Fall Creek Head of Reservoir site, three displayed descaling less than 20% and one had fin damage. These injuries were likely the result of contact with debris or trap surfaces upon capture. Additionally, two fish had copepods present on fins and one had copepods attached in the branchial cavity. Figure 29 shows total number of observed copepods versus fork length for the fish captured at the Fall Creek Head of Reservoir site.

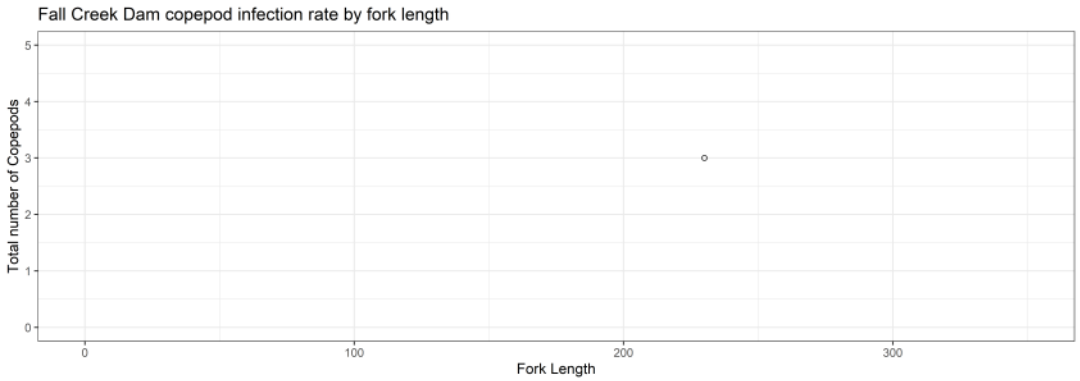

Figure 28. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Fall Creek Dam Tailrace.

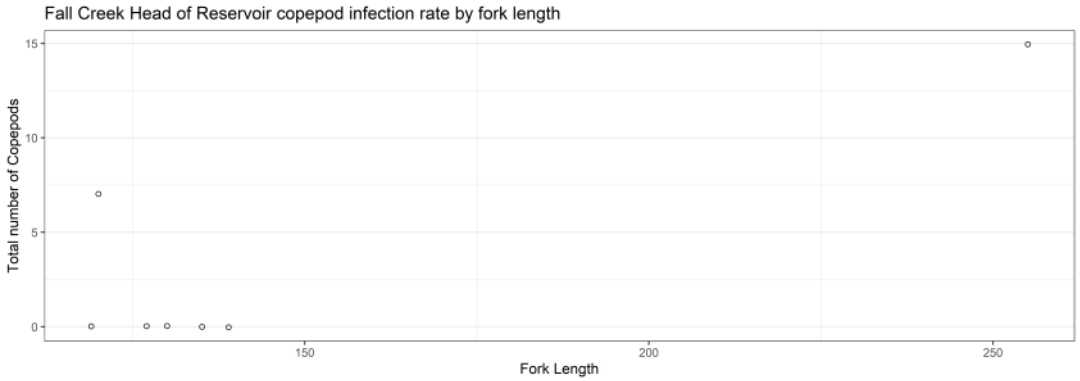

Figure 29. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at the Fall Creek Head of Reservoir site.

PIT Tagged/VIE Marked fish and Downstream Detections

A total of five fish was PIT tagged at the Fall Creek Head of Reservoir site and zero fish were tagged at the Fall Creek Dam Tailrace site in 2022. As of February 1, 2023, none of the tagged fish were redetected at downstream sites. No Chinook were captured and VIE marked at the Fall Creek Head of Reservoir site in 2022 as no sub-yearling fish were captured. Further information on tagged fish at this site is available in Appendix C.

Non-Target Capture Data

The Fall Creek Dam Tailrace trap captured 4,200 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught are provided in Table 28. The most commonly captured non-target species were Dace and Bullhead Catfish.

Table 28. Summary of non-target fish catch at the Fall Creek Dam Tailrace RST.

Bluegill	1	0
Brook lamprey	19	0
Brown bullhead	384	149
Chinook (clipped)	2	0
Crappie	1	0
Cutthroat trout	39	1
Dace	3,224	190
Largescale sucker	121	18
Mosquitofish	113	6
Northern pikeminnow	2	0
O. mykiss	248	2
Pacific lamprey	4	0
Peamouth	15	1
Redside shiner	12	0
Sculpin	10	1
Unknown	5	1
Totals	**4,200**	**369**

The Fall Creek Head of Reservoir trap captured 776 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught are provided in Table 29. The most commonly captured non-target species were Brook Lamprey and Rainbow Trout.

Table 29. Summary of non-target fish catch at the Fall Creek Head of Reservoir RST.

Brook lamprey	284	3
Cutthroat trout	73	0
Dace	56	0
O. mykiss	282	10
O. mykiss (clipped)	80	0
Sculpin	1	1
Totals	**776**	**14**

Dexter Dam Tailrace

Monitoring of a single 5-foot RST in the Dexter Dam Tailrace began on March 7, 2022. The trap sampled 282 days in 2022. The trap did not sample from October 10, 2022, to October 16, 2022, due to safety concerns from the Cedar Creek fire. Additional sampling outages that resulted from high flows and high debris are listed in Appendix B.

Target Catch and Passage Timing

The trap captured 99 juvenile Chinook salmon in 2022. Peak passage of juvenile Chinook salmon leaving Dexter Reservoir occurred in May and June (n= 84, 84.8%). Figure 30 shows raw and standardized catch overlayed with flow at the Dexter Dam Tailrace. Chinook catch consisted of two BY classes, BY 2021 (n= 71, 71.7%) and BY 2020 (n= 28, 28.3%). Brood year 2021 Chinook were the dominant age class captured at this site throughout the year (Figure 31). The first BY 2021 fish captured at the trap occurred on June 5. The first BY 2020 yearling was captured on April 3. Yearling catch continued through June, with one yearling

caught in late December, suggesting that most BY 2020 fish exited the reservoir in late spring. Peak passage at Dexter Dam shows an association with surface spill events at Lookout Dam.

BY 2021 Chinook had an average fork length of 112.7 mm (n= 71, min: 46 mm, max: 145 mm, median: 117 mm) and an average weight of 16.4 g (min: 1.4 g, max: 29.3 g, median: 16.3 g). BY 2020 had an average fork length of 170.2 mm (n= 28, min: 142 mm, max: 226 mm, median: 163 mm) and an average weight of 49.4 g (min: 6.4 g, max: 162.3 g, median: 44.6 g).

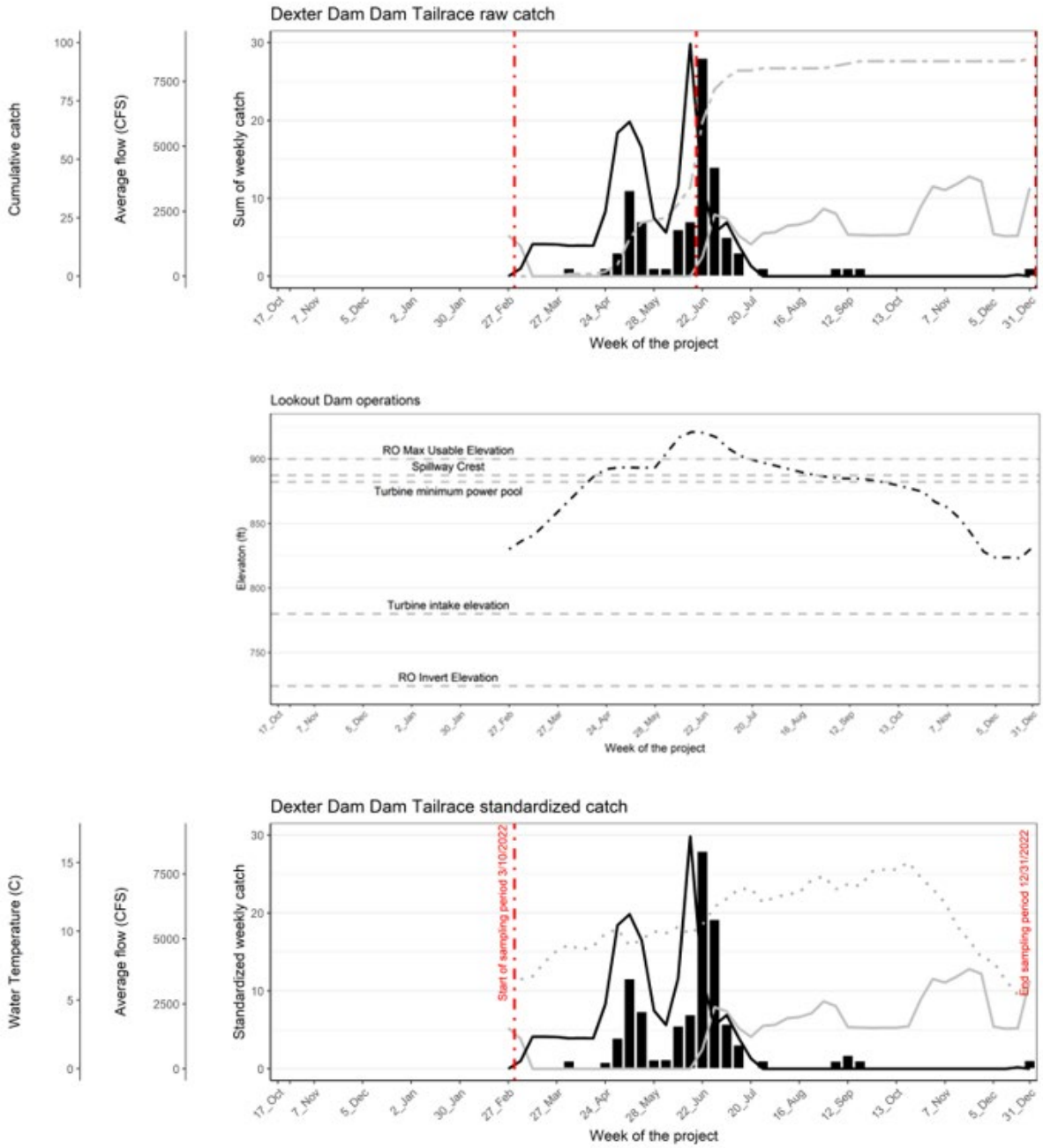

Figure 30. Raw catch (top panel), Lookout Dam forebay and intake elevations, and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Dexter Dam Tailrace site with spill (black line), powerhouse outflow (gray line), cumulative catch (gray dot dash line), and water temperature (gray dots) for 2022.

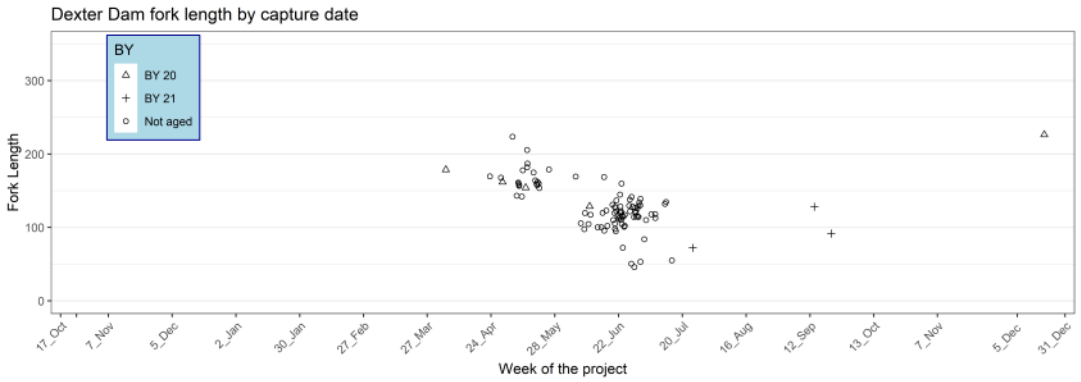

Figure 31. Length-frequency of juvenile Chinook salmon by brood year at the Dexter Dam Tailrace site.

Trapping Efficiency Trials

A total of nine trapping efficiency trials occurred using hatchery reared Chinook salmon at the Dexter Dam Tailrace site, 3 in the spillway outflow and six in Powerhouse outflow. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 30. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled. Trapping efficiencies in the spillway release ranged from 0.2% to 6.6% and those in Powerhouse ranged from 0.1% to 1.0%. Only two spill trials and one Powerhouse trial yielded the minimum number of five recaptures in a week needed to calculate efficiencies. We estimate that 724 (95% CI: 515 to 1,220) juvenile Chinook migrated past our trap during spill in April, May, and June (Figure 32). This estimate has a high level of uncertainty as efficiencies at this site are very low and often variable. We also were unable to calculate estimates for fish passage through the Powerhouse as we were unable to get enough recaptures. Trials in future years with larger release groups are needed to provide more clarity on passage at this site.

Table 30. Summary table of marked hatchery Chinook releases at Dexter Dam Tailrace for trapping efficiency.

Dexter Dam Spillway	3/23/2022	1,240	988	2	0.2%
Dexter Dam Spillway	5/4/2022	5,040	995	43	4.3%
Dexter Dam Spillway	5/24/2022	2,620	1,018	67	6.6%
Dexter Dam Powerhouse	7/21/2022	1,560	976	2	0.2%
Dexter Dam Powerhouse	10/26/2022	2,950	1,007	1	0.1%
Dexter Dam Powerhouse	11/1/2022	3,670	755	1	0.1%
Dexter Dam Powerhouse	11/17/2022	3,450	991	4	0.4%
Dexter Dam Powerhouse	12/6/2022	1,610	1,010	10	1.0%
Dexter Dam Powerhouse	12/15/2022	1,540	1,025	1	0.1%

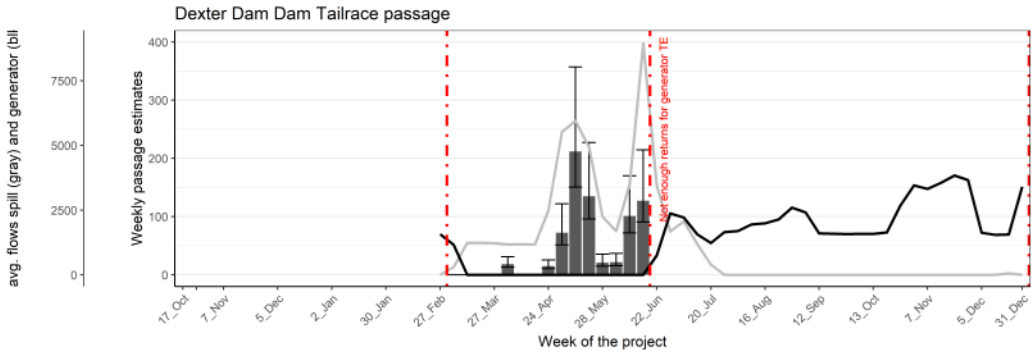

Figure 32. Passage estimates with 95% confidence for juvenile Chinook salmon at the Dexter Dam Tailrace site with spill (black line) and powerhouse outflow (gray line) for the 2022 sampling period.

Injury Data

A total of 91 juvenile Chinook displayed at least one of the injury code conditions listed in Table 2. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type both pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. This was then applied as a correction factor to provide more clarity to injury resulting from passage. The most common injuries observed at this site include descaling less and greater than 20% and fin damage (Table 31). Figure 33 shows the proportion of fish displaying injuries by type over the sampling period. Copepod presence on captured Chinook salmon showed a positive correlation with the size of fish, similar to observations from other sites within the basin (Figure 34). It is likely that observations of gas bubble disease are higher for RST captured fish than those that are not captured in an RST as these fish are often captured and held in areas of higher dissolved gas.

Table 31. Summary of observed injuries on trapping efficiency and natural origin juvenile Chinook captured in the Dexter Dam Tailrace

NXI	94	83	40.8%	8	5
MUNK	0	0	0.0%	0	0
DS<2	89	27	-1.3%	60	61
DS>2	49	3	-9.9%	23	25
BLO	2	0	-0.5%	0	0
EYB	0	2	1.6%	6	6
BVT	0	0	0.0%	1	1
FVB	0	0	0.0%	5	5
GBD	0	0	0.0%	21	21
POP	0	0	0.0%	0	0
HIN	0	1	0.8%	6	6
OPD	2	2	1.1%	6	6
TEA	4	0	-1.0%	4	4
BRU	1	0	-0.3%	3	3
HBP	0	0	0.0%	0	0
HO	0	0	0.0%	0	0
BO	0	0	0.0%	0	0
HBO	0	0	0.0%	0	0
FID	24	32	18.8%	46	37
PRD	0	0	0.0%	0	0
COP	0	0	0.0%	12	12
BKD	0	0	0.0%	0	0
FUN	0	0	0.0%	0	0

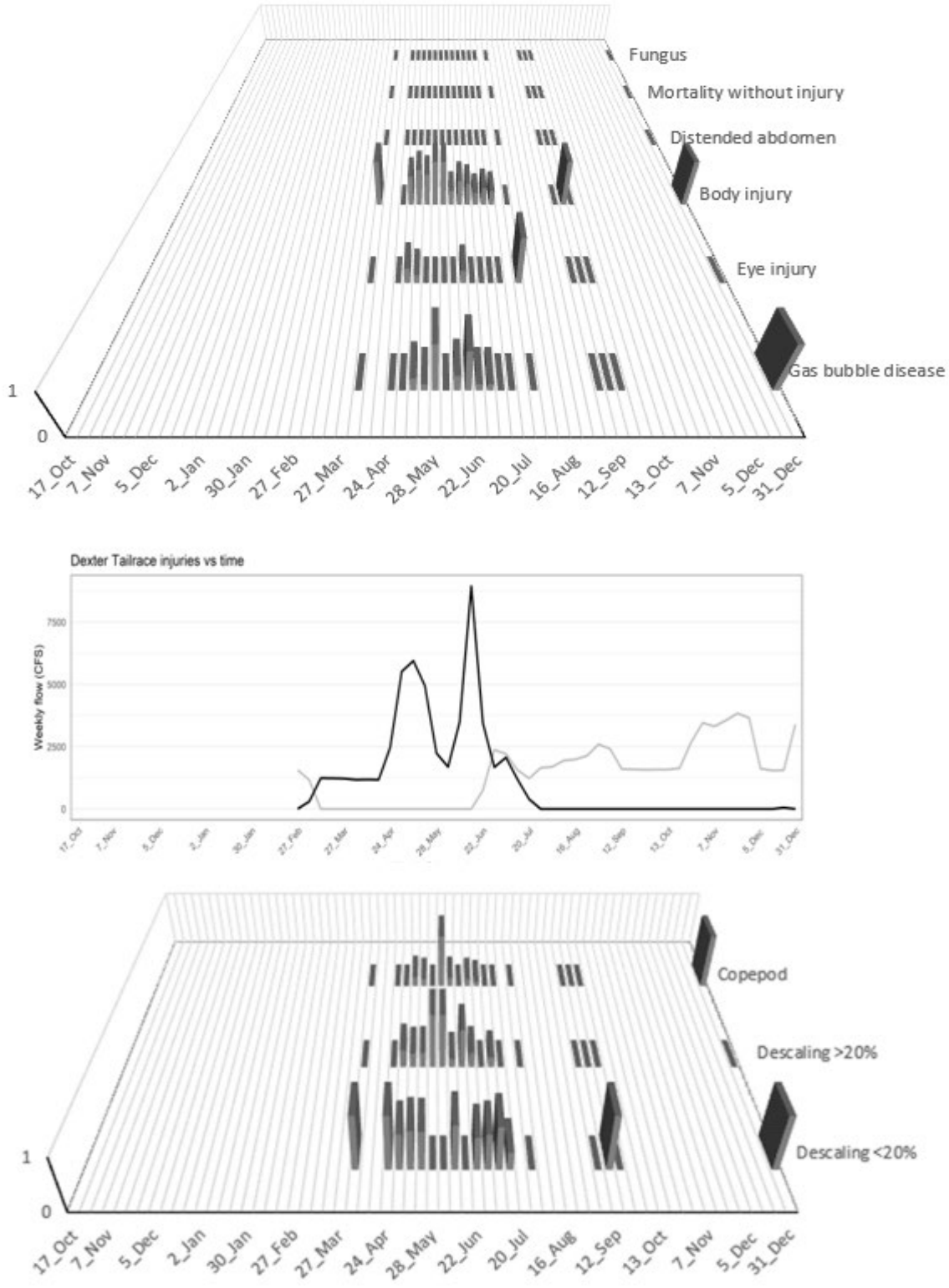

Figure 33. Proportion of captured juvenile Chinook displaying descaling less or greater than 20% descaling (top panel), operations data from Dexter Dam Tailrace showing cfs of spill (black line) and powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook displaying injuries by type (bottom panel).

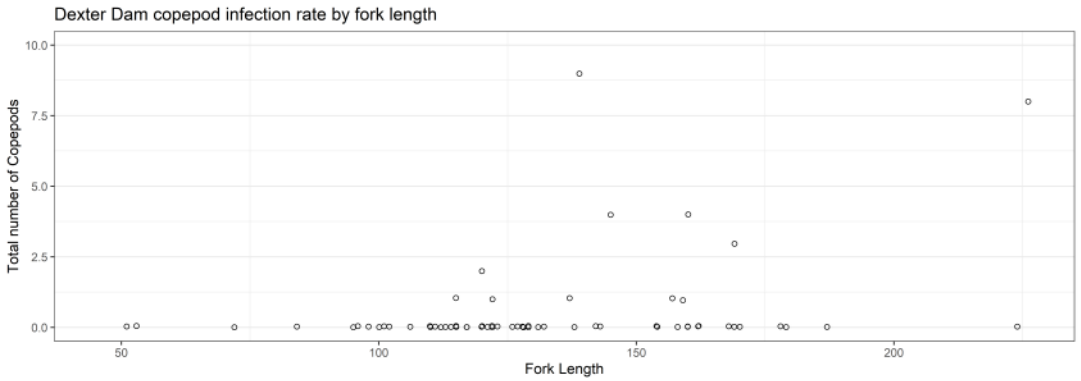

Figure 34. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Dexter Dam Tailrace.

24 Hour Hold Trials

24 hour hold trials were performed on natural origin juvenile Chinook captured in the Dexter Dam Tailrace to assess delayed mortality resulting from RST capture, handling, or dam passage. The first fish entered hold trials at Dexter Dam Tailrace in April. 68 Chinook were held in 2022 (Table 32). A total of 11 Chinook died during hold (16.2%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100%.

Table 32. Summary of 24-hour hold trials for fish captured in the RST at the Dexter Dam Tailrace site.

4/1/22 – 4/15/22	1	0	100%
4/16/22 – 4/30/22	1	0	100%
5/16/22 – 5/31/22	7	3	57.1%
6/1/22 – 6/15/22	9	2	77.8%
6/16/22 – 6/30/22	44	4	90.9%
7/1/22 – 7/15/22	2	0	100%
7/16/22 – 7/31/22	1	0	100%
9/1/22 – 9/15/22	1	1	0%
9/16/22 – 9/30/22	1	0	100%
12/16/22 – 12/31/22	1	1	0%

PIT Tagged/VIE Marked fish and Downstream Detections

A total of 11 fish was PIT tagged at the Dexter Dam Tailrace site in 2022. As of February 1, 2023, no tagged fish were redetected at downstream sites. Furthermore, no VIE marked fish from upstream sites were detected at the Dexter Dam Tailrace RST site.

Non-Target Capture Data

We captured 1,161 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught are provided in Table 33. The most commonly captured non-target species were sculpin and clipped Chinook (escapees from the Dexter Fish Facility).

Table 33. Summary of non-target fish captured in the RST at the Dexter Dam Tailrace site.

Bass	99	1
Bluegill	11	1
Chinook (adult)	2	2
Chinook (clipped)	360	7
Crappie	102	5
Cutthroat	3	0
Dace	31	6
Largescale sucker	5	1
O. mykiss	17	0
O. mykiss (clipped)	34	2
Pikeminnow	1	0
Redside shiner	3	0
Sculpin	479	15
Unknown	14	4
Totals	**1,161**	**44**

Lookout Dam Tailrace

Monitoring in the Middle Fork Willamette River in the Lookout Dam Tailrace began on March 15, 2022. The Powerhouse channel traps sampled 262 days in 2022 and the spill channel trap fished 260 days. A summary of sampling outages at this site can be found in Appendix B.

Target Catch and Passage Timing

A total of 78 juvenile Chinook salmon was captured in the Lookout Dam Tailrace during the 2022 sampling period, 40 in the Powerhouse traps (51.3% of total catch, 26 in PH 1, 14 in PH 2) and 38 in the spill trap (48.7% of total catch). Date of capture for 77 of the 78 Chinook occurred between April 28, 2022, and July 13, 2022. The only other fish captured was on December 31, 2022 (Figures 35, 36, and 37). From April to July, Chinook capture was comprised of individuals from BY 2020 and 2021 (Figure 38). A majority of these fish were BY 2021 sub-yearlings (n=56, 71.8% of total catch) with an average fork length of 114.6 mm (min: 58 mm, max: 146 mm, median: 119 mm) and average weight of 18.0 g (min: 1.4 g, max: 32.3 g, median: 19.4 g). BY 2020 yearlings (n=22, 28.2% of total catch) had an average fork length of 173.0 mm (min: 151 mm, max: 256 mm, median: 165.5) and an average weight of 59.0 g (min: 35.5 g, max: 108.9 g, median: 53.3 g).

Our trapping rate in the Lookout Dam Tailrace was approximately 0.3 fish per day. This is similar to rates reported for sampling conducted from 2011 to 2015 in which the traps averaged roughly 0.3 fish per day (Romer et al. 2012–2016) and slightly higher than the catch rate observed in 2021 (Cramer 2022). However, these rates are all lower than those observed from sampling by Keefer et al. from 2007 to 2010 which had a capture rate 0.7 fish per day.

Observations from sampling in 2012 and 2013 found that fish passed in the summer when spill occurred at the Lookout Dam Tailrace. On years when no spring/summer spill occurred and water primarily passed through the turbines, Chinook passage occurred predominantly in the fall months (Romer et al. 2013). Catch below Lookout Point Dam in 2022 coincided with surface spill events in the late spring and early summer, in concurrence with previous studies conclusions.

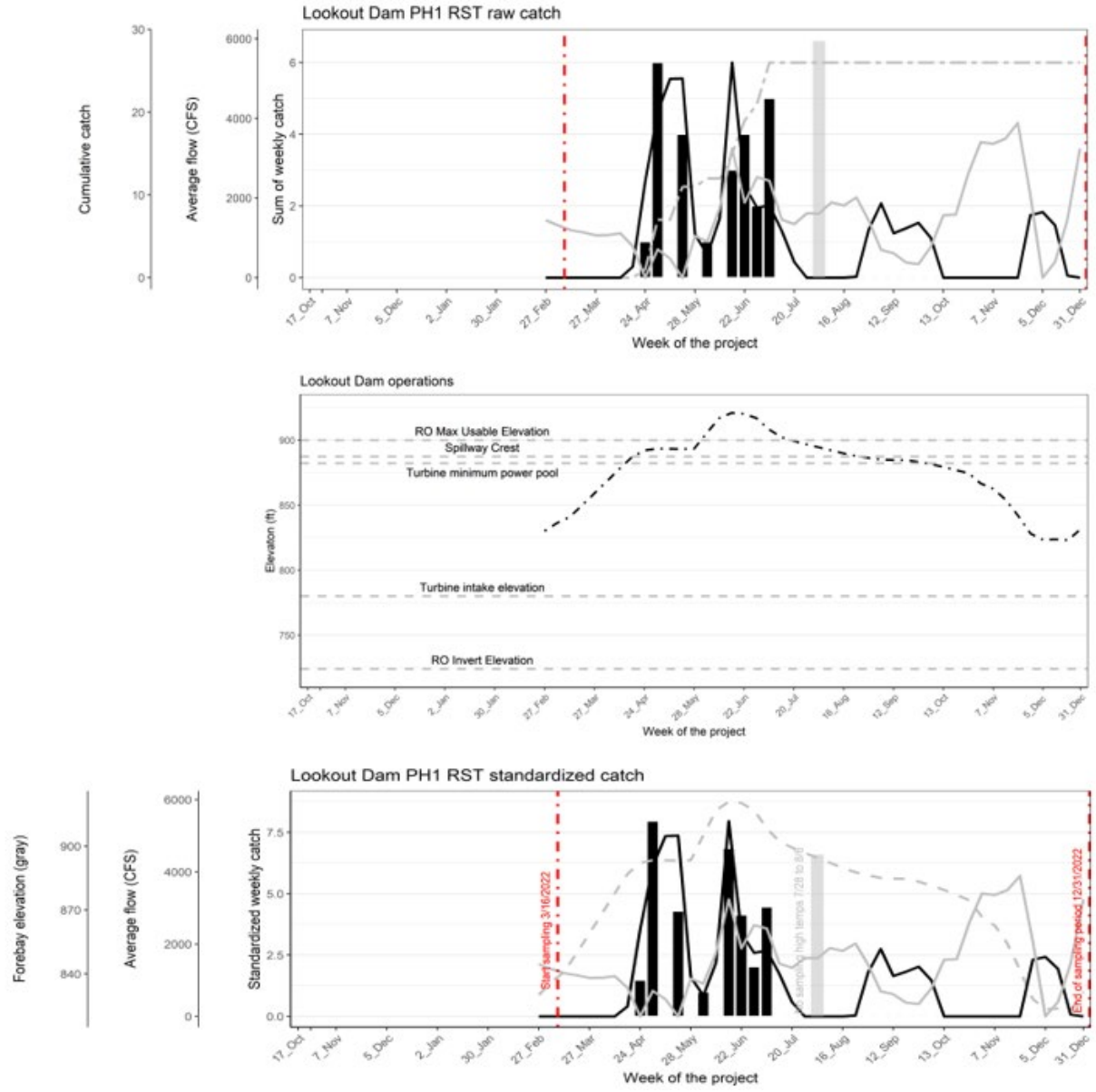

Figure 35. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Lookout Point Dam Tailrace PH 1 trap with spill (black line), powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) for 2022.

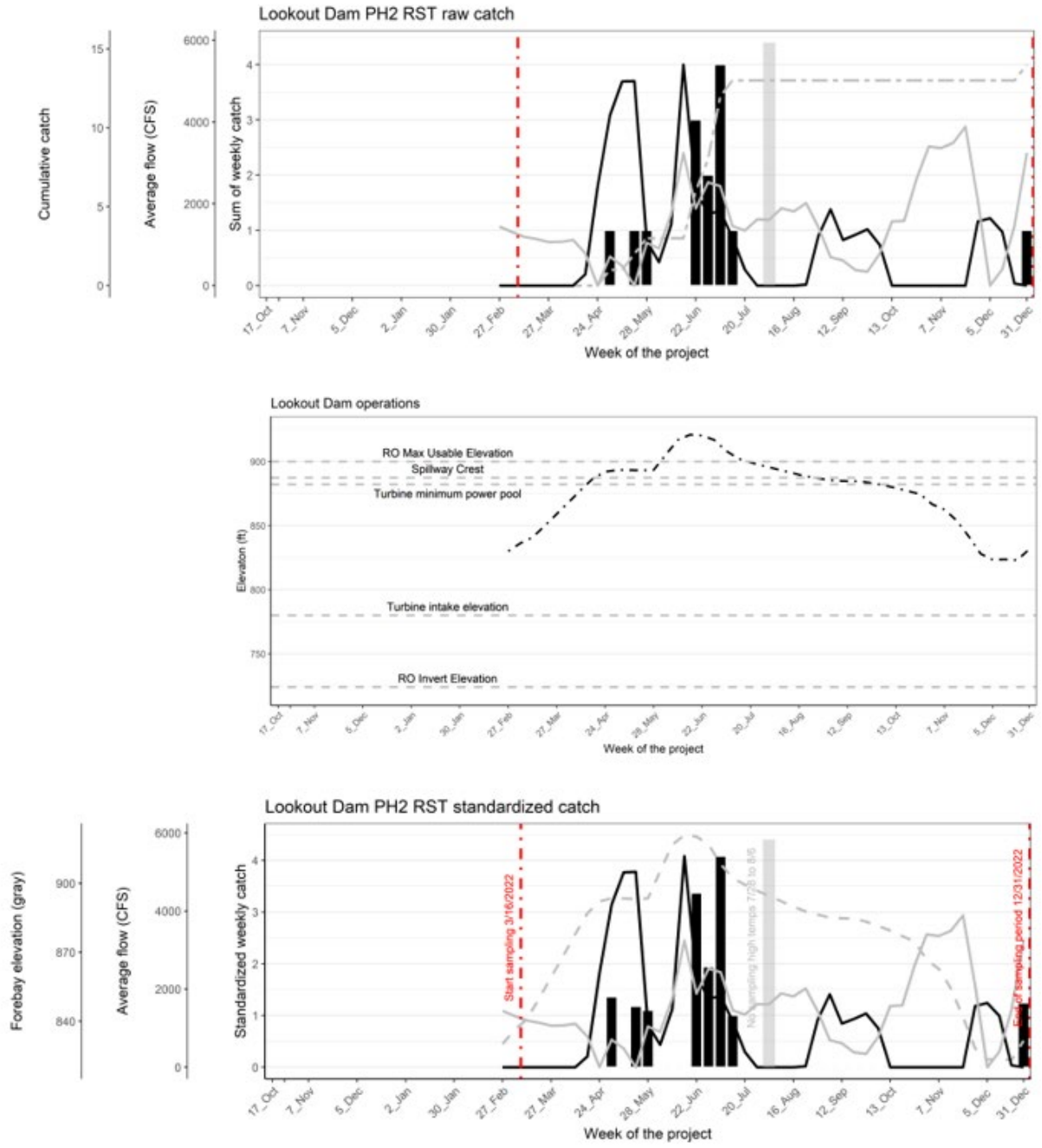

Figure 36. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Lookout Dam Tailrace PH 2 trap with spill (black line), powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) for 2022.

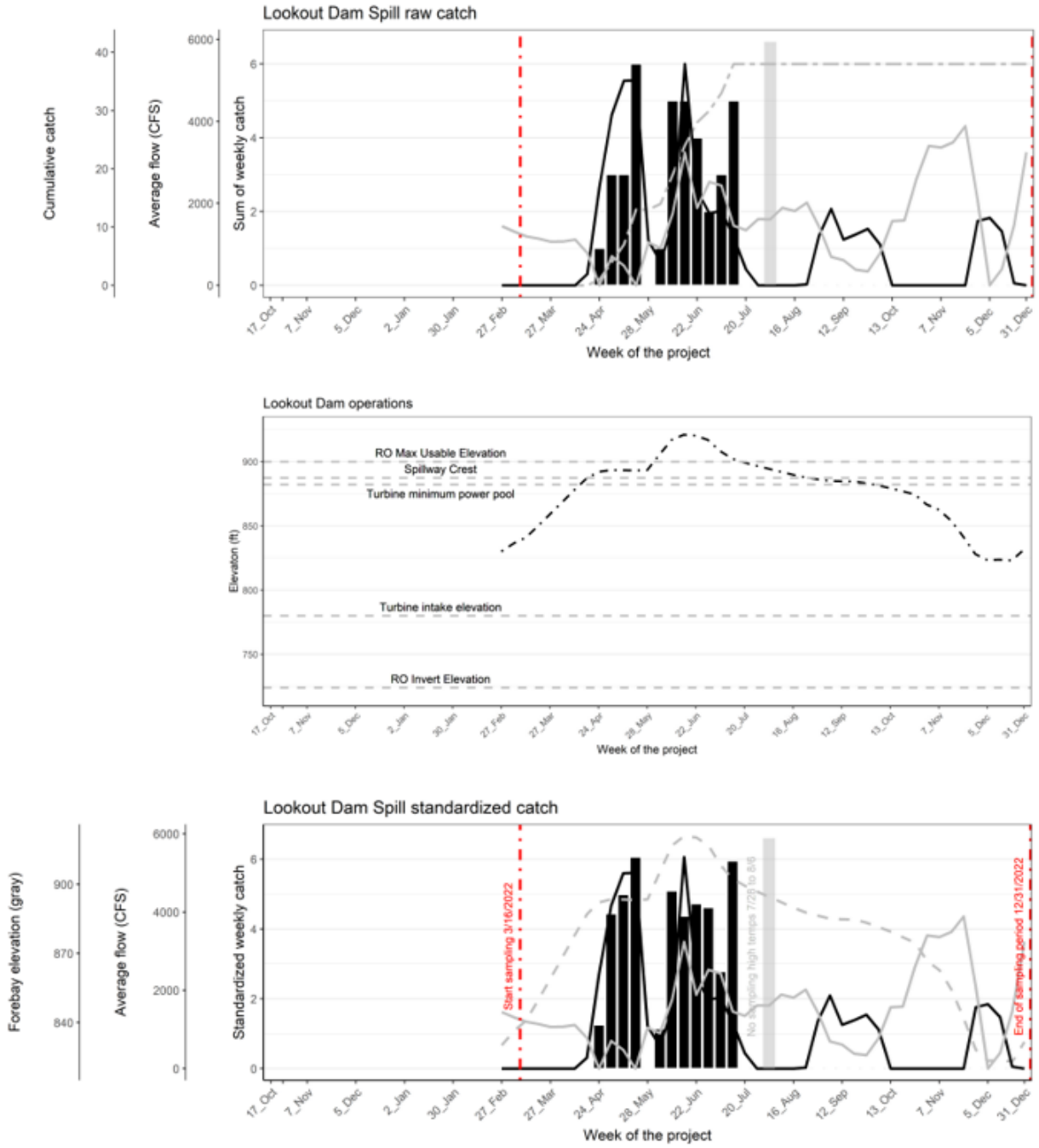

Figure 37. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Lookout Dam Tailrace Spill trap with spill (black line), powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) for 2022.

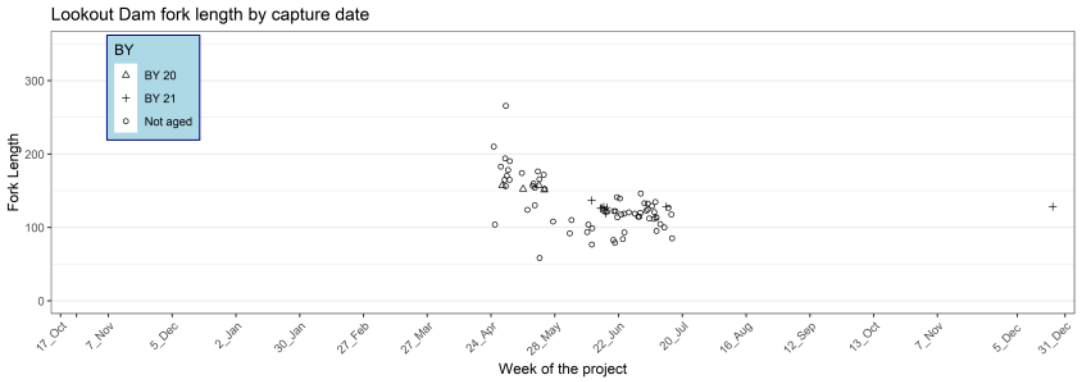

Figure 38. Length-frequency analysis for age of juvenile Chinook captured below Lookout Point Dam.

Trapping Efficiency Trials

A total of one trapping efficiency trial occurred using hatchery reared Chinook salmon at the Lookout Dam Tailrace site. A summary of fish release numbers, recaptures, and flow level for the trial is provided in Table 34. The trial did not yield any recaptures. Due to limited availability of hatchery fish in the Middle Fork Willamette basin and the low efficiency of the traps at this site, no additional trials were performed in 2022. Due to limited data, we were unable to calculate a passage estimate for this location.

Table 34. Summary of trapping efficiency trials below Lookout Point Dam in 2022.

Lookout Dam Powerhouse	4/13/2022	2,925	998	0	0%

Injury Data

A total of 73 juvenile Chinook displayed at least one of the injury code conditions listed in Table 2. Without any recaptures from trapping efficiency trials we are unable to investigate trap effects on observed injuries on RST captured Chinook at this site. Furthermore, without additional data from recaptured trapping efficiency fish, we cannot distinguish passage route through the dam for the purpose of separating injury by route. All observed injuries from capture at all traps are combined for reporting purposes. The most common injuries observed at this site include descaling less than 20%, descaling greater than 20%, and fin damage (Table 35). Figure 39 shows the proportion of captured Chinook displaying injuries by type over the sampling period. Observations of gas bubble disease are likely higher for RST captured fish than those that are not captured in an RST as these fish are often captured and held in areas of higher dissolved gas. Copepod presence on captured Chinook salmon showed a positive correlation with the size of fish similar to observations made by previous studies (Cramer 2022; Monzyk et al. 2015). However, this correlation is not as strong as those seen in other basins (Figure 40).

Table 35. Summary of observed injuries on natural origin juvenile Chinook captured in the Lookout Dam Tailrace

NXI	6
MUNK	0
DS<2	42
DS>2	28
BLO	1
EYB	15
BVT	2
FVB	6
GBD	8
POP	0
HIN	9
OPD	15
TEA	1
BRU	9
HBP	2
HO	0
BO	0
HBO	0
FID	45
PRD	0
COP	14
BKD	0
FUN	1

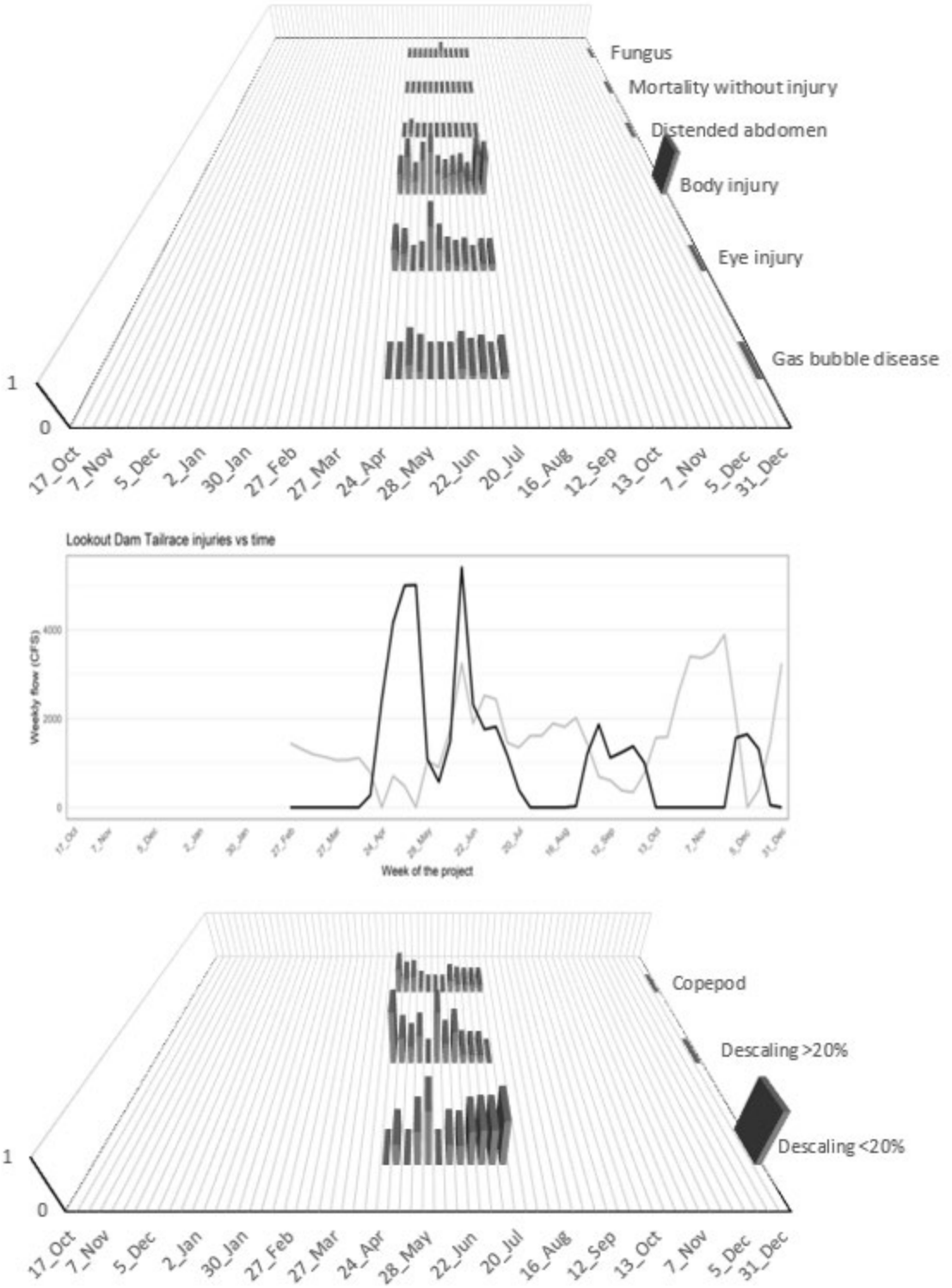

Figure 39. Proportion of captured juvenile Chinook displaying injuries by type (top panel), operations data from the Lookout Dam Tailrace showing cfs of spill (black line) and powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook displaying descaling injuries and copepod presence (bottom panel).

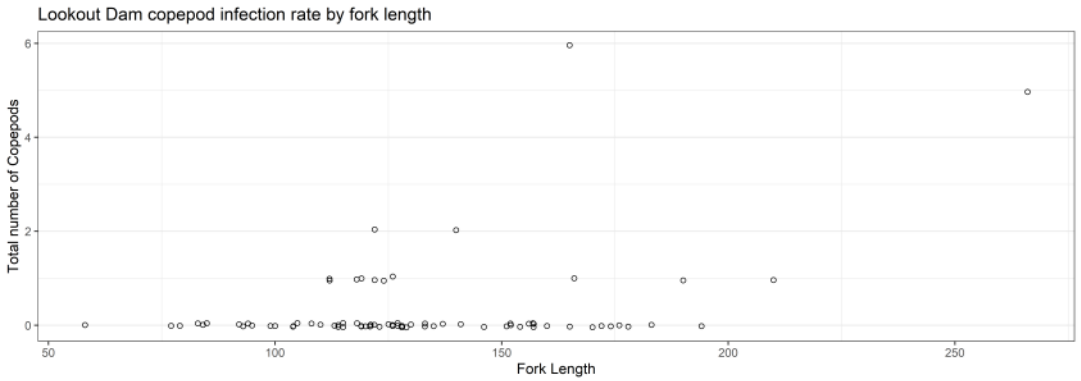

Figure 40. Copepod prevalence vs fork length on juvenile Chinook captured below Lookout Point Dam.

24 Hour Hold Trials

24-hour hold trials were performed at the Lookout Dam Tailrace site to evaluate delayed mortality of natural origin Chinook resulting from RST capture, handling, or dam passage. The first fish entered hold trials below Lookout Dam in April. 50 natural origin Chinook were held in 2022 (Table 36). A total of 12 fish died during hold (24.0%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100%.

Table 36. Summary of 24-hour hold trials for fish captured in the RSTs at the Lookout Dam Tailrace sites.

4/16/22 – 4/30/22	Spill	1	0	100%
5/1/22 – 5/15/22	Spill	7	2	71.4%
5/1/22 – 5/15/22	PH 1	1	0	100%
5/16/22 – 5/31/22	PH 1	1	1	0%
5/16/22 – 5/31/22	PH 2	1	1	0%
5/16/22 – 5/31/22	Spill	2	0	100%
6/1/22 – 6/15/22	PH 1	1	1	0%
6/1/22 – 6/15/22	Spill	6	0	100%
6/16/22 – 6/30/22	PH 1	3	0	100%
6/16/22 – 6/30/22	PH 2	4	0	100%
6/16/22 – 6/30/22	Spill	6	0	100%
7/1/22 – 7/15/22	PH 1	5	2	60.0%
7/1/22 – 7/15/22	PH 2	5	2	60.0%
7/1/22 – 7/15/22	Spill	7	3	57.1%

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 15 juvenile Chinook was PIT tagged at the RST sites below Lookout Point Dam in 2022. As of February 1, 2023, no fish have been redetected downstream. No fish were VIE marked at this location in 2022 and no VIE marked fish from upstream sites were detected.

Non-Target Species

A total of 94,728 non-target fish was captured in the RSTs below Lookout Point Dam (Table 37). The most common non-target species encountered were crappie and bass.

Table 37. Summary of non-target fish capture below Lookout Point Dam.

Bass unknown	4,969	3,664
Bluegill	76	14
Bullhead	4	2
Chinook (clipped)	9	1
Crappie	89,389	51,053
Cutthroat	1	0
Dace	7	0
Largemouth bass	4	0
Smallmouth bass	5	4
Spotted bass	2	0
Largescale sucker	29	16
Northern pikeminnow	59	10
O. mykiss	8	1
O. mykiss (clipped)	2	1
Red-sided shiner	3	0
Sculpin	144	12
Walleye	13	3
Unknown	4	2
Totals	**94,728**	**54,783**

Lookout Point Head of Reservoir – Middle Fork Willamette River

Monitoring of a single 5-foot RST in the Middle Fork Willamette River above Lookout Point Reservoir began on March 10, 2022. The trap sampled 250 days in 2022. The trap did not sample from October 10, 2022, to October 22, 2022, due to safety concerns from the Cedar Creek fire. Additional sampling outages that resulted from high flows and high debris are listed in Appendix B.

Catch

The trap captured 108 juvenile Chinook salmon. Peak passage of juvenile Chinook salmon entering Lookout Point Reservoir occurred in March and April (n= 56, 52.3%). Figure 41 shows raw and standardized catch overlayed with flow at the Lookout Point Head of Reservoir site. Chinook catch consisted of two BY classes, BY 2021 sub-yearlings (n= 84, 77.8%) and BY 2020 yearlings (n= 24, 22.2%). Brood year 2021 Chinook were the dominant age class captured at this site throughout the year (Figure 42.). The first BY 2021 fry captured at the trap occurred on March 11, one day after the start of sampling. The first BY 2020 yearling was captured on March 16. Yearling catch continued through April, with one yearling caught in late June, suggesting that most BY 2020 fish had migrated to the reservoir prior to the summer months. BY 2021 Chinook had an average fork length of 56.5 mm (n= 84, min: 28 mm, max: 119 mm, median: 57 mm) and an average weight of 4.5 g (n=56, min: 0.3 g, max: 18.2 g, median: 3.3 g). BY 2020 Chinook had an average fork length of 98.2 mm (n= 24, min: 86 mm, max: 118 mm, median: 95 mm) and an average weight of 9.7 g (n=24, min: 4.1 g, max: 19.8 g, median: 8.6 g).

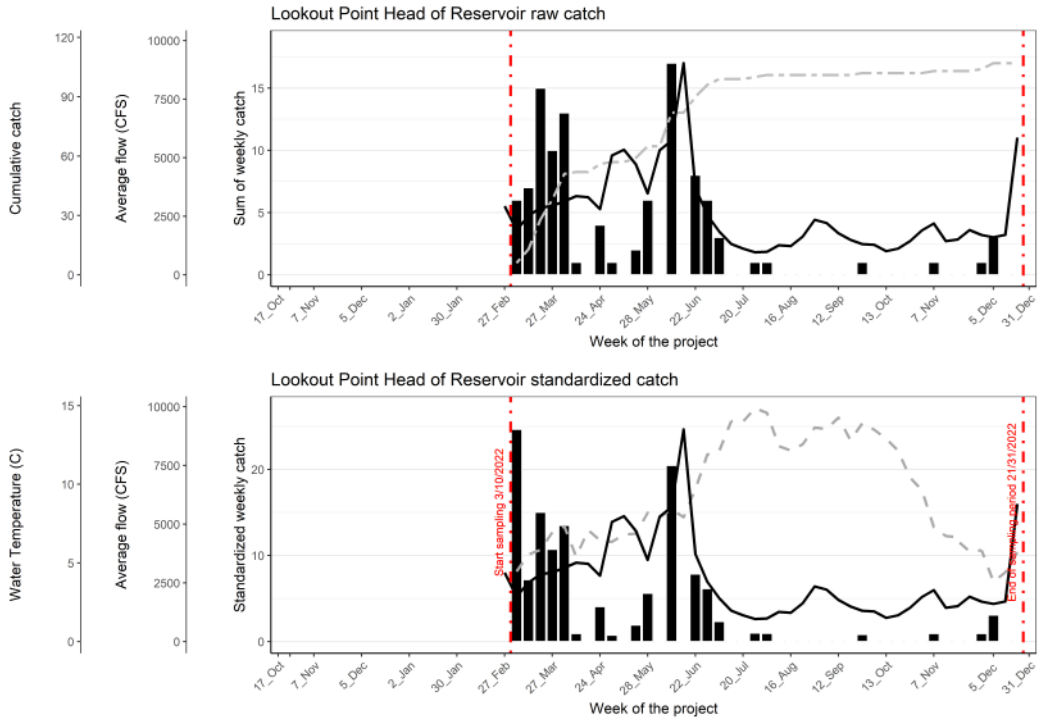

Figure 41. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Lookout Point Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), and stream temperature (gray dash line) for 2022.

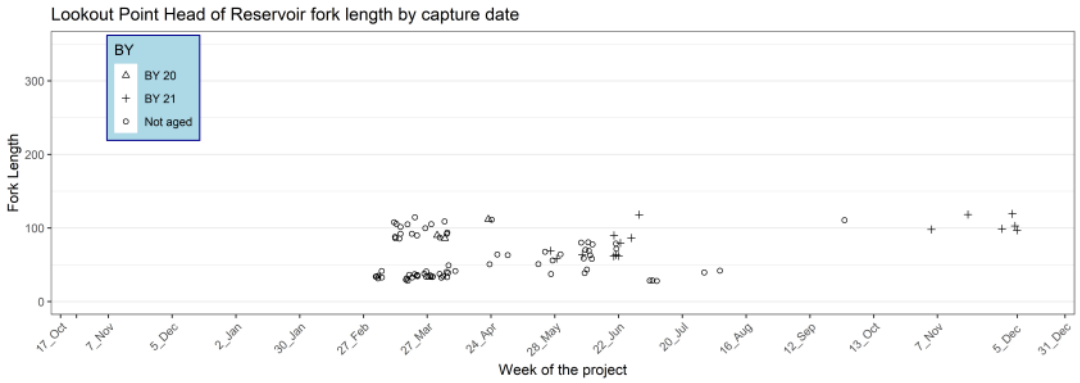

Figure 42. Length-frequency of juvenile Chinook salmon at the Lookout Point Head of Reservoir site.

Trapping Efficiency Trials

A total of seven trapping efficiency trials occurred using hatchery reared Chinook salmon at the Lookout Point Head of Reservoir site. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 38. Two trials near the end of the year yielded zero recaptures. Crew observations from this time suggest that the trap may have been visited by mammalian predators at night between trap checks that could have potentially cleared the live well of fish. Trapping efficiencies ranged from 0 to 12.5%. Due to limited availability of hatchery fish in the Middle Fork Willamette basin we were unable to perform additional trials at this site in 2022. Due to limited data, we were unable to calculate a passage estimate for this location.

Table 38. Summary of trapping efficiency trials in the Middle Fork Willamette above Lookout Point Dam in 2022.

Lookout Point Head of Reservoir	4/5/2022	3,620	993	53	5.3%
Lookout Point Head of Reservoir	4/14/2022	3,821	987	19	1.9%
Lookout Point Head of Reservoir	5/18/2022	4,538	1,004	125	12.5%
Lookout Point Head of Reservoir	7/20/2022	915	1,005	9	0.9%
Lookout Point Head of Reservoir	10/27/2022	1,522	506	9	1.8%
Lookout Point Head of Reservoir	11/17/2022	1,403	510	0	0%
Lookout Point Head of Reservoir	12/12/2022	1,580	510	0	0%

Injury Data

A total of 39 juvenile Chinook displayed at least one of the injury code conditions listed in Table 2. The only injuries observed at this site include descaling less than 20%, operculum damage, copepods, bruising, and fin damage (Table 39). These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap.

Table 39. Summary of observed injuries on natural origin juvenile Chinook captured in the Lookout Point Head of Reservoir RST

NXI	69
MUNK	0
DS<2	35
DS>2	0
BLO	0
EYB	0
BVT	0
FVB	0
GBD	0
POP	0
HIN	0
OPD	1
TEA	0
BRU	1
HBP	0
HO	0
BO	0
HBO	0
FID	14
PRD	0
COP	1
BKD	0
FUN	0

PIT Tagged/VIE Marked fish and Downstream Detections

A total of 51 juvenile Chinook was PIT tagged and four were VIE marked at the Lookout Point Head of Reservoir site in 2022. As of February 1, 2023, no tagged fish were redetected at downstream sites. Table 40 shows a summary of VIE marked fish with the tagging period and mark details.

Table 40. Summary of VIE tagged Chinook at the Lookout Point Head of Reservoir site.

6/25/2022 – 7/15/2022	Yellow	3	0
7/16/2022 – 7/31/2022	Red	1	0

Non-Target Capture Data

We captured 377 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught are provided in Table 41. The most commonly captured non-target species were Dace and Rainbow Trout.

Table 41. Summary of non-target fish capture at the Lookout Point Head of Reservoir site.

Bass unknown	4	1
Bluegill	3	0
Chinook (clipped)	28	0
Cutthroat trout	10	0
Dace	134	0
Lamprey	2	0
Largescale sucker	17	1
Mountain whitefish	3	0
Northern pikeminnow	24	0
O. mykiss	91	3
O. mykiss (clipped)	2	0
Peamouth	1	0
Pumpkinseed	1	1
Red-sided shiner	2	0
Sculpin	30	7
Smallmouth bass	8	0
Spotted bass	1	0
Unknown	16	0
Totals	**377**	**13**

Hills Creek Dam

Monitoring in the Middle Fork Willamette River in the Hills Creek Dam began on October 15, 2021. The traps sampled until the end of the RO spill for fish passage operation on March 1, 2022, when they were removed for the sampling season to prioritize the limited number of screw traps to other locations. The traps were reinstalled and began sampling again on September 15, 2022. The traps sampled 242 days from October 15, 2021, through 2022. A summary of sampling outages at this site can be found in Appendix B. The RO trap at Hills Creek Dam is positioned below the confluence of the RO and powerhouse outlet channels. This trap captures fish from both outlets and thus juvenile Chinook encountered in this RST cannot be assigned to a route of passage. For interpretation of results, it is important to note that no BY 2020 juvenile hatchery Chinook (i.e., yearlings typically released in June 2021) or adult Chinook in 2021 were outplanted above Hills Creek due to low adult returns (i.e., no

production of BY 2021 juvenile Chinook above Hills Creek Dam). For additional information, see the W-FPOM MFR, Title – 21DEX02 MFR Middle Fork Willamette Adult Chinook Outplanting, Subject – W9127N19C0030, Middle Fork Willamette Adult Chinook Outplanting and Juvenile Fingerling Release(s) (http://pweb.crohms.org/tmt/documents/FPOM/2010/Willamette_Coordination/2021_WFPOM/2021_SEP/). In calendar year 2022, 462 adult spring Chinook were outplanted above Hills Creek Dam. This consisted of 198 females, 250 males, and 14 jack Chinook.

A total of 140 juvenile Chinook salmon was captured in the Hills Creek Dam RSTs during the 2021 and 2022 sampling period, 56 in the Powerhouse trap (40.0% of total catch) and 84 in the RO trap (60.0% of total catch) (Figures 43 and 44). 95 juvenile Chinook were captured from October 23, 2021, to January 23, 2022, during the first sampling period (67.9% of total catch). 63 fish were captured in the RO trap (66.3% of catch from this period) 32 were captured in the Powerhouse trap (33.7% of catch from this period). 45 juvenile Chinook were captured from September 18, 2022, through the end of 2022 (32.1% of total catch). 21 were captured in the RO trap (46.7% of catch for this period) and 24 were captured in the Powerhouse trap (53.3% of catch for this period). Scale age analysis showed that a majority of fish captured in the first monitoring period were BY 2019 fish (n=6, 71.6% of catch for this period) and the rest were BY 2020 fish (n=20, 20.4% of catch for this period). The average length of BY 2019 fish was 239.1 mm (min: 201 mm, max: 265 mm, median: 245 mm) with an average weight of 150.0 g (min: 77.8 g, max: 192.3 g, median: 152.5 g). BY 2020 fish caught in this period had an average fork length of 118.3 mm (min: 69 mm, max: 159 mm, median: 120.5 mm) with an average weight of 19.3 g (min: 3.7 g, max: 46.6 g, median: 16.8 g). During the second period, from September 2022 to the end of the year, catch was comprised of BY 2020 Chinook. The average fork length for this group was 228.4 mm (min: 188 mm, max: 280 mm, median: 225 mm) with an average weight of 137.7 g (min: 74.0 g, max: 245.5, median: 131.7 g) (Figure 45).

A majority of observed Chinook passage at Hills Creek Dam occurred during our sampling from October 2021 to the end of January 2022. Prior monitoring found that peak passage at Hills Creek Dam occurred November through January (Keefer et al. 2012). Previous studies also captured no small sub-yearling Chinook below Hills Creek Dam. Much like our data, previous catch at this site consists of yearlings in the 80 to 150 mm range and larger fish of mixed age in the 160 to 300+ mm range.

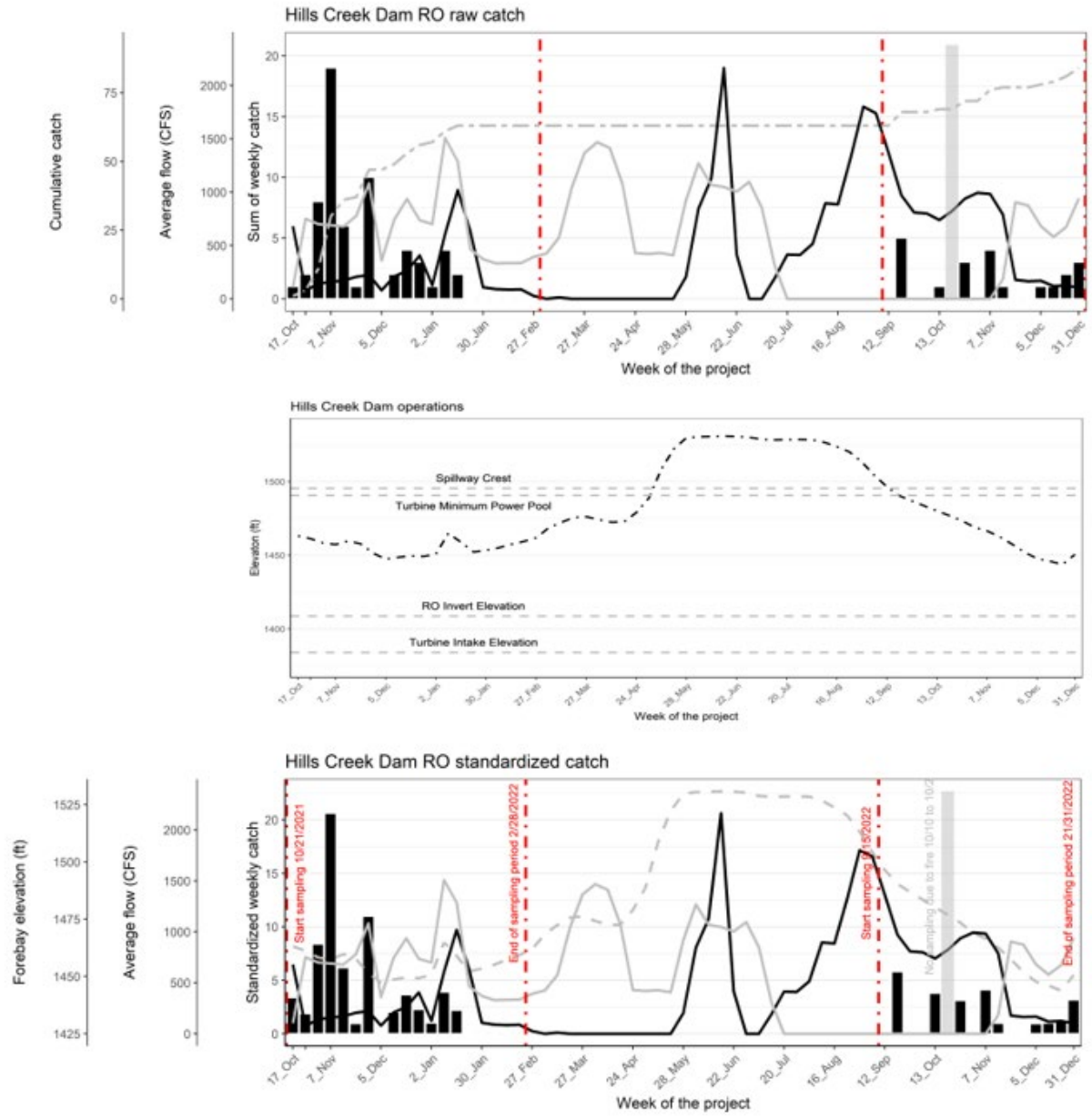

Figure 43. Raw (top panel) and weekly standardized (bottom panel) catch RO outflow (black line), Powerhouse outflow (gray line), cumulative catch (gray dash dot line), and forebay elevation (gray dash line) for the RO trap below Hills Creek Dam for sampling from October 15, 2021, through December 31, 2022. Middle panel displays forebay elevation with dam intake elevations.

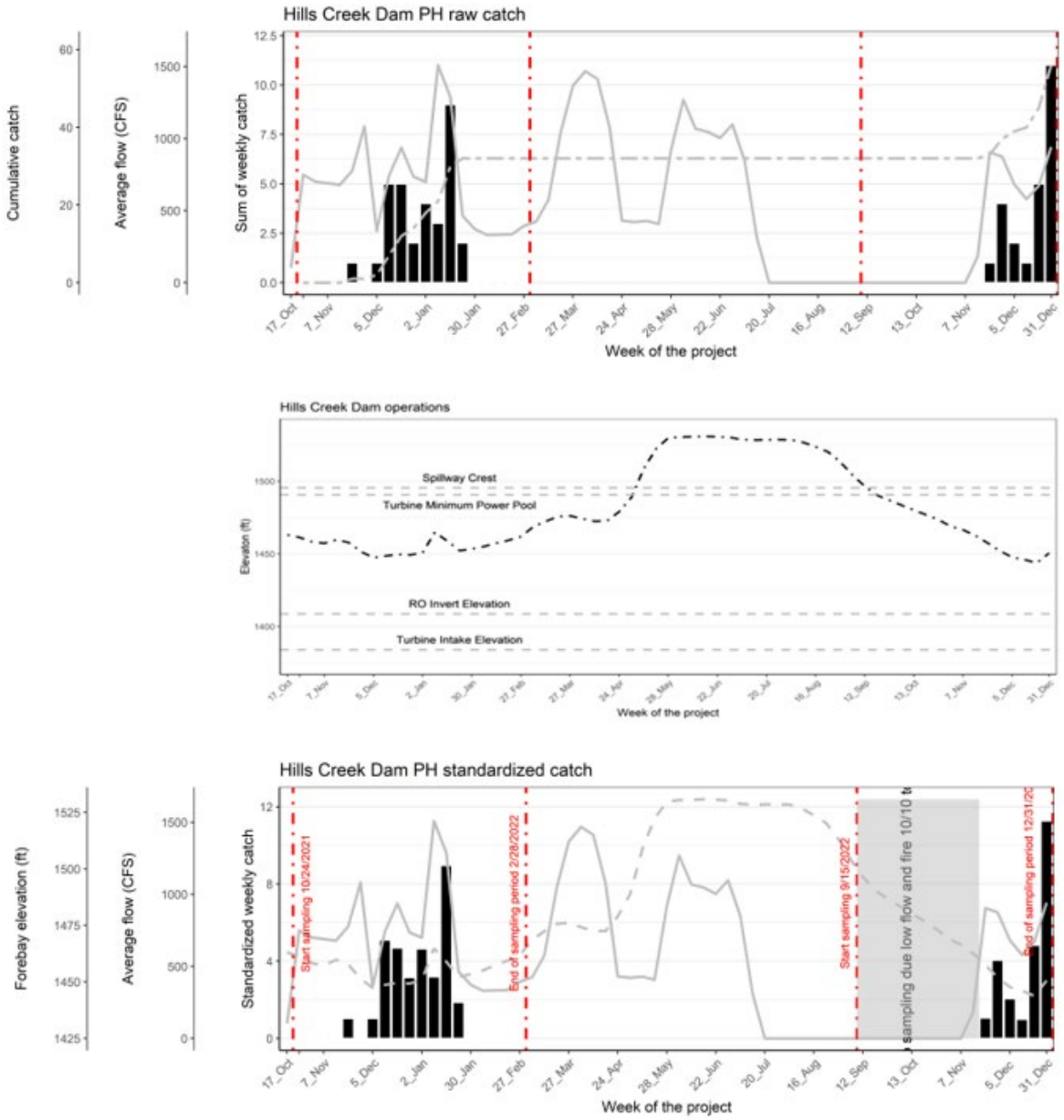

Figure 44. Raw (top panel) and weekly standardized (bottom panel) catch overlayed with Powerhouse outflow (gray line), cumulative catch (gray dash dot line), and forebay elevation (gray dash line) for the PH trap below Hills Creek Dam for sampling from October 15, 2021, through December 31, 2022. Middle panel displays forebay elevation with dam intake elevations.

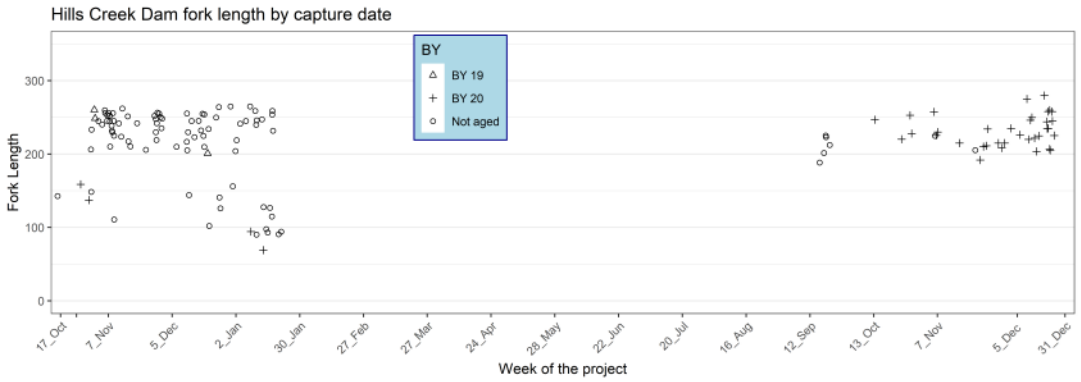

Figure 45. Length-frequency of juvenile Chinook salmon by brood year at the Hills Creek Dam site.

Trapping Efficiency Trials

A total of 12 trapping efficiency trials occurred using hatchery reared Chinook salmon in the Hills Creek Dam sites. Fish released in the Powerhouse channel can be captured in the RO trap. Thus, each Powerhouse release is treated as a trial for both the Powerhouse and RO trap. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 42. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled (Figure 46). Trapping efficiencies ranged from 0 to 12.5%. We estimate that 1,923 (95% CI: 1,160 to 5,612) juvenile Chinook passed through the Powerhouse and 4,339 (95% CI: 2,705 to 10,949) through the RO at Hills Creek Dam during the 2022 sampling period . Total passage at Hills Creek Dam is estimated to be 6,262 (95% CI: 3,865 to 16,561). This estimate is likely low as passage of Powerhouse fish captured in the RO trap could not be calculated as the trapping efficiency trials for this event did not yield enough recaptures to perform the estimate.

Table 42. Summary of trapping efficiency trials below Hills Creek Dam in 2022.

Hills Creek Dam Powerhouse Route	1/6/2022	810	596	20	3.4%
Hills Creek Dam Regulating Outlet Route	1/6/2022	820	605	13	2.1%
Hills Creek Dam Powerhouse Route	2/16/2022	410	600	12	2.0%
Hills Creek Dam Regulating Outlet Route	2/16/2022	410	593	19	3.2%
Hills Creek Dam Powerhouse Route	2/25/2022	410	604	6	1.0%
Hills Creek Dam Regulating Outlet Route	2/25/2022	420	625	6	1.0%
Hills Creek Dam Powerhouse Route	12/7/2022	890	514	29	5.6%
Hills Creek Dam Regulating Outlet Route	12/13/2022	630	516	1	0.2%
Hills Creek Dam Powerhouse- RO Trial	1/6/2022	810	596	5	0.8%
Hills Creek Dam Powerhouse- RO Trial	2/16/2022	410	600	0	0%

Hills Creek Dam Powerhouse- RO Trial	2/25/2022	410	604	1	0.2%
Hills Creek Dam Powerhouse- RO Trial	12/7/2022	890	514	3	0.6%

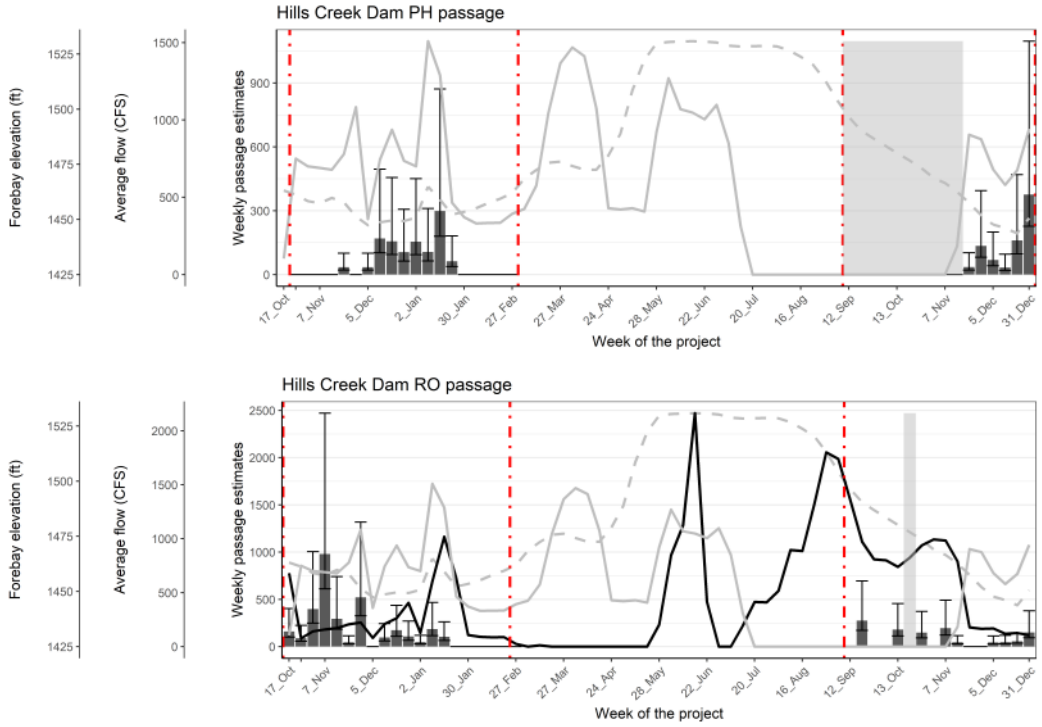

Figure 46. Estimated passage at Hills Creek Dam through the powerhouse (top panel) and regulating outlet (bottom panel) with 95% confidence intervals overlayed with RO outflow (black line), Powerhouse outflow (gray line), and forebay elevation (gray dash line) for October 15, 2021, through December 31, 2022.

Injury Data

A total of 133 (95%) juvenile Chinook displayed at least one of the injury code conditions listed in Table 2. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type both pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. This was then applied as a correction factor to provide more clarity to injury resulting from passage. The most common injuries observed at this site include descaling less and greater than 20%, bleeding from vent, fin damage, and copepods (Tables 43 and 44). It is likely that observations of gas bubble disease are higher for RST captured fish than those that are not captured in an RST as these fish are often captured and held in areas of higher dissolved gas. The proportion of fish displaying injuries overtime is displayed in Figure 47. Copepod presence on captured Chinook salmon showed a positive correlation with the size of fish (Figure 48).

Table 43. Summary of observed injuries on trapping efficiency and natural origin juvenile Chinook captured in the RO RST at Hills Creek Dam.

NXI	41	3	-20.9%	5	6
MUNK	0	0	0.0%	1	1
DS<2	44	29	31.3%	43	30
DS>2	0	4	8.3%	33	30
BLO	0	0	0.0%	0	0
EYB	0	7	14.6%	8	7
BVT	0	0	0.0%	26	26
FVB	0	0	0.0%	4	4
GBD	0	0	0.0%	5	5
POP	0	0	0.0%	2	2
HIN	1	1	1.4%	6	6
OPD	0	2	4.2%	14	13
TEA	0	0	0.0%	2	2
BRU	1	1	1.4%	6	6
HBP	0	0	0.0%	6	6
HO	0	0	0.0%	0	0
BO	0	0	0.0%	6	6
HBO	0	0	0.0%	0	0
FID	21	43	75.7%	33	8
PRD	0	0	0.0%	0	0
COP	0	0	0.0%	70	70
BKD	0	0	0.0%	0	0
FUN	0	0	0.0%	0	0

Table 44. Summary of observed injuries on trapping efficiency and natural origin juvenile Chinook captured in the Powerhouse RST at Hills Creek Dam

NXI	41	2	-24.3%	2	2
MUNK	0	0	0.0%	0	0
DS<2	44	32	18.4%	27	22
DS>2	0	21	31.3%	25	17
BLO	0	0	0.0%	1	1
EYB	0	5	7.5%	11	10
BVT	0	1	1.5%	17	17
FVB	0	0	0.0%	7	7
GBD	0	0	0.0%	11	11
POP	0	1	1.5%	0	0
HIN	1	1	0.8%	3	3
OPD	0	1	1.5%	7	7
TEA	0	0	0.0%	4	4
BRU	1	1	0.8%	6	6
HBP	0	0	0.0%	2	2
HO	0	1	1.5%	2	2
BO	0	0	0.0%	4	4
HBO	0	1	1.5%	1	1
FID	21	62	78.5%	27	6
PRD	0	0	0.0%	0	0
COP	0	0	0.0%	45	45
BKD	0	0	0.0%	0	0
FUN	0	1	1.5%	0	0

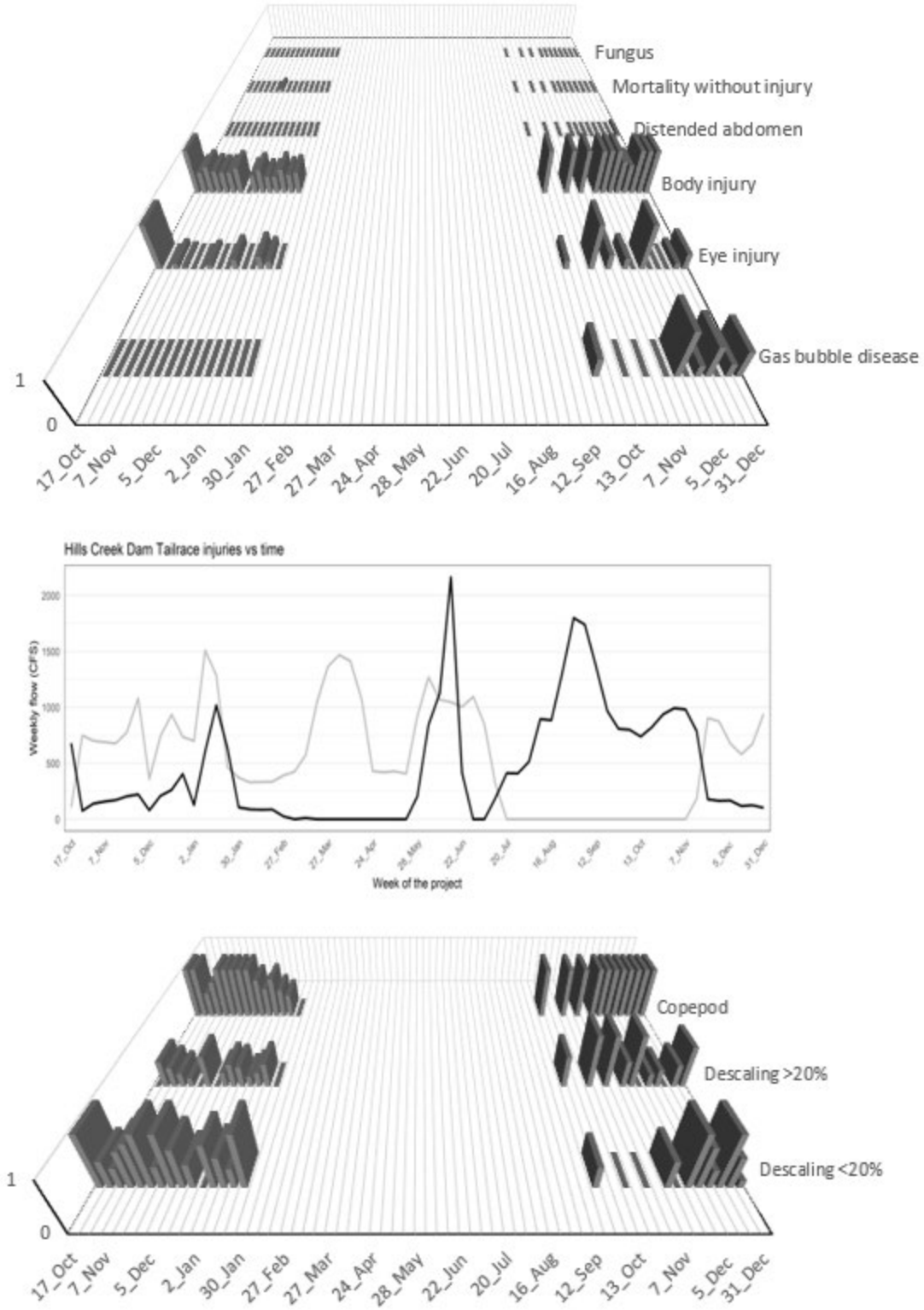

Figure 47. Proportion of captured juvenile Chinook displaying injuries by type (top panel), operations data from the Hills Creek Dam showing cfs of spill (black line) and powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook displaying descaling injuries and copepods (bottom panel).

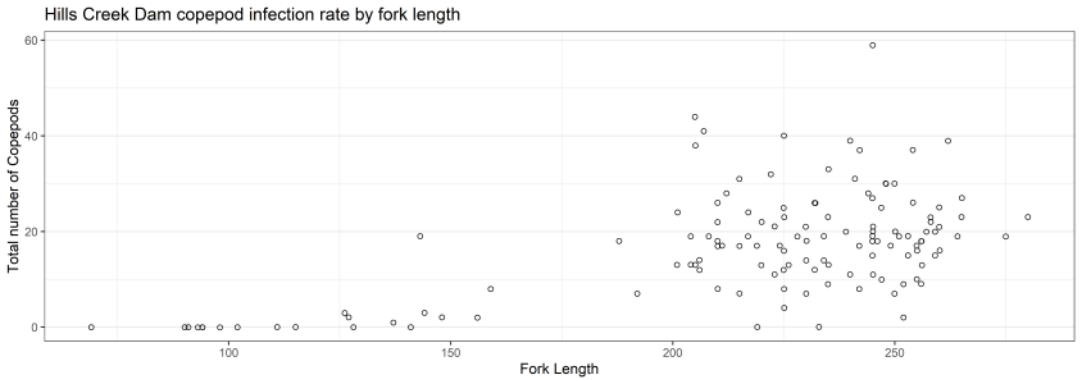

Figure 48. Copepod presence vs fork length on juvenile Chinook captured below Hills Creek Dam.

24 Hour Hold Trials

24-hour hold trials on natural origin juvenile Chinook to assess delayed mortality from dam passage were not implemented at Hills Creek Dam until the fall 2022 monitoring period. The first fish entered hold trials at Hills Creek Dam in September of 2022. A total of 20 Chinook was held in 2022 (Table 45) with zero mortalities during the holding period.

Table 45. Summary of 24-hour hold trials for fish captured in the RST at the Hills Creek Dam site.

9/16/22 – 9/30/22	RO	1	0	100%
10/16/22 – 10/31/22	RO	3	0	100%
11/1/22 – 11/15/22	RO	3	0	100%
11/16/22 – 11/30/22	RO	1	0	100%
11/16/22 – 11/30/22	Powerhouse	3	0	100%
12/1/22 – 12/15/22	Powerhouse	1	0	100%
12/16/22 – 12/31/22	RO	3	0	100%
12/16/22 – 12/31/22	Powerhouse	5	0	100%

PIT Tagged/VIE Marked Fish and Downstream Detections

At the Hills Creek Dam RST sites, four fish were PIT tagged and no fish were VIE marked. The tagged fish were not redetected downstream as of February 1, 2023.

Non-Target Species

In addition to natural origin juvenile Chinook, 612 non-target fish were captured. A summary of species and numbers of fish caught is provided in Table 46. The most commonly captured non-target species were Dace and Rainbow Trout. The Bull Trout captured at this site was collected by ODFW staff. Information regarding Bull Trout captures, fork lengths, and PIT tags is provided in Appendix C.

Table 46. Summary of non-target catch for the RSTs in the Hills Creek Dam.

Bass Unknown	32	18
Bluegill	160	82
Brook Lamprey	2	0
Bullhead Catfish	2	0
Bull Trout	1	0
Crappie	112	64
Cutthroat	1	1
Dace	5	0
Red-Sided Shiner	26	5
Sculpin	85	1
Spotted Bass	70	61
Smallmouth Bass	11	10
Largescale Sucker	5	2
Mountain Whitefish	1	1
Northern Pikeminnow	2	0
O. mykiss	83	24
Unknown	14	2
Totals	**612**	**271**

Citations

Beeman, J.W., Hansen, A.C., & Sprando, J.M. 2015. Observational data on the effects of infection by the copepod Salmincola californiensis on the short-and long-term viability of juvenile Chinook salmon (Oncorhynchus tshawytscha) implanted with telemetry tags. *Animal Biotelemetry*, *3*(1), 1-7.

Cheng, Yuk W., and Michael P. Gallinat. 2004. "Statistical analysis of the relationship among environmental variables, inter-annual variability and smolt trap efficiency of salmonids in the Tucannon River." Fisheries Research 70, no. 2-3 (2004): 229-238.

Cramer Fish Sciences. 2023. Willamette Valley Fish Passage Monitoring via Rotary Screw Traps, 2021 Final Report. Prepared for: United States Army Corps of Engineers under Contract W9127N19D0009-W9127N21F0030. Prepared by: Ryan Flaherty, Hans Berge, and Caitlyn Jobanek of Cramer Fish Sciences, Portland Oregon. February 2023.

Dambacher, J.M. 1991. Distribution, Abundance, and Emigration of Juvenile Steelhead (*Oncorynchus mykiss*), and Analysis of Stream Habitat in the Steamboat Creek Basin, Oregon. : Oregon State University.

Dambacher, J.M. 2023. Personal Communication, February 24, 2023.

Hansen, A.C., Kock, T.J., and Hansen, G.S. 2017. Synthesis of downstream fish passage information at projects owned by the U.S. Army Corps of Engineers in the Willamette River Basin, Oregon: U.S. Geological Survey Open File Report 2017-1101, 118 p., https://doi.org/10.3133/ofr20171101.

Herron, C.L., Kent, M.L., and Schreck, C.B. 2018. Swimming endurance in juvenile Chinook salmon infected with Salmincola californiensis. Journal of Aquatic Animal Health, 30(1), 81–89. https://doi. org/10.1002/aah.10010

Keefer, M.L., Taylor, G.A., Garletts, D.F., Helms, C.K., Gauthier, G.A., Pierce, T M., and Caudill, C.C. 2012. Reservoir entrapment and dam passage mortality of juvenile Chinook salmon in the Middle Fork Willamette River. Ecology of Freshwater Fish 2012: 21: 222–234. DOI: 10.1111/j.1600-0633.2011.00540.x

Keefer, M.L., Taylor, G.A., Garletts, D.F., Helms, C.K., Gauthier, G.A., Pierce, T.M., and Caudill, C.C. 2013. High-Head Dams Affect Downstream Fish Passage Timing and Survival in the Middle Fork Willamette River. River Research and Applications 29: 483–492. Published online 6 January 2012 in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rra.1613

Monzyk, F.R., Friesen, T.A., and Romer J.D. 2015. Infection of juvenile salmonids by Salmincola californiensis (Copepoda: Lernaeopodidae) in reservoirs and streams of the Willamette River basin, Oregon. Transactions of the American Fisheries Society 144: 891-902.

Myers. J., Busack, C., Rawding, D., Marshall, A., Teel, D., Van Soornik, D.M. and Maher, M.T. 2006. Historical population of Pacific salmonids in the Willamette and lower Columbia River basins. Seattle, WA, USA: NMFS, NMFSWFSC-73.

NMFS (National Marine Fisheries Service) 2008. Endangered Species Act section 7(a)(2) consultation biological opinion and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat consultation. Portland, OR, USA: NMFS

NMFS. 2008c. Endangered Species Act Section 7 (a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program. Revised and reissued pursuant to court order NWF v. NMFS Civ. No. CV 01-640-RE (D. Oregon). NMFS Northwest Region, Portland, Oregon.

NMFS. 2008. 2008-2023 Willamette River Basin Project Biological Opinion. NOAA's National Marine Fisheries Service, Northwest Region, Seattle, WA. F/NWR/2000/02117.

Rayton, Michael D., and Wagner, P. "Field Manual: Okanogan Basin monitoring and evaluation program rotary screw trap protocols." *The Colville Confederated Tribes. Omak, WA* (2006).

Romer, J.D., Monzyk, F.R., Emig, R., and Friesen T.A. 2012. Juvenile salmonid outmigration monitoring at Willamette Valley Project reservoirs. 2011 Annual Report to U.S. Army Corps of Engineers, Portland, Oregon. Task Order W9127N-10-2-0008-0006. Oregon Department of Fish and Wildlife, Corvallis, OR.

Romer, J.D., Monzyk, F.R., Emig, R., and Friesen, T.A. 2013. Juvenile salmonid outmigration monitoring at Willamette Valley Project reservoirs. 2012 Annual Report to U.S. Army Corps of Engineers, Portland, Oregon. Task Order W9127N-10-2-0008-0010. Oregon Department of Fish and Wildlife, Corvallis, OR.

Romer, J.D., Monzyk, F.R., Emig, R., and Friesen, T.A. 2014. Juvenile Salmond Outmigration Monitoring at Willamette Valley Project Reservoirs. Prepared by Oregon Department of Fish and Wildlife, Willamette Research, Monitoring, and Evaluation Program for U.S. Army Corps of Engineers, Portland District during 2013 with final report delivered August 2014; Contract W9127N-10-2-0008-0019.

Romer, J.D., Monzyk, F.R., Emig, R., and Friesen, T.A. 2015. Juvenile Salmond Outmigration Monitoring at Willamette Valley Project Reservoirs. Prepared by Oregon Department of Fish and Wildlife, Willamette Research, Monitoring, and Evaluation Program for U.S. Army Corps of Engineers,

Portland District during 2014 with final report delivered June 2015; Contract W9127N-10-2-0008-0026.

Romer, J.D., Monzyk, F.R., Emig, R., and Friesen, T.A. 2016. Juvenile Salmond Outmigration Monitoring at Willamette Valley Project Reservoirs. Prepared by Oregon Department of Fish and Wildlife, Willamette Research, Monitoring, and Evaluation Program for U.S. Army Corps of Engineers, Portland District during 2015 with final report delivered June 2016; Contract W9127N-10-2-0008-0035.

Romer, J.D., Monzyk, F.R., Emig, R., and Friesen, T.A. 2017. Juvenile Salmond Outmigration Monitoring at Willamette Valley Project Reservoirs. Prepared by Oregon Department of Fish and Wildlife, Willamette Research, Monitoring, and Evaluation Program for U.S. Army Corps of Engineers, Portland District during 2016 with final report delivered September 2017; Contract W9127N-10-2-0008-0035.

Volkhardt, Gregory C., Johnson, Steven L., Miller, Bruce A., Nickelson, Thomas E., and Seiler, David E. “Rotary screw traps and inclined plane screen traps.” Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland 6, no. 8 (2007): 235-266.

Voss, Scott D. and Poytress, William R. “Brood year 2018 juvenile salmonid production and passage indices at the Red Bluff Diversion Dam.” Red Bluff, CA: US Fish and Wildlife Service (2020).

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Appendix A –
Locations of Rotary Screw Traps

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Appendix A: Locations of Rotary Screw Traps

Figure A-1. Big Cliff Dam
Figure A-2. Green Peter Tailrace – Middle Santiam River
Figure A-3. Foster Dam Head of Reservoir – South Santiam River
Figure A-4. Cougar Dam
Figure A-5. Cougar Dam Head of Reservoir
Figure A-6. Fall Creek Dam Tailrace
Figure A-7. Fall Creek Head of Reservoir
Figure A-8. Dexter Dam Tailrace
Figure A-9. Lookout Dam Tailrace
Figure A-10. Lookout Point Head of Reservoir
Figure A-11. Hills Creek Dam

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FIGURE A-1
Big Cliff Dam

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-2
Green Peter Tailrace - Middle Santiam River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-3

Foster Dam Head of Reservoir - South Santiam River

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES

Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-4
Cougar Dam

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-5
Cougar Dam Head of Reservoir

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-6
Fall Creek Dam Tailrace

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-7
Fall Creek Head of Reservoir

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-8
Dexter Dam Tailrace

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-9
Lookout Dam Tailrace

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

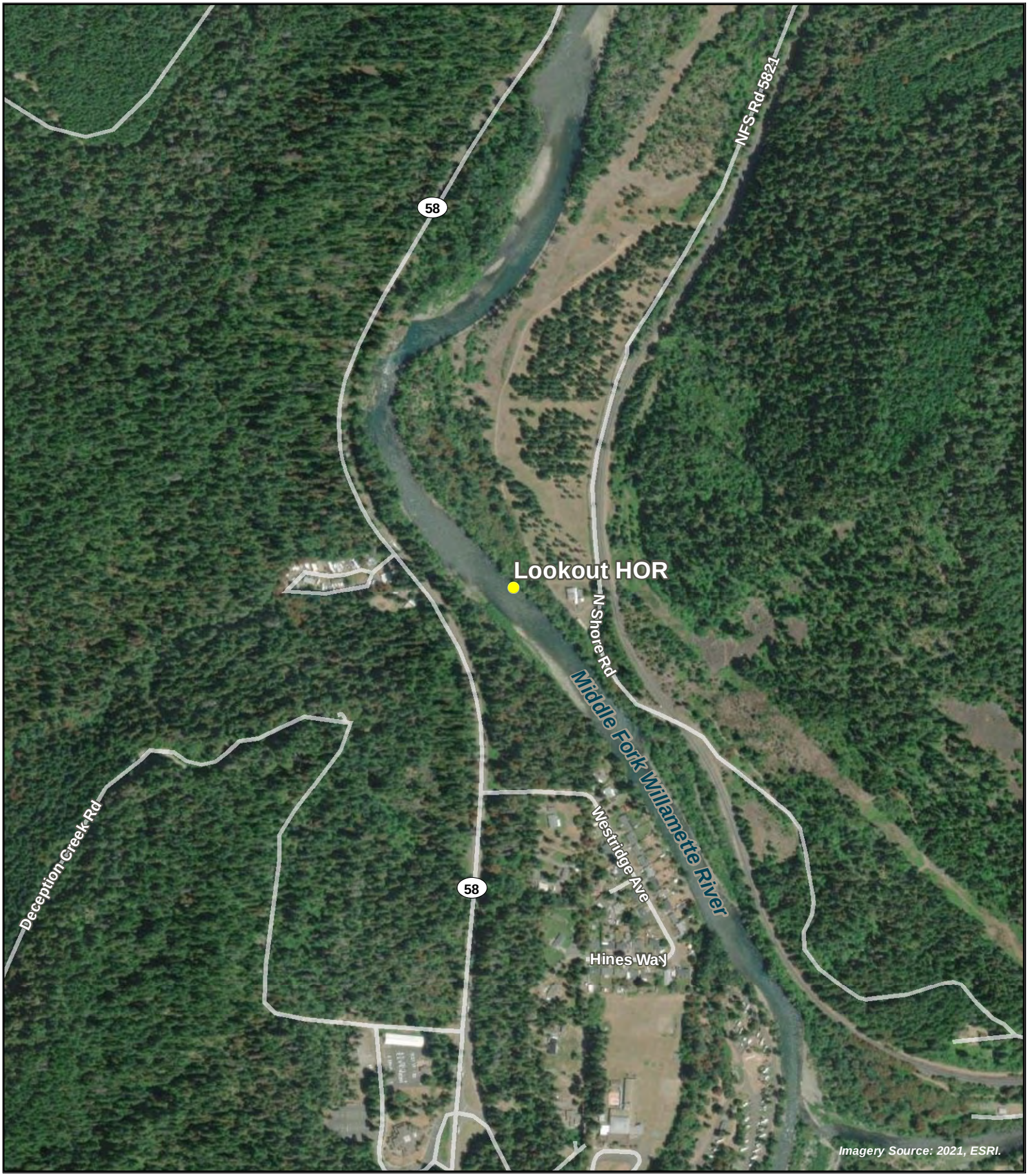

FIGURE A-10
Lookout Point Head of Reservoir

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-11
Hills Creek Dam

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

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Appendix B –
Sampling Outages by Site

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Appendix B: Sampling Outages by Site

Big Cliff Dam	02/16/2022 to 03/15/2022	Monitoring paused while passage measures were not being implemented.
Big Cliff Dam	05/03/2022 to 05/13/2022	Flows increased to levels where the trap could not be accessed or fished safely.
Big Cliff Dam	6/12/2022 to 6/14/2022	Cone raised due to unsafe flow conditions.
Green Peter Tailrace-Middle Santiam River	04/02/2022 to 04/13/2022	Initiation of spill resulted in high debris load that created fish health concerns and resulted in the cone being raised.
Green Peter Tailrace-Middle Santiam River	05/07/2022 to end of period	Rapid increase in flow caused damage to the highline anchor, trap was removed to prevent further damage to highline or trap.
Foster Dam Head of Reservoir- South Santiam River	03/01/2022 to 03/16/2022	Trap was not available until 03/16/2022. It was installed the same day it was delivered.
Foster Dam Head of Reservoir- South Santiam River	05/05/2022 to 05/10/2022	Flows and debris load increased to levels that made it unsafe to access and fish the trap.
Foster Dam Head of Reservoir- South Santiam River	05/28/2022 to 05/30/2022	Flows and debris load increased to levels that made it unsafe to access and fish the trap.
Foster Dam Head of Reservoir- South Santiam River	06/12/2022 to 06/14/2022	Flows and debris load increased to levels that made it unsafe to access and fish the trap.
Foster Dam Head of Reservoir- South Santiam River	11/04/2022 to 11/07/2022	Flows and debris load increased to levels that made it unsafe to access and fish the trap.
Cougar Dam RO RST	05/05/2022	Trap was raised due to large increase in flow. Flow was reduced to a safe level during the night and the trap resumed fishing.
Cougar Dam RO RST	05/09/2022	Flows increased to a level that prevented safe access onto the trap. Flows were decreased later that night.
Cougar Dam RO RST	07/19/2022	Cone raised to allow for hydro testing.
Cougar Dam RO RST	09/11/2022 to 09/12/2022	Cone was raised due to access and hazardous air resulting from the Cedar Creek fire.
Cougar Dam PH RSTs	07/29/2022 to 08/02/2022	Cones raised due to excessively high debris load from aquatic vegetation creating unsafe trap operations.
Cougar Dam PH RSTs	09/11/2022 to 09/12/2022	Cones were raised due to access and hazardous air resulting from the Cedar Creek fire.
Cougar Dam PH RSTs	10/08/2022 to 12/30/2022	Cones were raised due to low water levels that prevented cones from being able to be lowered into the sampling position.
Cougar Dam Head of Reservoir	04/08/2022 to 04/22/2022	A large snow event restricted access to the site. Cone was raised the day before the storm in anticipation of the event. Road conditions were checked daily during this time.
Cougar Dam Head of Reservoir	05/05/2022 to 05/09/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Cougar Dam Head of Reservoir	05/28/2022 to 05/30/2022	Cone raised due to high flows and debris loads resulting in unsafe trapping conditions.
Cougar Dam Head of Reservoir	06/11/2022 to 06/14/2022	Cone raised due to high flows and debris loads resulting in unsafe trapping conditions.
Cougar Dam Head of Reservoir	09/01/2022 to 09/16/2022	Damage incurred to anchor trees necessitated the identification and relocation of the anchor trees. New highline installed on 09/15/2022.
Cougar Dam Head of Reservoir	11/04/2022 to 11/07/2022	Cone raised due to high flows and debris loads resulting in unsafe trapping conditions.
Fall Creek Dam Tailrace	12/05/2022 to 12/31/2022	Reservoir drawdown resulted in bed movement that filled the RO channel with sediment and debris to a level that prevented the

		cone from sampling. Storm sampling protocol was implemented during this time when possible.
Fall Creek Head of Reservoir	01/02/2022 to 01/14/2022	Trap installation was postponed until 01/11/2022 due to high flows access issues. Trap was unable to sample until 01/14/2022 when flows and debris level decreased to a safe level for sampling.
Fall Creek Head of Reservoir	03/02/2022 to 03/04/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Fall Creek Head of Reservoir	05/05/2022 to 05/09/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Dexter Dam Tailrace	03/01/2022 to 03/09/2022	Trap was not available to install until March 3, 2022. Additional trap structures had to be built after initial install and effective sampling was delayed until March 9, 2022.
Dexter Dam Tailrace	05/05/2022 to 05/07/2022	Forecasted high flows prompted raising the cone to the non-sampling position. Trap resumed fishing after spill patterns were changed to allow for safe access and sampling.
Dexter Dam Tailrace	09/11/2022 to 09/12/2022	Cone was raised due to access and hazardous air resulting from the Cedar Creek fire.
Dexter Dam Tailrace	10/10/2022 to 10/16/2022	Cone was raised due to hazardous air resulting from the Cedar Creek fire.
Lookout Point Dam Tailrace	05/05/2022 to 05/10/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Lookout Point Dam Tailrace PWR RSTs	06/12/2022 to 06/16/2022	High flows created hazardous access to traps.
Lookout Point Dam Tailrace RO RST	06/28/2022 to 06/30/2022	Trap collar bolts broke, trap raised to non-sampling position until repairs were completed.
Lookout Point Dam Tailrace	07/28/2022 to 08/06/2022	Water temperatures exceeded permitted thresholds for sampling. Cones were raised to non-sampling position.
Lookout Point Dam Tailrace	09/11/2022 to 09/12/2022	Cones were raised due to hazardous air resulting from the Cedar Creek fire.
Lookout Point Dam Tailrace	10/10/2022 to 10/17/2022	Cones were raised due to hazardous air resulting from the Cedar Creek fire.
Lookout Point Dam Tailrace	10/19/2022 to 10/22/2022	Cones were raised due to hazardous air resulting from the Cedar Creek fire.
Lookout Point Head of Reservoir	03/01/2022 to 03/10/2022	Trap was not available for install until 03/10/2022.
Lookout Point Head of Reservoir	05/05/2022 to 05/10/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Lookout Point Head of Reservoir	05/14/2022 to 05/16/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Lookout Point Head of Reservoir	05/27/2022 to 06/01/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Lookout Point Head of Reservoir	06/04/2022 to 06/07/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Lookout Point Head of Reservoir	06/11/2022 to 06/17/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Lookout Point Head of Reservoir	09/09/2022 to 09/13/2022	Cone raised due to access and safety concerns from the Cedar Creek fire.
Lookout Point Head of Reservoir	09/14/2022 to 09/16/2022	Cone raised due to road closure resulting from the Cedar Creek fire.
Lookout Point Head of Reservoir	09/23/2022 to 09/24/2022	Cones were raised due to hazardous air resulting from the Cedar Creek fire.
Lookout Point Head of Reservoir	10/10/2022 to 10/22/2022	Cones were raised due to hazardous air resulting from the Cedar Creek fire.
Lookout Point Head of Reservoir	11/06/2022 to 11/07/2022	Flows and debris load increased to levels that made it unsafe to fish or access the trap.

Lookout Point Head of Reservoir	12/26/2022 to 12/31/2022	Cone raised due to hazardous weather conditions. Flows and debris load increased to levels that made it unsafe to fish or access the trap.
Hill Creek Dam PH and RO	09/23/2022 to 09/25/2022	Cones were raised due to hazardous air resulting from the Cedar Creek fire.
Hill Creek Dam PH and RO	10/10/2022 to 10/22/2022	Cones were raised due to hazardous air resulting from the Cedar Creek fire.

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Appendix C –
PIT Tags and VIE Tagging

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Appendix C: PIT Tags and VIE Tagging

Sections

VIE Mark **C-5**

PIT Tags **C-5**

Figures and Tables

Figure C-1. Example of a VIE marked Chinook salmon. A green fluorescent elastomer mark can be seen along the dorsal fin. C-5

Table C-1. PIT tag metadata for fish tagged at RST sites. C-5

Table C-2. Summary of fish PIT tagged at RST sites. C-5

Table C-3. List of downstream redetections for fish PIT tagged at RST sites. Of note, many fish marked at recaptured at the same site are fish that were transported and released upstream of the RST site for the purpose of conducting run of river trapping efficiency trials. C-6

Table C-3. List of VIE tagged fish at RST sites. C-16

Table C-4. List of Bull Trout captured at RST sites and collected data. C-17

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VIE Mark

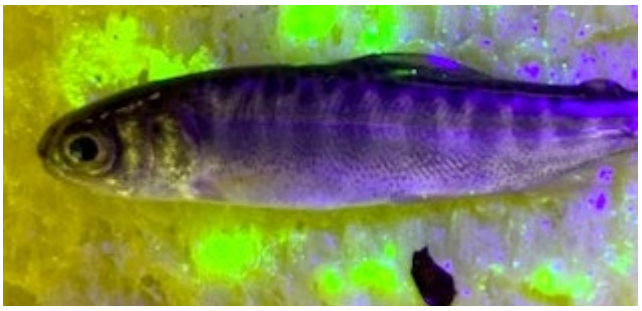

Figure C-1. Example of a VIE marked Chinook salmon. A green fluorescent elastomer mark can be seen along the dorsal fin.

PIT Tags

Table C-1. PIT tag metadata for fish tagged at RST sites.

Big Cliff Dam	BCL	BCLTAL
Green Peter Dam Tailrace - Middle Santiam River	GPD	GPD
Foster Dam Head of Reservoir - South Santiam River	SAN	SSANTR
Cougar Dam	CGR	CGRTAL
Cougar Dam Head of Reservoir	SMK	MCKESF
Fall Creek Dam Tailrace	FAL	FALTAL
Fall Creek Head of Reservoir	FCA	FALL2C
Dexter Dam Tailrace	DEX	DEXTAL
Lookout Dam Tailrace	LOP	LOPTAL
Lookout Point Head of Reservoir	LOA	WILRMF
Hills Creek Dam	HCR	HCRREG
Species	**SRR Code**	
Wild Spring Chinook	11W	
Hatchery Spring Chinook	11H	
Wild Winter Steelhead	34W	

AI	Adipose intact
AD	Adipose clipped
RE	Recapture

Table C-2. Summary of fish PIT tagged at RST sites.

Big Cliff Dam	261
Foster Head of Reservoir- South Santiam	245
Cougar Dam	1332
Cougar Head of Reservoir	4055
Dexter Dam	10

Lookout Point Dam	12
Lookout Point Head of Reservoir	49
Hills Creek Dam	5

Table C-3. List of downstream redetections for fish PIT tagged at RST sites. Of note, many fish marked at recaptured at the same site are fish that were transported and released upstream of the RST site for the purpose of conducting run of river trapping efficiency trials.

3DD.003E1BC840	5/3/2022	Big Cliff Dam	5/8/2022	TWX - Estuary Towed Array (Exp.)
3DD.003BEE1651	10/23/2022	Foster Dam Head of Reservoir - South Santiam River	10/25/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1664	10/23/2022	Foster Dam Head of Reservoir - South Santiam River	10/27/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1676	10/25/2022	Foster Dam Head of Reservoir - South Santiam River	10/25/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1678	10/25/2022	Foster Dam Head of Reservoir - South Santiam River	10/25/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE167B	10/25/2022	Foster Dam Head of Reservoir - South Santiam River	10/25/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE167D	10/25/2022	Foster Dam Head of Reservoir - South Santiam River	10/25/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE166C	10/25/2022	Foster Dam Head of Reservoir - South Santiam River	10/28/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1674	10/27/2022	Foster Dam Head of Reservoir - South Santiam River	10/28/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1684	10/27/2022	Foster Dam Head of Reservoir - South Santiam River	10/28/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1691	10/27/2022	Foster Dam Head of Reservoir - South Santiam River	10/28/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE17F5	10/29/2022	Foster Dam Head of Reservoir - South Santiam River	10/30/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE17E8	10/30/2022	Foster Dam Head of Reservoir - South Santiam River	11/2/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BD226AE	11/1/2022	Foster Dam Head of Reservoir - South Santiam River	11/2/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE2A44	11/2/2022	Foster Dam Head of Reservoir - South Santiam River	11/3/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE2A9E	11/2/2022	Foster Dam Head of Reservoir - South Santiam River	11/3/2022	Foster Dam Head of Reservoir - South Santiam River

3DD.003BD22787	11/8/2022	Foster Dam Head of Reservoir - South Santiam River	11/9/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BD2272F	11/9/2022	Foster Dam Head of Reservoir - South Santiam River	11/10/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BD22734	11/9/2022	Foster Dam Head of Reservoir - South Santiam River	11/10/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1E10	11/16/2022	Foster Dam Head of Reservoir - South Santiam River	11/17/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1E1A	11/18/2022	Foster Dam Head of Reservoir - South Santiam River	11/19/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1E1C	11/19/2022	Foster Dam Head of Reservoir - South Santiam River	11/20/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE1DD8	11/22/2022	Foster Dam Head of Reservoir - South Santiam River	11/23/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BD39729	11/23/2022	Foster Dam Head of Reservoir - South Santiam River	11/24/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BD396C0	11/24/2022	Foster Dam Head of Reservoir - South Santiam River	11/25/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BD225BD	11/27/2022	Foster Dam Head of Reservoir - South Santiam River	11/28/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BD2258E	11/28/2022	Foster Dam Head of Reservoir - South Santiam River	11/29/2022	Foster Dam Head of Reservoir - South Santiam River
3DD.003BEE167B	10/25/2022	Foster Dam Head of Reservoir - South Santiam River	11/11/2022	LD2 - Lebanon Dam North Ladder
3DD.003BEE29F6	10/29/2022	Cougar Dam	10/30/2022	Cougar Dam
3DD.003BEE29FB	10/29/2022	Cougar Dam	10/30/2022	Cougar Dam
3DD.003BD39723	10/31/2022	Cougar Dam	11/1/2022	Cougar Dam
3DD.003BD39734	10/31/2022	Cougar Dam	11/1/2022	Cougar Dam
3DD.003BD3974B	10/31/2022	Cougar Dam	11/1/2022	Cougar Dam
3DD.003BEE1CA9	11/1/2022	Cougar Dam	11/2/2022	Cougar Dam
3DD.003BEE1CB0	11/1/2022	Cougar Dam	11/2/2022	Cougar Dam
3DD.003BEE1CEA	11/1/2022	Cougar Dam	11/2/2022	Cougar Dam
3DD.003BD23012	11/4/2022	Cougar Dam	11/5/2022	Cougar Dam
3DD.003BEE1DD4	11/5/2022	Cougar Dam	11/6/2022	Cougar Dam
3DD.003BD2275D	11/7/2022	Cougar Dam	11/8/2022	Cougar Dam
3DD.003BD2276F	11/7/2022	Cougar Dam	11/8/2022	Cougar Dam
3DD.003BD22792	11/7/2022	Cougar Dam	11/8/2022	Cougar Dam
3DD.003BD22794	11/7/2022	Cougar Dam	11/8/2022	Cougar Dam
3DD.003BD22797	11/7/2022	Cougar Dam	11/12/2022	Cougar Dam
3DD.003BEE1DE9	11/9/2022	Cougar Dam	11/11/2022	Cougar Dam
3DD.003BD39636	11/11/2022	Cougar Dam	11/27/2022	Cougar Dam
3DD.003E1BC7D6	4/11/2022	Cougar Dam	5/27/2022	TWX - Estuary Towed Array (Exp.)

3DD.003E1BC80A	5/10/2022	Cougar Dam	5/24/2022	TWX - Estuary Towed Array (Exp.)
3DD.003BEE2A5C	9/19/2022	Cougar Dam Head of Reservoir	9/20/2022	Cougar Dam Head of Reservoir
3DD.003BEE2A78	9/19/2022	Cougar Dam Head of Reservoir	9/20/2022	Cougar Dam Head of Reservoir
3DD.003BEE2A87	9/19/2022	Cougar Dam Head of Reservoir	9/20/2022	Cougar Dam Head of Reservoir
3DD.003BEE2A97	9/19/2022	Cougar Dam Head of Reservoir	9/20/2022	Cougar Dam Head of Reservoir
3DD.003BEE2A9A	9/19/2022	Cougar Dam Head of Reservoir	9/20/2022	Cougar Dam Head of Reservoir
3DD.003BEE264C	9/21/2022	Cougar Dam Head of Reservoir	10/31/2022	Cougar Dam
3DD.003BEE16BC	9/22/2022	Cougar Dam Head of Reservoir	9/25/2022	Cougar Dam Head of Reservoir
3DD.003BEE16D7	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE16F5	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE16FD	9/22/2022	Cougar Dam Head of Reservoir	10/26/2022	Cougar Dam Head of Reservoir
3DD.003BEE1741	9/22/2022	Cougar Dam Head of Reservoir	9/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE175F	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE176A	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE1849	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE185B	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE1885	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE18C0	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE18D2	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE18D8	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE18E3	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE190D	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE1916	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE1917	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE1928	9/22/2022	Cougar Dam Head of Reservoir	10/28/2022	Cougar Dam
3DD.003BEE192E	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE1935	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE1965	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir

3DD.003BEE2213	9/22/2022	Cougar Dam Head of Reservoir	10/31/2022	Cougar Dam
3DD.003BEE223A	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE223B	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE223F	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE224D	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2252	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2253	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2266	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE227B	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2284	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2293	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE22AB	9/22/2022	Cougar Dam Head of Reservoir	11/12/2022	Cougar Dam
3DD.003BEE22B8	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE22B9	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE22CE	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE240E	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2422	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE242B	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2443	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2449	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE244B	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE244E	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2464	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2482	9/22/2022	Cougar Dam Head of Reservoir	10/26/2022	Cougar Dam
3DD.003BEE2483	9/22/2022	Cougar Dam Head of Reservoir	10/31/2022	Cougar Dam
3DD.003BEE2489	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2494	9/22/2022	Cougar Dam Head of Reservoir	10/26/2022	Cougar Dam

3DD.003BEE24AD	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE24BF	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE24D6	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE24D7	9/22/2022	Cougar Dam Head of Reservoir	10/28/2022	Cougar Dam
3DD.003BEE2517	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2519	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE26C9	9/22/2022	Cougar Dam Head of Reservoir	10/29/2022	Cougar Dam
3DD.003BEE26CC	9/22/2022	Cougar Dam Head of Reservoir	9/27/2022	Cougar Dam Head of Reservoir
3DD.003BEE26D0	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE26D4	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE26D4	9/22/2022	Cougar Dam Head of Reservoir	10/28/2022	Cougar Dam
3DD.003BEE26F9	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE270D	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2AAF	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2AB1	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2AC4	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2AEF	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2AF3	9/22/2022	Cougar Dam Head of Reservoir	9/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE2AFB	9/22/2022	Cougar Dam Head of Reservoir	9/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE16C5	10/5/2022	Cougar Dam Head of Reservoir	10/10/2022	Cougar Dam Head of Reservoir
3DD.003BEE16D3	10/5/2022	Cougar Dam Head of Reservoir	10/7/2022	Cougar Dam Head of Reservoir
3DD.003BEE16EC	10/5/2022	Cougar Dam Head of Reservoir	10/7/2022	Cougar Dam Head of Reservoir
3DD.003BEE16F8	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE1706	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE170A	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE172A	10/5/2022	Cougar Dam Head of Reservoir	11/2/2022	Cougar Dam
3DD.003BEE172B	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir

3DD.003BEE174C	10/5/2022	Cougar Dam Head of Reservoir	11/5/2022	Cougar Dam
3DD.003BEE1757	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE176B	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE1857	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE186E	10/5/2022	Cougar Dam Head of Reservoir	10/7/2022	Cougar Dam Head of Reservoir
3DD.003BEE18A0	10/5/2022	Cougar Dam Head of Reservoir	12/31/2022	Cougar Dam
3DD.003BEE18AA	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE18B5	10/5/2022	Cougar Dam Head of Reservoir	10/7/2022	Cougar Dam Head of Reservoir
3DD.003BEE18B6	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE18CA	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE18D4	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE18E2	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE18EA	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE18F0	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE1901	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE1910	10/5/2022	Cougar Dam Head of Reservoir	10/8/2022	Cougar Dam Head of Reservoir
3DD.003BEE192B	10/5/2022	Cougar Dam Head of Reservoir	10/9/2022	Cougar Dam Head of Reservoir
3DD.003BEE192F	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE1933	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE1939	10/5/2022	Cougar Dam Head of Reservoir	11/5/2022	Cougar Dam
3DD.003BEE1953	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE1957	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE224B	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE225E	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE226B	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE226D	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE2291	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir

3DD.003BEE22C8	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE23FC	10/5/2022	Cougar Dam Head of Reservoir	10/7/2022	Cougar Dam Head of Reservoir
3DD.003BEE2418	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE241F	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE242F	10/5/2022	Cougar Dam Head of Reservoir	10/29/2022	Cougar Dam
3DD.003BEE2474	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE2485	10/5/2022	Cougar Dam Head of Reservoir	11/5/2022	Cougar Dam
3DD.003BEE2492	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE2504	10/5/2022	Cougar Dam Head of Reservoir	10/27/2022	Cougar Dam
3DD.003BEE2506	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE26BE	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE26C4	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE26EA	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE26F1	10/5/2022	Cougar Dam Head of Reservoir	11/5/2022	Cougar Dam
3DD.003BEE26FE	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE2711	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE2713	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE2AA7	10/5/2022	Cougar Dam Head of Reservoir	10/6/2022	Cougar Dam Head of Reservoir
3DD.003BEE2AF1	10/5/2022	Cougar Dam Head of Reservoir	11/2/2022	Cougar Dam
3DD.003BEE1CA3	10/21/2022	Cougar Dam Head of Reservoir	10/22/2022	Cougar Dam Head of Reservoir
3DD.003BEE2C65	10/23/2022	Cougar Dam Head of Reservoir	10/27/2022	Cougar Dam
3DD.003BEE2C4C	10/25/2022	Cougar Dam Head of Reservoir	10/26/2022	Cougar Dam Head of Reservoir
3DD.003BEE0705	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE07FC	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0A9E	11/10/2022	Cougar Dam Head of Reservoir	11/23/2022	Cougar Dam Head of Reservoir
3DD.003BEE0AA2	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0AAB	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir

3DD.003BEE0AAC	11/10/2022	Cougar Dam Head of Reservoir	12/26/2022	Cougar Dam
3DD.003BEE0AC4	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0B4B	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0B75	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0B97	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0BA3	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0BFC	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0C58	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0C72	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0C82	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0DBE	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0DE6	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0DF3	11/10/2022	Cougar Dam Head of Reservoir	12/28/2022	Cougar Dam
3DD.003BEE0F51	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0F62	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE0FC8	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE127A	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE127E	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE12B9	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE12BB	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE12C3	11/10/2022	Cougar Dam Head of Reservoir	12/30/2022	Cougar Dam
3DD.003BEE12C5	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE12DC	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE1311	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE1319	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE1323	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE1474	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir

3DD.003BEE147E	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE148E	11/10/2022	Cougar Dam Head of Reservoir	11/22/2022	Cougar Dam
3DD.003BEE15FD	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE1616	11/10/2022	Cougar Dam Head of Reservoir	11/11/2022	Cougar Dam Head of Reservoir
3DD.003BEE07A8	11/16/2022	Cougar Dam Head of Reservoir	12/30/2022	Cougar Dam
3DD.003BEE081F	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE08A8	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE08A8	11/16/2022	Cougar Dam Head of Reservoir	11/30/2022	Cougar Dam
3DD.003BEE093F	11/16/2022	Cougar Dam Head of Reservoir	11/19/2022	Cougar Dam Head of Reservoir
3DD.003BEE0A1D	11/16/2022	Cougar Dam Head of Reservoir	12/14/2022	Cougar Dam
3DD.003BEE0AA6	11/16/2022	Cougar Dam Head of Reservoir	11/20/2022	Cougar Dam Head of Reservoir
3DD.003BEE0AB5	11/16/2022	Cougar Dam Head of Reservoir	12/28/2022	Cougar Dam
3DD.003BEE0ABB	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0AE2	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0B38	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0C14	11/16/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0C1A	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0C2C	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0C47	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0C96	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0D9F	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0DEC	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0EA3	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0EAC	11/16/2022	Cougar Dam Head of Reservoir	11/29/2022	Cougar Dam Head of Reservoir
3DD.003BEE0F92	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE1206	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE12BE	11/16/2022	Cougar Dam Head of Reservoir	11/20/2022	Cougar Dam Head of Reservoir

3DD.003BEE12EE	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE152D	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE15AE	11/16/2022	Cougar Dam Head of Reservoir	11/17/2022	Cougar Dam Head of Reservoir
3DD.003BEE0787	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE08AB	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE08B7	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0921	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE092C	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE097E	11/23/2022	Cougar Dam Head of Reservoir	11/29/2022	Cougar Dam
3DD.003BEE09A7	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE09B3	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE09C2	11/23/2022	Cougar Dam Head of Reservoir	11/29/2022	Cougar Dam Head of Reservoir
3DD.003BEE0A51	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0A5B	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0A6B	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0A77	11/23/2022	Cougar Dam Head of Reservoir	12/30/2022	Cougar Dam
3DD.003BEE0A78	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0A7A	11/23/2022	Cougar Dam Head of Reservoir	12/28/2022	Cougar Dam
3DD.003BEE0B3F	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0B8E	11/23/2022	Cougar Dam Head of Reservoir	11/29/2022	Cougar Dam Head of Reservoir
3DD.003BEE0CD5	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0CF5	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0D22	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0D2E	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0D7F	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0D83	11/23/2022	Cougar Dam Head of Reservoir	12/31/2022	Cougar Dam
3DD.003BEE0E6E	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir

3DD.003BEE0E75	11/23/2022	Cougar Dam Head of Reservoir	12/5/2022	Cougar Dam
3DD.003BEE0E7C	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0E7E	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0E8E	11/23/2022	Cougar Dam Head of Reservoir	11/30/2022	Cougar Dam
3DD.003BEE0E91	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0EC1	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0EFC	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0F18	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0F1B	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE0F20	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE123B	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE1260	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE14EF	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE1503	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE1512	11/23/2022	Cougar Dam Head of Reservoir	11/30/2022	Cougar Dam
3DD.003BEE15AF	11/23/2022	Cougar Dam Head of Reservoir	11/24/2022	Cougar Dam Head of Reservoir
3DD.003BEE08C8	11/29/2022	Cougar Dam Head of Reservoir	12/30/2022	Cougar Dam
3DD.003BEE0E23	11/29/2022	Cougar Dam Head of Reservoir	12/5/2022	Cougar Dam
3DD.003BEE1252	11/29/2022	Cougar Dam Head of Reservoir	12/28/2022	Cougar Dam

Table C-3. List of VIE tagged fish at RST sites.

Cougar Dam Head of Reservoir	6/25/2022 to 7/15/2022	Yellow	30	0
Cougar Dam Head of Reservoir	9/15/2022 to 9/30/2022	Orange	1	0
Cougar Dam Head of Reservoir	10/1/2022 to 10/15/2022	Pink	1	0
Cougar Dam Head of Reservoir	11/1/2022 to 11/15/2022	Green	1	0
Lookout Point Head of Reservoir	6/25/2022 to 7/15/2022	Yellow	3	0
Lookout Point Head of Reservoir	7/16/2022 to 7/31/2022	Red	1	0

Table C-4. List of Bull Trout captured at RST sites and collected data.

Cougar Dam PH	3/14/2022	279	None	Injured
Cougar Dam Head of Reservoir	5/10/2022	220	None	Unharmed
Cougar Dam Head of Reservoir	5/21/2022	155	None	Unharmed
Cougar Dam Head of Reservoir	10/16/2022	457	384.3515E4B149	Unharmed
Cougar Dam Head of Reservoir	10/18/2022	404	None	Unharmed
Cougar Dam Head of Reservoir	10/19/2022	240	None	Unharmed
Cougar Dam Head of Reservoir	10/20/2022	430	None	Unharmed
Cougar Dam Head of Reservoir	10/25/2022	460	None	Unharmed
Cougar Dam Head of Reservoir	10/30/2022	305	None	Unharmed
Cougar Dam Head of Reservoir	11/16/2022	310	None	Unharmed
Cougar Dam Head of Reservoir	11/23/2022	160	None	Dead
Cougar Dam Head of Reservoir	11/27/2022	130	None	Unharmed
Hills Creek Dam	12/26/2021	N/A	None	Injured

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Appendix D –
Example of Injury Photos

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Appendix D: Example of Injury Photos

Figures

Figure D-1. Live fish with no external injuries (NXI) D-5
Figure D-2. Descaling less than 20% (DS<2) D-5
Figure D-3. Bloody Eye (hemorrhage) (EYB) D-5
Figure D-4. Bleeding from Vent (BVT) D-5
Figure D-5. Fin Blood Vessels Broken (FVB) D-6
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Figure D-7. Pop Eye (eye popping out of head/missing eye) (POP) D-7
Figure D-8. Head Injury (HIN) D-7
Figure D-9. Operculum Damage (OPD) D-7
Figure D-10. Body Injury (tears, scrapes, mechanical damage) (TEA) D-7
Figure D-11. Bruising (any part of the body) (BRU) D-8
Figure D-12. Hole Behind Pectoral Fin (HBP) D-8
Figure D-13. Descaling greater than 20% (DS>2) D-8
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Figure D-15. Body Only (BO) D-9
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Figure D-18. Predation Marks (vert. claw or teeth marks) (PRD) D-10
Figure D-19. Copepods (on gills or fins) (COP) D-10
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Figure D-1. Live fish with no external injuries (NXI)

Figure D-2. Descaling less than 20% (DS<2)

Figure D-3. Bloody Eye (hemorrhage) (EYB)

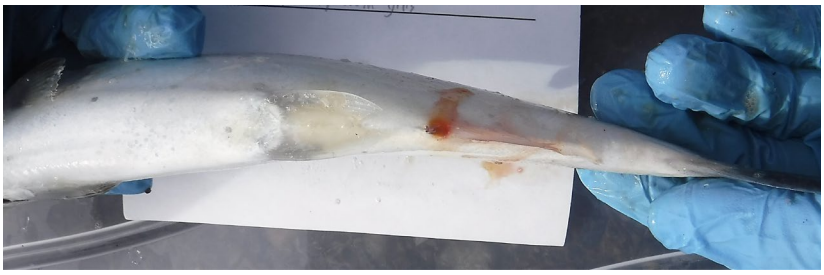

Figure D-4. Bleeding from Vent (BVT)

Figure D-5. Fin Blood Vessels Broken (FVB)

Figure D-6. Gas Bubble Disease (fin ray/eye inclusions) (GBD)

Figure D-7. Pop Eye (eye popping out of head/missing eye) (POP)

Figure D-8. Head Injury (HIN)

Figure D-9. Operculum Damage (OPD)

Figure D-10. Body Injury (tears, scrapes, mechanical damage) (TEA)

Figure D-11. Bruising (any part of the body) (BRU)

Figure D-12. Hole Behind Pectoral Fin (HBP)

Figure D-13. Descaling greater than 20% (DS>2)

Figure D-14. Head Only (HO)

Figure D-15. Body Only (BO)

Figure D-16. Head Barely Connected (HBO)

Figure D-17. Fin Damage (FID)

Figure D-18. Predation Marks (vert. claw or teeth marks) (PRD)

Figure D-19. Copepods (on gills or fins) (COP)

Figure D-20. Fungus (FUN)

Appendix E –
Images of Non-Target Species

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Appendix E: Images of Non-Target Species

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Figure E-1. Bluegill

Figure E-2. Brook Lamprey

Figure E-3. Brown Bullhead

Figure E-4. Bull Trout

Figure E-5. Crappie

Figure E-6. Cutthroat Trout

Figure E-7. Longnose Dace

Figure E-8. Kokanee

Figure E-9. Sculpin

Figure E-10. Smallmouth Bass

Figure E-11. Spotted Bass

Figure E-12. Walleye

Figure E-13. Western Mosquitofish

Appendix F –
Images of Traps Sampling in Various Conditions

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Appendix F: Images of Traps Sampling in Various Conditions

Figures

Figure F-1. Labelled image of a rotary screw trap showing parts and terminology. F-5
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Figure F-1. Labelled image of a rotary screw trap showing parts and terminology.

Images of traps at various flow levels

Figure F-2. Big Cliff Dam

Figure F-3. Green Peter Dam Tailrace – Middle Santiam River

Figure F-4. Foster Dam Head of Reservoir – South Santiam River

Figure F-5. Cougar Dam – Regulating Outlet

Figure F-6. Cougar Dam – Powerhouse Channel

Figure F-7. Cougar Dam Head of Reservoir

Figure F-8. Fall Creek Dam Tailrace

Figure F-9. Fall Creek Head of Reservoir

Figure F-10. Dexter Dam Tailrace

Figure F-11. Lookout Dam Tailrace – Spillway

Figure F-12. Lookout Dam Tailrace – Powerhouse Channel

Figure F-13. Lookout Point Head of Reservoir

Figure F-14. Hills Creek Dam – Regulating Outlet

Figure F-15. Hills Creek Dam – Powerhouse Channel