Final

DOWNSTREAM JUVENILE FISH PASSAGE MONITORING VIA ROTARY SCREW TRAPS

Bi-Annual Report

Prepared for

US Army Corps of Engineers

Portland District

211 E. 7th St., Ste. 480
Eugene, OR 97401-2773

Prepared by

EAS Environmental Assessment Services

350 Hills St, Suite 112
Richland, Washington 99354

August 2024

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Acronyms and Abbreviations

AICc	Akaike Information Criterion
AQI	Air Quality Index
Big Cliff	Big Cliff Dam
BiOp	Willamette Project Biological Opinion
BPA	Bonneville Power Administration
BY	Brood Year
CI	Confidence Interval
cfs	cubic feet per second
CFS/Cramer	Cramer Fish Sciences
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
HOR	Head of Reservoir
Lookout Dam HOR	Lookout Dam Head of Reservoir
Lookout Dam TR	Lookout Dam Tailrace
NMFS	National Marine Fisheries Service
NOR	Natural Origin
ODFW	Oregon Department of Fish and Wildlife
PH	Powerhouse
PIT	Passive Integrated Transponder
PNNL	Pacific Northwest National Laboratory
PTAGIS	PIT Tag Information System
RO	Regulating Outlet
ROR	Run of River
RPA	Reasonable and Prudent Alternative
RST	Rotary screw traps
TE	Trapping Efficiency
US	United States
USACE	US Army Corps of Engineers
USGS	US Geological Survey
UWR	Upper Willamette River
VIE	Visible Implant Elastomer
WVP	Willamette Valley Project

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Rotary Screw Trap Program Bi-Annual Report

Introduction

The US 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 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 2008a). High-head, flood risk management dams in Oregon's Willamette River basin are operated differently than the run of river (ROR) 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 2008b). The National Marine Fisheries Service (NMFS) worked with the USACE, the US 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 2008b). In the BiOp, NMFS identified a Reasonable and Prudent Alternative (RPA) that set forth specific actions in which 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 2008b).

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 US 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 Upper Willamette River 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) and compared them to similar sampling that occurred prior to their implementation.

Rotary screw traps (RSTs) 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 Detroit, Green Peter, Foster, Cougar, Fall Creek, Lookout Point, and Hills Creek 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 and weight data of natural origin (NOR) juvenile salmonids passing through WVP reservoirs, migration timing, evaluating juvenile salmonids for presence of injuries, gathering information on relative abundance of incidental fish species, assessing post-collection mortality, and to provide data to compare to previously collected information from RSTs operating prior to the commencement of the injunction measures described above. At sites where trapping efficiency (TE) trials provided sufficiently robust results, an objective of the RSTs was to estimate the abundance of out-migrating juvenile salmonids.

Previous RST sampling was conducted by Cramer Fish Sciences (CFS) at certain sites through November 2021 to meet interim injunctive measure requirements (CFS 2023a) and the Corps at Fall Creek Tailrace through winter 2022. For information regarding these sampling efforts, please refer to their associated reports.

RST sampling was conducted by EAS for the USACE under EAS base contract W9127N19D0007 at the following locations: Big Cliff Dam Tailrace, Green Peter Dam Tailrace, Foster Head of Reservoir – South Santiam, Cougar Dam Tailrace, 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 Tailrace in 2023. Additionally, EAS performed RST sampling in 2023 for Cramer Fish Sciences under contract W9127N19D0009 at the following sites: Breitenbush River, Detroit Head of Reservoir – North Santiam River, Big Cliff Dam Tailrace, Green Peter Head of Reservoir – Middle Santiam River, Green Peter Dam Tailrace, Cougar Dam Tailrace, Fall Creek Dam Tailrace, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point Head of Reservoir, Hills Creek Dam Tailrace, and Hills Creek Head of Reservoir. Results for sampling at these sites can be found in the associated reports (EAS 2024 and EAS 2024a).

This report was written by Environmental Assessment Services, LLC (EAS) for Cramer Fish Sciences under contract W9127N19D0009. Sampling of all RSTs from January 1, 2024, through June 30, 2024, was performed by EAS as a sub-contractor for Cramer Fish Sciences under contract W9127N19D0009.

This report contains a compiled summary and analysis of the field study implemented by EAS for RST sampling efforts from January 1, 2024, through June 30, 2024, at the following sites: Breitenbush River, Detroit Head of Reservoir – North Santiam River, Big Cliff Dam Tailrace, Green Peter Head of Reservoir – Middle Santiam River, Green Peter Dam Tailrace, Foster Dam Head of Reservoir- South Santiam River, Cougar Head of Reservoir, Cougar Dam Tailrace, Fall Creek Head of Reservoir, Fall Creek Dam Tailrace, Hills Creek Head of Reservoir – Middle Fork Willamette, Hills Creek Dam Tailrace, Lookout Point Head of Reservoir – Middle Fork Willamette, Lookout Dam Tailrace, and Dexter Dam Tailrace.

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 a 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 H.

Traps are predominantly set in the river thalweg or in positions likely to capture juvenile fish as they travel downstream through the sampling area. However, during times of heavy debris or high flow rates near the operational limits of the RSTs, they are positioned outside of the thalweg to prevent the trap from clogging between checks, getting damaged, and avoiding fish mortality. Traps were accessed either by wading, with inflatable kayaks, or by being pulled nearshore with the highline. 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.

Under this contract, RSTs were operated at 15 locations in the southern Willamette River watershed: Breitenbush River, Detroit Head of Reservoir – North Santiam River, Big Cliff Dam Tailrace, Green Peter Head of Reservoir – Middle Santiam River, Green Peter Dam Tailrace, Foster Dam Head of Reservoir- South Santiam River, Cougar Dam Head of Reservoir, Cougar Dam Tailrace, Fall Creek Head of Reservoir, Fall Creek Dam Tailrace, Hills Creek Head of Reservoir – Middle Fork Willamette, Hills Creek Dam Tailrace, Lookout Point Head of Reservoir – Middle Fork Willamette, Lookout Dam Tailrace, and Dexter Dam Tailrace. 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 trap's capture efficiency. For locations of traps for sampling before and after 2021, refer to Appendix A. Below is the list of sites where traps were operated:

- A 5-foot RST operated in the Breitenbush River approximately 100 meters downstream of the first bridge. Trap operation began on February 1, 2024, and continued through June 30, 2024.
- A 5-foot RST operated at the Detroit Head of Reservoir – North Santiam River below the Cooper's Ridge Road bridge from February 1, 2024, through June 30, 2024.
- An 8-foot RST operated in the Big Cliff Dam Tailrace from January 1, 2023, through June 30, 2024.
- A 5-foot RST operated at the Green Peter Head of Reservoir – Middle Santiam River site approximately 200 meters downstream from the US Geological Survey (USGS) gauging station, from February 1, 2024, through June 30, 2024.
- An 8-foot RST operated in the Green Peter Dam Tailrace – Middle Santiam River from January 1, 2024, through June 30, 2024.
- A 5-foot RST operated at the Foster Dam Head of Reservoir – South Santiam River site from February 1, 2024, through June 30, 2024.
- A 5-foot RST operated at the Cougar Head of Reservoir site – South Fork McKenzie River, from February 1, 2024, to June 30, 2024.
- Two 8-foot RSTs in the Powerhouse (PH) channel and one 5-foot RST in the Regulating Outlet (RO) channel operated in the Cougar Dam Tailrace, from February 1, 2024, through June 30, 2024.
- An 8-foot RST operated at the Fall Creek Head of Reservoir site approximately 250 meters downstream from Dolly Varden Campground from January 1, 2024, to June 30, 2024.
- An 8-foot RST operated in the Fall Creek Dam Tailrace RO channel from January 1, 2024, through June 30, 2024.
- A 5-foot RST operated at the Hills Creek Head of Reservoir site in the Middle Fork Willamette River above Hills Creek Reservoir below the USGS gauging station, from February 1, 2024, through June 30, 2024.
- An 8-foot RST in the PH channel and a 5-foot RST in the RO channel operate in the Hills Creek Dam Tailrace from January 1, 2024, through June 30, 2024.
- A 5-foot RST operated at the Lookout Head of Reservoir – Middle Fork Willamette River site at the US Forest Service Seed Farm, from January 1, 2024, through June 30, 2024.
- Three 8-foot RSTs (two in the PH channel and one in the Spill channel) operated below the Lookout Dam Tailrace from January 1, 2024, through June 30, 2024.
- A 5-foot RST operated in the Dexter Dam Tailrace from January 1, 2024, through June 30, 2024.

Maps showing trap deployment locations for each site can be found in 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 is provided in Table 1.

Table 1. Rotary screw trap locations, installation dates, sampling periods, and total days sampled for the report period

Site	Trap Installation	Reporting Period
Breitenbush River	01/25/2024	02/01/2024–6/30/2024
Detroit Head of Reservoir – North Santiam	01/31/2023	02/01/2024–06/30/2024
Big Cliff Dam Tailrace	05/23/2021[d]	01/01/2024–06/30/2024[a]
Green Peter Head of Reservoir – Middle Santiam	04/05/2023[b]	02/01/2024–06/30/2024
Green Peter Dam Tailrace – Middle Santiam	03/14/2023[c]	01/01/2024–06/30/2024[a]
Foster Dam Head of Reservoir- South Santiam	01/24/2024	02/01/2024–06/30/2024[a]
Cougar Head of Reservoir	01/23/2024	02/01/2024–06/30/2024[a]
Cougar Dam Tailrace PH	03/24/2021[d]	01/01/2024–06/30/2024[a]
Cougar Dam Tailrace RO	03/24/2021[d]	01/01/2024–06/30/2024[a]
Fall Creek Head of Reservoir	01/01/2024	01/01/2024-6/30/2024
Fall Creek Dam Tailrace	03/15/2022	01/01/2024–06/30/2024[a]
Hills Creek Head of Reservoir – Middle Fork Willamette	01/24/2023	02/01/2024–06/30/2024[a]
Hills Creek Dam Tailrace PH	09/15/2022	01/01/2024–06/30/2024[a]
Hills Creek Dam Tailrace RO	09/15/2022	01/01/2024–06/30/2024[a]
Lookout Point Head of Reservoir – Middle Fork Willamette	03/06/2022	01/01/2024–06/30/2024[a]
Lookout Point Dam Tailrace	03/15/2021[d]	01/01/2024–06/30/2024[a]
Dexter Dam Tailrace	03/03/2022	01/01/2024–06/30/2024[a]

a Previously monitored by EAS for the USACE under contract W9127N23R0019.
b Initiation of sampling delayed following contract award in March 2023 and permits approval.
c Initiation of sampling was delayed until a new anchor system could be installed.
d Previously monitored by CFS for the USACE

Data Collection

Fish Collection, Trap and Environmental Metrics

RSTs were typically checked once per day unless conditions necessitated additional checks for fish or trap safety. In extreme circumstances, such as ice storms which resulted in an Oregon State of Emergency, enforcing road closures and making travel unsafe, it was not possible to monitor and sample the RST daily. For a detailed list on RST sampling throughout the year, please see Appendix B. 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 HOBO Loggers in the trap live wells, USGS gauges, and USACE dam operations data which included inflow, outflow by route, water temperature, and dissolved oxygen concentration where available. Target fish species were removed from traps and transported to a safe work-up location. 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 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. Furthermore, these 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 fully replaced if the surrounding water temperature increased 2°C. At sites located in the Santiam basin, all unmarked juvenile *Oncorhynchus mykiss* (*O. mykiss*) were treated and reported as winter steelhead.

Biological Data and Tagging

Biological data was collected for each target fish captured. At all sites, juvenile Chinook salmon that did not display any clip, tag, or dye and were presumed to be of NOR and considered targets. Additionally, at sites in the Santiam River Basin, winter steelhead were considered target fish. Winter Steelhead have not been out planted above Detroit or Green Peter Reservoirs in the recent era, but sampling of *O. mykiss* is required by the injunction order. Therefore, all juvenile *O. mykiss* captured that did not display any clip, tag, or dye and were presumed to be of NOR were treated as targets, as it is not possible to accurately distinguish between resident rainbow trout and anadromous steelhead trout.

Table 2 lists all sites and the target species at each site. Data collected included species, fork length to the nearest millimeter, weight to the nearest 0.1-gram, fish condition, injuries, lifestage, and assessment for the presence of tags or other marks. Lifestage in the field was delineated as fry, parr, smolt, or adult based on morphological characteristics. In general, fry were subyearling fish under 50 mm fork length, parr were fish larger than 50 mm that displayed parr marks, and smolt were fish that had become silvery in appearance. This is a subjective delineation dependent on environmental conditions and life history with some overlap in lengths. A list of injury codes used for assessments is provided in Table 3. In addition to the injury codes listed, EAS 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). Additionally, standard biological metrics were recorded from all marked Chinook captured in RSTs. These fish were then identified as those used by the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024) or from other Willamette Valley projects.

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 nearly all fish meeting these criteria unless they were too damaged or decomposed to provide viable samples. Aged fish were then delineated as yearlings or sub-yearlings and assigned an appropriate brood year (BY) category based on the age class determined from scales and time of capture. Fish were reported as sub-yearling or yearling along with the BY they were assigned. In some cases, small sub-yearling fish are referred to as fry and large yearlings as smolt. All fish with a fork length of 65 mm or larger, not being placed in 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. In total, EAS monitors 9 sites where target species have the potential to be recaptured at another RST site further downstream. Therefore, fish that were non-sac-fry, smaller than 65 mm, and larger than 35 mm were marked with visible implant elastomer (VIE). Photos of target species encountered, and injuries were collected throughout the sampling periods and are provided in Appendix F.

Table 2. Summary of data collected at each RST site

Rotary Screw Trap Sampling Site	Trap Efficiency Trials	Target Species	Biological and Injury Data	Scale and DNA Samples	24-hour Holds (post collection)	PIT Tagging (>65 mm)	Elastomer Tagging (<65 mm)
Breitenbush River	Yes, Run of River Fish, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Detroit Head of Reservoir – North Santiam	Yes, Run of River Fish, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Big Cliff Dam Tailrace	Yes, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hour holds	No
Green Peter Head of Reservoir – Middle Santiam	Yes, Run of River Fish, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Green Peter Dam Tailrace	Yes, Hatchery Fish	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No
Cougar Head of Reservoir	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	Yes
Cougar Dam Tailrace	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No
Fall Creek Head of Reservoir	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes	Yes
Fall Creek Dam Tailrace	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes	No
Hills Creek Head of Reservoir – Middle Fork Willamette	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Hills Creek Dam Tailrace	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	Yes, on fish not included in 24-hr holds
Lookout Point Head of Reservoir	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Lookout Dam Tailrace	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	Yes, on fish not included in 24-hr holds
Dexter Dam Tailrace	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No

Table 3. List of injury codes and abbreviations for injury assessments

Description of Injury/Condition	Injury Code
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

Trapping Efficiency Trials and Approach

Approach

Hatchery reared Chinook salmon were utilized for TE trials because catch of ROR fish were frequently insufficient to perform effective trials. However, due to finite hatchery fish availability and inconsistent catch of ROR fish for TE trials, EAS attempted to use a flow-based TE model approach to evaluate the efficiency of each trap at the start of this project in late 2021. EAS chose this approach because water flow has been shown to be a dominant factor affecting TE in multiple RST out-migrating juvenile salmonid studies (Cheng and Gallinat 2004; Dambacher 1991; Rayton and Wagner 2006; Volkhardt et al. 2007; Voss and Poytress 2020).

Additionally, EAS anticipated it would take a substantial amount of time to perform enough TE trials to model a single variable, so we focused on flow. As a rule of thumb, sample sizes of approximately 30 are needed to provide enough information to make a statistically sound conclusion to model a single variable. In regression analysis with one independent variable, having an adequate sample size is crucial to ensure the reliability and generalizability of the results. Generally, a minimum of 30 samples is recommended for several reasons such as having enough statistical power, meeting normality assumptions, having robustness against outliers, reduction in standard error, and applicability to larger populations from the samples. This is well documented in statistical literature. For example, Montgomery et al. (2012) emphasizes the importance of sample size in ensuring the validity of regression results. When additional variables are included in the regression model, it is generally recommended to have more samples to maintain statistical power and reliability. A general rule of thumb is that at least 10 more samples per additional variable helps to account for the increased complexity of the model and the potential for overfitting. This ensures that there are an adequate number of observations for each predictor variable, which improves the stability and generalizability of the regression results (Cohen et al. 2003; Hair et al. 2019).

In addition to flow, we collect data on other variables with the intent to use them to improve TE estimates. EAS has started investigating alternative variables such as brood year, lifestage, size, and the volume flow across the submerged portion of an RST cone at select sites. However, up to this point EAS has focused on obtaining enough TE trials to determine associations or lack thereof with flow. Once enough samples (approximately n=30 successful TE trials) to draw conclusions of TE in relation to flow are collected, EAS plans to investigate other variables in more depth.

With the flow-based approach in mind, EAS conducted multiple trials with marked hatchery fish across a range of flows to calculate weekly estimates for each location based on the flows occurring during that time span. When enough ROR fish were available, captured fish were uniquely marked and released upstream of the trap. EAS also tracked trials based on size of hatchery fish used. This allowed EAS to further evaluate the differences in capture efficiency by flow, fish size, and origin. With this approach, EAS hypothesized we would be able to use historical data to supplement efficiency calculations and continue to add to data in subsequent years as more trials are performed.

It is important to note that RSTs are designed to capture fish actively out-migrating and generally do not capture fish that are moving upstream or rearing near sampling sites. Additionally, environmental variables such as ice storms and forest fires, biological variables related to poor water quality, decreased fish health, increased sedimentation, rapidly changing Dam operations, predators entering traps and consuming fish from trials, and other unplanned factors has led to some TE trials being unsuccessful. Many sites experience a wide range of flows throughout sampling and the performance of the RST varies widely across these ranges. During this reporting period, flow rates at some sites decreased to the point where the trap would barely spin, allowing fish to potentially avoid capture. Trials performed at these low flow rates often do not yield enough recaptures to be considered successful but provide information on the lower range of flows in which traps effectively sampled. Furthermore, it is assumed that all fish released for TE trials migrate downstream past the trapping site within a one-week period. Additional assumptions are provided in the subsequent TE trial sections.

Utilizing the work from previous years, a sufficient number of TE trials have occurred to begin relating TE to flow conditions at the different sampling sites. In order to accomplish this, we decided to model discharge and cone revolutions per hour at sites with both data sets available. These sites include Breitenbush River, Detroit Head of Reservoir, Big Cliff Dam, Green Peter Dam, Foster Head of Reservoir, Cougar Head of Reservoir, Cougar Dam, Fall Creek Dam, Hills Creek Dam, Lookout Point Head of Reservoir, Lookout Dam, and Dexter Dam. This analysis is intended to be a foundation for determining what variables drive TE at each individual sampling site. In the future we intend to include additional covariates such as gage height (where discharge is not available) and fish size. These are variables that have been found in other studies to have an impact on trap efficiency. A full description of analysis methods, results, and future modelling plans is available in Appendix E: Trap Efficiency Plots.

Trapping Efficiency Trials

Hatchery Fish. Trapping efficiency was able to be performed at all sites during the first half of 2024 using large quantities of hatchery reared Chinook salmon. 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 from ODFW hatcheries in the basin. Water temperature and dissolved oxygen levels were continuously monitored during fish transportation and corrected as necessary. Upon arrival at the release site, river water was slowly mixed into transport and marking tanks to acclimate fish to the site conditions 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 NOR 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 Breitenbush River, Detroit Head of Reservoir – North Santiam River, Green Peter Head of Reservoir – Middle Santiam River, Cougar Dam Head of Reservoir, 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 NOR 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 Tailrace, Green Peter Dam Tailrace, Cougar Dam Tailrace, Fall Creek Dam Tailrace, Dexter Dam Tailrace, Lookout Dam Tailrace, and Hills Creek Dam Tailrace, the first 60 NOR juvenile Chinook salmon (or *O. mykiss* 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 ROR fish captured each week were placed into a holding tank. Where applicable, fish passing through a regulating outlet (RO) 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 salmon 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 Dam PH, Cougar Dam RO, and Hills Creek Dam PH, 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 EAS to standardize catch to 24-hour periods. Across all sites for this reporting period, RSTs were fished a total of 2,720 start/stop times with an average duration of 24.33 hours between checks (standard deviation of 6.2 hours). Trap sampling time between checks ranged from 4.0 and 125.25

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 15 to 34 hours. In a few instances (n=9) traps were not fished overnight, typically during high flows due to safety concerns, or debris clogging issues classified as weather event checks and subsequently excluded from analysis. Furthermore, an ice storm in January prevented crews from being able to access trap sites and resulted in traps sampling between 40 and 125 hours between checks. Additionally, data was excluded (<3%) 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 standardized 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 CFS (2023), we calculated trap capture efficiency by marking hatchery Chinook salmon for each TE trial. Fish were released upstream ~500 m from the trap, or as far upstream as possible at the below dam sites. Fish for TE 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), and BBY 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 TE 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 (cfs) as represented at specific sites by total river discharge, river gage height, PH discharge, Spill discharge, and RO discharge depending on the site. Water flow has been shown to be the dominant factor affecting TE in multiple RST out-migrating juvenile salmonid studies (Cheng and Gallinat 2004; Dambacher 1991; Rayton and Wagner 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, ROR 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.

Previous RST work has shown flow rates to be one of the largest factors in TE (Tattam et al. 2013). Therefore, EAS started with the assumption that flow would be the best predictor of TE. For this project, EAS attempted to build models based on flows in association with hatchery TE trials. EAS has since gained further insight with a growing pool of TE trials and has found that association of TE to flow to be on a site-by-site basis. A table detailing sampling constraints due to high flows and other factors is available in Appendix H (Table H-1). Details about specific TE trials are reported in the results section. Data regarding TE trials against flow are presented in Appendix E.

For several sites, too few TE trials were deemed successful to effectively model TE in relation to flows. At these sites there are either not enough trials conducted at specific flows (typically high flow), total trials conducted (small sample size), or not enough recaptures (multiple TEs with <5 recaptures) for TE data to be modeled in relation to flow. There appear to be linear trends in relation to flow at some sites with small sample size, but at this time, not enough successful trials have been conducted (particularly at high flows) to model the data.

At other sites, there appears to be no relationship between flow and TE. In those instances, all hatchery TE trials (except when trap was non-functional) were pooled to calculate an average TE and 95% confidence intervals (CI) based on the standard deviation.

Additionally, we theorize TE functionally changes at different flow rates for Big Cliff, similar to observations from the work of 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 over time that can predict TE based on flow rates. This would reduce the overall number of additional TEs and decrease error estimates.

CIs 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
- α = 0.05 level of significance
- s = standard deviation of trap efficiency trials for a given site, route, and flow
- n = number of trap efficiency trials for a given site, route, and flow rate.

Weekly passage was not estimated for the corresponding project week if the trap was out of operation for five consecutive days due to any of the following conditions: low flow preventing the trap from spinning, cone raised due to dangerously high flows or debris volume, access blocked due to weather or wildfire, or a requested non-sampling period. If TE criteria were not met (five TE fish recaptures per release) for a particular site, those trials were not used for any calculations.

Furthermore, in some instances (e.g., Lookout Tailrace) TE is so low that most trials are not successful even with releases as high as 4,000 fish. At the Lookout Dam Tailrace, the PH traps were sampled in their historic locations until September 5, 2023, when they were moved to sample side by side in order to alleviate crew safety concerns. It was anticipated that this reconfiguration of the traps would provide similar or improved results in regard to capture efficiency. Lookout PH had multiple TE releases of 4,000 fish, yet few of those TEs were found to be successful (both pre and post PH traps reconfiguration).

In future, we plan to further explore and if possible, incorporate other variables such as age class, fish size, and time of the year in relation to TE. Please refer to Appendix E: Trap Efficiency Plots for a detailed synopsis of our approach for TE Trials and analysis moving forward.

Brood Year

A subset of scales collected from juvenile Chinook salmon (and *O. mykiss* in Santiam basin sites) were mounted and read to determine the age of collected fish. Scales were read for at least 10% of the total catch for each site. Scale readers were provided with samples labelled with a unique identification number, location of capture, and date of capture. Fish length and weight were not included to not bias the reader. Scale readers would classify samples as either yearlings or sub-yearlings. Each sample was read by two individuals, independently. For samples with conflicting age classifications based on independent scale reads, a third read was performed by another reader. Additionally, a random subset of samples was read a third time to confirm age classifications. Fish age classes were then correlated back to individual fish using the unique identification number and used to determine BY for size class of fish throughout the year. BY determinations were made by considering all information gathered for the fish, including length, date of capture, and age classification.

When aged samples for subsets of total catch show clear size delineations by BY, size metrics will be reported by BY. In some instances, such as Big Cliff Dam out-migrants, significant overlap in size ranges between multiple BYs of fish are observed. Without being able to age every fish captured and verify age, it is not appropriate to report summary metrics for size by BY. In these instances, we will report size metrics for the overlapping BYs together to provide information on the fish out-migrating during that time period as a whole.

Trapping Injuries

To provide additional insight for injuries associated with handling and capture in a RST, injury data was collected on hatchery fish being released for TE 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. This data was compiled for each below dam site for hatchery fish captured since 2021. This data is available in appendix D.

Through ongoing data collection and monitoring, EAS has found that NOR Chinook and *O. Mykiss* typically illustrate signs of injury that are associated with dam passage and trap capture. Similar yet distinct observations show that fish utilized in TE trials present injuries associated with hatchery rearing and trap capture, while bulk marked released fish exhibit injuries related to hatchery rearing, dam passage, and trap capture.

Results

Breitenbush River

A single 5-foot RST was deployed in the Breitenbush River above Detroit Reservoir on February 1, 2024, and continued sampling until June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B. It is important to note that previous sampling efforts in the Breitenbush River occurred at a sampling site downstream of the current location (see Appendix A). Due to damage from the 2020 wildfires, we were unable to utilize the previous, historic sampling location.

Trapping Efficiency Trials

A total of six TE trials occurred from February 7, 2024, through June 25, 2024, in the Breitenbush River using hatchery reared Chinook salmon. Collectively, 14 TE trials have occurred at this site since June 21, 2023. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 4.

TEs ranged from 0.9% to 20.3%, with a pooled average of 6.5% (95% CI ± 3.2%, n = 14) across all successful trials with five or more recaptures. Model results from the discharge and revolutions per hour analysis indicate that one to two models had a modest fit for the site. The full model incorporating log-transformed flow, trap revolutions per hour, and the interaction between the covariates had the highest pseudo R^2 ($R^2 = 0.40$), explaining twice the amount of variation relative to the discharge or revolutions per hour models. However, this model also had the highest AICc score, suggesting that the increased complexity of the model only provided modest improvements in fit relative to the simpler models included in the comparison. Full results and methods for the flow modeling are located in Appendix E.

Table 4. Summary table of marked hatchery Chinook salmon releases at the Breitenbush River RST site for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Breitenbush River	6/21/2023	231	749	53	7.1%
Breitenbush River	7/6/2023	173	763	25	3.3%
Breitenbush River	8/2/2023	133	791	12	1.5%
Breitenbush River	9/20/2023	114	756	7	0.9%
Breitenbush River	10/5/2023	131	789	18	2.3%
Breitenbush River	10/25/2023	289	750	51	6.8%
Breitenbush River	11/10/2023	578	750	152	20.3%
Breitenbush River	11/21/2023	405	900	55	6.1%
Breitenbush River	2/7/2024	730	750	15	2.0%
Breitenbush River	2/21/2024	715	750	134	17.9%
Breitenbush River	3/6/2024	540	748	78	10.4%
Breitenbush River	3/25/2024	822	243	11	4.5%
Breitenbush River	5/15/2024	819	692	9	1.3%
Breitenbush River	6/25/2024	297	752	45	6.0%

Run of River Trapping Efficiency Trials

Releases for ROR TE trials were pooled by month. A total of 2,252 Chinook salmon and zero *O. mykiss* were released for ROR TE trials for three months in the Spring of 2024 (Table 5). Since September 2023, 2,395 Chinook have been released during five ROR TE trials. TEs for ROR trials ranged from 0.0% to 9.2%, however sample sizes were highly variable ranging from 2 to 1,139 (Table 5). To account for sample size variability, monthly calculations were weighted based on sample size and then summed yielding an estimated TE for ROR trials of 4.5%. We found TE using ROR Chinook at Breitenbush River was 2% lower than TE using hatchery reared Chinook, however more ROR TE trials are necessary to increase the overall sample size.

Table 5. Summary table of run of river releases at the Breitenbush River site for trapping efficiency.

Release Location	Date of Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Breitenbush River	September 2023	141	13	9.2%
Breitenbush River	October 2023	2	0	0.0%
Breitenbush River	February 2024	450	9	2.0%
Breitenbush River	March 2024	1139	66	5.8%
Breitenbush River	April 2024	663	19	2.9%

Target Catch, Passage Estimates and Passage Timing

A total of 3,108 juvenile Chinook salmon and 57 juvenile *O. mykiss* were captured through the Spring of 2024 (Figure 1). Juvenile Chinook salmon catch consisted of two brood years, BY 2022 yearlings (n= 29, 0.9% of total Chinook catch) and BY 2023 sub-yearlings (n= 3,079, 99.1% of total Chinook catch) (Figure 2). The first BY 2023 Chinook salmon was captured on February 2, 2024, on the second day of sampling. Capture of juvenile Chinook continued throughout the sampling period. Peak capture of Chinook occurred in March (n= 1530, 49.2% of total Chinook catch). Similarly, peak passage during previous sampling efforts occurred in March and April (Romer et al. 2016, Figure 1). Using pooled averages of hatchery Chinook TEs, we estimate that 46,287 (95% CI: 31,104 to 90,423) juvenile Chinook salmon passed the trapping site during sampling in the Spring of 2024 (Figure 1).

Peak capture of juvenile *O. mykiss* during the monitoring period occurred in June (n=25, 43.9% of the total *O. mykiss* catch) (Figure 3). The *O. mykiss* captured at this site consists of juveniles from three BYs: BY 2022, BY 2023, and BY 2024 (Figure 4). BY 2023 *O. mykiss* comprised the majority of the catch, with fish being captured throughout the monitoring period (n= 48, 84.2% of total catch). A single BY 2022 fish was captured on February 19, 2024, and the first BY 2024 fish was captured on June 8, 2024. The observed range of sizes within BYs suggests that there may be populations of *O. mykiss* that spawn in the Breitenbush River at different times throughout the year. A summary of fork lengths and weights for captured Chinook salmon and *O. mykiss* at this site is provided in Table 6.

Table 6. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* at the Breitenbush River RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	2/1/24–6/30/24	23	3079	36.4	29	69	36	N/A	N/A	N/A	N/A
Chinook	2/1/24–6/30/24	22	29	96.7	81	147	95	13.9	5.6	105	9.5
O. mykiss	2/1/24–6/30/24	24	8	28.9	26	31	29	N/A	N/A	N/A	N/A
O. mykiss	2/1/24–6/30/24	23	48	101.3	33	193	90	16.6	<1	67.4	8.7
O. mykiss	2/1/24–6/30/24	22	1	270	270	270	N/A	183.0	183.0	183.0	N/A

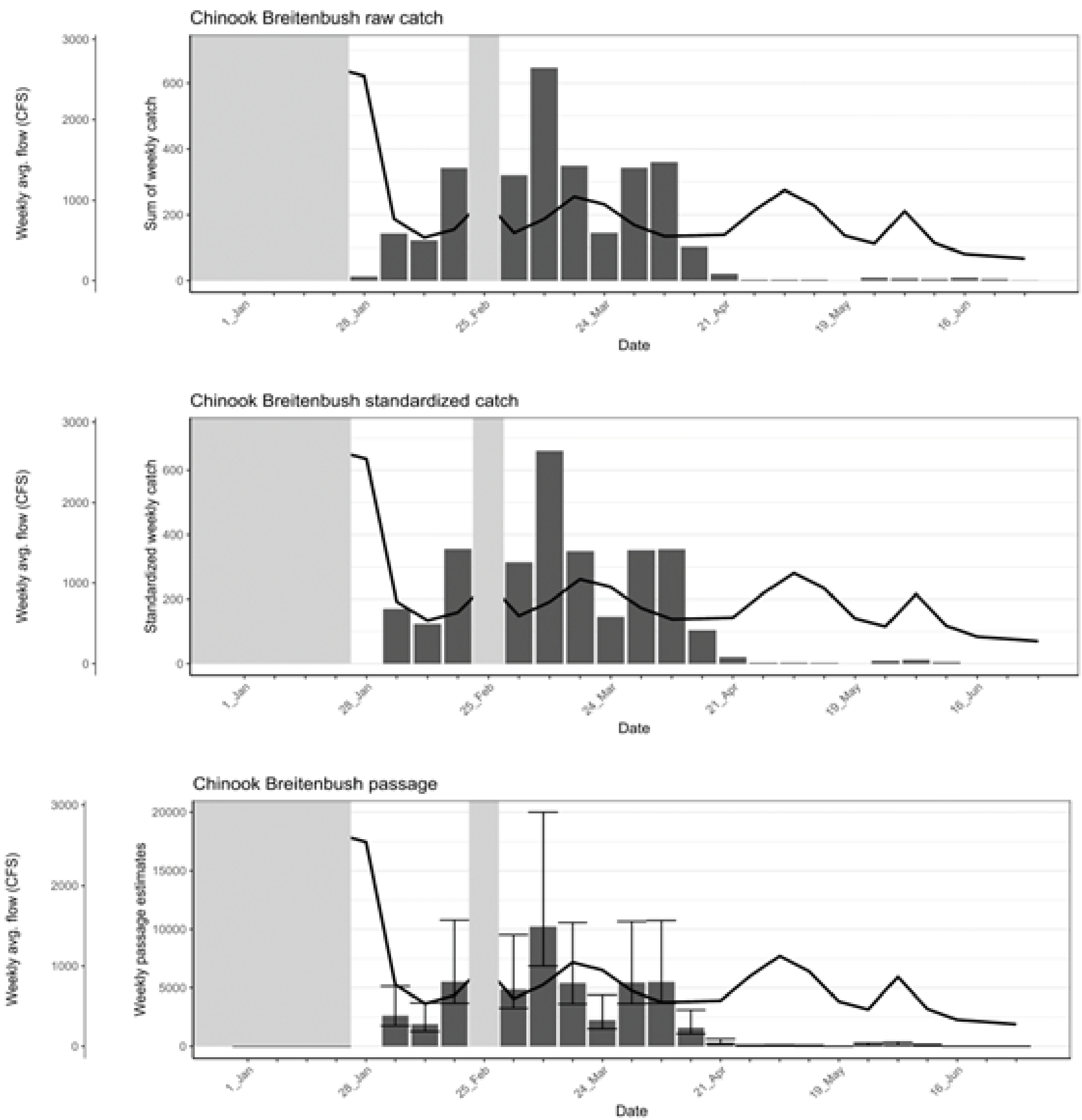

Figure 1. Raw catch (top panel), standardized catch (middle panel), and weekly passage estimates (bottom panel) of NOR juvenile Chinook at the Breitenbush River RST site overlayed with flow (black line) and non-sampling weeks shaded out (gray).

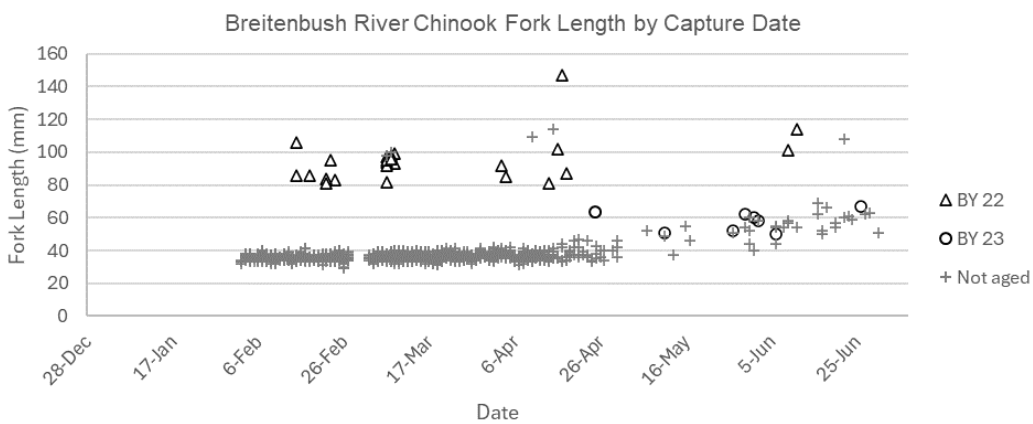

Figure 2. Length-frequency analysis for juvenile Chinook salmon at the Breitenbush River RST site.

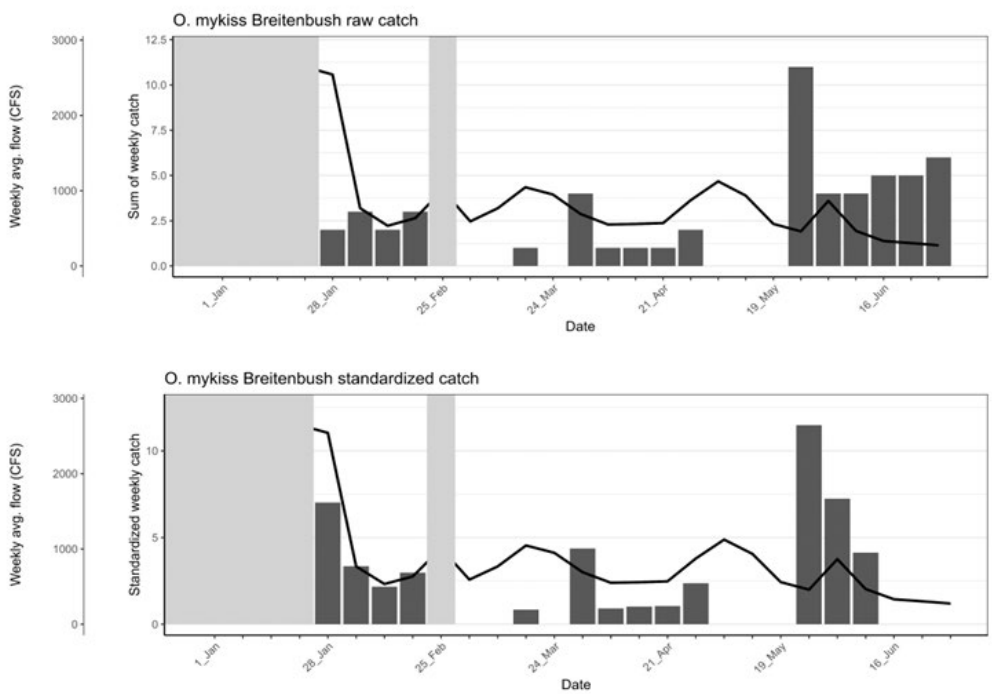

Figure 3. Raw catch (top panel) and weekly standardized catch (bottom panel) of juvenile *O. mykiss* overlayed with flow (black line) and non-sampling weeks shaded out (gray) at the Breitenbush River RST site.

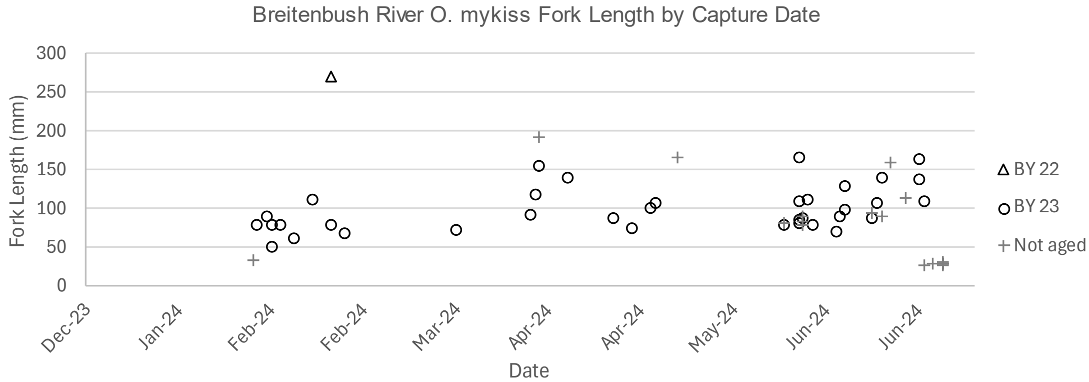

Figure 4. Length-frequency analysis by brood year for juvenile *O. mykiss* at the Breitenbush River RST site.

Injury Data

A total of 186 juvenile Chinook salmon (5.9% of total Chinook salmon catch) and 39 juvenile *O. mykiss* (68.4% of total *O. mykiss* catch) displayed at least one of the injury code conditions listed in Table 3. The most predominant injuries encountered on Chinook salmon observed at this site include fin damage and descaling greater than 20% (Table 7). Descaling and fin damage injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces of the trap. Most of the Chinook salmon encountered at the Breitenbush River RST were evidenced to have no external injuries (94.0%) (Table 7). Eleven Chinook salmon were bulk mark release recaptures at the Breitenbush River site. Of these fish, descaling greater than 20% and fin damage were the predominant injuries observed (Table 7). Furthermore, TE hatchery Chinook were observed with higher percentages of descaling greater than 20%, fin damage, and fungus when compared to NOR Chinook (Table 7). These injuries are associated with being reared in the hatchery and can be observed at all sites that EAS monitors.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

For the *O. mykiss* that had injuries present, the most predominant injuries include descaling greater than 20% and fin damage (Table 7). Like the Chinook salmon encountered, these *O. mykiss* injuries were likely incurred upon capture due to the trap itself. Copepod presence on both Chinook salmon and *O. mykiss* was only observed on fish with fork lengths greater than 60 mm (Figure 5 and Figure 6). However, infection rate did not increase with the size of fish, as has been seen in many below dam sites. Table 7 provides a summary of injuries observed on both Chinook salmon and *O. mykiss* at the Breitenbush River site. Additional information regarding injuries by size and average injuries per fish is available in Appendix F.

Table 7. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon, in addition to *O. mykiss* at the Breitenbush River RST site.

Injury Code	Chinook Injuries (NOR) (N=3108)	Bulk Marked Released Chinook (n=11)	Trapping Efficiency Hatchery Chinook (n=287)	*O. mykiss* Injuries (NOR) (n=57)
NXI (no external injury)	94.0%	0.0%	4.9%	31.6%
MUNK	0.1%	0.0%	0.0%	0.0%
DS<2	0.8%	9.1%	1.0%	5.3%
DS>2	1.8%	90.9%	85.4%	47.4%
BLO	0.1%	0.0%	0.0%	1.8%
EYB	0.4%	0.0%	0.0%	0.0%
BVT	0.1%	0.0%	0.0%	0.0%
FVB	0.6%	0.0%	0.3%	1.8%
GBD	0.0%	0.0%	0.0%	0.0%
POP	1.1%	0.0%	0.3%	1.8%
HIN	1.2%	0.0%	0.3%	0.0%
OPD	1.4%	0.0%	3.1%	0.0%
TEA	1.2%	0.0%	0.3%	1.8%
BRU	1.0%	0.0%	0.3%	5.3%
HBP	0.0%	9.1%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%
BO	0.1%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%
FID	2.2%	81.8%	87.5%	43.9%
PRD	0.1%	0.0%	0.0%	1.8%
COP	0.2%	9.1%	0.0%	3.5%
BKD	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	21.3%	0.0%

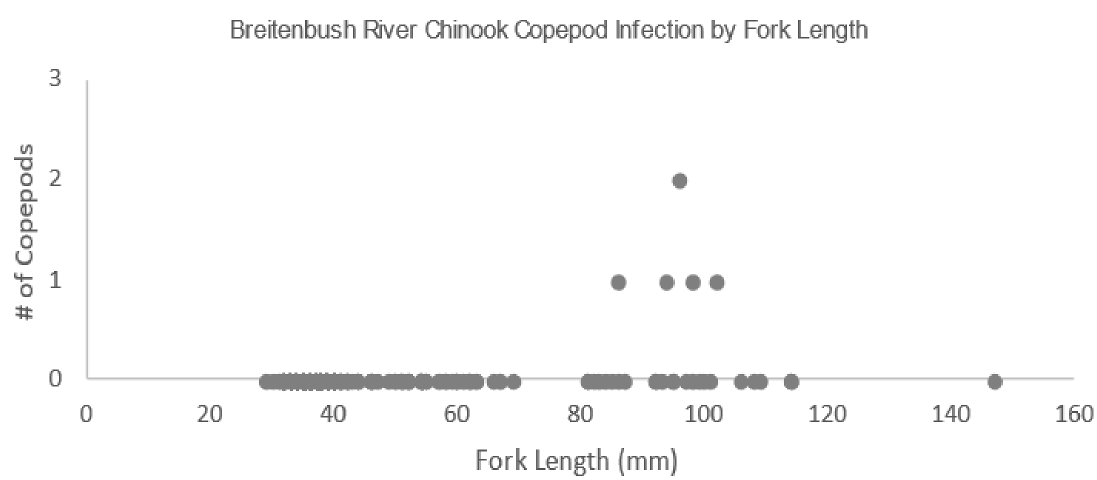

Figure 5. Copepod prevalence vs fork length on juvenile Chinook salmon captured at the Breitenbush River RST site.

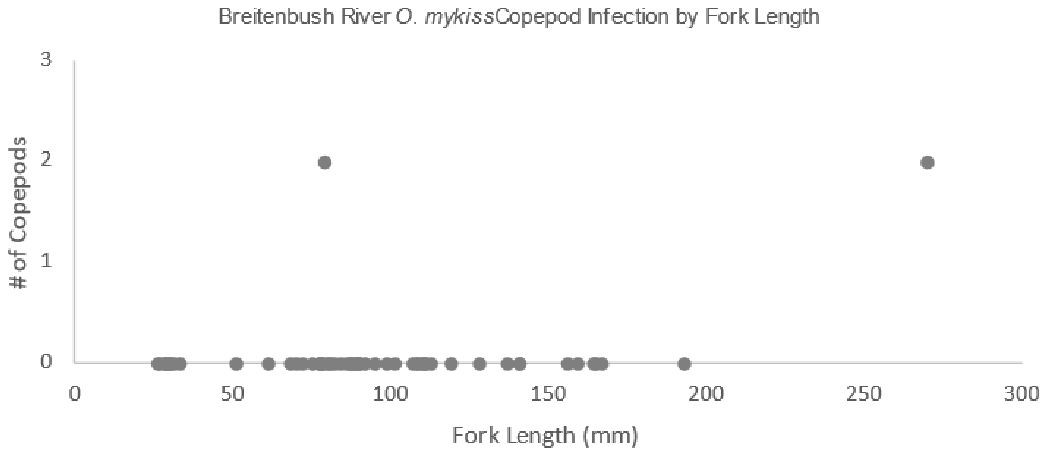

Figure 6. Copepod prevalence vs fork length on juvenile *O. mykiss* captured at the Breitenbush River RST site.

PIT Tagged and VIE Marked Fish

A total of 32 juvenile Chinook salmon and 43 juvenile *O. mykiss* were PIT tagged and released at the Breitenbush River site during the Spring of 2024. Additionally, a total of 2,360 Chinook salmon and 3 *O. mykiss* were VIE marked at the Breitenbush site in this reporting period. Some fish were not tagged, as they were still sac-fry or too small to safely mark. None of the VIE marked fish have been detected at downstream sites. 5 PIT tagged Chinook and 1 PIT tagged *O. mykiss* were recaptured at Big Cliff Dam Tailrace during this reporting period. The average travel time was 175.2 days (range 28 to 233 days). A summary of downstream PIT tag detections is provided in Table 8 and a summary of VIE marked fish is provided in Table 9. More information regarding PIT tags at the RST and other sites can be found in Appendix C.

Table 8. Summary of PIT tagged fish downstream redetections for the Breitenbush River RST site.

Species	PIT Tag #	Mark Date	Redetection Date	Recap Site	Travel Time (days)
Chinook	3DD.003BEE0FF3	6/21/2023	1/1/2024	Big Cliff Dam	194
Chinook	3DD.003BD397FF	10/6/2023	4/17/2024	Big Cliff Dam	194
Chinook	3DD.003BD397FC	10/6/2023	4/23/2024	Big Cliff Dam	200
O. mykiss	3DD.003E5283EC	4/4/2024	5/2/2024	Big Cliff Dam	28
Chinook	3DD.003BEE1AB2	9/13/2023	5/3/2024	Big Cliff Dam	233
Chinook	3DD.003BEE1373	10/18/2023	5/7/2024	Big Cliff Dam	202

Table 9. Summary table of VIE marked Chinook salmon at the Breitenbush River RST site

Date Tagged	Species	Tag Location	VIE Color	# Tagged	# Recaptured
02/01/2024–02/15/2024	Chinook	Head	Yellow	126	0
02/01/2024–02/15/2024	*O. mykiss*	Head	Yellow	2	0
02/16/2024–02/29/2024	Chinook	Head	Yellow	322	0
02/16/2024–02/29/2024	*O. mykiss*	Head	Yellow	0	0
03/01/2024–03/15/2024	Chinook	Head	Red	670	0
03/01/2024–03/15/2024	*O. mykiss*	Head	Red	0	0
03/16/2024–03/31/2024	Chinook	Head	Red	541	0
03/16/2024–03/31/2024	*O. mykiss*	Head	Red	0	0
04/01/2024–04/15/2024	Chinook	Head	Blue	633	0
04/01/2024–04/15/2024	*O. mykiss*	Head	Blue	0	0
04/16/2024–04/30/2024	Chinook	Head	Blue	35	0
04/16/2024–04/30/2024	*O. mykiss*	Head	Blue	0	0
05/01/2024–05/15/2024	Chinook	Head	Orange	3	0
05/01/2024–05/15/2024	*O. mykiss*	Head	Orange	0	0
05/16/2024-05/31/2024	Chinook	Head	Orange	9	0
05/16/2024-05/31/2024	*O. mykiss*	Head	Orange	0	0
06/01/2024-06/15/2024	Chinook	Head	Pink	12	0
06/01/2024-06/15/2024	*O. mykiss*	Head	Pink	1	0
06/16/2024-06/30/2024	Chinook	Head	Pink	9	0
06/16/2024-06/30/2024	*O. mykiss*	Head	Pink	0	0

Willamette Valley Projects Encounters

There were 6 adipose clipped and PIT tagged Chinook encountered at this site through the Spring of 2024. These fish were all released by Cramer Fish Sciences Bulk Mark Release project and used for trapping efficiency trials. For more information regarding bulk mark releases and detections of associated fish, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

A total of 20 non-target fish were captured in addition to NOR juvenile Chinook salmon and *O. mykiss* at the Breitenbush River site through the Spring of 2024. A summary of non-target species is provided in Table 10. The most frequently caught non-target species were sculpin.

Table 10. Summary of non-target fish capture at the Breitenbush River RST site.

Species	Season Total	Season Total Mortality (subset of total)
O. mykiss (clipped)	1	0
Cutthroat Trout	2	0
Sculpin	16	5
Unknown Salmonid	1	1
Totals	**20**	**6**

Detroit Head of Reservoir – North Santiam River

A single 5-foot RST was deployed in the North Santiam River above Detroit Reservoir on February 1, 2024, and continued sampling until June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Trapping Efficiency Trials

A total of six TE trials occurred from February 7, 2024, through June 18, 2024, at the Detroit Head of Reservoir – North Santiam site using hatchery reared spring Chinook salmon. Collectively, 15 TE trials have occurred at this site since June 6, 2023. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 11.

TEs ranged from 1.1% to 15.6% with a pooled average of 6.3% (95% CI ±2.2%, n=15) of all successful trials with five or more recaptures. Model results from the average weekly discharge and revolutions per hour analysis indicate that the model incorporating discharge, trap revolutions per hour, and the interaction between the two covariates (discharge multiplied by revolutions per hour) had the highest pseudo R^2 value ($R^2 = 0.212$) of all models (Table 11). This model also had a low AICc score relative to other models for the site, suggesting that the increased complexity of the model improved model fit (Table D-1). Full results and methods for the discharge and revolution per hour modeling are in Appendix E.

Table 11. Summary table of marked hatchery Chinook salmon releases at the Detroit Head of Reservoir – North Santiam River RST site for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Detroit Head of Reservoir – North Santiam River	6/6/2023	833	539	28	5.2%
Detroit Head of Reservoir – North Santiam River	6/20/2023	629	750	61	8.1%
Detroit Head of Reservoir – North Santiam River	7/6/2023	512	750	13	1.7%
Detroit Head of Reservoir – North Santiam River	8/2/2023	422	750	19	2.5%
Detroit Head of Reservoir – North Santiam River	9/6/2023	379	700	19	2.7%
Detroit Head of Reservoir – North Santiam River	10/5/2023	370	750	24	3.2%
Detroit Head of Reservoir – North Santiam River	10/25/2023	539	757	72	9.5%
Detroit Head of Reservoir – North Santiam River	11/10/2023	820	813	91	11.2%
Detroit Head of Reservoir – North Santiam River	11/21/2023	601	1,014	111	10.9%
Detroit Head of Reservoir – North Santiam River	2/7/2024	1,270	749	8	1.1%
Detroit Head of Reservoir – North Santiam River	2/21/2024	1,020	749	117	15.6%
Detroit Head of Reservoir – North Santiam River	3/6/2024	923	751	85	11.3%
Detroit Head of Reservoir – North Santiam River	5/15/2024	1,400	749	39	5.2%
Detroit Head of Reservoir – North Santiam River+	6/6/2024	1,200	450	13	2.9%
Detroit Head of Reservoir – North Santiam River	6/18/2024	786	836	32	3.8%

+Trapping efficiency release performed by Cramer Fish Sciences

Run of River Trapping Efficiency Trials

Releases for ROR TE trials were pooled by month. A total of 14,783 juvenile Chinook salmon were released between February 16 and May 22, 2024 (Table 12). Since October 2023, 15,142 Chinook have been released during six ROR TE trials at the Detroit HOR site. TEs for ROR trials ranged from 1.5% to 5.9% with sample sizes ranging from 157 to 9,059 (Table 12). To account for sample size variability, monthly calculations were weighted based on sample size and then summed yielding an estimated TE for ROR trials of 2.9%. Compared to the TE value using hatchery reared fish, TE using ROR fish was approximately 3.5% lower.

Table 12. Summary table of run of river releases at the Detroit Head of Reservoir RST site for trapping efficiency

Release Location	Date of Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Detroit Head of Reservoir	October 2023	157	6	3.8%
Detroit Head of Reservoir	November 2023	202	12	5.9%
Detroit Head of Reservoir	February 2024	392	6	1.5%
Detroit Head of Reservoir	March 2024	4,652	114	2.5%
Detroit Head of Reservoir	April 2024	9,059	293	3.2%
Detroit Head of Reservoir	May 2024	680	15	2.2%

Target Catch, Passage Estimates and Passage Timing

The trap captured 26,858 juvenile Chinook salmon and 63 juvenile *O. mykiss* through the Spring of 2024 (Figure 7 and Figure 9) between February 1, 2024, and June 30, 2024. Peak capture of juvenile Chinook salmon entering Detroit Reservoir in the spring occurred during April (n=13,805, 51.4% of total Chinook salmon catch). Chinook salmon catch from the initiation of sampling through June 30, 2023, was composed almost entirely of BY 2023 juveniles (n=26,808, 99.7% of total catch) (Figure 8). BY 2022 Chinook salmon were captured throughout the sampling period. The first BY 2023 sub-yearling captured at the trap occurred on the first day of sampling and the median migration date was April 12, 2024. Previous monitoring efforts observed median migration dates in May with the earliest median date of migration being April 20th (Romer et al. 2016). Using a pooled average of the hatchery fish TEs, we estimate that 426,159 (95% CI: 314,594 to 660,332) juvenile Chinook salmon passed the trapping site in 2023 (Figure 7).

Chinook catch in the Spring of 2024 was much higher than catch observed during previous efforts (Romer et al. 2016) and likely is a result of the increased number of adult outplants that occurred in 2023. Similar observations were made during previous sampling, where increased catch of juvenile Chinook at this site appeared to be related to the number of adult females transported upstream of the reservoir (Romer 2016 et al. Table B-1). Adult Chinook out planting numbers for 2010 through 2023 are provided in Appendix I, Table I-1.

Peak capture of juvenile *O. mykiss* in the spring monitoring period occurred in June (n=24, 37.5% of total *O. mykiss* catch) (Figure 9). *O. mykiss* catch consisted of four BYs: BY 2021, 2022, 2023, and 2024 (Figure 10). BY 2023 was the dominant age class captured at the site, with 40 individuals (62.5% of spring capture). A total of 1 BY 2021, 12 BY 2022, and 10 BY 2024 *O. mykiss* were also captured during this time. A summary of fork length and weight data for Chinook salmon and *O. mykiss* captured at this site through the Spring of 2024 is provided in Table 13.

Table 13. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* of NOR at the Detroit Head of Reservoir RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	2/1/24–6/30/24	22	49	86.6	69	107	86	7.1	3.4	11.9	7.1
Chinook	2/1/24–6/30/24	23	26808	36.6	28	72	36	N/A	N/A	N/A	N/A
O. mykiss	2/1/24–6/30/24	21	1	315	315	315	N/A	309.1	309.1	309.1	N/A
O. mykiss	2/1/24–6/30/24	22	12	170.3	142	197	170	52.2	29.4	79.6	53.5
O. mykiss	2/1/24–6/30/24	23	40	72.8	34	115	74	5.9	<1	16.1	5.5
O. mykiss	2/1/24–6/30/24	24	10	30.1	22	39	28.5	N/A	N/A	N/A	N/A

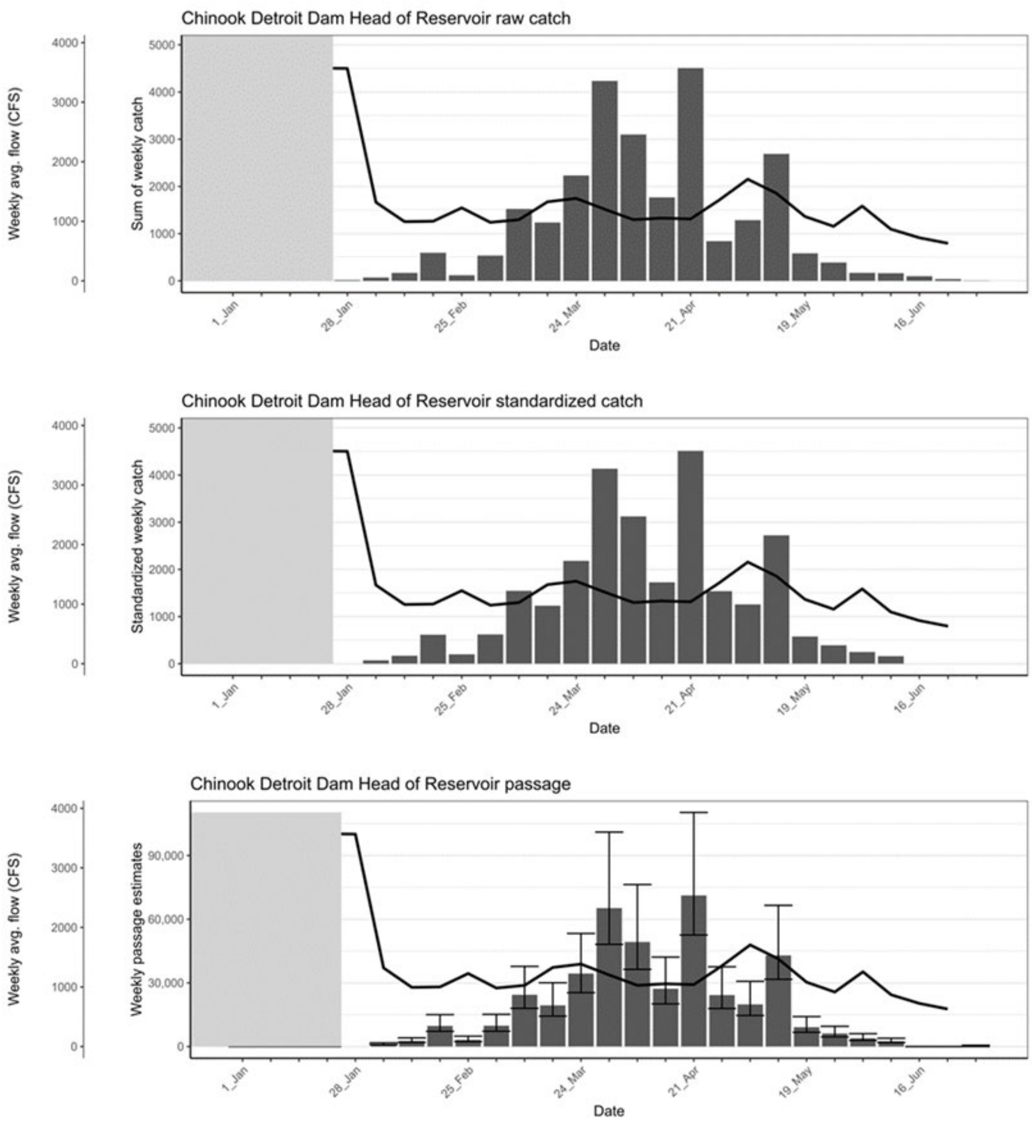

Figure 7. Raw catch (top panel), standardized catch (middle panel), and weekly passage estimates (bottom panel) of NOR juvenile Chinook at the Detroit Head of Reservoir- North Santiam River RST site with stream flow (black line) and non-sampling weeks shaded out (gray).

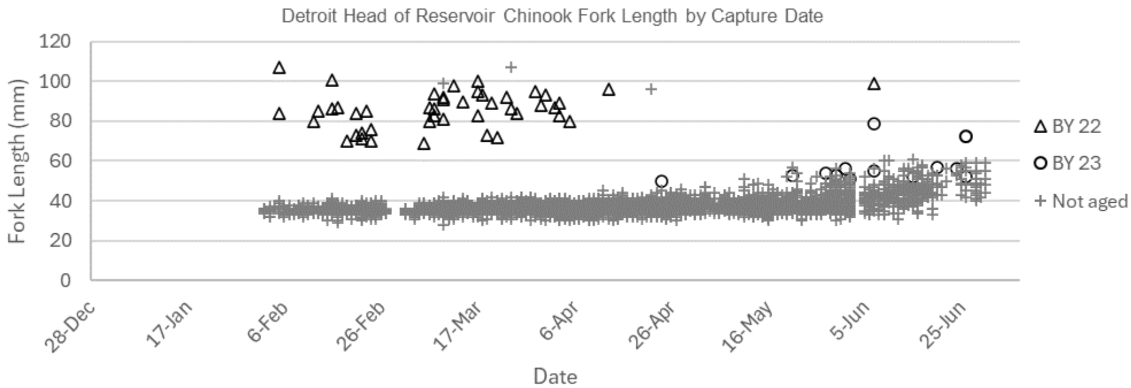

Figure 8. Length-frequency of juvenile Chinook salmon by brood year at the Detroit Head of Reservoir – North Santiam site.

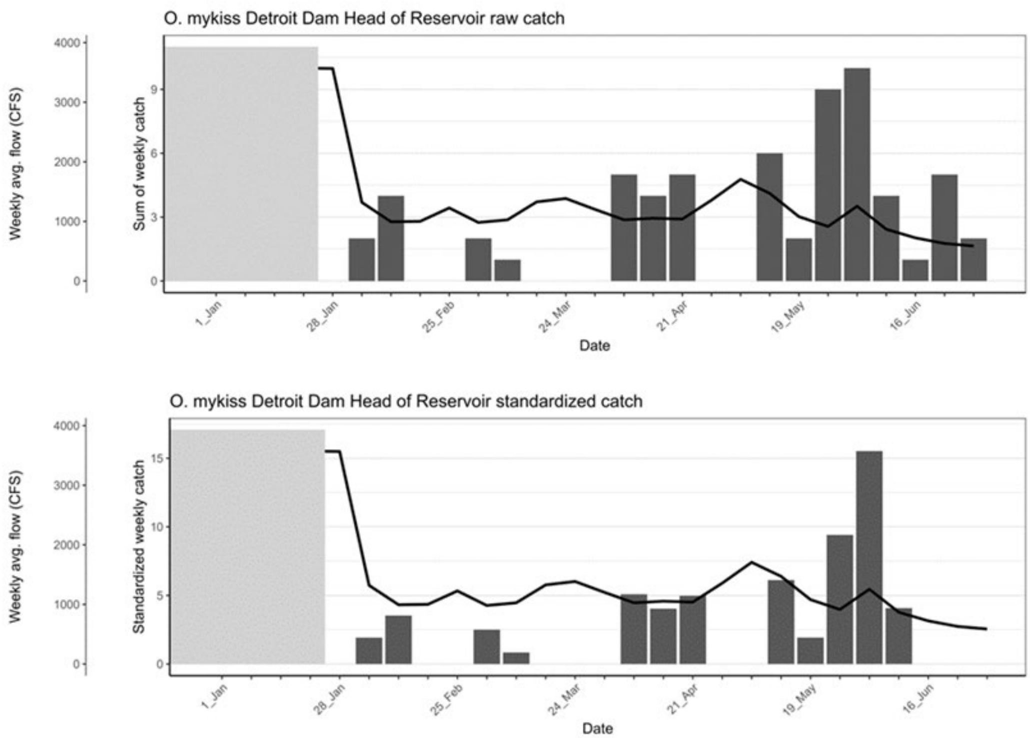

Figure 9. Shows raw catch (top panel) and weekly standardized catch (bottom panel) of juvenile *O. mykiss* overlayed with flow (black line) and non-sampling weeks shaded out (gray) at the Detroit Head of Reservoir – North Santiam site.

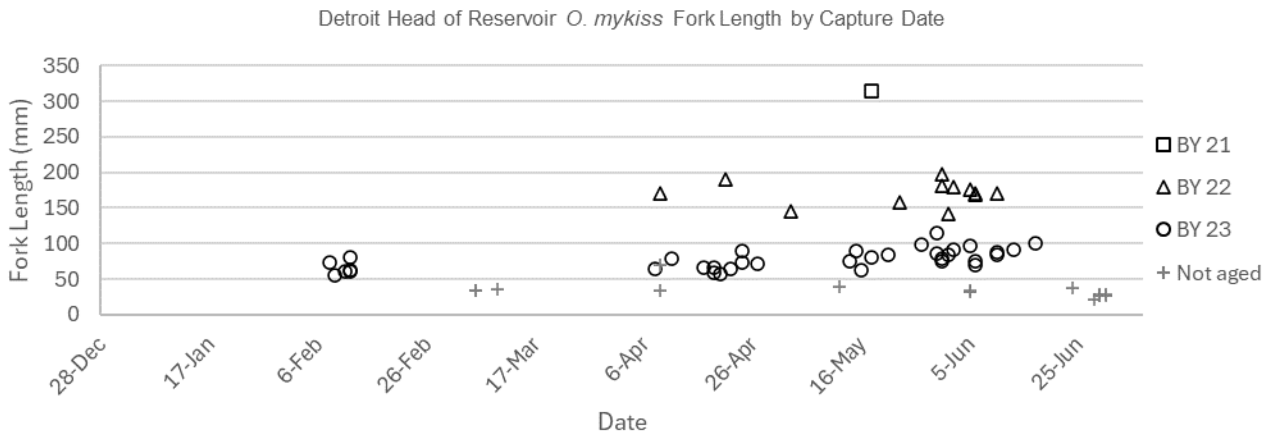

Figure 10. Length-frequency of juvenile *O. mykiss* by brood year at the Detroit Head of Reservoir – North Santiam River site.

Injury Data

A total of 1,000 juvenile Chinook salmon (3.7% of total Chinook salmon catch) and 36 *O. mykiss* (57.1% of total *O. mykiss* catch) displayed at least one of the injury code conditions listed in Table 3. The most frequently observed injury in Chinook salmon at this site was fin damage. The most frequently observed injuries in *O. mykiss* at this site were descaling greater than 20% and fin damage (Table 14). Observed injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. A significant portion of the Chinook salmon target catch (96.3%) at this site were evidenced to have no external injuries (Table 14). Comparatively, the bulk marked released Chinook salmon illustrated similar trends to the NOR Chinook salmon, being predominantly unharmed, with the most frequent injuries recorded being descaling greater than 20% and fin damage (Table 14). TE hatchery reared Chinook salmon were found to have higher occurrences of descaling greater than 20%, head injuries, operculum damage, fin damage, and fungus when compared to both bulk marked released and NOR Chinook (Table 14).

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

There were 419 Chinook salmon mortalities (1.6% of Chinook salmon catch) likely resulting from high debris in the trap, increased flows, and their smaller body size this time of year. Copepods were only observed on Chinook salmon with fork lengths greater than 90 mm, and *O. mykiss* with fork lengths greater than 50 mm. Copepod presence results did not show a strong association with an increased size of fish, as has more recently been observed below dams (Figure 11 and Figure 12). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 14. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon, in addition to *O. mykiss* at the at the Detroit Head of Reservoir – North Santiam River RST site.

Injury Code	Chinook Injuries (NOR) (n=26,858)	Bulk Marked Released Chinook (n=15)	Trapping Efficiency Hatchery Chinook (n=270)	*O. mykiss* Injuries (NOR) (n=63)
NXI (no external injury)	96.3%	86.7%	21.5%	42.9%
MUNK	0.0%	0.0%	0.0%	0.0%
DS<2	0.8%	0.0%	0.4%	6.3%
DS>2	0.7%	6.7%	76.7%	30.2%
BLO	0.0%	0.0%	0.0%	0.0%
EYB	0.4%	0.0%	0.0%	3.2%
BVT	0.1%	0.0%	0.0%	0.0%
FVB	0.4%	0.0%	0.0%	1.6%
GBD	0.0%	0.0%	0.0%	0.0%
POP	0.8%	0.0%	0.0%	1.6%
HIN	1.0%	0.0%	1.9%	7.9%
OPD	0.8%	0.0%	2.2%	7.9%
TEA	0.9%	0.0%	0.0%	0.0%
BRU	0.9%	0.0%	0.0%	0.0%
HBP	0.0%	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%
BO	0.2%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%
FID	1.3%	6.7%	77.4%	38.1%
PRD	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.5%	4.8%
BKD	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	8.5%	0.0%

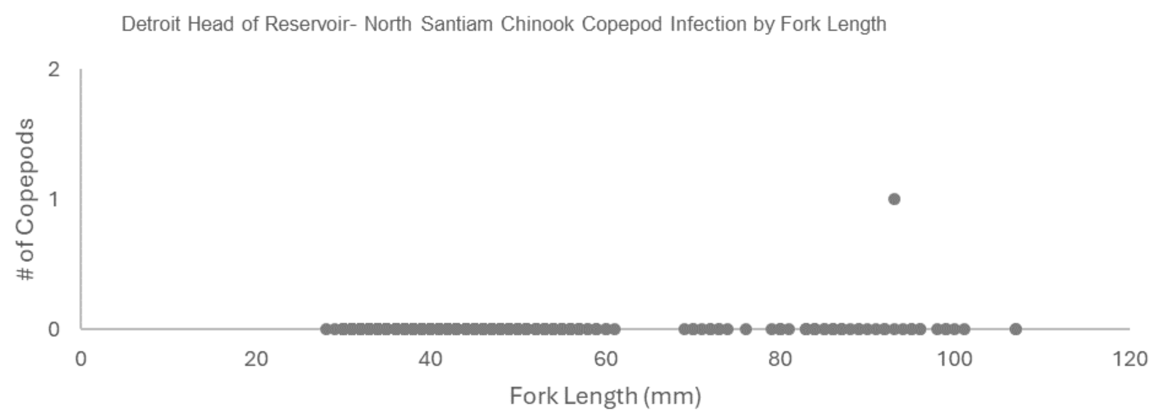

Figure 11. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Detroit Head of Reservoir RST site.

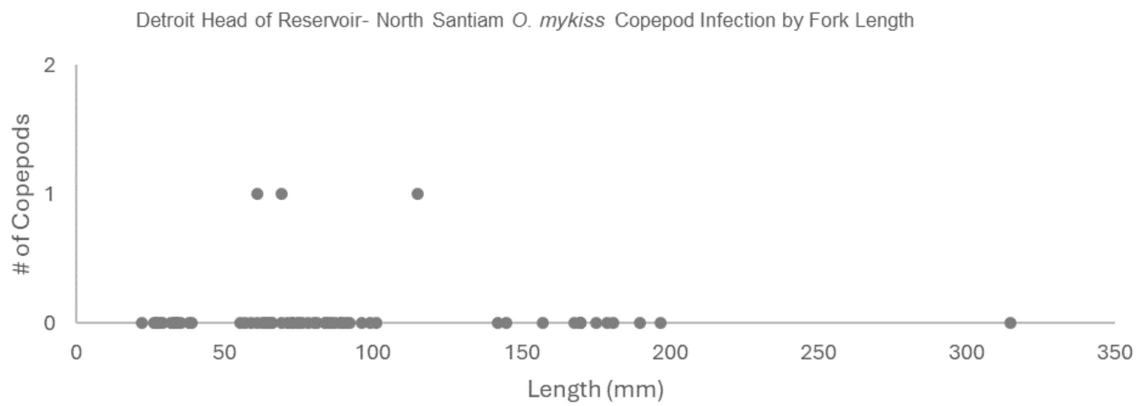

Figure 12. Copepod prevalence vs fork length on juvenile *O. mykiss* captured at Detroit Head of Reservoir RST site.

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 49 Chinook salmon and 40 *O. mykiss* were PIT tagged at this site in the Spring of 2024. A total of 20,289 Chinook salmon and 11 *O. mykiss* were VIE marked during this reporting period. Additionally, another 1,691 Chinook salmon fry were Bismarck brown dyed and used for ROR trapping efficiency trials. Some fish were not marked, as they were still sac-fry or too small to safely mark. No VIE marked fish have been detected at downstream sites. 1 PIT tagged Chinook was recaptured downstream at Big Cliff Dam Tailrace in the Spring of 2024. The travel time was 183 days. 2 PIT tagged Chinook were observed downstream at the Columbia River Estuary through the Spring of 2024. The average travel time was 229 days. A summary of downstream PIT tag detections is provided in Table 15, and Table 16 provides a summary of VIE marked fish for the reporting period. More information regarding PIT tags at the RST and other sites can be found in Appendix C.

Table 15. Summary of PIT tagged juvenile Chinook downstream redetections for the Detroit Dam Head of Reservoir site.

PIT Tag #	Mark Date	Redetection Date	Recap Site	Travel Time (Days)
3DD.003BEE1AA8	9/6/2023	5/2/2024	PD5 - Columbia River Estuary rkm 62	239
3DD.003BEE11EF	11/5/2023	5/6/2024	Big Cliff Dam	183
3DD.003BD22603	11/2/2023	6/8/2024	PD8 - Columbia River Estuary rkm 82	219

Table 16. Summary table of VIE marked fish at the Detroit Head of Reservoir – North Santiam RST site.

Date Tagged	Species	Tag Location	VIE Color	# Tagged	# Recaptured
02/01/2024–02/15/2024	Chinook	Right Dorsal	Yellow	78	0
02/01/2024–02/15/2024	*O. mykiss*	Right Dorsal	Yellow	4	0
02/16/2024–02/29/2024	Chinook	Right Dorsal	Yellow	415	0
02/16/2024–02/29/2024	*O. mykiss*	Right Dorsal	Yellow	0	0
03/01/2024–03/15/2024	Chinook	Right Dorsal	Red	1439	0
03/01/2024–03/15/2024	*O. mykiss*	Right Dorsal	Red	1	0
03/16/2024–03/31/2024	Chinook	Right Dorsal	Red	3334	0
03/16/2024–03/31/2024	*O. mykiss*	Right Dorsal	Red	0	0
04/01/2024–04/15/2024	Chinook	Right Dorsal	Blue	5379	0
04/01/2024–04/15/2024	*O. mykiss*	Right Dorsal	Blue	1	0
04/16/2024–04/30/2024	Chinook	Right Dorsal	Blue	4527	0
04/16/2024–04/30/2024	*O. mykiss*	Right Dorsal	Blue	3	0
05/01/2024–05/15/2024	Chinook	Right Dorsal	Orange	3112	0
05/01/2024–05/15/2024	*O. mykiss*	Right Dorsal	Orange	0	0
05/16/2024-05/31/2024	Chinook	Right Dorsal	Orange	1533	0
05/16/2024-05/31/2024	*O. mykiss*	Right Dorsal	Orange	1	0
06/01/2024-06/15/2024	Chinook	Right Dorsal	Pink	333	0
06/01/2024-06/15/2024	*O. mykiss*	Right Dorsal	Pink	0	0
06/16/2024-06/30/2024	Chinook	Right Dorsal	Pink	139	0
06/16/2024-06/30/2024	*O. mykiss*	Right Dorsal	Pink	1	0

Willamette Valley Projects Encounters

There were 13 adipose clipped and PIT tagged Chinook encountered at this site during monitoring in the Spring of 2024. These fish were all released by Cramer Fish Sciences Bulk Mark Release project and used for trapping efficiency trials. For more information regarding bulk mark releases and detections of associated fish, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

EAS captured 338 non-target fish in addition to NOR juvenile Chinook salmon. A summary of species and numbers of fish caught is provided in Table 17. The most commonly captured non-target species were adipose clipped *O. mykiss and* wild kokanee.

Table 17. Summary of non-target fish capture at the Detroit Head of Reservoir – North Santiam RST site

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	2	0
Cutthroat Trout	8	0
Dace	7	0
Kokanee (wild)	82	5
Mountain Whitefish	1	0
O. mykiss (clipped)	145	2
Sculpin	16	7
Largescale Sucker	1	0
Unknown Salmonid*	76	76
Totals	**338**	**90**

*Species denoted as “unknown” were too small and/or too decomposed to identify.

Big Cliff Dam Tailrace

A single 8-foot RST continued monitoring activities at Big Cliff Dam and sampled from January 1, 2024, through June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Additionally, the trap did not sample from January 17, 2024, to February 8, 2024, due to high flows from flood evacuations that created unsafe sampling conditions for both captured fish and crew.

Trapping Efficiency Trials

A total of six TE trials occurred from February 14, 2024, through June 18, 2024, in the Big Cliff Dam tailrace using hatchery reared juvenile Chinook salmon. Collectively, 34 TE trials have occurred at this site since December 22, 2021. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 18.

TEs ranged from 0.0% to 20.7% with a pooled average of 6.9% (95%CI ±1.6%, n=32) of all successful trials with five or more recaptures. Two of the trials did not recapture enough fish to be used in the passage estimate calculation. Model results from the discharge and revolutions per hour analysis indicate that none of the models tested showed a strong fit for the site (R^2 = 0.05 – 0.27, n = 34). The full model incorporating log-transformed flow, trap revolutions per hour, and the interaction between the covariates had the highest pseudo R^2 (R^2 = 0.27). This model had a moderate AICc score, indicating that the increased complexity did not significantly improve the fit compared to the other simpler models included in the comparison. Other factors (i.e., fish size) may be influencing TE at this site and will be explored in future modeling efforts. Full results and methods for the flow modeling are located in Appendix E.

Table 18. Summary table of marked hatchery Chinook salmon releases at Big Cliff Dam for trapping efficiency

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent 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%
Big Cliff Dam Tailrace	1/25/2023	1,320	500	56	11.2%
Big Cliff Dam Tailrace	2/17/2023	1,470	499	38	7.6%
Big Cliff Dam Tailrace	3/7/2023	1,260	2,968	61	2.1%
Big Cliff Dam Tailrace	3/10/2023	1,320	541	112	20.7%
Big Cliff Dam Tailrace	4/28/2023	2,440	498	34	6.8%
Big Cliff Dam Tailrace	5/23/2023	1,080	500	6	1.2%
Big Cliff Dam Tailrace	6/21/2023	1,270	500	8	1.6%
Big Cliff Dam Tailrace	7/5/2023	1,260	500	33	6.6%
Big Cliff Dam Tailrace	8/3/2023	1,080	474	42	8.9%
Big Cliff Dam Tailrace	9/19/2023	1,580	424	64	15.1%
Big Cliff Dam Tailrace	10/6/2023	1,590	500	56	11.2%
Big Cliff Dam Tailrace	10/25/2023	1,630	633	99	15.6%
Big Cliff Dam Tailrace	11/16/2023	4,200	527	0	0.0%
Big Cliff Dam Tailrace	11/21/2023	3,750	500	30	6.0%
Big Cliff Dam Tailrace	12/28/2023	1,520	550	56	10.2%
Big Cliff Dam Tailrace	2/14/2024	1,550	500	16	3.2%
Big Cliff Dam Tailrace	2/21/2024	1,060	464	52	11.2%
Big Cliff Dam Tailrace	3/6/2024	1,810	556	18	3.2%
Big Cliff Dam Tailrace	3/7/2024	1,820	1,959	1	0.05%
Big Cliff Dam Tailrace	3/12/2024	1,780	550	18	3.3%
Big Cliff Dam Tailrace	5/7/2024	3,310	493	1	0.2%
Big Cliff Dam Tailrace	6/18/2024	1,440	499	18	3.6%

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Big Cliff Dam tailrace through the Spring of 2024. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study and are not tagged. Thus, sufficient numbers of natural-origin fish to perform trials were not available during sampling in the Spring of 2024.

Target Catch, Passage Estimates and Passage Timing

The trap captured 937 juvenile Chinook salmon and 74 juvenile *O. mykiss* during the reporting period. It is assumed that *O. mykiss* captured at this site are primarily composed 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 capture of juvenile Chinook salmon exiting Big Cliff Dam in the spring occurred in April (n=555, 59.2% of total Chinook salmon) (Figure 13). Chinook salmon catch in the spring consisted of three BY classes: BY 2021, BY 2022, and BY 2023 (Figure 16). There were 42 BY 2023 (4.5% of total Chinook capture) Chinook salmon captured during the spring sampling period at this site. The first BY 2023 sub-yearling Chinook salmon was captured on February 18, 2024. The migration timing of sub-yearling Chinook salmon through Big Cliff Dam is similar to observations from previous years (Romer et al. 2016). Scale age analysis from this period shows a significant amount of overlap in size between fish from BY 2021 and BY 2022 (figure 16). This overlap in size of Chinook salmon is similar to what was observed during RST sampling in 2022 and 2023 (EAS 2023) and from scale samples collected from Chinook salmon in the forebay of Detroit Reservoir by Monzyk and Romer (2015). Due to this overlap, we cannot reliably assign a BY category to fish where scales were not aged and will report size metrics on the two BYs together. Using pooled averages of hatchery Chinook TEs, we estimate that 13,174 (95% CI: 10,669 to 17,216) juvenile Chinook salmon passed the trapping site during RST sampling in the Spring of 2024 (Figure 13).

O. mykiss capture in the RST below Big Cliff Dam in the spring consisted of four BYs, BY 2021, BY 2022, BY 2023, and BY 2024 (Figure 17). The first BY 2024 fish was captured on May 24, 2024. A majority of the O. *mykiss* captured in the spring occurred during May and June (n=59, 79.7% of total *O. mykiss* capture) (Figure 15). A single BY 2021 *O. mykiss* was captured on January 1, 2024. Information on fork lengths and weights of each BY captured for Chinook salmon and *O. mykiss* at Big Cliff Dam is provided in Table 19.

Peak capture of Chinook salmon and *O. mykiss* at Big Cliff Dam coincided with spill operations at Detroit Dam that began in April and continued into June (Figure 14). Downstream movement of active tagged fish in Big Cliff Reservoir suggests that fish typically take about a day (mean: 1.11 days, range: 0.14–45.59 days) to navigate from the Detroit Dam Tailrace to the forebay of Big Cliff Dam (Beeman et al. 2015, Table 1-12). Assuming these migration rates for fish to reach the forebay of Big Cliff Dam from the Detroit Dam Tailrace, it is reasonable to accept that the increase in catch at Big Cliff Dam Tailrace in the spring is associated with Detroit Dam surface spill operations. Results from studies by CFS in 2021 (Cramer 2023) also observed increased catch associated with spill operations. Figures displaying weekly raw catch for sampling at the Big Cliff Dam RST site for sampling from 2021 through 2023 and numbers of adult Chinook out plants above Detroit Reservoir for 2010 through 2023 are available in Appendix I.

Table 19. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* of NOR at the Big Cliff Dam RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/2024–6/30/2024	21 and 22	895	144.8	80	231	142	32.7	6.8	186.0	28.7
Chinook	1/1/2024–6/30/2024	23	42	98.4	35	121	107	14.5	7.2	20.1	14.8
O. mykiss	1/1/2024–6/30/2024	21	1	275	275	275	N/A	247.1	247.1	247.1	N/A
O. mykiss	1/1/2024–6/30/2024	22	39	199.4	154	260	195	73.1	30.0	181.0	64.6
O. mykiss	1/1/2024–6/30/2024	23	8	78.8	34	124	79	8.0	<1	18.3	6.1
O. mykiss	1/1/2024–6/30/2024	24	26	30.4	25	39	29	N/A	N/A	N/A	N/A

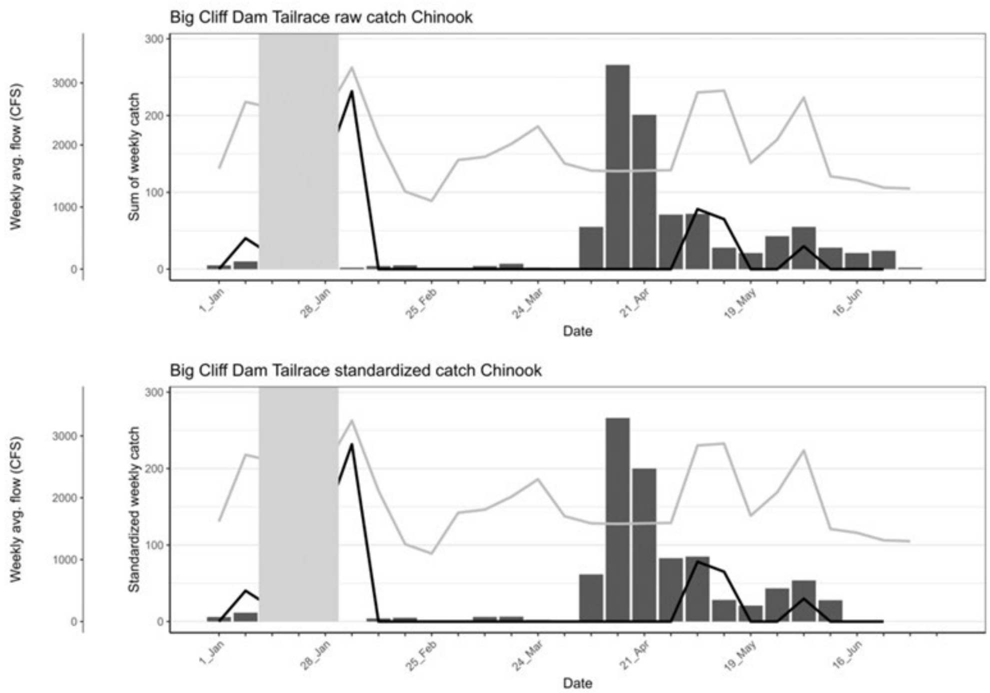

Figure 13. Raw catch (top panel) and weekly standardized catch (bottom panel) of NOR juvenile Chinook salmon at Big Cliff Dam with spill (black line), Powerhouse (gray line) and non-sampling weeks shaded out (gray).

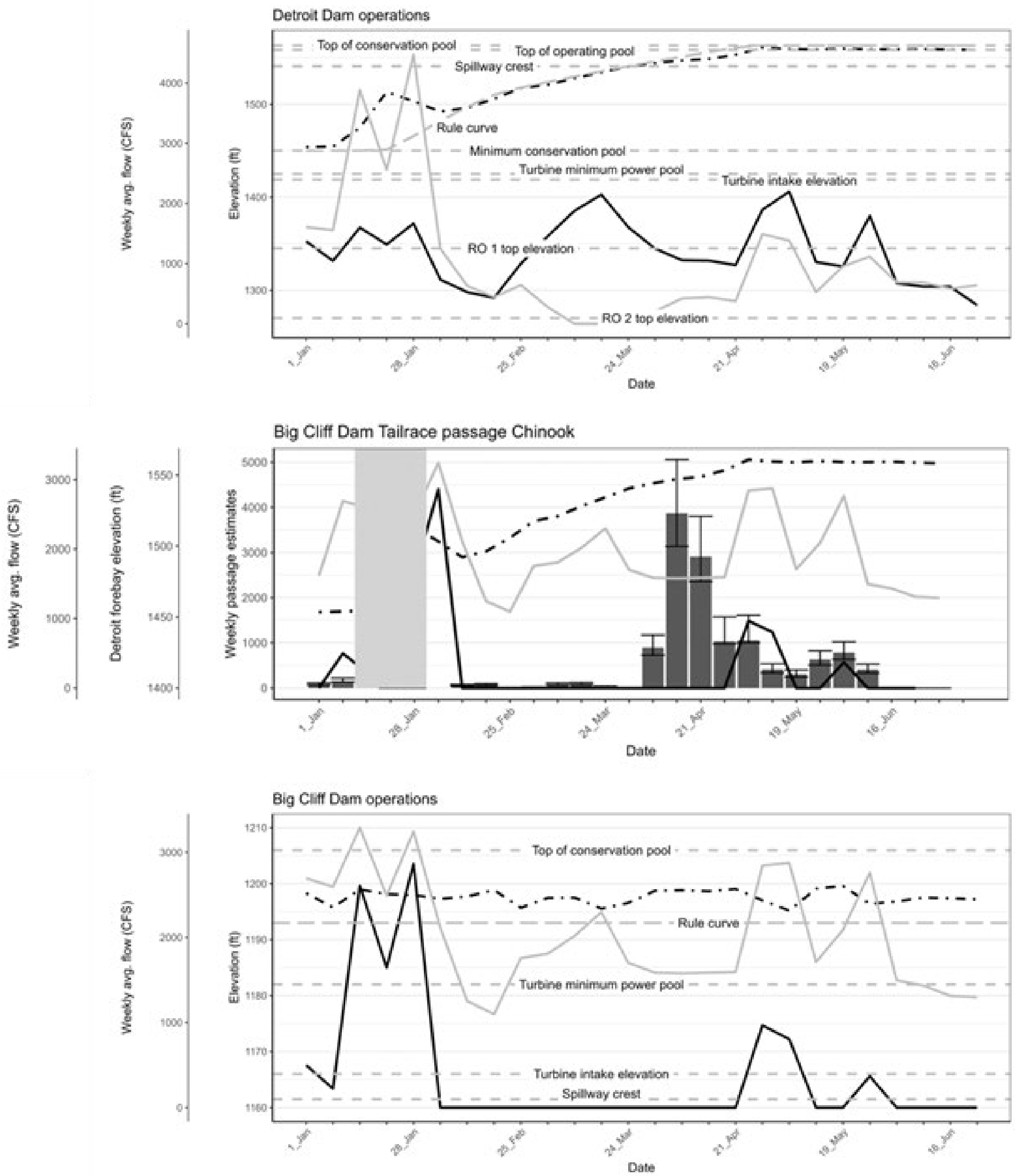

Figure 14. Detroit Dam (top panel) and Big Cliff Dam (bottom panel) operations with forebay elevation (black dot dash line), spill/RO outflow (black line) and powerhouse outflow (gray line). Passage estimates with 95% confidence for juvenile Chinook salmon at Big Cliff Dam (middle panel) with spill at Big Cliff Dam (black line), Powerhouse outflow from Big Cliff Dam (gray line), Detroit forebay elevation (black dot dash line), and non-sampling weeks shaded out (gray).

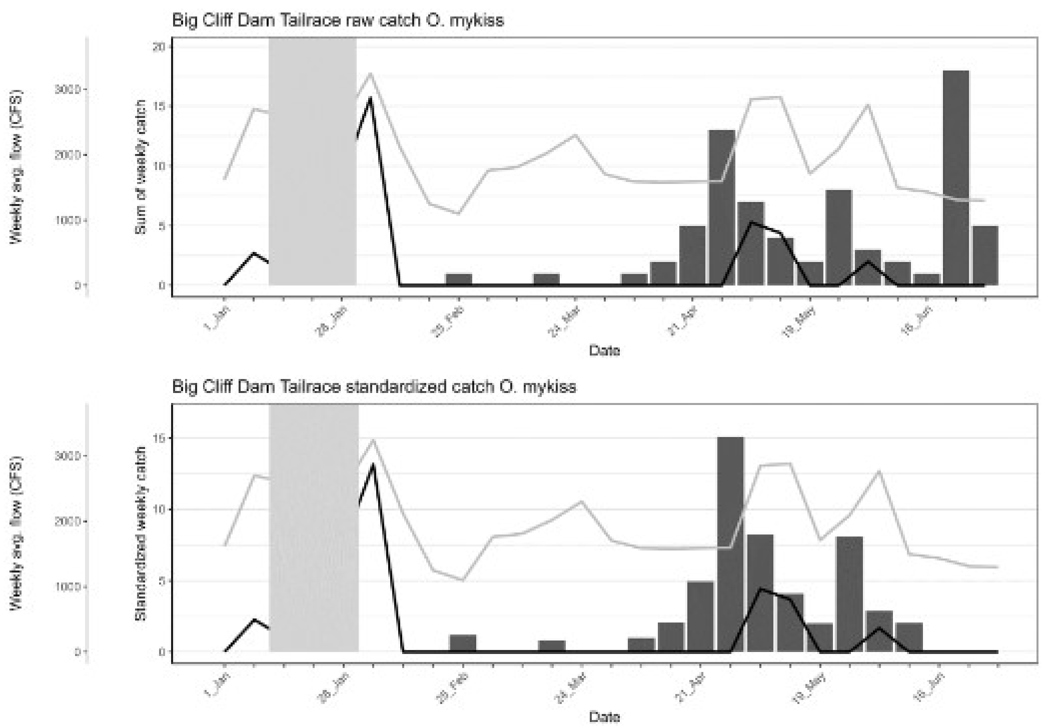

Figure 15. Raw catch (top panel) and weekly standardized catch (bottom panel) of NOR juvenile *O. mykiss* at Big Cliff Dam with spill (black line), Powerhouse (gray line) and non-sampling weeks shaded out (gray).

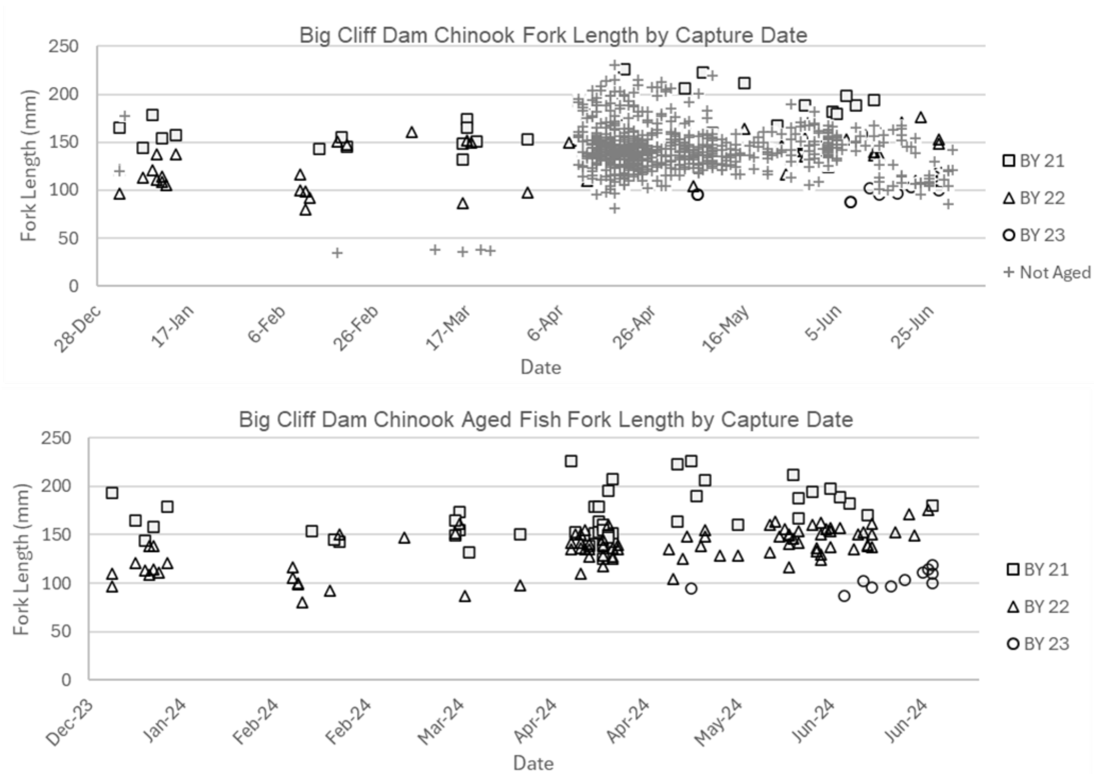

Figure 16. Length-frequency of juvenile Chinook salmon at the Big Cliff Dam Tailrace site. Top panel shows all fish and bottom panel shows only the aged fish.

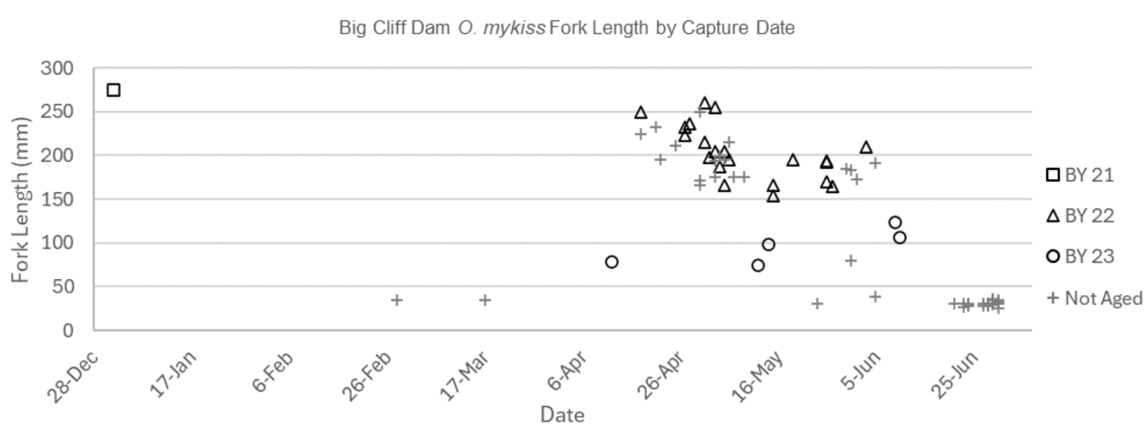

Figure 17. Length-frequency of juvenile *O. mykiss* at the Big Cliff Dam Tailrace site.

Injury Data

A total of 933 juvenile Chinook salmon (99.6% of total Chinook salmon catch) and 46 juvenile *O. mykiss* (62.2% of total *O. mykiss* catch) displayed at least one of the injury code conditions, other than copepods, listed in Table 3. During RST monitoring and data collection, 145 Chinook salmon (15.5%) and 10 *O. mykiss* (21.7%) were observed dead. To provide insight on injuries associated with capture in the RST, injury data was collected from bulk marked released and TE Chinook salmon. The most common injuries associated with trap capture include descaling greater than 20% and fin damage (Table 20). Additionally, 3.2% of the total Chinook salmon catch and 2.7% of the total *O. mykiss* catch displayed evidence of gas bubble disease. 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.

Increases in the proportion of fish displaying injury often coincided with spill operations at Big Cliff Dam. Figure 18 illustrates that as tailrace flows increase, so does bodily injury, specifically, descaling less than 20%. Copepod presence on captured Chinook salmon shows a positive correlation with the size of fish, similar to observations made by previous studies (CFS 2023a; Monzyk et al. 2015) (Figure 19). 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 salmon, a trend also observed in *O. mykiss* captured at the Big Cliff Dam site (Figure 20).

Furthermore, of the 76 bulk marked released Chinook salmon captured, the predominant injuries observed were descaling greater than 20%, fin damage, presence of copepods, and descaling less than 20%. (Table 20). Similar injuries were observed in the TE hatchery Chinook salmon. The predominant injuries observed in TE Chinook were descaling greater than 20%, and fin damage (Table 20). Further assessment and increased sample sizes will be utilized to yield more informed discussions.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Preliminary findings illustrated that smaller Chinook salmon (<60 mm) were less likely to encounter injury during dam passage and subsequent RST capture. Descaling less than 20%, descaling greater than 20%, bruising, fin damage, and the presence of copepods were found to significantly increase as fish grew in size (Appendix D, Table D-1). Additional information regarding injuries by size and average injuries per fish by size is available in Appendix D.

Table 20. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon, in addition to *O. mykiss* at the Big Cliff Dam RST site.

Injury Code	Chinook Injuries (NOR) (n=937)	Bulk Marked Released Chinook (n=76)	Trapping Efficiency Hatchery Chinook (n=123)	*O. mykiss* Injuries (NOR) (n=74)
NXI (no external injury)	0.4%	0.0%	10.6%	37.8%
MUNK	0.0%	0.0%	0.0%	0.0%
DS<2	25.0%	22.4%	17.9%	20.3%
DS>2	73.1%	76.3%	66.7%	37.8%
BLO	2.5%	3.9%	0.0%	0.0%
EYB	9.8%	13.2%	6.5%	14.9%
BVT	6.4%	3.9%	0.0%	4.1%
FVB	10.9%	9.2%	1.6%	9.5%
GBD	3.2%	5.3%	0.0%	2.7%
POP	2.7%	0.0%	0.0%	2.7%
HIN	12.0%	2.6%	0.0%	10.8%
OPD	19.7%	14.5%	9.8%	18.9%
TEA	4.5%	3.9%	0.0%	4.1%
BRU	14.9%	11.8%	0.0%	13.5%
HBP	1.2%	3.9%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%
BO	2.1%	1.3%	0.0%	0.0%
HBO	0.2%	0.0%	0.0%	0.0%
FID	85.8%	89.5%	88.6%	56.8%
PRD	0.1%	0.0%	0.0%	0.0%
COP	82.4%	50.0%	0.0%	36.5%
BKD	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	1.6%	0.0%

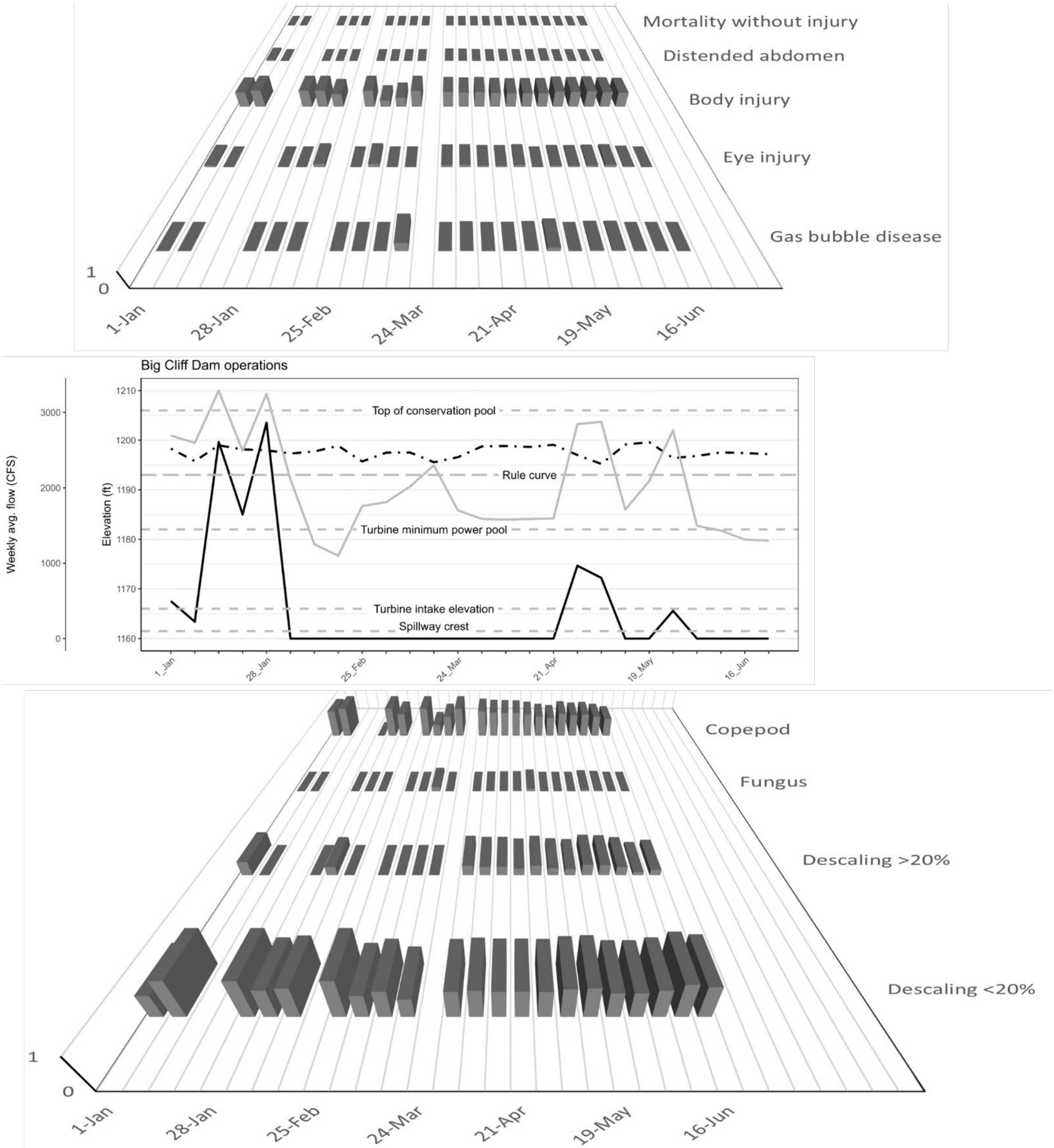

Figure 18. Injury rate of captured Chinook salmon below Big Cliff Dam displaying proportion of fish with injuries by type (top panel) and descaling injuries and copepod presence (bottom panel). The middle panel shows Big Cliff Dam operations with forebay elevation (black dot dash line), spill (black line) and Powerhouse flow (gray line) at Big Cliff Dam.

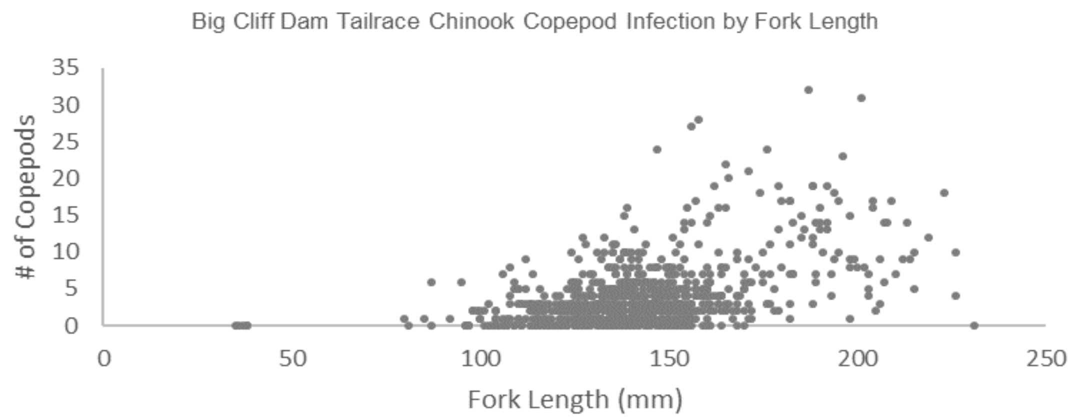

Figure 19. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Big Cliff Dam Tailrace.

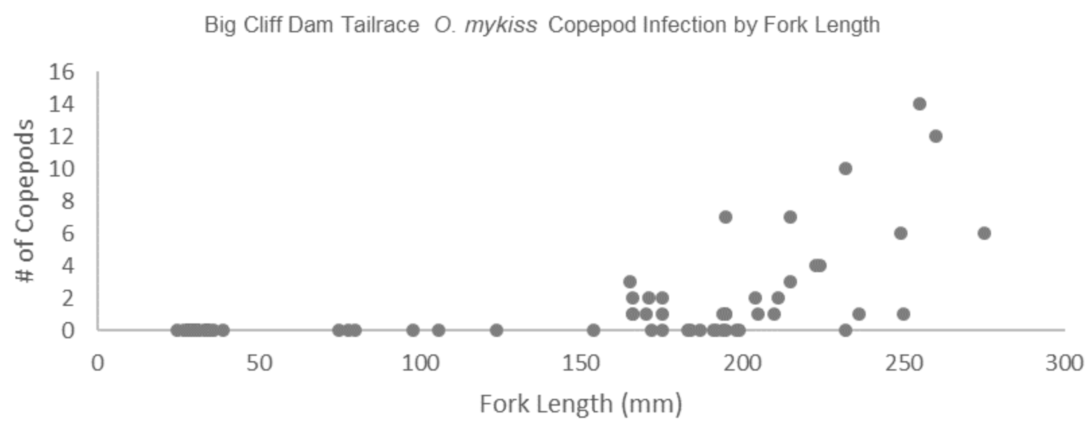

Figure 20. Copepod prevalence vs fork length on juvenile *O. mykiss* captured at Big Cliff Dam Tailrace.

24-Hour Hold Trials

24-hour hold trials were performed on NOR juvenile Chinook salmon and *O. mykiss* captured at the Big Cliff Dam Tailrace to assess delayed mortality resulting from dam passage. A total of 494 fish, 442 Chinook salmon and 52 *O. mykiss*, were held in the Spring of 2024 (Table 21). A total of 65 fish died during hold (13.2%), 59 of the 442 Chinook salmon (13.3%) and 5 of the 52 *O. mykiss* (9.6%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100%.

Table 21. Summary of 24-hour hold trials for fish captured in the RST at the Big Cliff Dam Tailrace site

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
January 1–15, 2024	Chinook	10	2	80.0%
January 1–15, 2024	*O. mykiss*	1	1	0.0%
January 16–31, 2024	Chinook	0	0	--
January 16–31, 2024	*O. mykiss*	0	0	--
February 1–15, 2024	Chinook	6	1	83.3%
February 1–15, 2024	*O. mykiss*	0	0	--
February 16–29, 2024	Chinook	5	0	100.0%
February 16–29, 2024	*O. mykiss*	1	0	100.0%
March 1–15, 2024	Chinook	1	0	100.0%
March 1–15, 2024	*O. mykiss*	0	0	--
March 16–31, 2024	Chinook	12	2	83.3%
March 16–31, 2024	*O. mykiss*	1	0	100.0%
April 1–15, 2024	Chinook	56	11	80.4%
April 1–15, 2024	*O. mykiss*	0	0	--
April 16–30, 2024	Chinook	91	17	81.3%
April 16–30, 2024	*O. mykiss*	3	0	100.0%
May 1–15, 2024	Chinook	80	10	87.5%
May 1–15, 2024	*O. mykiss*	13	2	84.6%
May 16–31, 2024	Chinook	56	5	91.1%
May 16–31, 2024	*O. mykiss*	6	2	66.7%
June 1–15, 2024	Chinook	80	8	90.0%
June 1–15, 2024	*O. mykiss*	5	1	80.0%
June 16–30, 2024	Chinook	45	3	93.3%
June 16–30, 2024	*O. mykiss*	22	0	100.0%

PIT Tagged Fish and Downstream Detections

A total of 294 fish were PIT tagged at the Big Cliff Dam site during the Spring of 2024, 288 juvenile Chinook salmon and 6 juvenile *O. mykiss*. The first 60 target fish captured at this location every week are prioritized for the 24-hour hold study and are not tagged. No PIT tagged fish were detected downstream and no VIE marked fish were detected at the site from upstream release sites. 5 PIT tagged Chinook and 1 PIT tagged *O. mykiss* that were tagged at the Breitenbush River RST were recaptured at this site during monitoring in the Spring of 2024. 1 PIT tagged Chinook that was tagged at the Detroit Head of Reservoir RST was recaptured at this site in the Spring 2024. A summary of downstream PIT tag detections is provided in Table 22 and more information regarding PIT tags at the RST and other sites can be found in Appendix C.

Table 22. Summary of PIT tagged juvenile Chinook downstream redetections for the Big Cliff Dam Tailrace site.

PIT Tag #	Mark Date	Redetection Date	Recap Site	Travel Time (Days)
3DD.003BE9F161	5/4/2024	5/9/2024	PD7 - Columbia River Estuary rkm 70	5
3DD.003BE9FE5C	4/26/2024	5/10/2024	TWX - Estuary Towed Array (Exp.)	14

Willamette Valley Projects Encounters

On March 7, 2024, ODFW released 110,250 Chinook fry dyed with Bismarck brown into Detroit Reservoir at the Mongold boat ramp and 1,959 Chinook fry at the base of Big Cliff Dam. One fish from the Big Cliff Dam tailrace release group was captured on March 9, 2024. No other fish from these release groups were detected in the RST.

A total of 75 adipose clipped and PIT tagged Chinook salmon from Cramer Fish Science's bulk mark releases were detected at the Big Cliff Dam RST during the Spring 2024 monitoring period. For more information regarding release groups, dates, and other redetections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

A total of 463 non-target fish were captured in addition to NOR juvenile Chinook salmon and *O. mykiss* at the Big Cliff Dam RST site in the Spring of 2024 (Table 23). The most common non-targets captured were clipped Chinook and wild kokanee.

Table 23. Summary of non-target species captured at the Big Cliff Dam RST site.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	22	15
Brown Bullhead	2	0
Chinook (clipped)	194	25
Coho Salmon	36	0
Cutthroat Trout	1	0
Kokanee (wild)	154	52
Kokanee (clipped)	23	6
O. mykiss (clipped)	7	2
Pumpkinseed	19	6
Unknown Salmonid*	2	2
Mountain Whitefish	1	0
Unknown*	2	2
Totals	**463**	**110**

*Species denoted as "unknown" were too small and/or too decomposed to identify.

Green Peter Head of Reservoir – Middle Santiam River

A single 5-foot RST was deployed in the Middle Santiam River above Green Peter Reservoir on February 1, 2024, and continued sampling until June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Additionally, the trap did not sample from February 27, 2024, to March 4, 2024, due to an incoming storm which subsequently caused projected flows to drastically increase, creating uncertain road, weather, and flow conditions for both EAS crew and captured fish.

Trapping Efficiency Trials

A total of eight TE trials occurred from February 8, 2024, through June 5, 2024, at the Green Peter Head of Reservoir – Middle Santiam site using hatchery reared Chinook salmon. Of these, two trials used dead fish and six used live fish. Collectively, thirteen live fish TE trials and four dead fish trials have occurred at this site since June 7, 2023. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 24. TEs ranged from 0.0% to 3.5% with a pooled average of 1.8% (95%CI ±1.7%, n=3) for all successful trials with five or more recaptures. Only one fish was captured in the trap between the two dead fish trials. Of the six live fish trials only three trials captured more than five fish to be used to calculate a passage estimate. On June 23, 2024, the flow at this site became too low (gage height <2 feet), resulting in the cone ceasing to rotate. By this time, all TE trials were complete, and the maximum six days required for fish to pass the trap had occurred. Due to the limited number of successful TE trials, a passage estimate cannot be calculated until additional data is collected when flows increase in the fall.

The placement of the RST is constrained by the requirement that both the trap and its associated highline must be entirely situated on land owned by the Bureau of Land Management. The local landowner upstream of this land has declined permission for the placement of an RST and any associated equipment on their property. This restricts the sampling location to a single pool in a relatively wide and flat section of the river. The RST is located within the thalweg, the best overall sampling position for the RST across all seasons. However, it does not spin appropriately at low flows in the summer, an occurrence commonly evidenced when operating sampling machinery of this nature. Therefore, efficient sampling at this site can only occur during sufficient flow. Comparing flow rate against gage height, the trap stops spinning at and below a gage height of 2 ft. Based on current flow conditions and weekly gage height averages from 2023, the trap is expected to be non-functional from late June to early November (Environmental Assessment Services 2024).

Table 24. Summary of trapping efficiency trials at the Green Peter Head of Reservoir – Middle Santiam River RST site.

Release Location	Date of Release	Gage Height at Release (ft)	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Green Peter Head of Reservoir – Middle Santiam	6/7/2023	2.0	750	0	0%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	6/7/2023	2.0	1,000	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	7/28/2023	1.02	750	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	8/30/2023	0.9	749	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	9/27/2023	1.29	741	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	10/11/2023	2.69	750	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	10/31/2023	1.45	750	0	0.0%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	10/31/2023	1.45	1,000	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	11/15/2023	2.53	749	1	0.1%
Green Peter Head of Reservoir – Middle Santiam	2/8/2024	3.21	753	4	0.5%
Green Peter Head of Reservoir – Middle Santiam	3/14/2024	3.43	800	4	0.5%
Green Peter Head of Reservoir – Middle Santiam	4/2/2024	3.35	754	2	0.3%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	4/2/2024	3.35	1,002	1	0.1%
Green Peter Head of Reservoir – Middle Santiam+	4/12/2024	3.04	2,500	23	0.9%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	4/19/2024	2.63	1,000	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	5/15/2024	3.17	998	35	3.5%
Green Peter Head of Reservoir – Middle Santiam	6/5/2024	3.52	1,083	10	0.9%

+Trapping efficiency release performed by Cramer Fish Sciences

Run of River Trapping Efficiency Trials

Releases for ROR TE trials were pooled by month. A total of 511 juvenile Chinook salmon and zero *O. mykiss* were released between February 3, 2024, and March 25, 2024, after which ROR trials were discontinued (Table 25). In total, seven fish were recaptured from the 2024 trials with TEs ranging from 0.6-1.7%. To account for sample size variability, monthly calculations were weighted based on sample size and then summed yielding an estimated TE for ROR trials of 1.4%. This value is similar to TE using hatchery reared Chinook salmon (1.8%); however, the limited number of trials indicates that more data is needed to increase the overall sample size.

Table 25. Summary table of run of river releases at the Green Peter Head of Reservoir RST site for trapping efficiency

Release Location	Date of Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Green Peter Head of Reservoir	February 2024	349	6	1.72%
Green Peter Head of Reservoir	March 2024	162	1	0.62%

Target Catch, Passage Estimates, and Passage Timing

The trap captured 811 juvenile Chinook salmon and 24 juvenile *O. mykiss*. Peak capture of juvenile Chinook salmon in the spring occurred in February (n=600, 74.0% of total catch) (Figure 21). Chinook salmon catch was composed primarily of BY 2023 fish (n= 806, 99.4 % of total Chinook catch) (Figure 23). Additionally, 5 BY 2022 yearlings were captured between February and March. The first BY 2023 sub-yearling Chinook captured at the trap occurred on the first day of sampling and catch continued until mid-May. Capture of Chinook fry on the first day of sampling and peak capture of fish occurring in February suggest that many Chinook salmon sub-yearlings likely passed the trapping site prior to the initiation of sampling. Figure 21 shows raw and standardized catch overlayed with flow at the Green Peter Head of Reservoir- Middle Santiam site.

Due to the relatively few successful trials (n=3) and range of flows encountered, we were unable to create a passage estimate for this location. Additional trials are planned for this site and will be needed to create estimates in the future.

Peak capture of juvenile *O. mykiss* at Green Peter Head of Reservoir occurred in May (n=10, 41.7% of total catch). *O. mykiss* capture consisted of fish from four brood years: BY 2021, BY 2022, BY 2023 and BY 2024 (Figure 24). A summary of fork lengths and weights of captured Chinook salmon and *O. mykiss* by BY is provided in Table 26.

Table 26. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* of NOR at the Green Peter Head of Reservoir RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	2/1/24–6/30/24	22	5	91.6	81	104	92	8.7	5.8	10.9	8.9
Chinook	2/1/24–6/30/24	23	806	36.2	32	70	36	N/A	N/A	N/A	N/A
O. mykiss	2/1/24–6/30/24	21	1	255	255	255	N/A	147.5	147.5	147.5	N/A
O. mykiss	2/1/24–6/30/24	22	3	174	139	215	168	53.3	27.5	88.8	43.6
O. mykiss	2/1/24–6/30/24	23	18	95.2	75	115	92	9.1	6.4	18.4	9.1
O. mykiss	2/1/24–6/30/24	24	2	23.5	20	27	N/A	N/A	N/A	N/A	N/A

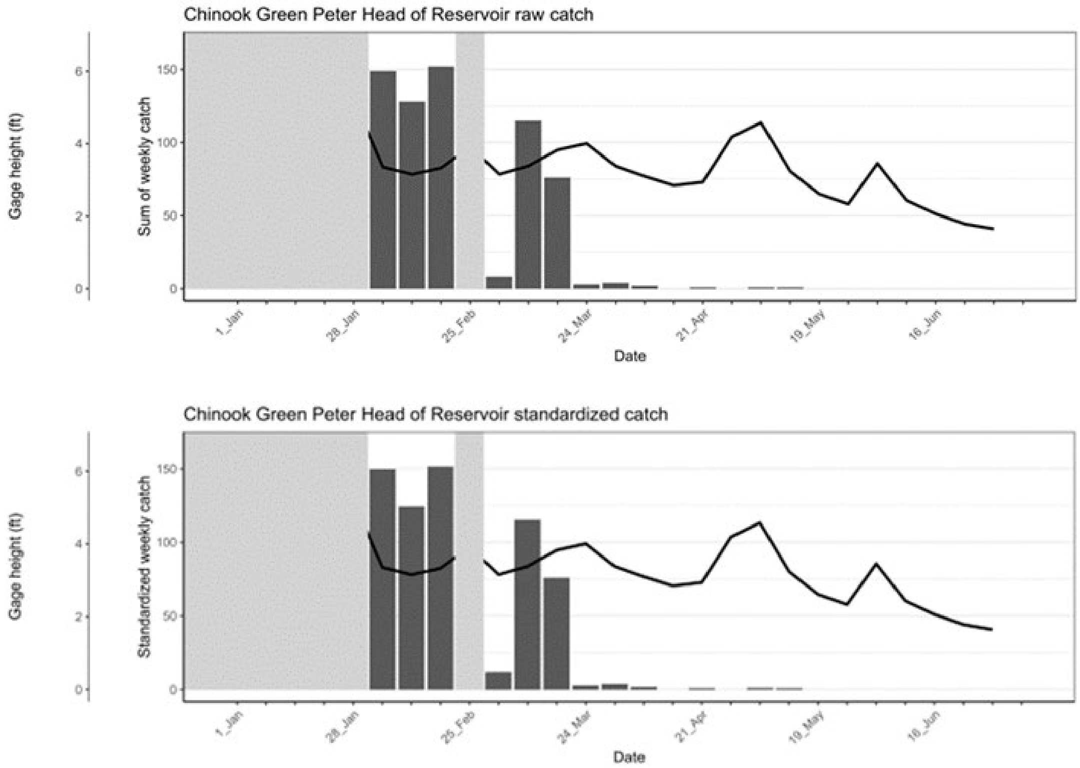

Figure 21. Raw catch (top panel) and weekly standardized catch (bottom panel) of NOR juvenile Chinook salmon at the Green Peter Head of Reservoir with stream gage height (black line) and non-sampling weeks shaded out (gray).

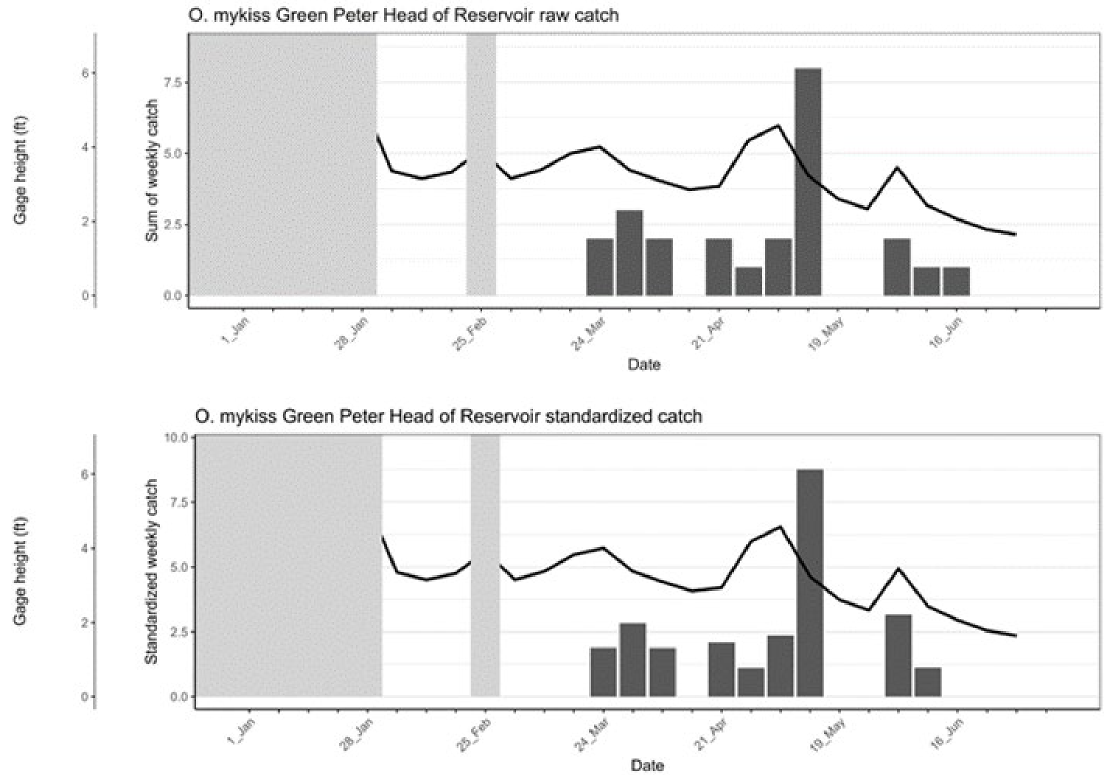

Figure 22. Raw catch (top panel) and weekly standardized catch (bottom panel) of NOR juvenile *O. mykiss* at Green Peter Head of Reservoir with stream gage height (black line) and non-sampling weeks shaded out (gray).

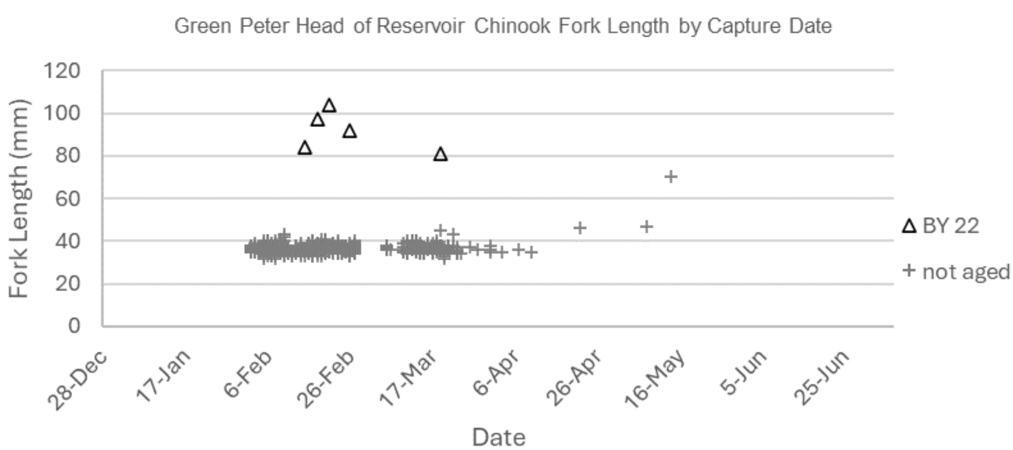

Figure 23. Length-frequency of juvenile Chinook salmon at the Green Peter Head of Reservoir site.

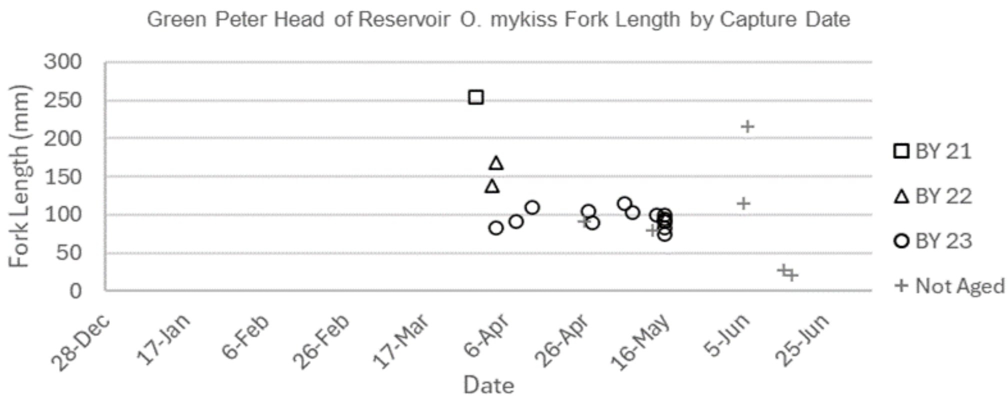

Figure 24. Length-frequency of juvenile *O. mykiss* at the Green Peter Head of Reservoir site.

Injury Data

A total of 55 juvenile Chinook salmon (6.8% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 3. Descaling greater than 20%, bruising, head injury, and operculum damage were the most common injuries seen in Chinook salmon at the Green Peter Head of Reservoir RST (Table 27). These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. Bulk marked released Chinook at this site were observed having a higher percentage of descaling greater than 20%, operculum damage, tears, ventral fin bleeding, and fin damage when compared to the NOR Chinook. Similarly, TE hatchery Chinook salmon were found to have higher percentages of descaling greater than 20%, descaling less than 20%, operculum damage, fin damage, and head injuries as compared to both NOR and bulk marked released Chinook (Table 27).

Data collected on the injury rates of TE hatchery fish illustrated that the percentage of fish with injuries increased, while the average number of injuries per fish remained consistent from pre-release to recaptured observations of Chinook salmon at the Green Peter Head of Reservoir RST site (Appendix D). Detailed findings on injury type are further presented in Appendix D.

A total of 16 *O. mykiss* (66.6% of total *O. mykiss* catch) displayed at least one of the injury codes detailed in Table 3. The most frequently observed injuries for *O. mykiss* were illustrated to be descaling greater than 20% and fin damage. Copepods were observed on 8.3% of the *O. mykiss* encountered. There were no copepods observed on Chinook salmon at this site (Figure 25 and Figure 26). The presence of copepods found on *O. mykiss* did not illustrate any relationship with size. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 27. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon, in addition to *O. mykiss* at the Green Peter Head of Reservoir – Middle Santiam River RST site.

Injury Code	Chinook Injuries (NOR) (n=812)	Bulk Marked Released Chinook (n=53)	Trapping Efficiency Hatchery Chinook (n=57)	*O. mykiss* Injuries (NOR) (n=24)
NXI (no external injury)	93.1%	66.0%	5.3%	33.3%
MUNK	0.0%	0.0%	0.0%	4.2%
DS<2	0.5%	1.9%	8.8%	0.0%
DS>2	1.4%	22.6%	50.9%	41.7%
BLO	0.0%	0.0%	0.0%	0.0%
EYB	0.4%	0.0%	0.0%	0.0%
BVT	0.1%	0.0%	1.8%	0.0%
FVB	0.7%	1.9%	3.5%	0.0%
GBD	0.0%	0.0%	0.0%	0.0%
POP	0.9%	0.0%	0.0%	0.0%
HIN	1.4%	0.0%	1.8%	0.0%
OPD	3.1%	5.7%	8.8%	0.0%
TEA	1.0%	3.8%	0.0%	0.0%
BRU	1.8%	0.0%	5.3%	0.0%
HBP	0.0%	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%
FID	1.2%	15.1%	84.2%	33.3%
PRD	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	8.3%
BKD	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%	0.0%

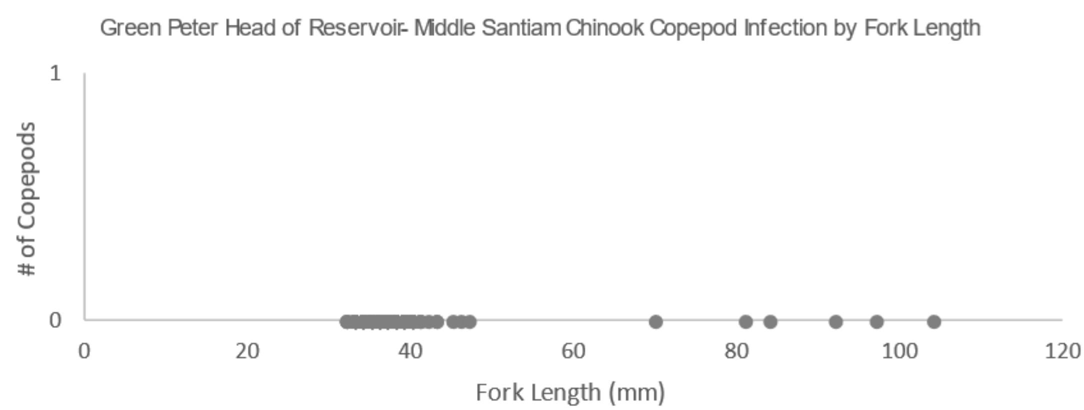

Figure 25. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Green Peter Head of Reservoir.

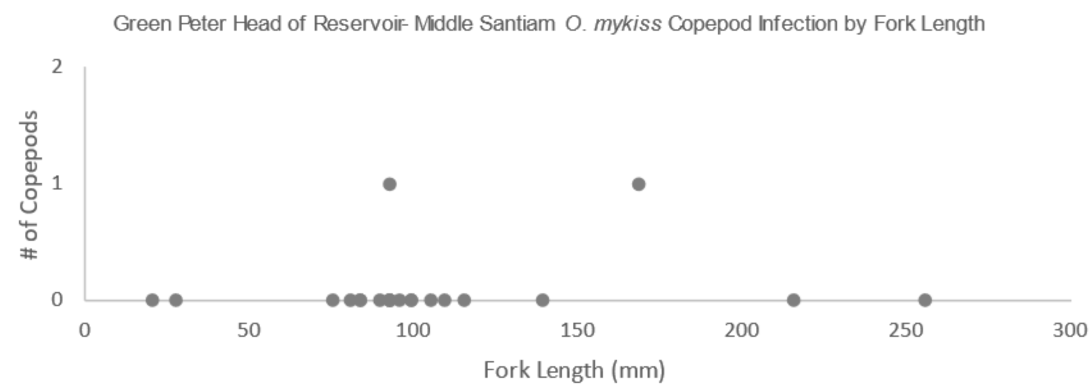

Figure 26. Copepod prevalence vs fork length on juvenile *O. mykiss* captured at Green Peter Head of Reservoir.

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 5 juvenile Chinook salmon and 22 juvenile *O. mykiss* were PIT tagged at the Green Peter Head of Reservoir – Middle Santiam site through the Spring of 2024. 601 juvenile Chinook and 0 *O. mykiss* were VIE marked. Some fish did not meet length requirements or were still sac-fry that were not able to be marked. No VIE or PIT tagged fish were redetected at downstream sites. Table 28 shows a summary of VIE marked fish with the tagging period and mark details.

Table 28. Summary table of VIE tagged fish at the Green Peter Head of Reservoir – Middle Santiam River RST site.

Date Tagged	Species	Tag Location	VIE Color	# Tagged	# Recaptured
02/01/2024–02/15/2024	Chinook	Right Dorsal	Yellow	177	0
02/01/2024–02/15/2024	*O. mykiss*	Right Dorsal	Yellow	0	0
02/16/2024–02/29/2024	Chinook	Right Dorsal	Yellow	239	0
02/16/2024–02/29/2024	*O. mykiss*	Right Dorsal	Yellow	0	0
03/01/2024–03/15/2024	Chinook	Right Dorsal	Red	91	0
03/01/2024–03/15/2024	*O. mykiss*	Right Dorsal	Red	0	0
03/16/2024–03/31/2024	Chinook	Right Dorsal	Red	89	0
03/16/2024–03/31/2024	*O. mykiss*	Right Dorsal	Red	0	0
04/01/2024–04/15/2024	Chinook	Right Dorsal	Blue	3	0
04/01/2024–04/15/2024	*O. mykiss*	Right Dorsal	Blue	0	0
04/16/2024–04/30/2024	Chinook	Right Dorsal	Blue	1	0
04/16/2024–04/30/2024	*O. mykiss*	Right Dorsal	Blue	0	0
05/01/2024–05/15/2024	Chinook	Right Dorsal	Orange	1	0
05/01/2024–05/15/2024	*O. mykiss*	Right Dorsal	Orange	0	0
05/16/2024–05/31/2024	Chinook	Right Dorsal	Orange	0	0
05/16/2024–05/31/2024	*O. mykiss*	Right Dorsal	Orange	0	0
06/01/2024–06/15/2024	Chinook	Right Dorsal	Pink	0	0
06/01/2024–06/15/2024	*O. mykiss*	Right Dorsal	Pink	0	0
06/16/2024–06/30/2024	Chinook	Right Dorsal	Pink	0	0
06/16/2024–06/30/2024	*O. mykiss*	Right Dorsal	Pink	0	0

Willamette Valley Projects Encounters

A total of 52 adipose clipped and PIT tagged Chinook salmon from Cramer Fish Science's bulk mark releases were detected at the Green Peter Head of Reservoir RST through the Spring of 2024. 49 of these fish were considered recaptures for trapping efficiency trials. For more information regarding release groups, dates, and other redetections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

A total 42 non-target fish were captured in addition to NOR juvenile Chinook salmon and *O. mykiss*. A summary of species and numbers of fish caught are provided in Table 29. The most commonly captured non-target species were dace and clipped Chinook.

Table 29. Summary of non-target fish capture at the Green Peter Head of Reservoir – Middle Santiam River RST site.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	4	0
O. mykiss	1	0
Unknown Salmonid	1	0
Dace	35	3
Kokanee (wild)	1	0
Totals	**42**	**3**

Green Peter Dam Tailrace – Middle Santiam River

A single 8-foot RST continued monitoring activities in the Green Peter Dam Tailrace and sampled from January 1, 2024through June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

The RST was raised to its non-sampling position from January 19, 2024, to February 9, 2024, due to high flows which subsequently caused safety concerns for both crew and fish as well as increasing overall debris loads. Additionally, the RST was raised to its non-sampling position from February 29, 2024, to March 4, 2024, as the operator informed EAS that high flows, exceeding preset safety thresholds, were expected.

In both calendar year 2022 and 2023, 800 adult Chinook salmon were released in tributaries above Green Peter Reservoir to spawn, 200 in Quartzville Creek, and 600 in the Middle Santiam River (CFS 2023b).

Trapping Efficiency Trials

A total of ten TE trials occurred from January 9, 2024, through June 18, 2024, in the Green Peter Dam Tailrace using hatchery reared Chinook salmon. Of these, two trials used dead fish and eight used live fish. Collectively, twenty-seven TE trials have occurred at this site since March 29, 2022. Five of these trials were dead fish releases. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 30.

For the live fish releases, TEs ranged from 0.0% to 2.7% with a pooled average of 1.4% (95%CI ±0.5%, n=12) of all successful trials with five or more recaptures. Ten of the live fish trials did not recapture enough fish to be used in the passage estimate calculation. Dead fish releases were not included in the passage estimate, because all fish that enter the trap are assumed to be alive at the time of capture. To date not enough successful dead fish releases have been completed to estimate the probability of a fish that dies while passing the dam being captured in the trap. Dead fish releases will continue in the future when enough hatchery fish are available. Modeling results from the discharge and revolutions per hour analysis indicate there were poor model fits for all models at Green Peter Dam. The model incorporating discharge and revolutions per hour as independent covariates had the highest pseudo R^2 (R^2 = 0.107), as well as having the third lowest AICc score with a ΔAICc of 2.54 from the null model with the lowest AICc score. The full model incorporating discharge, revolutions per hour and their interaction had the second highest pseudo R^2 (R^2 = 1.06), only slightly lower, but also has a greater AICc score, ΔAICc of 5.925 from the null model. This indicates that additional complexity of the full model fails to capture more variability than the model with discharge and revolutions per hour as independent covariates.

Table 30. Summary table of marked hatchery Chinook salmon releases in the Green Peter Dam Tailrace for trapping efficiency

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent 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%
Green Peter Dam Tailrace – Spill (dead fish)*	5/11/2023	1,910	1,001	0	0.0%
Green Peter Dam Tailrace – Spill*	5/11/2023	1,910	999	9	0.9%
Green Peter Dam Tailrace – PWR*	5/25/2023	1,980	1,000	10	1.0%
Green Peter Dam Tailrace – Powerhouse (dead fish)	6/30/2023	2,190	1,000	9	0.9%
Green Peter Dam Tailrace – Powerhouse*	6/30/2023	1980	1,000	23	2.3%
Green Peter Dam Tailrace – PWR*	7/27/2023	50	1,009	13	1.3%
Green Peter Dam Tailrace – PWR*	8/16/2023	50	1,008	7	0.7%
Green Peter Dam Tailrace – PWR*	8/31/2023	1,970	1,000	8	0.8%
Green Peter Dam Tailrace – PWR*	10/4/2023	2,930	1,005	0	0.0%
Green Peter Dam Tailrace*	11/1/2023	1,800	1,000	22	2.2%
Green Peter Dam Tailrace*	11/14/2023	1,300	1,000	7	0.7%
Green Peter Dam Tailrace – Spill*	11/29/2023	630	1,000	28	2.8%
Green Peter Dam Tailrace – Spill (dead fish)*	11/29/2023	630	3,999	11	0.3%
Green Peter Dam Tailrace	12/8/2023	3,700	1,000	25	2.5%
Green Peter Dam Tailrace – Spill	12/19/2023	50	1,000	3	0.3%

*Denotes that two trials with differentially marked fish occurred with overlapping recapture periods.
**Three releases conducted in one day. Ad-clip only for morning Powerhouse flow, dead BBY marked fish for evening spill, and upper-caudal clipped live fish for evening spill.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Green Peter Dam during the Spring 2024 monitoring period. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study. Sufficient numbers of NOR fish were not available to perform ROR TE trials.

Target Catch, Passage Estimates and Passage Timing

The trap captured 128 naturally produced juvenile Chinook salmon and 8 juvenile *O. mykiss* at this site in the Spring 2024 monitoring period. *O. mykiss* captured at this location are likely progeny of resident trout, as winter steelhead are not transported above Green Peter Dam in recent years. However, all NOR juvenile *O. mykiss* at this site were treated as target fish. Peak capture of juvenile Chinook salmon in the spring occurred in June (n=47, 36.7% of total Chinook salmon catch) (Figure 27). Chinook salmon catch was composed primarily of BY 2023 sub-yearlings (n= 77, 60.2% of total Chinook capture) (Figure 29). The first BY 2023 sub-yearling Chinook was captured on January 4, 2024, and catch of these fish continued into June. BY 2022 yearlings were encountered from mid-January through early May.

Peak capture of juvenile *O. mykiss* occurred in April (n=5, 66.6% of total *O. mykiss* catch) (Figure 28).The *O. mykiss* captured consisted entirely of BY 2023 fish and were only captured in April and May (Figure 30). Descriptive statistics on fork length and size of fish captured at Green Peter Dam by BY is provided below in Table 31.

Periods of increased catch of both Chinook salmon and *O. mykiss* occurred in the spring and coincided with surface spill operations at Green Peter Dam. Peak capture at Green Peter Dam coincided with a spill event that occurred in June. It also appears that capture of both species increased once spill operations switched from intermittent surface spill to continuous spill operations in both the April and June capture events. However, the trap had to be raised to non-sampling position from January 19, 2024, to February 9, 2024, due to high flows which subsequently caused safety concerns for both crew and fish as well as increasing overall debris loads. It is possible that juvenile Chinook passed through the sampling site during this time with the increased flows and short spill period that occurred. Capture of fish prior to the initiation of surface spill and after the extended spill operation in the spring suggests that Chinook arrive to the forebay of Green Peter Dam throughout the spring period. Using pooled averages of hatchery Chinook TEs, EAS estimates that 8,945 (95% CI: 6,816 to 13,008) juvenile Chinook salmon passed through Green Peter Dam Tailrace during sampling in the Spring of 2024 (Figure 27).

Table 31. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* of NOR at the Green Peter Dam Tailrace RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/2024–6/30/2024	22	51	146.6	98	173	149	35.1	9.8	56.5	36.1
Chinook	1/1/2024–6/30/2024	23	77	105.3	36	141	107	15.3	1.9	27.3	14.6
O. mykiss	1/1/2024–6/30/2024	23	8	188.9	162	225	187.5	63.0	38.0	90.5	63.1

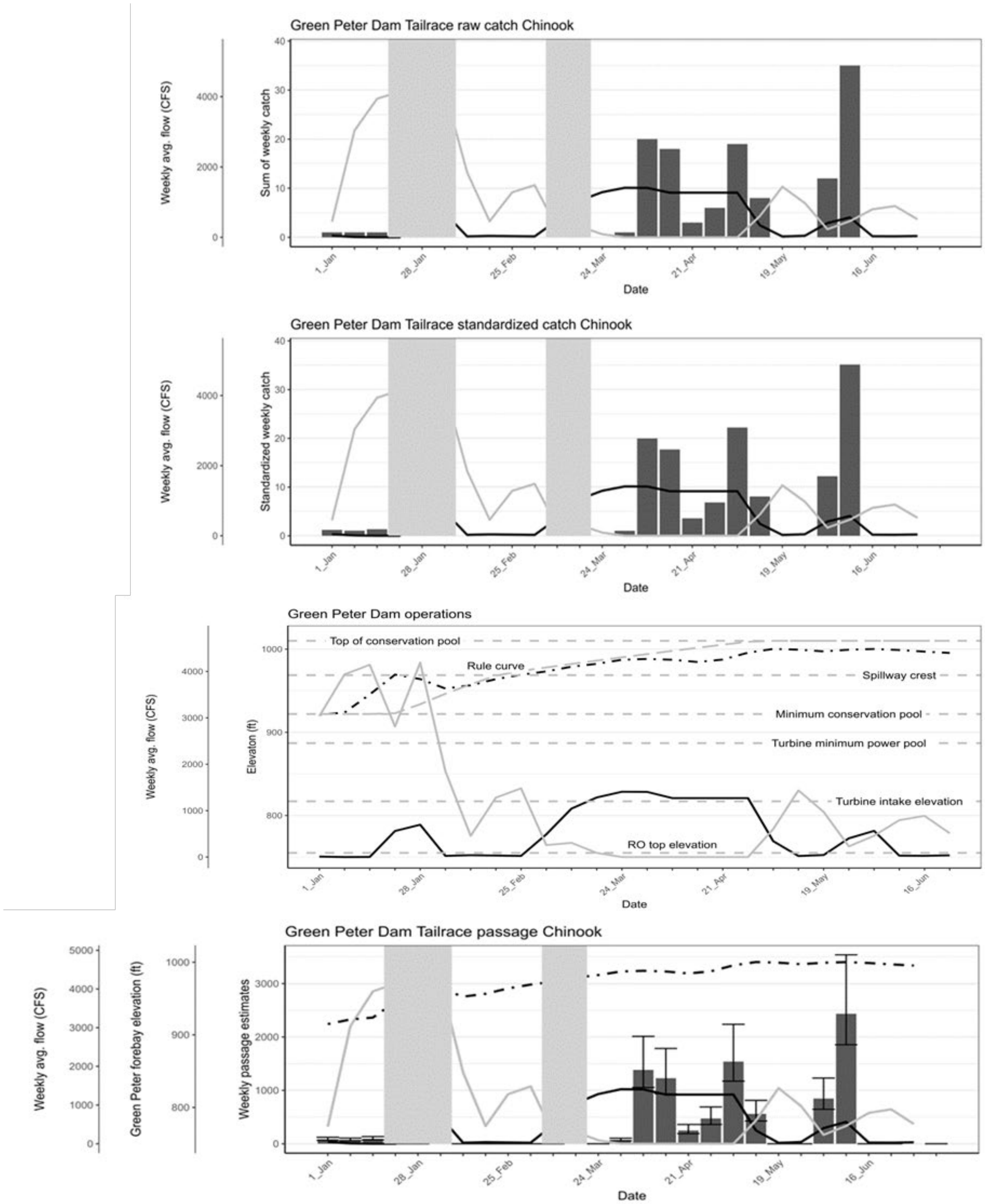

Figure 27. Raw catch (top panel), weekly standardized catch (second panel), and weekly passage estimates (bottom panel) of NOR juvenile Chinook salmon at Green Peter Dam Tailrace with spill/RO (black line), Powerhouse flow (gray line), and non-sampling weeks shaded out (gray). The third panel displays Green Peter Dam operations and features of interest with spill/RO outflow (black line), Powerhouse outflow (gray line), and forebay elevation (black dot dash line).

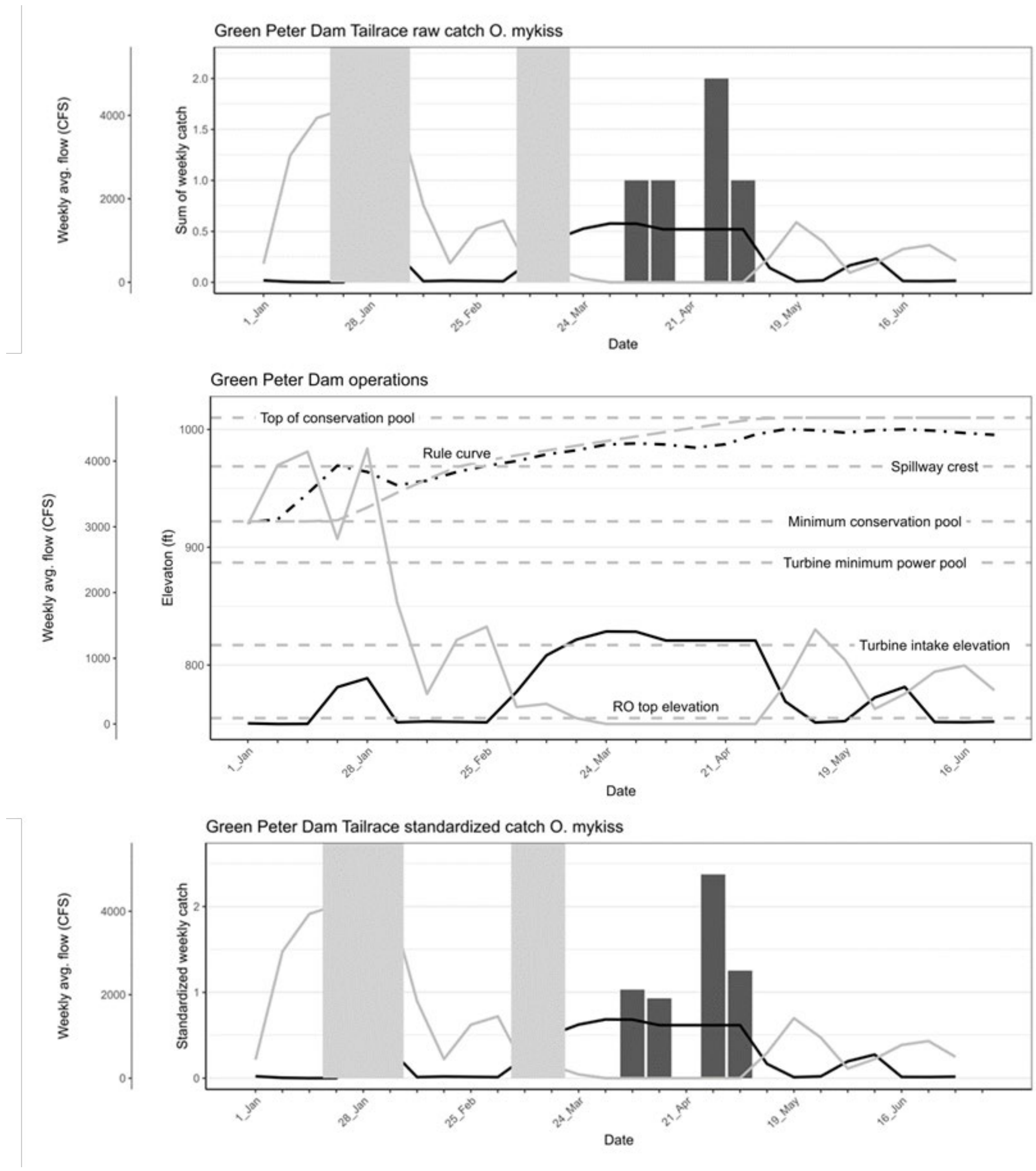

Figure 28. Raw catch (top panel) and weekly standardized catch (bottom panel) of NOR juvenile Chinook at Green Peter Dam Tailrace with spill (black line), Powerhouse (gray line), and non-sampling weeks shaded out (gray). The middle panel displays Green Peter Dam operations and features of interest with spill/RO outflow (black line), Powerhouse outflow (gray line), and forebay elevation (black dot dash line).

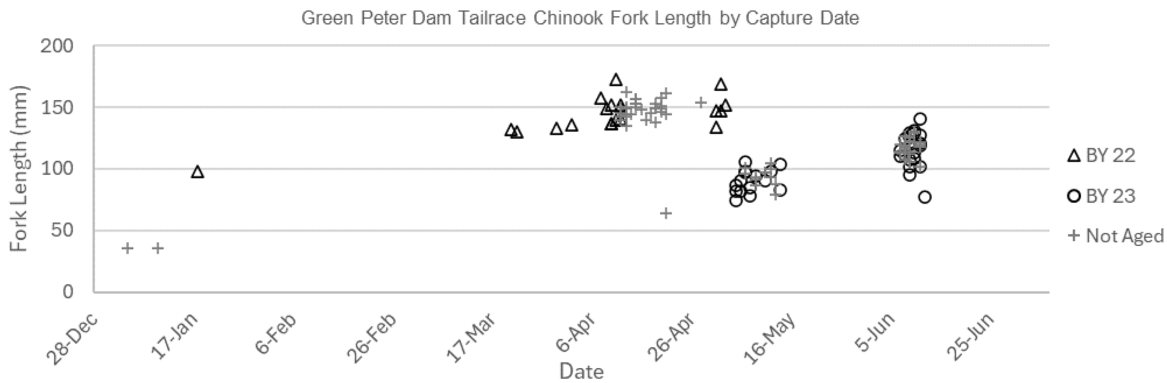

Figure 29. Age length-frequency for captured NOR Chinook salmon at the Green Peter Dam Tailrace site.

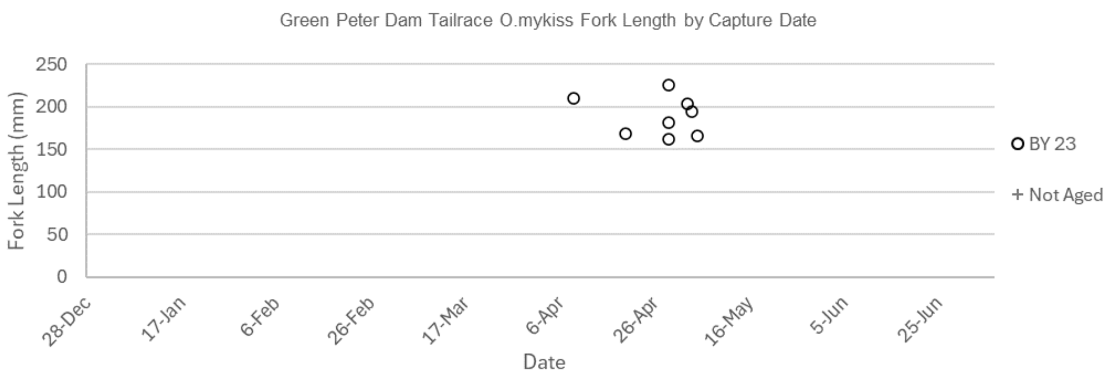

Figure 30. Age length-frequency for captured NOR *O. mykiss* at the Green Peter Dam Tailrace site.

Injury Data

A total of 125 juvenile Chinook salmon (97.6%) and 8 juvenile *O. mykiss* (100.0%) displayed at least one of the injury code conditions listed in Table 3. To provide insight on injuries associated with capture in a RST, injury data was collected from bulk marked released Chinook salmon and hatchery fish utilized for TE trials. Data from TE recaptures show that injuries observed on fish were not a direct result of RST capture at this site. The predominant injury seen in fish prior to TE releases were descaling less than 20% and fin damage. Upon recapture of these TE fish, descaling less than 20%, descaling greater than 20% and fin damage were observed at higher rates, in addition to gas bubble disease, operculum damage and bruising (Appendix D). For interpretation of results, it is important to note that this is a small sample size and observed trends should be considered preliminary until more data is available.

The most common injuries observed on juvenile Chinook salmon and *O. mykiss* at this site include descaling, fin damage and gas bubble disease (Table 32). Figure 32 and Figure 33 illustrate that there is no discernable relationship between overall size of Chinook salmon or *O. mykiss* and the presence of copepods.

Chinook salmon that were bulk marked recaptures evidenced nominally higher rates of descaling, bloating, bloody eye (hemorrhage), bleeding from vent, operculum damage, head injuries, tears, bruising, and fin damage, as compared to NOR Chinook salmon caught at the Green Peter Dam RST site (Table 32). The bulk marked Chinook salmon are hatchery reared fish that are subsequently released upstream of the dam and experience the same factors related to dam passage as the NOR Chinook. These fish display injuries related to dam passage and trap capture as well as injuries such as descaling and fin damage that are commonly observed in hatchery reared fish.

Figure 31 illustrates that increases in flow from the spill at Green Peter Dam directly affects overall bodily injury and gas bubble disease (Figure 31). Furthermore, it is evidenced that as spill at Green Peter Dam Tailrace increases, so does descaling less than 20% in juvenile Chinook salmon (Figure 31). 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 caught and held in areas of higher dissolved gas. Surface spill periods are displayed in Table 33 and denoted in Figure 31.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Similar to findings from Big Cliff Dam Tailrace, it was illustrated that juvenile Chinook salmon less than 60 mm incurred fewer injuries than those above 60 mm (Appendix D, Table D-2). All juvenile Chinook salmon greater than 110 mm were observed to have injuries.

During the time of trap check, 15 Chinook salmon (11.7% of total Chinook catch) were observed as being found deceased. A summary of injury type by species is included in Table 32. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 32. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon, in addition to *O. mykiss* at the Green Peter Dam RST site.

Injury Code	Chinook Injuries (NOR) (n=128)	Bulk Marked Released Chinook (n=88)	Trapping Efficiency Hatchery Chinook (n=24)	*O. mykiss* Injuries (NOR) (n=8)
NXI (no external injury)	2.3%	1.1%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%	0.0%
DS<2	33.6%	36.4%	12.5%	87.5%
DS>2	59.4%	60.2%	87.5%	12.5%
BLO	2.3%	4.5%	0.0%	0.0%
EYB	18.0%	22.7%	4.2%	25.0%
BVT	3.1%	4.5%	0.0%	0.0%
FVB	36.7%	25.0%	8.3%	25.0%
GBD	48.4%	37.5%	16.7%	62.5%
POP	3.1%	3.4%	0.0%	0.0%
HIN	18.0%	21.6%	4.2%	50.0%
OPD	24.2%	26.1%	29.2%	25.0%
TEA	5.5%	8.0%	0.0%	0.0%
BRU	18.0%	23.9%	0.0%	50.0%
HBP	1.6%	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%
FID	85.2%	93.2%	79.2%	100.0%
PRD	0.0%	0.0%	0.0%	0.0%
COP	4.7%	3.4%	0.0%	37.5%
BKD	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%	0.0%

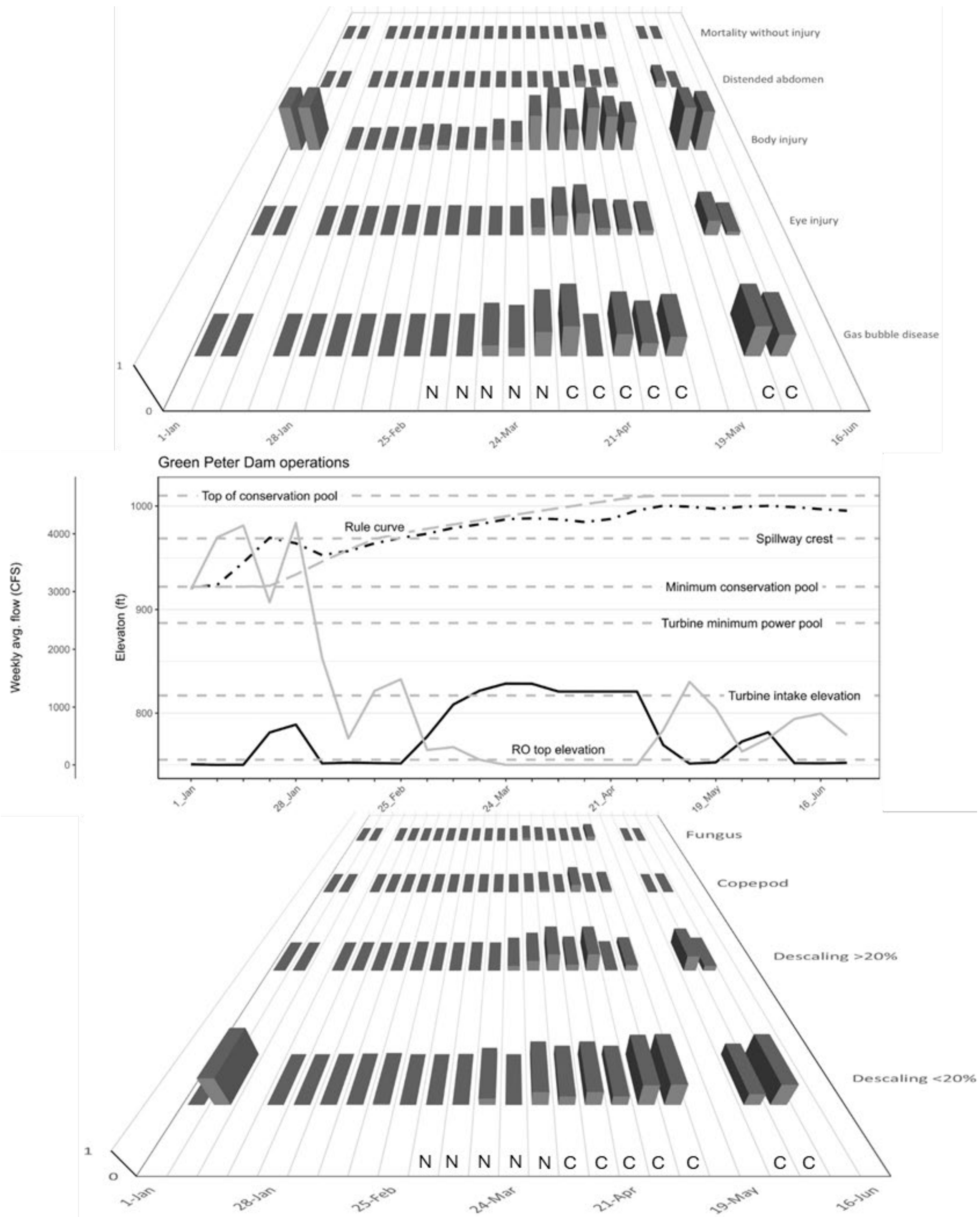

Figure 31. Injury rate of captured Chinook salmon below Green Peter Dam displaying proportion of fish with injuries by type (top panel) and descaling injuries and copepod presence (bottom panel). The middle panel shows Green Peter Dam operations and features of interest with spill/RO flow (black line), Powerhouse flow (gray line), and forebay elevation (black dot dash line). Bars with a "C" denote weeks in which continuous surface spill occurred while those with "N" denote weeks when nighttime surface spill operations occurred.

Table 33. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon, in addition to O. mykiss at the Green Peter Dam RST site.

Site	Dates	Description
Green Peter Dam	3/13/2024 – 4/11/2024	Nighttime Surface Spill Operations
Green Peter Dam	4/11/2024 – 5/13/2024	Continuous Surface Spill
Green Peter Dam	6/7/2024 – 6/11/2024	Continuous Surface Spill

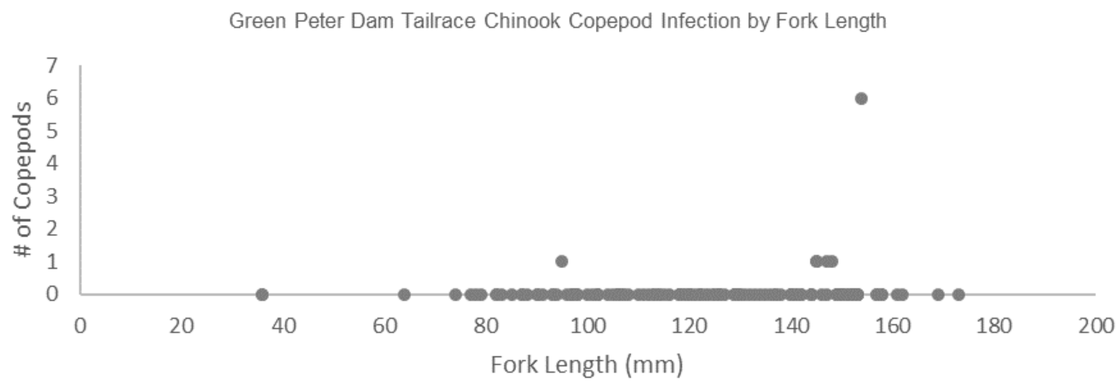

Figure 32. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Green Peter Dam Tailrace.

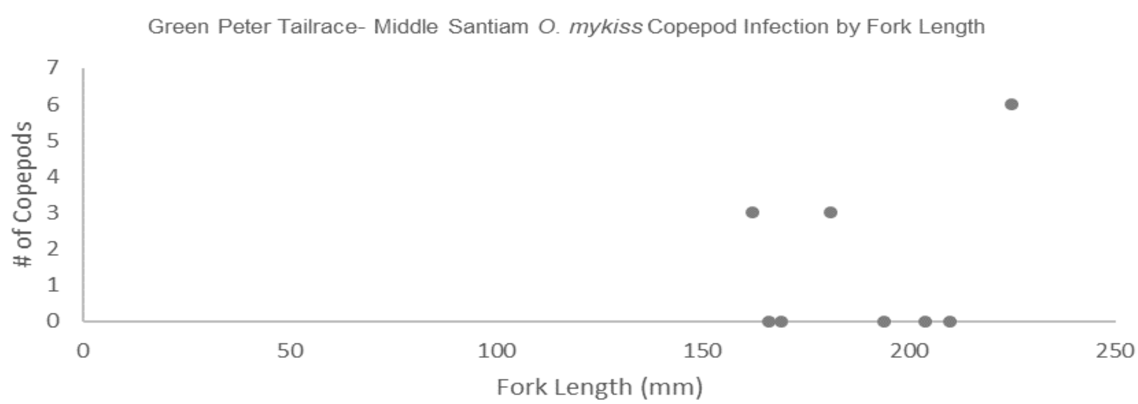

Figure 33. Copepod prevalence vs fork length on juvenile *O. mykiss* captured at Green Peter Dam Tailrace.

24-Hour Hold Trials

24-hour hold trials were performed on NOR juvenile Chinook salmon and *O. mykiss* captured in the Green Peter Dam Tailrace to assess delayed mortality resulting from dam passage. A total of 121 fish, 113 Chinook salmon and 8 *O. mykiss*, were held during the Spring 2024 monitoring period (Table 34). A total of 32 fish died during hold (26.4%), 29 of the 113 Chinook salmon (25.7%) and 3 of the 8 *O. mykiss* (37.5%). Mortality rates across the two-week period in which fish were held ranged from 0 to 66.7%.

Table 34. Summary of 24-hour hold trials for fish captured in the RST at the Green Peter Dam Tailrace site.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
January 1–15, 2024	Chinook	2	0	100.0%
January 1–15, 2024	*O. mykiss*	0	0	--
January 16–31, 2024	Chinook	1	0	100.0%
January 16–31, 2024	*O. mykiss*	0	0	--
February 1–15, 2024	Chinook	0	0	--
February 1–15, 2024	*O. mykiss*	0	0	--
February 16–29, 2024	Chinook	0	0	--
February 16–29, 2024	*O. mykiss*	0	0	--
March 1–15, 2024	Chinook	0	0	--
March 1–15, 2024	*O. mykiss*	0	0	--
March 16–31, 2024	Chinook	2	0	100.0%
March 16–31, 2024	*O. mykiss*	0	0	--
April 1–15, 2024	Chinook	28	15	46.4%
April 1–15, 2024	*O. mykiss*	1	0	100.0%
April 16–30, 2024	Chinook	11	1	90.9%
April 16–30, 2024	*O. mykiss*	4	1	75.0%
May 1–15, 2024	Chinook	27	4	85.2%
May 1–15, 2024	*O. mykiss*	3	2	33.3%
May 16–31, 2024	Chinook	0	0	--
May 16–31, 2024	*O. mykiss*	0	0	--
June 1–15, 2024	Chinook	42	9	21.4%
June 1–15, 2024	*O. mykiss*	0	0	--
June 16–30, 2024	Chinook	0	0	--
June 16–30, 2024	*O. mykiss*	0	0	--

PIT Tagged Fish and Downstream Detections

No fish were PIT tagged at the Green Peter Dam Tailrace site by EAS in the Spring of 2024 as catch never exceeded the 60 fish per week set aside for the 24-hour hold study. No PIT tagged or VIE marked fish were detected at the site from upstream release sites. A summary including tag numbers, observation date, and site can be found in Appendix C.

Willamette Valley Projects Encounters

4 radio and PIT tagged Chinook salmon were captured in the Green Peter Dam Tailrace trap during the reporting period. These fish are a part of a PNNL/USACE dam passage study. Additionally, 88 adipose clipped and PIT tagged Chinook salmon were captured in the spring 2024 period that were associated with large bulk mark releases performed by Cramer Fish Sciences. For more information regarding release groups, dates, and other redetections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

A total of 157 non-target fish were captured in addition to NOR juvenile *O. mykiss* in the Green Peter Dam Tailrace RST in the Spring of 2024 (Table 35). The most common species captured were clipped Chinook, bluegill, and wild kokanee.

Table 35. Summary of non-target fish capture at the Green Peter Dam Tailrace site.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	118	20
Bluegill	10	2
Crappie	2	1
Kokanee (wild)	7	3
Kokanee (clipped)	1	1
O. mykiss (clipped)	1	0
O. mykiss (adult)	7	1
Smallmouth Bass	5	1
Brown Bullhead Catfish	3	0
Largescale Sucker	2	1
Unknown*	1	1
Totals	**157**	**31**

*Species denoted as "unknown" were too small and/or too decomposed to identify.

Foster Dam Head of Reservoir – South Santiam River

A single 5-foot RST was deployed in the South Santiam River above Foster Reservoir on February 1, 2024, and continued sampling until June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Trapping Efficiency Trials

A total of six TE trials occurred from February 2, 2024, through June 5, 2024, in the South Santiam River above Foster Reservoir using hatchery reared Chinook salmon. Collectively, 24 trials have occurred at this site since September 29, 2022. A summary of fish release numbers, recaptures, and flow level for each trial conducted is provided in Table 36.

TEs ranged from 0.0% to 26.1% with a pooled average of 6.3% (95%CI +/- 3.0%, n=19) for all successful trials with five or more recaptures. Five of the trials did not recapture enough fish to be used in the passage estimate calculation. Model results from the discharge and revolutions per hour analysis indicate that four models had a modest to excellent fit for the site. The full model incorporating log-transformed flow, trap revolutions per hour, and the interaction between the covariates had the highest pseudo R^2 ($R^2 = 0.80$) and explained twice the amount of the variation compared to the model incorporating only revolutions per hour. The R^2 value of the full model demonstrates that it was a good fit and explained a significant amount of the variation in the data. Despite its complexity, it achieved the lowest (best) AICc score for the site, indicating that the additional complexity significantly enhanced the model's fit. Interestingly, the model incorporating just discharge as an independent variable had a very poor fit (pseudo $R^2 = <0.01$). Full results and methods for the flow modeling are located in Appendix E.

Past results have shown that low flows in the late spring and summer often result in low recapture numbers. In addition, sub-yearling fish are often recaptured in low numbers, possibly due to the long distance from the release site to the trap. It is also important to note that late spring/summer flows often result in the trap rotating slowly, allowing fish to easily avoid capture. As described in the methods section, it is assumed that fish migrate past the trap within one week of release. In low flow conditions, fish may hold in deep pools instead of actively migrating, resulting in failed TE trials.

Table 36. Summary table of marked hatchery Chinook salmon releases at the Foster Dam Head of Reservoir site for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Foster Dam Head of Reservoir – South Santiam River	9/29/2022	51	1,063	0	0.0%
Foster Dam Head of Reservoir – South Santiam River	10/25/2022	211	821	116	14.1%
Foster Dam Head of Reservoir – South Santiam River	11/1/2022	261	1006	263	26.1%
Foster Dam Head of Reservoir – South Santiam River	11/9/2022	560	1007	68	6.8%
Foster Dam Head of Reservoir – South Santiam River	11/15/2022	240	1009	55	5.5%
Foster Dam Head of Reservoir – South Santiam River	11/22/2022	165	933	163	17.5%
Foster Dam Head of Reservoir – South Santiam River	2/27/2023	376	1,002	21	2.1%
Foster Dam Head of Reservoir – South Santiam River	3/9/2023	313	995	62	6.2%
Foster Dam Head of Reservoir – South Santiam River	3/15/2023	966	1,025	0	0.0%

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Foster Dam Head of Reservoir – South Santiam River	5/11/2023	1,130	985	20	2.0%
Foster Dam Head of Reservoir – South Santiam River	6/2/2023	313	1,003	2	0.2%
Foster Dam Head of Reservoir – South Santiam River	6/29/2023	93	1,000	22	2.2%
Foster Dam Head of Reservoir – South Santiam River	7/27/2023	49	989	0	0.0%
Foster Dam Head of Reservoir – South Santiam River	8/31/2023	35	1,000	0	0.0%
Foster Dam Head of Reservoir – South Santiam River	9/26/2023	50	1,000	6	0.6%
Foster Dam Head of Reservoir – South Santiam River	10/10/2023	52	1,016	55	5.4%
Foster Dam Head of Reservoir – South Santiam River	11/14/2023	431	1,000	102	10.2%
Foster Dam Head of Reservoir – South Santiam River	11/22/2023	321	1,001	79	7.9%
Foster Dam Head of Reservoir – South Santiam River	2/2/2024	1,270	1,005	46	4.6%
Foster Dam Head of Reservoir – South Santiam River	3/19/2024	1,320	1,000	12	1.2%
Foster Dam Head of Reservoir – South Santiam River	4/3/2024	923	1,003	16	1.6%
Foster Dam Head of Reservoir – South Santiam River	4/4/2024	774	1,909	28	1.5%
Foster Dam Head of Reservoir – South Santiam River+	5/15/2024	753	999	30	3.0%
Foster Dam Head of Reservoir – South Santiam River	6/5/2024	1,160	1,000	5	0.5%

+Trapping efficiency release performed by Cramer Fish Sciences

Run of River Trapping Efficiency Trials

No ROR trials occurred during the Spring2024 reporting period due to insufficient numbers of fish captured. Past ROR trials have resulted in small numbers of fish recaptured, likely due to the limited number of fish released. Large numbers of fish are required for release in order to get enough recaptures for meaningful insight. Additional trials will be attempted in the future. A summary of ROR TE trials by month is provided in Table 37.

Table 37. Summary table of run of river releases at the Foster Dam HOR site for trapping efficiency.

Release Location	Date of Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Foster Dam Head of Reservoir	February 2023	5	0	0%
Foster Dam Head of Reservoir	March 2023	17	0	0%
Foster Dam Head of Reservoir	April 2023	10	0	0%
Foster Dam Head of Reservoir	May 2023	19	0	0%
Foster Dam Head of Reservoir	June 2023	5	0	0%
Foster Dam Head of Reservoir	October 2023	62	1	1.6%
Foster Dam Head of Reservoir	November 2023	20	1	5.0%

Target Catch, Passage Estimates and Passage Timing

A total of 39 juvenile Chinook salmon and 205 juvenile *O. mykiss* were captured during monitoring in the Spring of 2024. Peak capture of juvenile Chinook salmon entering Foster Reservoir in the spring occurred during February (n=31, 79.5% of total Chinook salmon catch) (Figure 34). BY 2022 yearlings (n=3, 7.7% of total Chinook salmon catch) and BY 2023 sub-yearling (n=36, 92.3% of total Chinook salmon catch) Chinook salmon were captured at the trap during the spring monitoring period (Figure 36). The first BY 2023 sub-yearling Chinook was captured on February 7, 2024, and catch of Chinook continued through May. Previous studies by Romer (2015) captured the most sub-yearling Chinook salmon 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. Past observations combined with our fry capture during the first week of sampling suggest that we may have missed Chinook salmon fry passing through the trap site prior to the initiation of sampling. For raw weekly Chinook capture at the Foster Dam Head of Reservoir- South Santiam RST site for sampling from 2022 and 2023 as well as adult Chinook out plants from 2010 to 2023, please refer to Appendix I. Using pooled averages of hatchery Chinook TEs, we estimate that 663 (95% CI: 448 to 1,275) juvenile Chinook salmon passed the trapping site during monitoring the Spring of 2024 (Figure 34).

Peak capture of juvenile *O. mykiss* in the spring monitoring period occurred in June (n=160, 78.0% of total *O. mykiss* catch) (Figure 35). *O. mykiss* catch in the spring was comprised of three BYs, BY 2022 (n=19, 9.3% of total *O. mykiss* catch), BY 2023 (n=25, 12.2%), and BY 2024 (n=159, 77.6%) (Figure 37). BY 2022 fish were captured March through June and BY 2023 fish were captured throughout the entire period. The first BY 2024 *O. mykiss* was captured on June 6, 2024, and catch continued throughout the sampling period. The timing of BY 2024 fry is consistent with previous studies observed in the basin (Romer et al. 2010-2016). Sub-yearling fry passage timing and size of age 1- and 2-year-old *O. mykiss* closely resemble observations from catch in this basin by previous studies (Romer et al. 2012-2015). Information regarding length and weight for each BY is summarized in Table 38.

Table 38. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* at the Foster Dam Head of Reservoir RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	2/1/24–6/30/24	22	3	100.7	79	120	103	14.3	5.3	21.6	16.1
Chinook	2/1/24–6/30/24	23	36	40.3	35	86	38	N/A	N/A	N/A	N/A
O. mykiss	2/1/24–6/30/24	22	19	180.1	135	232	186	60.4	27.6	124.2	60.4
O. mykiss	2/1/24–6/30/24	23	25	97.3	71	132	98	11.3	4.3	25.8	10.2
O. mykiss	2/1/24–6/30/24	24	159	31.1	24	51	30	N/A	N/A	N/A	N/A

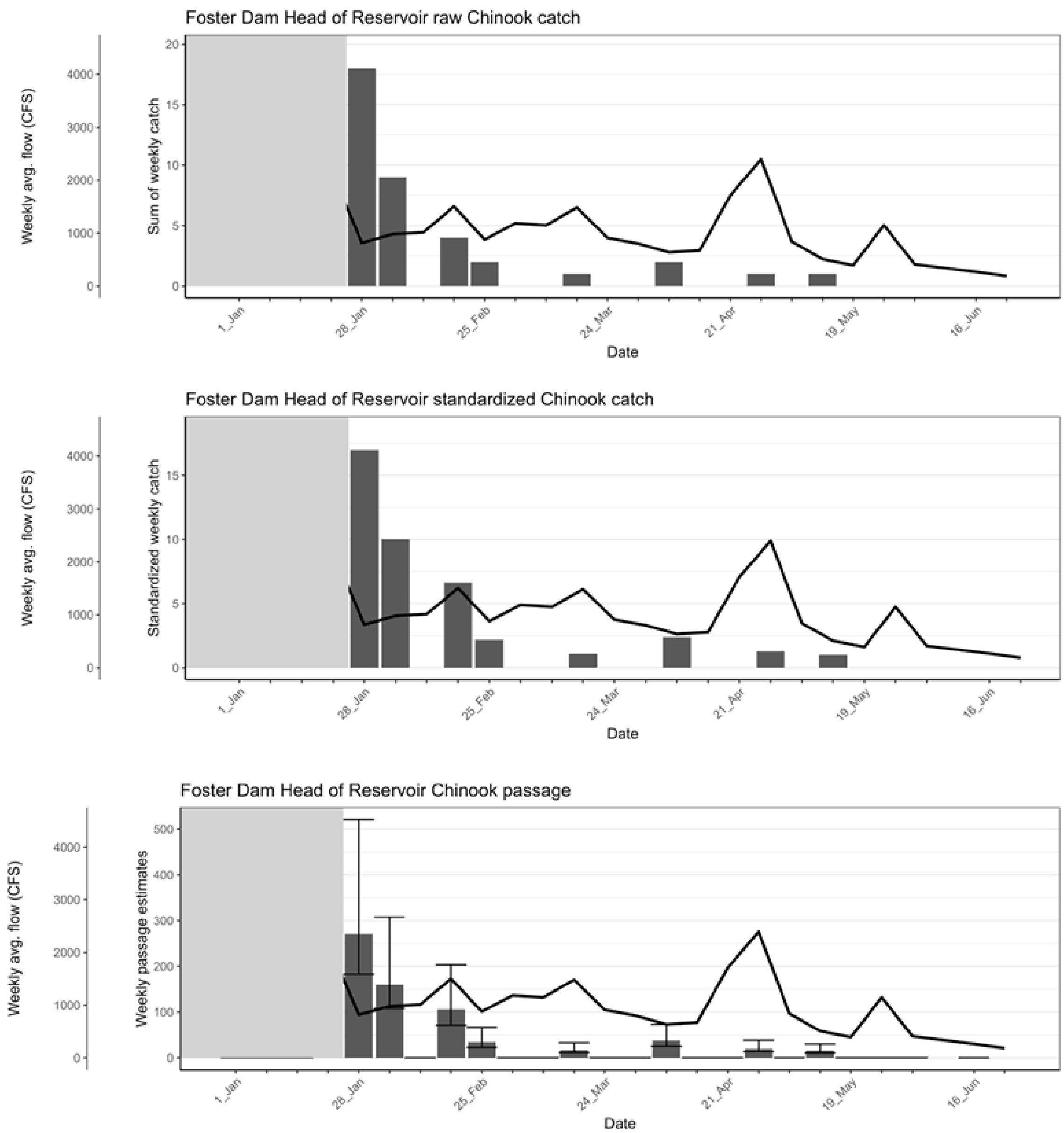

Figure 34. Raw catch (top panel), standardized catch (middle panel), and weekly passage estimates (bottom panel) overlayed with flow (black line) and non-sampling weeks shaded out (gray).

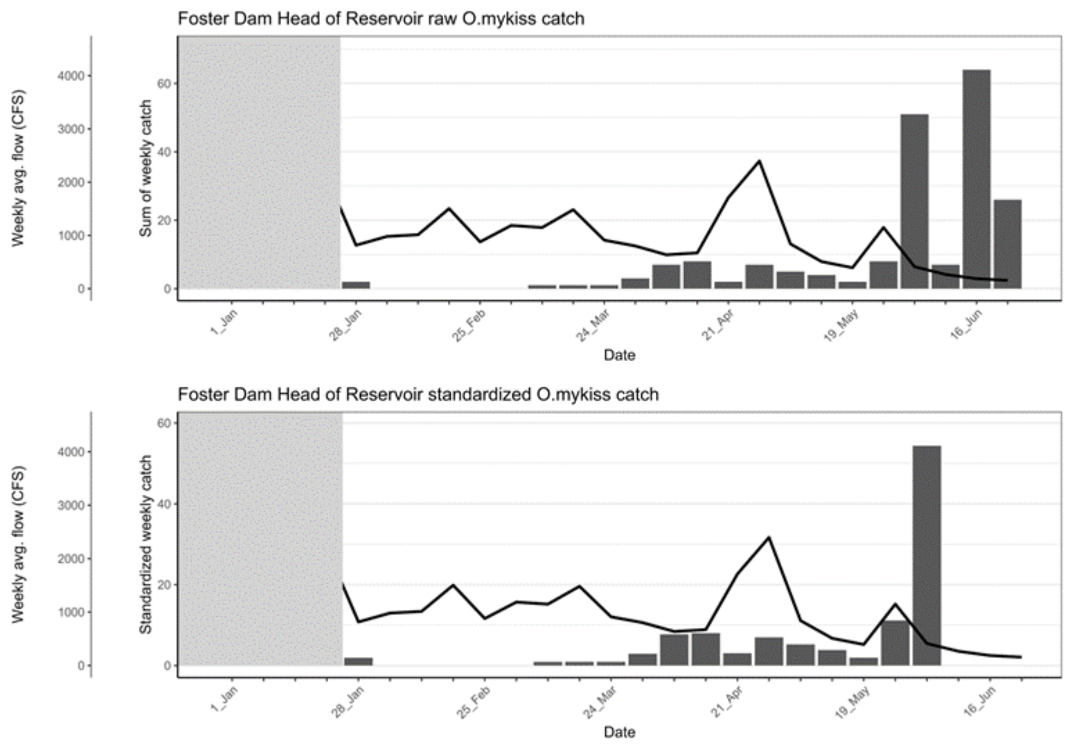

Figure 35. Shows raw (top panel) and weekly standardized (bottom panel) catch of juvenile *O. mykiss* overlayed with stream flow (black line) and non-sampling weeks shaded out (gray).

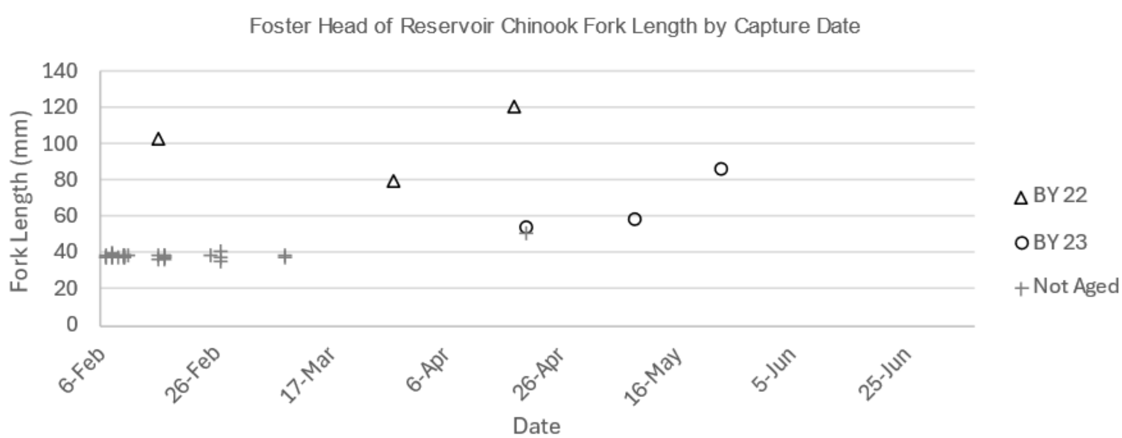

Figure 36. Length-frequency analysis for juvenile Chinook salmon at the Foster Dam Head of Reservoir site.

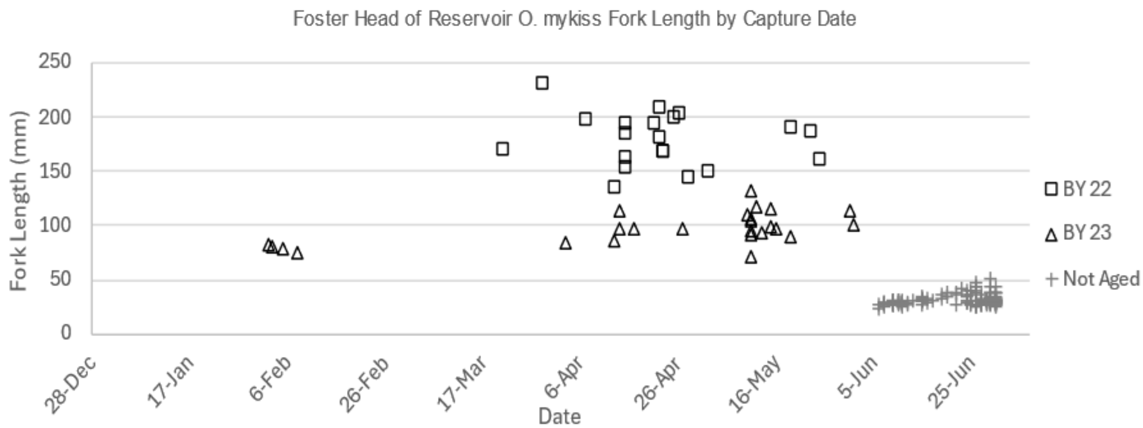

Figure 37. Shows length-frequency analysis by brood year for juvenile *O. mykiss* at the Foster Dam Head of Reservoir site.

Injury Data

A total of 7 juvenile Chinook salmon (18.0% of total Chinook salmon catch) and 42 juvenile *O. mykiss* (20.5% of total *O. mykiss* catch) displayed at least one of the injury code conditions listed in Table 3. The most common injury observed at this site for both Chinook salmon and *O. mykiss* was descaling greater than 20%. These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. Furthermore, 1 Chinook salmon (2.5%) and 1 *O. mykiss* (0.49%) were dead at the time of trap check.

Bulk marked released and TE hatchery Chinook salmon were found to have higher percentages of injuries, including descaling greater than and less than 20%, eye bleeding (hemorrhage), and fin damage as compared to the NOR Chinook salmon from the Foster Dam Head of Reservoir RST site. Descaling greater than 20% and fin damage are common injuries observed within hatchery reared fish (Table 39).

The *O. mykiss* encountered at Foster Dam Head of Reservoir were found to have a higher copepod infection rate than their Chinook salmon counterparts (Figure 38 and Figure 39). Table 39 provides a summary of injuries observed on Chinook salmon and *O. mykiss* at the Foster Dam Head of Reservoir site.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Table 39. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon, in addition to *O. mykiss* at the Foster Dam Head of Reservoir RST site.

Injury Code	Chinook Injuries (NOR) (n=40)	Bulk Marked Released Chinook (n=28)	Trapping Efficiency Hatchery Chinook (n=109)	*O. mykiss* Injuries (NOR) (n=205)
NXI (no external injury)	80.0%	0.0%	0.0%	79.5%
MUNK	2.5%	0.0%	0.0%	0.0%
DS<2	0.0%	10.7%	12.5%	1.0%
DS>2	7.5%	89.3%	87.5%	14.6%
BLO	0.0%	0.0%	0.0%	0.0%
EYB	0.0%	14.3%	4.2%	0.0%
BVT	0.0%	0.0%	0.0%	0.0%
FVB	0.0%	0.0%	8.3%	1.0%
GBD	0.0%	0.0%	16.7%	0.0%
POP	0.0%	7.1%	0.0%	0.0%
HIN	2.5%	3.6%	4.2%	1.5%
OPD	2.5%	0.0%	29.2%	0.5%
TEA	0.0%	0.0%	0.0%	0.5%
BRU	2.5%	3.6%	0.0%	2.4%
HBP	0.0%	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%
FID	0.0%	100.0%	79.2%	14.6%
PRD	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	1.5%
BKD	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%	0.0%

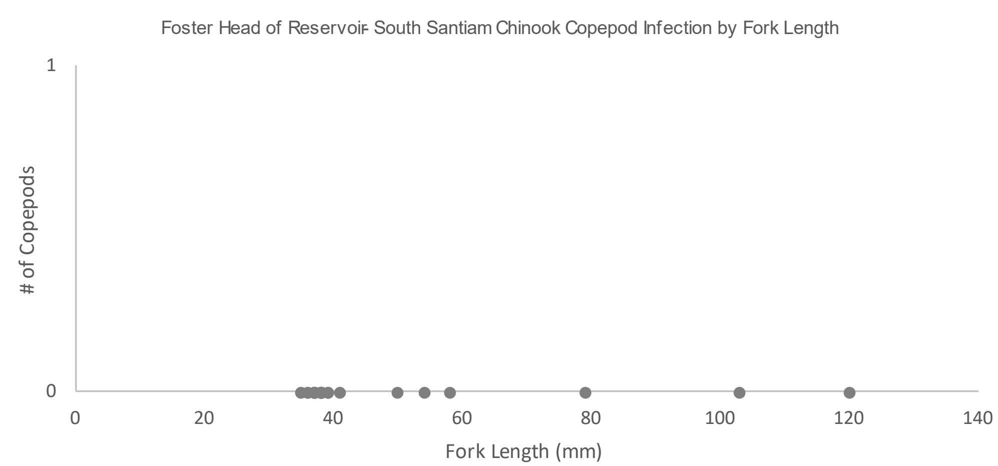

Figure 38. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Foster Dam Head of Reservoir.

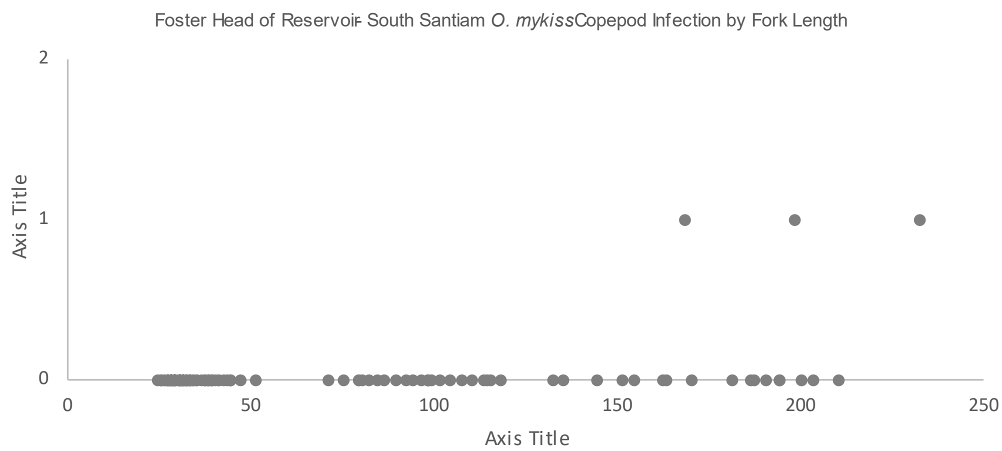

Figure 39. Copepod prevalence vs fork length on juvenile *O. mykiss* captured at Foster Dam Head of Reservoir.

PIT Tagged Fish and Downstream Detections

A total of 4 juvenile Chinook salmon and 43 juvenile *O. mykiss* were PIT tagged and released at the Foster Dam Head of Reservoir site during sampling in the Spring of 2024. A total of two fish were detected at downstream sites, one Chinook salmon and one *O. mykiss.* One PIT tagged Chinook salmon was detected downstream on the PD5 – Columbia River Estuary (rkm 62) 196 days after release at the RST site. One PIT tagged *O. mykiss* was detected on the PD8 – Columbia River Estuary (rkm 82) 320 days after release at the RST site. Table 40 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 40. Summary of PIT tagged fish downstream redetections for the Foster Dam Head of Reservoir site.

Species	PIT Tag #	Mark Date	Redetection Date	Recap Site	Travel Time (Days)
Chinook	3DD.003BD22B76	10/12/2023	4/25/2024	PD5 - Columbia River Estuary rkm 62	196
O. mykiss	3DD.003BD395E4	6/21/2023	5/6/2024	PD8 - Columbia River Estuary rkm 82	320

Willamette Valley Projects Encounters

There were 28 adipose clipped and PIT tagged Chinook encountered at this site in the Spring of 2024. These fish were all released by Cramer Fish Sciences Bulk Mark Release project and used for trapping efficiency trials. For more information regarding release groups, dates, and other redetections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

We captured 86 non-target fish in addition to NOR juvenile Chinook salmon and *O. mykiss* at the Foster Dam Head of Reservoir site (Table 41). Dace and clipped Chinook were the most encountered non-target species.

Table 41. Summary of non-target fish capture at the Foster Dam Head of Reservoir- South Santiam River site.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	16	0
Kokanee (wild)	1	0
Lamprey	1	0
Dace	58	1
Largescale Sucker	1	0
Mountain Whitefish	6	0
Sculpin	2	1
Unknown*	1	0
Totals	**86**	**2**

*Species denoted as “unknown” were too small and/or too decomposed to identify.

Cougar Dam Head of Reservoir

A single 5-foot RST was deployed in the South Fork McKenzie River above Cougar Reservoir on February 1, 2024, and continued sampling until June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Trapping Efficiency Trials

A total of five TE trials occurred from February 6, 2024, through June 12, 2024, at the Cougar Dam Head of Reservoir site using hatchery reared Chinook salmon. Collectively, twenty-four trials have occurred at this site since March 18, 2022. A summary of the fish release numbers, recaptures, and discharge for each trial is provided in Table 42.

TEs ranged from 1.4% to 10.2% with a pooled average of 4.8% (95%CI ± 0.9%, n=24) of all successful trials with five or more recaptures. Model results from the weekly average discharge and revolutions per hour analysis indicate that the model incorporating discharge, trap revolutions per hour, and the interaction between the covariates (discharge multiplied by revolutions per hour) had the highest pseudo R^2 value (R^2 = 0.323) of all models for the site (Table D-1). This model also had a relatively low AICc score, suggesting that the increased complexity of the model provided improvements in model fit. Full results and methods for the flow modeling are in Appendix E.

Table 42. Summary table of marked hatchery Chinook salmon releases at the Cougar Dam Head of Reservoir site for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Cougar Dam Head of Reservoir	3/18/2022	774	806	40	5.0%
Cougar Dam Head of Reservoir	5/19/2022	1380	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%
Cougar Dam Head of Reservoir	4/14/2023	980	506	10	2.0%
Cougar Dam Head of Reservoir	5/10/2023	1,170	508	7	1.4%
Cougar Dam Head of Reservoir	5/16/2023	1,700	497	23	4.6%
Cougar Dam Head of Reservoir	6/8/2023	503	510	23	4.5%
Cougar Dam Head of Reservoir	7/27/2023	223	758	27	3.6%
Cougar Dam Head of Reservoir	9/21/2023	194	745	41	5.5%
Cougar Dam Head of Reservoir	10/19/2023	211	750	42	5.6%
Cougar Dam Head of Reservoir	11/14/2023	340	756	21	2.8%
Cougar Dam Head of Reservoir	11/28/2023	261	760	67	8.8%
Cougar Dam Head of Reservoir	2/6/2024	899	768	53	6.9%
Cougar Dam Head of Reservoir	3/12/2024	849	756	26	3.4%
Cougar Dam Head of Reservoir	4/1/2024	751	754	24	3.2%
Cougar Dam Head of Reservoir	5/22/2024	859	760	41	5.4%
Cougar Dam Head of Reservoir	6/12/2024	445	750	17	2.3%

Run of River Trapping Efficiency Trials

Releases for ROR TE trials were pooled by month. During sampling in the Spring of 2024, a sufficient number of fish to perform ROR trials only occurred in April. In April, 83 fish were released but none were recovered. TEs for releases in 2023 ranged from 2.7% to 25%, however the highest TE resulted from a release of only four fish (Table 43). The sum of the weighted TEs is 1.9% and represents the overall ROR TE at this site. Given the limited number of releases and small number of recaptures, more data is required for any meaningful insight or a comparison with trials using hatchery-origin fish.

Table 43. Summary table of run of river releases at the Cougar Dam Head of Reservoir site for trapping efficiency.

Release Location	Date of Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Cougar Dam Head of Reservoir	September 2023	71	2	2.7%
Cougar Dam Head of Reservoir	October 2023	4	1	25.0%
Cougar Dam Head of Reservoir	April 2024	83	0	0%

Target Catch, Passage Estimates and Passage Timing

The trap captured 254 juvenile Chinook salmon during this reporting period. Peak catch of juvenile Chinook salmon above Cougar Reservoir in the spring occurred in April (n= 174, 68.5% of total Chinook salmon catch). This timing is consistent with data from previous studies (Romer et al. 2016). Figure 40 shows raw and standardized catch overlayed with flow at the Cougar Dam Head of Reservoir site. Chinook salmon catch from February 1, 2024, through June 30, 2024, consisted of two BY classes, BY 2022 (n= 28, 11.0%) and BY 2023 (n= 226, 89.0%). BY 2023 sub-yearling Chinook salmon were the dominant age class captured at this site throughout the reporting period (Figure 41). The first BY 2023 Chinook salmon captured at the trap occurred on February 3, 2024, and catch of sub-yearlings continued through June. The first BY 2022 yearling was captured on February 2, 2024, and yearling catch continued into May. Since BY 2022 yearlings and 2023 sub-yearlings were captured so close to the initiation of sampling, it is likely that some early migrants were missed prior to sampling in 2024. Using pooled averages of hatchery Chinook TEs, EAS estimates that 5,747 (95% CI: 4,806 to 7,146) juvenile Chinook salmon passed the RST site during sampling in the Spring of 2024 (Figure 40). A summary of fork length and weight data by BY is provided in Table 44.

Table 44. Summary of fork length and weight observed on juvenile Chinook salmon at the Cougar Dam Head of Reservoir RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	2/1/2024–6/30/2024	22	28	79.6	51	95	82.5	5.8	1.8	9.1	5.85
Chinook	2/1/2024–6/30/2024	23	226	36.1	31	70	36	N/A	N/A	N/A	N/A

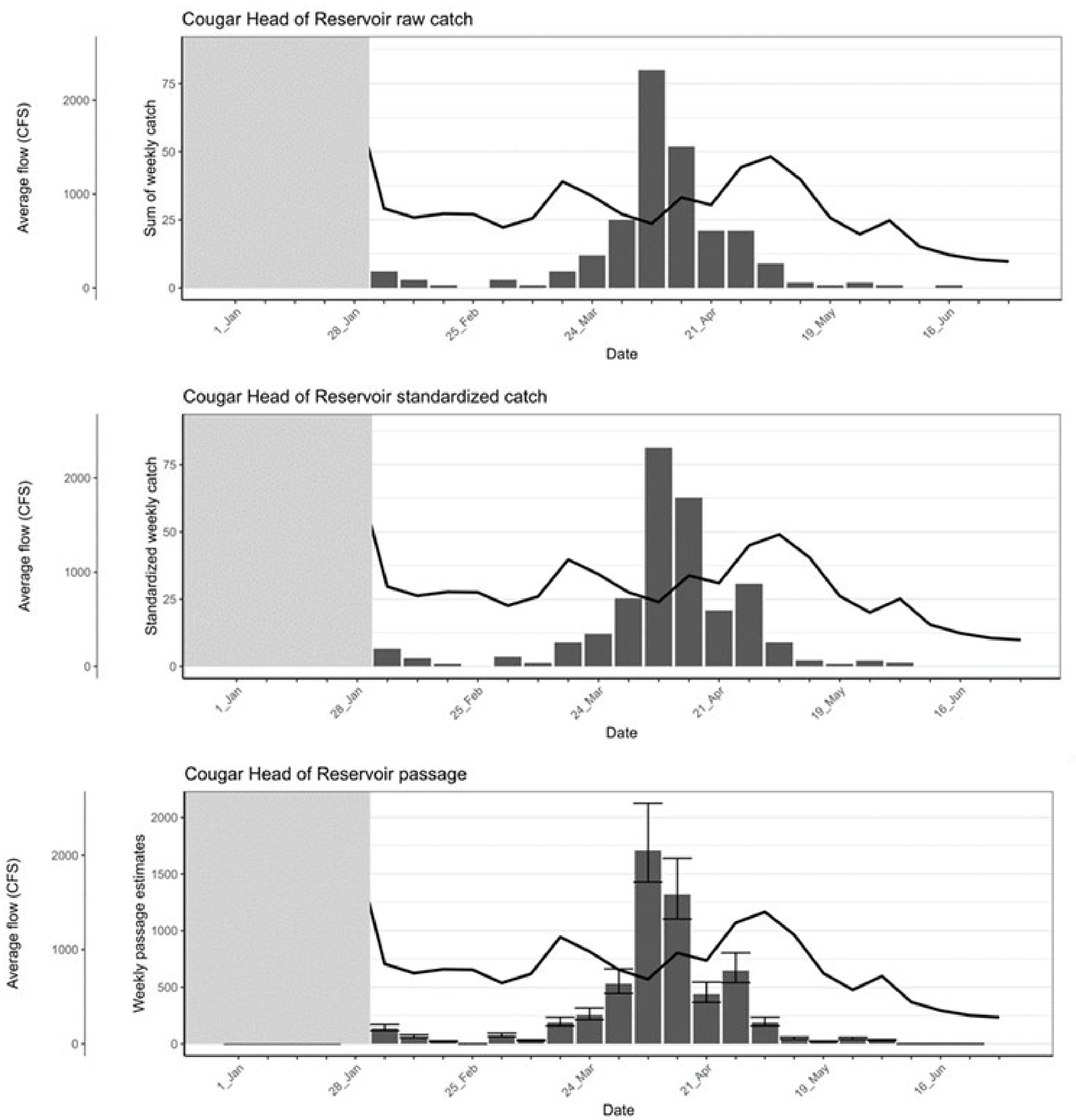

Figure 40. Raw catch (top panel), standardized catch (second panel), and weekly passage estimates (bottom panel) overlayed with stream flow (black line) for the Cougar Dam Head of Reservoir RST.

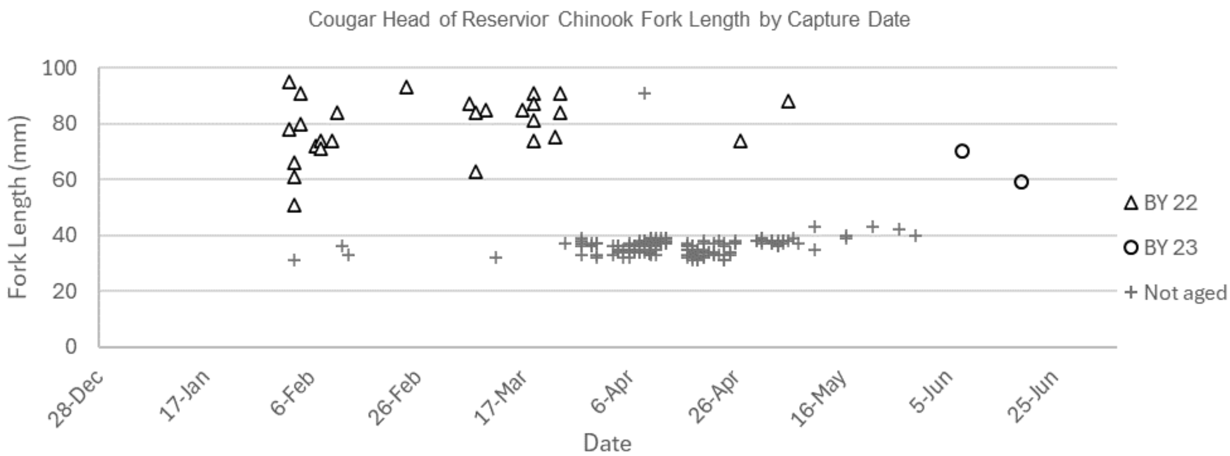

Figure 41. Length-frequency of juvenile Chinook salmon by Brood Year at the Cougar Dam Head of Reservoir site.

Injury Data

A total of 37 juvenile Chinook salmon (14.6% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 3. The most common injuries observed at this site include descaling greater 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.

Copepod presence on captured Chinook salmon showed a positive association with the size of fish similar to observations made by previous studies (Cramer Fish Sciences 2022; Monzyk et al. 2015). However, this correlation is not as strong as those seen in other basins (Figure 42). Copepod presence on Chinook salmon was only observed in fish that had a fork length of at least 60 mm. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

There were 2 mortalities (0.8% of total Chinook salmon catch) likely resulting from high debris in the trap. These Chinook salmon were found dead at the time of trap check. TE hatchery Chinook salmon exhibited higher percentages of descaling greater than 20%, operculum damage, fin damage, and fungus when compared to NOR fish. Additionally, no CFS bulk marked released Chinook salmon were found at this site by EAS personnel. A summary of injuries observed at the Cougar Dam Head of Reservoir site is provided in Table 45.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally decreased from pre-release to recaptured observations at the Cougar Head of Reservoir RST site (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Table 45. Summary of injuries observed on NOR and TE hatchery Chinook salmon at the Cougar Head of Reservoir RST site.

Injury Code	Chinook Injuries (NOR) (n=254)	Trapping Efficiency Hatchery Chinook (n=161)
NXI (no external injury)	85.4%	13.7%
MUNK	0.0%	0.0%
DS<2	0.4%	8.1%
DS>2	9.8%	71.4%
BLO	0.0%	0.0%
EYB	0.4%	0.0%
BVT	0.0%	0.0%
FVB	1.6%	0.0%
GBD	0.0%	0.0%
POP	0.4%	0.6%
HIN	2.0%	0.6%
OPD	1.2%	13.0%
TEA	1.2%	0.0%
BRU	2.4%	2.5%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	6.3%	75.2%
PRD	0.0%	0.0%
COP	2.0%	0.8%
BKD	0.0%	0.0%
FUN	0.0%	4.3%

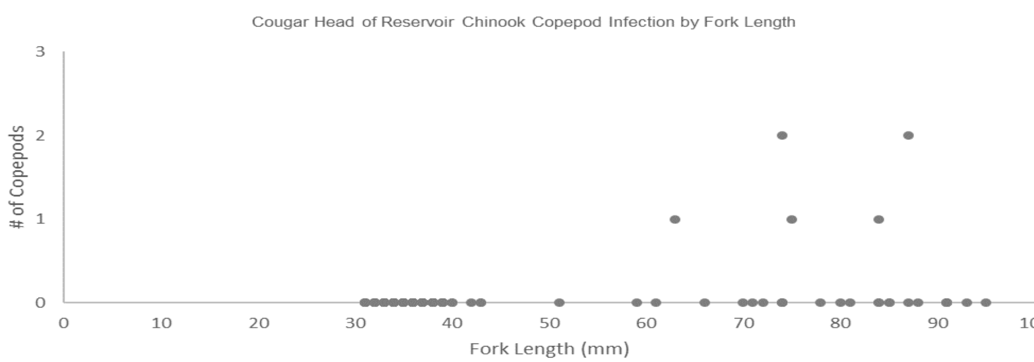

Figure 42. Copepod presence vs fork length on juvenile Chinook salmon captured at Cougar Dam Head of Reservoir.

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 25 NOR Chinook salmon were PIT tagged and 159 were VIE marked at Cougar Dam Head of Reservoir site in the Spring 2024 monitoring period. The rest of the captured fish were either sac-fry or did not meet minimum length requirements for tagging. No VIE marked fish have been detected downstream July of 2024.

As of June 30, 2024, data from the ODFW PIT arrays at Cougar Dam has not been available on PTAGIS or directly from ODFW. One Chinook salmon smolt was redetected at the Cougar Dam Tailrace PH trap. The travel time was 118 days. A summary of downstream PIT tag detections is provided in Table 46 and Table 47 provides a summary of VIE marked fish for the reporting period. See Appendix C for information regarding tags encountered at the Cougar Dam Head of Reservoir site and VIE marked fish.

Table 46. Summary of redetections of juvenile PIT tagged Chinook at the Cougar Dam Head of Reservoir site.

PIT Tag #	Mark Date	Redetection Date	Recap Site	Travel Time (Days)
3DD.003BD224C5	11/4/2023	3/1/2024	Cougar Dam	118

Table 47. Summary of VIE marked Chinook salmon at the Cougar Dam Head of Reservoir site.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured
02/01/2024–02/15/2024	Right Dorsal	Yellow	4	0
02/16/2024–02/29/2024	Right Dorsal	Yellow	0	0
03/1/2024–03/15/2024	Right Dorsal	Red	1	0
03/16/2024–03/31/2024	Right Dorsal	Red	12	0
04/01/2024–04/15/2024	Right Dorsal	Blue	79	0
04/16/2024–04/30/2024	Right Dorsal	Blue	31	0
05/01/2024–05/15/2024	Right Dorsal	Orange	27	0
05/16/2024–05/31/2024	Right Dorsal	Orange	4	0
06/01/2024–06/15/2024	Right Dorsal	Pink	0	0
06/16/2024–06/30/2024	Right Dorsal	Pink	1	0

Willamette Valley Projects Encounters

No adipose clipped and PIT tagged Chinook salmon were captured in the Cougar Dam Head of Reservoir trap during the Spring 2024 monitoring period. For more information regarding release groups, dates, and other redetections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

A total of 560 non-target fish were captured in addition to NOR juvenile Chinook salmon at the Cougar Dam Head of Reservoir RST site. A summary of species and numbers of fish caught are provided in Table 48. The most captured non-target species were *O. mykiss*. Additionally, the RST captured 4 Bull Trout that were reported to ODFW. All Bull Trout were measured and scanned for PIT tags. A juvenile Brook Trout was encountered this year and was reported to ODFW. Additional information on captured Bull Trout is provided in Appendix C.

Table 48. Summary of non-target species capture at the Cougar Dam Head of Reservoir RST site.

Species	Season Total	Season Total Mortality (subset of total)
Bull Trout	4	0
Brook Trout	1	0
Chinook (clipped)	2	0
Cutthroat Trout	3	0
Dace	2	0
Mountain Whitefish	2	0
O. mykiss	532	0
O. mykiss (adult)	6	0
Lamprey	3	0
Sculpin	5	0
Totals	**560**	**0**

*Species denoted as “unknown” were too small and/or too decomposed to identify.

Cougar Dam Tailrace

Two 8-foot RSTs in the PH channel and one 5-foot RST in the RO channel continued monitoring activities below Cougar Dam and sampled from January 1, 2024, through June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Trapping Efficiency Trials

A total of ten TE trials occurred below Cougar Dam from January 11, 2024, through June 12, 2024, using hatchery reared Chinook salmon. Of these, six occurred in the powerhouse (PH) channel and four in the regulating outlet (RO) channel. Collectively, 41 TE trials have occurred at this site (19 at the PH and 22 at the RO) since January 19, 2022. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 49.

TEs ranged from 0.0% - 12.9% in the RO channel and 1.0% to 29.9% in the PH channel. The pooled average is 6.3% (95%CI ±1.6%, n=18) for the RO channel and 11.8% (95%CI ±3.1%, n=19) for the PH channel of all successful trials with five or more recaptures. Four of the trials, all occurring in the RO channel, did not recapture enough fish to be used in the passage estimate calculation. For the RO channel, model results from the weekly average discharge and revolutions per hour analysis show that all models have low pseudo R^2 values (Table D-1). Of all the models for the RO channel, the model incorporating log-transformed discharge, trap revolutions per hour, and the interaction between the covariates had the highest pseudo R^2 value (R^2 = 0.027). This model also had the lowest AICc score for the RO site (Table D-1). For the PH channel, model results from the weekly average discharge and revolutions per hour analysis also show that all models have low pseudo R^2 values (Table D-1). Of all the models for the PH channel, the model incorporating discharge and trap revolutions per hour, had the highest pseudo R^2 value (R^2 = 0.179). The AIC score for this model fell out in the middle of the range for all model AICc scores for the PH site (Table D-1). Full results and methods for the flow modeling are in Appendix E.

Table 49. Summary table of marked hatchery Chinook salmon releases at Cougar Dam for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Cougar Dam Powerhouse Channel	1/19/2022	925	997	37	3.7%
Cougar Dam Regulating Outlet Channel	1/19/2022	1,000	995	26	2.6%
Cougar Dam Powerhouse Channel	4/20/2022	860	1,000	67	6.7%
Cougar Dam Regulating Outlet Channel	4/20/2022	400	995	16	1.6%
Cougar Dam Regulating Outlet Channel	5/15/2022	2,570	500	64	12.8%
Cougar Dam Powerhouse Channel	7/19/2022	310	535	148	27.7%
Cougar Dam Powerhouse Channel	8/11/2022	700	949	29	3.1%
Cougar Dam Regulating Outlet Channel	10/14/2022	890	509	49	9.6%
Cougar Dam Regulating Outlet Channel	11/22/2022	350	504	24	4.8%
Cougar Dam Regulating Outlet Channel	12/13/2022	430	502	42	8.4%
Cougar Dam Regulating Outlet Channel	12/15/2022	360	1,010	56	5.5%
Cougar Dam Regulating Outlet Channel	12/20/2022	360	1,014	61	6.0%

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Cougar Dam Regulating Outlet Channel	12/28/2022	900	704	14	2.0%
Cougar Dam Powerhouse Channel	1/12/2023	500	843	159	18.9%
Cougar Dam Regulating Outlet Channel	1/30/2023	350	509	6	1.2%
Cougar Dam Powerhouse Channel	3/23/2023	500	500	49	9.8%
Cougar Dam Regulating Outlet Channel	3/23/2023	800	511	3	0.6%
Cougar Dam Powerhouse Channel	3/30/2023	490	497	95	19.1%
Cougar Dam Regulating Outlet Channel	3/30/2023	300	491	31	6.3%
Cougar Dam Powerhouse Channel	4/18/2023	580	297	14	4.7%
Cougar Dam Regulating Outlet Channel	4/18/2023	800	501	2	0.4%
Cougar Dam Powerhouse Channel	5/10/2023	710	499	5	1.0%
Cougar Dam Regulating Outlet Channel	5/10/2023	600	499	0	0.0%
Cougar Dam Powerhouse Channel	6/6/2023	370	507	65	12.8%
Cougar Dam Powerhouse Channel	7/26/2023	370	510	63	12.4%
Cougar Dam Powerhouse Channel	9/21/2023	340	500	53	10.6%
Cougar Dam Powerhouse Channel	10/11/2023	290	500	83	16.6%
Cougar Dam Regulating Outlet Channel	10/11/2023	350	518	14	2.7%
Cougar Dam Regulating Outlet Channel	11/8/2023	1,100	508	43	8.5%
Cougar Dam Regulating Outlet Channel	11/30/2023	310	505	26	5.1%
Cougar Dam Regulating Outlet Channel	12/18/2023	1,200	505	2	0.4%
Cougar Dam Regulating Outlet Channel	1/11/2024	890	505	65	12.9%
Cougar Dam Powerhouse Channel	1/30/2024	1,040	502	70	13.9%
Cougar Dam Powerhouse Channel	2/7/2024	1,040	493	43	8.7%
Cougar Dam Regulating Outlet Channel	2/7/2024	2,000	505	9	1.8%
Cougar Dam Powerhouse Channel	3/11/2024	650	499	33	6.6%
Cougar Dam Regulating Outlet Channel	3/12/2024	720	499	16	3.2%
Cougar Dam Regulating Outlet Channel	4/1/2024	950	502	52	10.4%
Cougar Dam Powerhouse Channel	4/4/2024	1,010	501	33	6.6%
Cougar Dam Powerhouse Channel	5/22/2024	330	500	38	7.6%
Cougar Dam Powerhouse Channel	6/12/2024	500	501	102	20.4%

Run of River Trapping Efficiency Trials

Releases for ROR TE trials were pooled by month. A total of 78 Chinook salmon were released into the PH channel for ROR TE trials in February 2024 (Table 50). Of these, only five were recaptured in the trap for a TE of 6.4%. In total, 2,581 Chinook have been released into the RO channel and 84 have been released into the PH channel for ROR trials since April 2023. To account for sample size variability, monthly calculations were weighted based on sample size and then summed yielding an estimated TE for ROR trials of 4.8% and 6.0% for the RO and PH channels, respectively. These values were used to represent ROR TE for all corresponding RO and PH trials.

In addition to live fish trials, 45 dead Chinook were released into the PH channel in February 2024. These fish were found dead in the RST during trap checks and were used to conduct the trials. Fish were both upper and lower caudal clipped so as not to be confused with other dead fish found in the trap. Six of these fish were recaptured for a TE of 13.3%. However, the sample size is too small for meaningful insight from these trials. More dead fish trials will be performed in 2024 to increase the sample size.

Table 50. Summary table of run of river releases at the Cougar Dam site for trapping efficiency.

Release Location	Date of Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Regulating Outlet	April 2023	593	16	2.7%
Powerhouse	April 2023	6	0	0.0%
Regulating Outlet	October 2023	1,508	65	4.3%
Regulating Outlet	November 2023	480	43	9.0%
Powerhouse (dead)	February 2024	45	6	13.3%
Powerhouse	February 2024	78	5	6.4%

Target Catch, Passage Estimates and Passage Timing

A total of 1,131 juvenile Chinook salmon were captured at the Cougar Dam Tailrace during the reporting period. Of these, 305 Chinook salmon were captured in the PH traps (27.0% of total catch) (Figure 43) and 826 in the RO trap (73.0% of total catch) (Figure 44). Peak capture in the PH traps occurred in February (n=181, 36.1% of total PH catch). Peak capture in the RO channel occurred in February and March (n= 736, 89.1% of total RO catch). Total catch for the spring of 2024 was similar to that of 2023 but lower than the observed catch for the spring of 2022 and 2021. Total spring catch in 2024 was within the range observed from sampling by ODFW from 2011 to 2016 (see Appendix I and Romer et al. 2012–2016).

Chinook salmon catch was comprised of three BYs, BY 2021, BY 2022, and BY 2023 (Table 51 and Figure 45). Catch of yearling and older Chinook salmon below Cougar Dam during this period was significantly higher than had been observed in the past by previous monitoring efforts (Romer et al. 2016; CFS 2023a). This could be related to the number of adult Chinook out plants that occurred during 2021, 2022 and 2023. Sampling from 2015 (Romer et al. 2016) showed a majority of spring capture occurred in the powerhouse traps in contrast to observations from sampling through the Spring of 2024. The first BY 2023 sub-yearling was captured on February 13, 2024, significantly earlier than what was observed in 2023 (EAS 2023). Catch of BY 2023 sub-yearlings continued through the end of June. Scale age analysis shows a significant overlap in size between BY 2021 and BY 2022 Chinook captured at this site in 2024. This overlap does not allow us to assign a BY to a captured Chinook salmon based on its fork length and thus, length and size statistics for BY 2021 and BY 2022 Chinook salmon will be reported for both BYs combined. BY 2021 and 2022 Chinook comprised a majority of the catch in RSTs below Cougar Dam during monitoring in the Spring of 2024 (n= 1,091, 96.5% of total Chinook capture) and were encountered throughout the sampling period (Figure 45). A summary of fork length and weight data by BY is provided in Table 51.

Peak capture of Chinook salmon below Cougar Dam during the Spring of 2024 coincided with spring RO operations. Capture data shows significant increases in catch rate during spill operations in February and March and RO capture continued at a lower rate through the end of April. There was also an increase in Chinook salmon capture in the PH traps that occurred in June. We estimate that 12,935 (95% CI: 10,279 to 17,441) Chinook salmon passed through the RO and 2,519 (95% CI: 1,997 to 3,413) passed through the PH from January 1, 2024, through June 30, 2024 (Figure 43 and Figure 44). Total passage for this period at Cougar Dam is estimated to be 15,454 (95% CI: 12,276 to 20,854) juvenile Chinook salmon.

Table 51. Summary of fork length and weight observed on juvenile Chinook salmon of NOR at the Cougar Dam RST sites by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/24–6/30/24	21 and 22	1,091	116.2	57	207	118	18.1	2.9	80.3	16.5
Chinook	1/1/24–6/30/24	23	40	48.5	35	80	39.5	3.2	<1	6	1.0

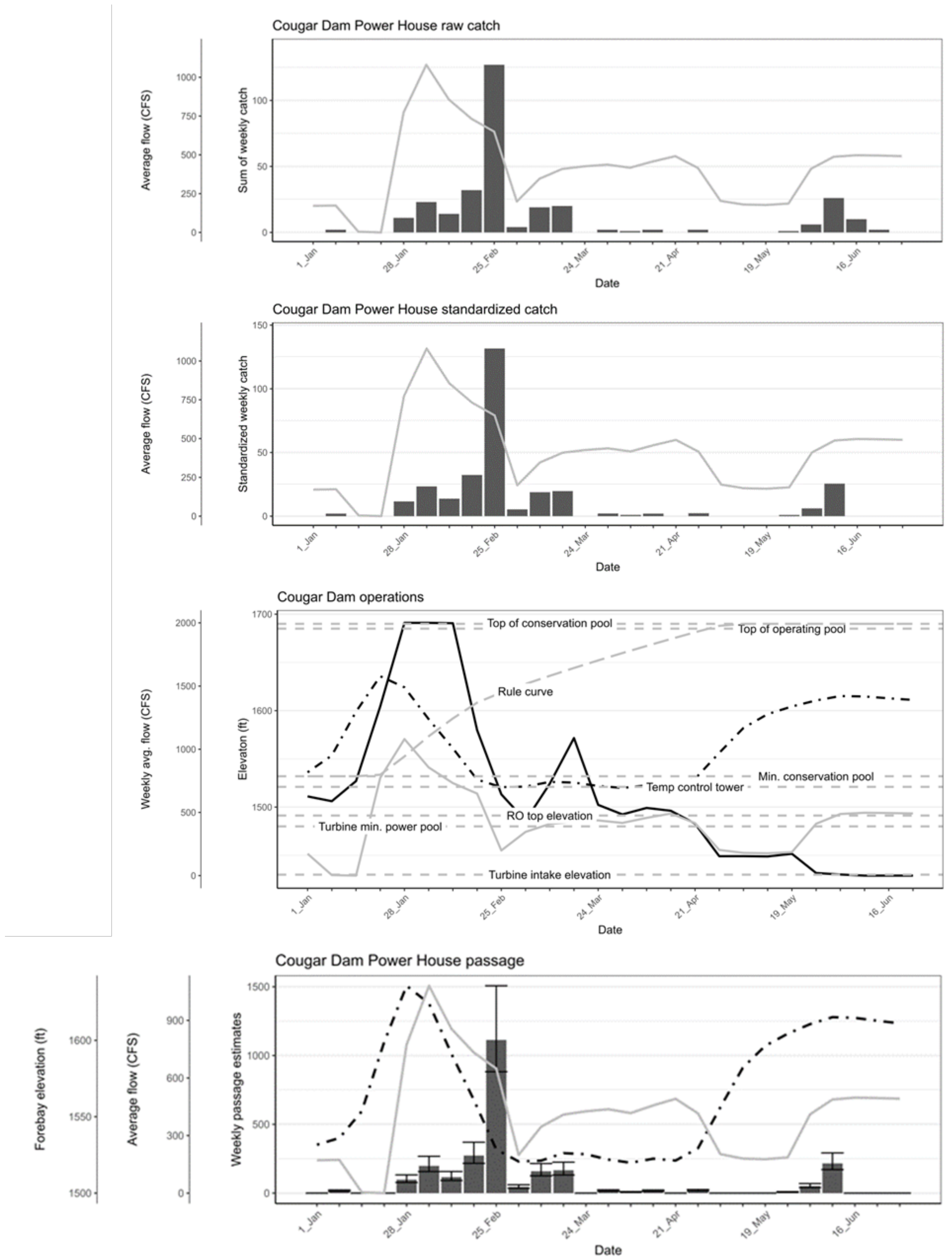

Figure 43. Raw catch (top panel), standardized catch (second panel), and weekly passage estimates (bottom panel) overlayed with Powerhouse outflow (gray line), forebay elevation (black dot dash line), and non-sampling weeks shaded out (gray) for the Powerhouse traps at Cougar Dam. The third panel displays Cougar Dam operations and features of interest with forebay elevation (black dot dash line).

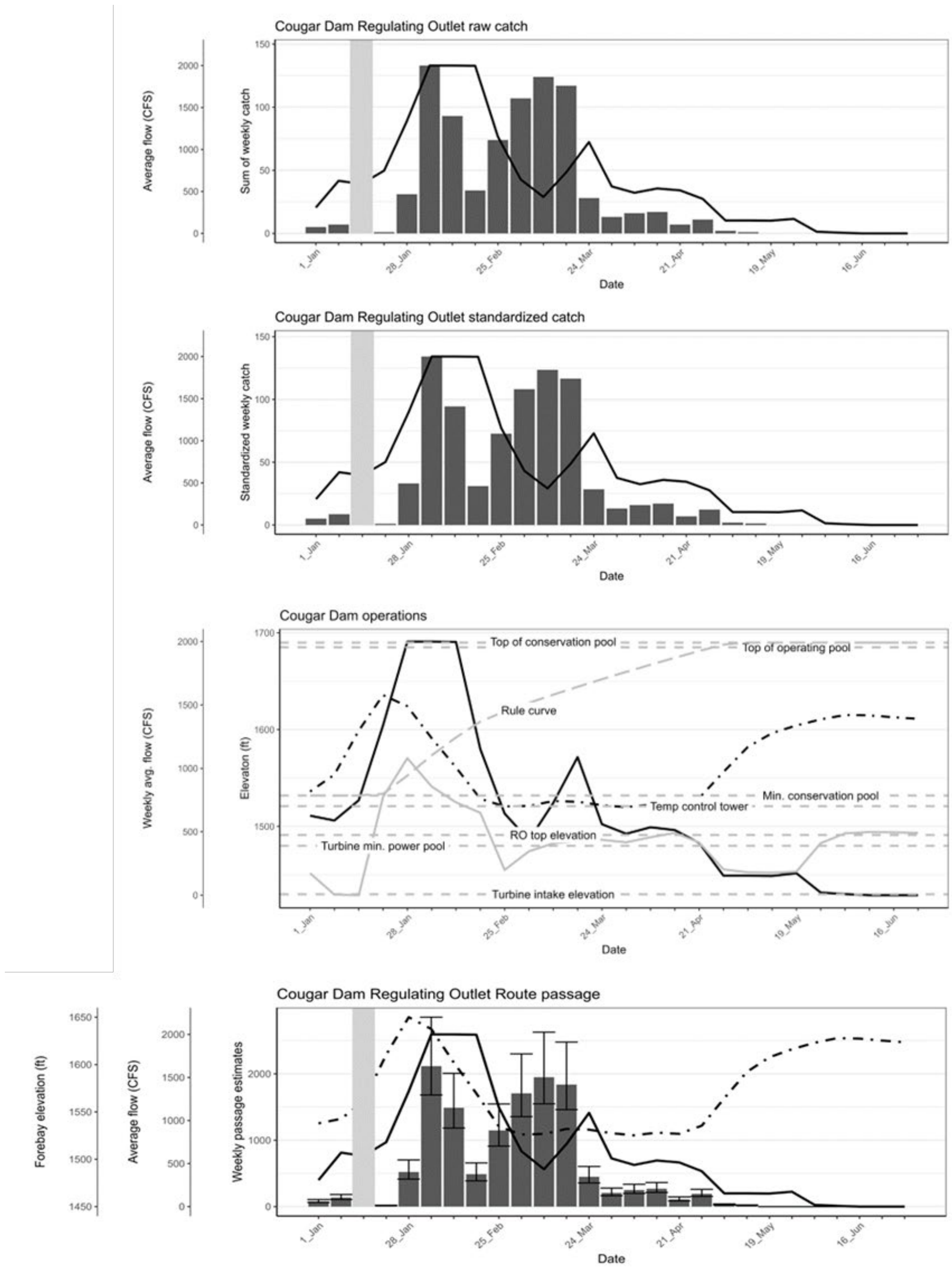

Figure 44. Raw catch (top panel), standardized catch (second panel), and weekly passage estimates (bottom panel) overlayed with Powerhouse outflow (gray line), forebay elevation (black dot dash line), and non-sampling weeks shaded out (gray) for the RO trap at Cougar Dam. The third panel displays Cougar Dam operations and features of interest with forebay elevation (black dot dash line).

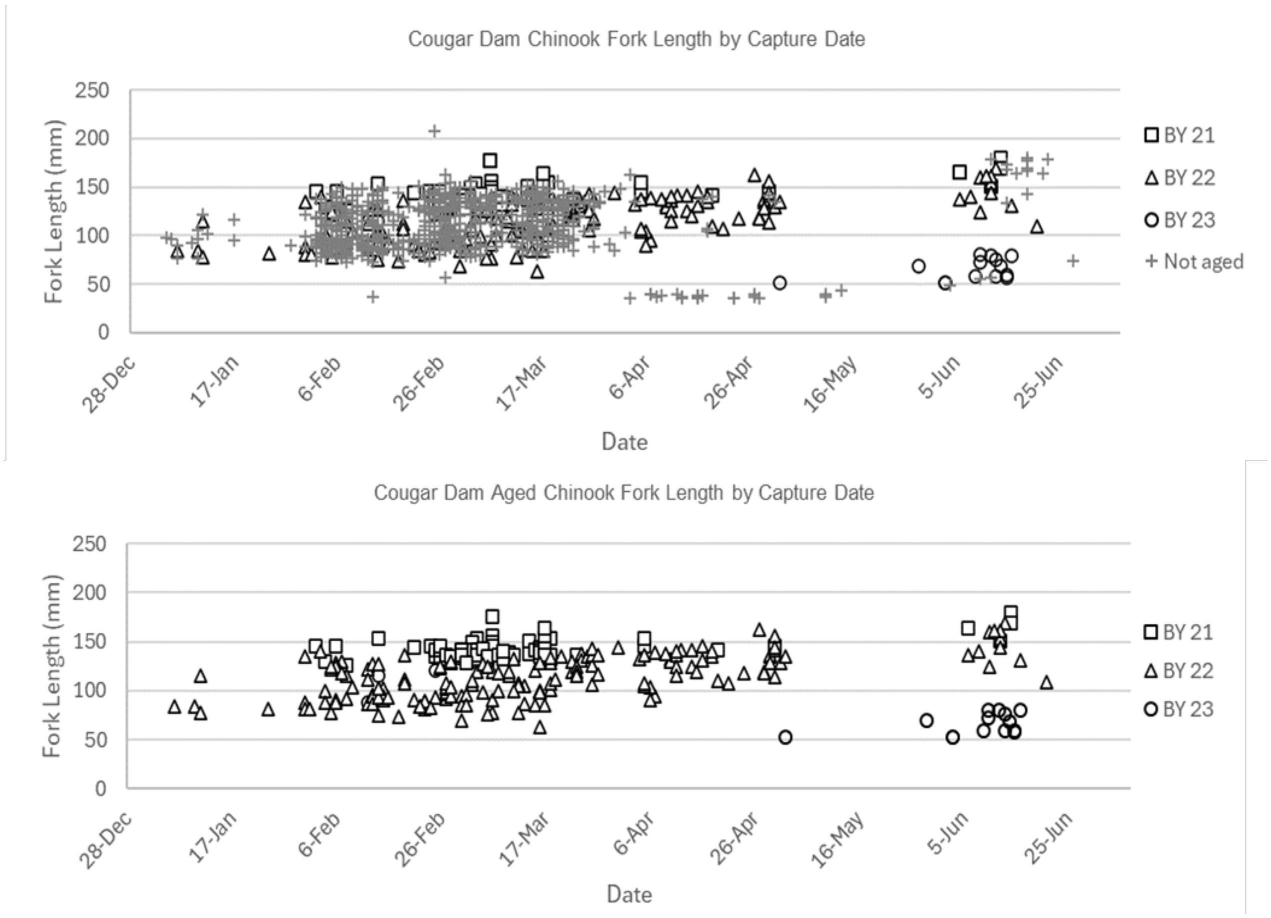

Figure 45. Length-frequency age analysis for juvenile Chinook salmon captured below Cougar Dam. The top panel shows all fish and bottom panel shows only the aged fish.

Injury Data

A total of 1,100 juvenile Chinook salmon (97.3% of total Chinook salmon catch), 810 captured in the RO trap (98.1% of total RO catch) and 290 captured in the PH traps (95.1% of total PH catch), displayed at least one of the injury code conditions listed in Table 3. The most predominant injuries observed among fish at the Cougar Dam RST site were descaling greater than 20%, fin damage, and the presence of copepods. Furthermore, EAS crews observed that 170 Chinook salmon (15.0% of total Chinook salmon catch) were dead at the time the RST was checked, 32 in the Powerhouse traps (10.5% of Powerhouse capture) and 138 in the RO trap (16.7% of total RO capture).

To provide insight on injuries associated with capture in a RST, injury data was collected from both bulk mark released Chinook and hatchery fish utilized for TE trials at time of release and upon recapture. Injury rates by type, pre and post capture were then compared to elucidate a rate of injury occurrence attributable to trap capture. The most common injuries associated with trap capture include descaling less than 20% and fin damage while the most common injuries observed on captured NOR fish include descaling less than 20%, descaling greater than 20%, operculum damage, and fin damage (Appendix D).

Similar to previous findings within this report, bulk mark recaptured Chinook salmon at both the PH and RO were evidenced to have a higher percentage of injuries as a whole (Table 52 and Table 53). The most predominant injuries observed on Chinook salmon that were bulk mark recaptured fish in both the PH and RO channels were descaling greater than 20% and fin damage. TE hatchery Chinook exhibited similar injuries to both the NOR and bulk marked released Chinook. Percentages of fish that were observed with descaling greater than 20% and fin damage remained consistent, while the TE Chinook had significantly higher levels of fungus, an injury code which can potentially be attributed to hatchery rearing.

For fish captured in the PH traps, the most common injuries are bleeding from vent and pop eye (eye popping out of head), while the most common injuries for fish in the RO are descaling greater than 20%, fin damage, and the presence of copepods. Injury rates generally increased with RO spill. 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 52 and Table 53 show injuries observed on Chinook salmon by route of passage. The proportion of fish displaying injuries by type over the sample period is shown in Figure 46. Furthermore, positive associations between spill at Cougar Dam Tailrace and bodily injury, specifically descaling greater than 20% in Chinook salmon are evident in Figure 46. Copepod presence on captured Chinook salmon (Figure 47) was evidenced to increase with the size of fish similar to observations made by previous studies (CFS 2023a; Monzyk et al. 2015). This is likely an association between time spent rearing in the reservoir rather than the size of the fish. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally decreased from pre-release to recaptured observations at the Cougar Dam PH RST site, while they increased at the Cougar Dam RO RST site (Appendix D). Detailed findings on injury type are further presented in Appendix D.

As with other observations made in this report and in alignment with findings from both Big Cliff Dam Tailrace and Green Peter Dam Tailrace, Chinook salmon less than 60 mm were found to exhibit significantly fewer injuries than their larger counterparts ranging from 60 mm – 100 mm and greater than 100 mm (Appendix D, Table D-3 and Table D-4).

In the summer of 2023, construction was performed on the RO chute at Cougar Dam. Table D-5 in Appendix D shows injury data for RO captured NOR Chinook for the months of October through December 2021, 2022, and 2023. Initial observations do not show significant differences in injuries before and after construction occurred. However, the data is limited at this time and other variables need to be investigated to determine what impact the work may have on Chinook during passage.

Table 52. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Cougar Dam Powerhouse RSTs.

Injury Code	Observed Chinook Injuries (n=305)	Bulk Marked Released Chinook (n=90)	Trapping Efficiency Hatchery Chinook (n=369)
NXI (no external injury)	4.9%	2.2%	3.4%
MUNK	0.0%	0.0%	0.0%
DS<2	11.5%	22.2%	10.0%
DS>2	78.4%	75.6%	73.0%
BLO	1.3%	4.4%	1.3%
EYB	4.9%	2.2%	1.6%
BVT	2.6%	4.4%	0.3%
FVB	11.5%	12.2%	0.9%
GBD	3.6%	6.7%	2.2%
POP	2.0%	0.0%	0.6%
HIN	3.9%	1.1%	1.6%
OPD	14.8%	11.1%	6.6%
TEA	6.9%	4.4%	1.6%
BRU	8.2%	6.7%	0.9%
HBP	3.0%	4.4%	0.3%
HO	0.0%	0.0%	0.0%
BO	1.3%	0.0%	0.0%
HBO	0.3%	0.0%	0.0%
FID	62.3%	87.8%	80.6%
PRD	0.3%	0.0%	0.6%
COP	63.3%	74.4%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	11.9%

Table 53. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Cougar Dam RO RST.

Injury Code	Observed Chinook Injuries (n=827)	Bulk Marked Released Chinook (n=526)	Trapping Efficiency Hatchery Chinook (n=142)
NXI (no external injury)	1.9%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	27.6%	23.4%	14.1%
DS>2	67.5%	76.4%	85.9%
BLO	2.3%	1.3%	4.9%
EYB	20.8%	13.9%	2.8%
BVT	3.5%	2.1%	0.0%
FVB	14.6%	8.2%	0.7%
GBD	47.3%	39.9%	11.3%
POP	3.6%	2.3%	4.2%
HIN	6.9%	4.0%	3.5%
OPD	20.4%	26.2%	10.6%
TEA	3.3%	3.4%	3.5%
BRU	10.0%	7.0%	0.0%
HBP	1.8%	0.2%	0.7%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.2%	0.0%
FID	79.9%	96.0%	100.0%
PRD	0.4%	0.6%	0.0%
COP	68.1%	32.9%	2.1%
BKD	0.0%	0.0%	0.0%
FUN	1.9%	0.0%	7.7%

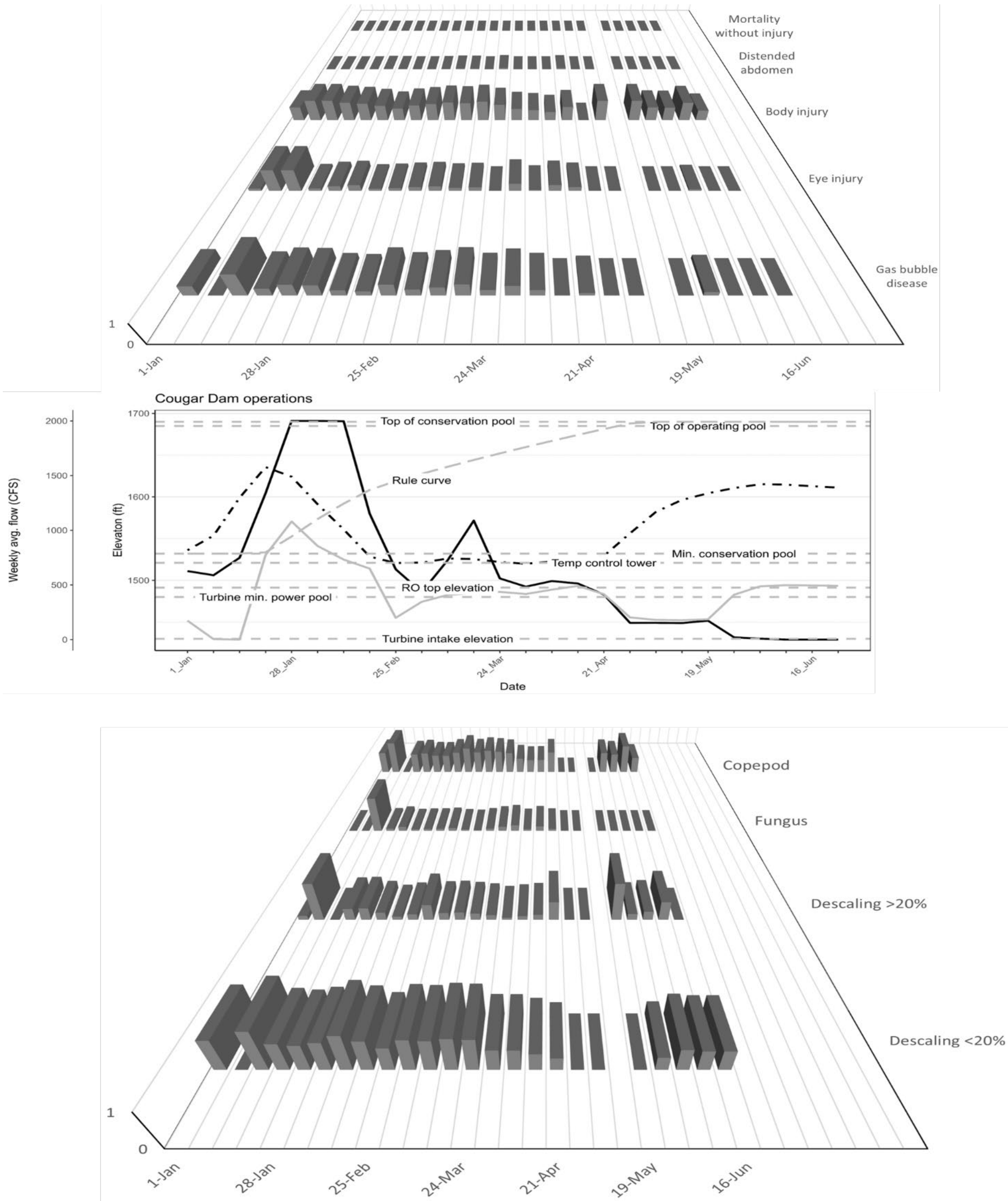

Figure 46. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data from Cougar Dam (middle panel) showing spill outflow (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), and proportion of captured juvenile Chinook displaying descaling and copepod injuries (bottom panel).

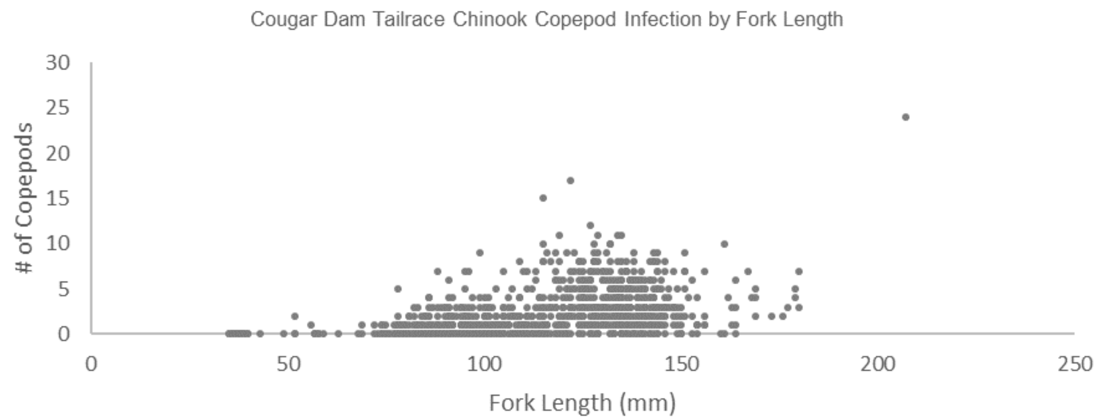

Figure 47. Copepod presence vs fork length on juvenile Chinook salmon captured at Cougar Dam.

24-Hour Hold Trials

24-hour hold trials were performed on NOR juvenile Chinook salmon captured at Cougar Dam to assess delayed mortality resulting from dam passage. A total of 631 fish, 468 from the RO and 163 from the PH, were held (Table 54). A total of 32 fish died during hold (5.1%), 21 of the RO Chinook salmon (4.5%) and 11 of the PH Chinook salmon (6.7%). Mortality rates across the two-week periods in which fish were held ranged from 0.0% to 33.3%.

Table 54. Summary of 24-hour trials for Chinook salmon captured in the RSTs at the Powerhouse and Regulating Outlet

Hold Period	Route	Number of Fish Held	Mortalities	% Survived
January 1–15, 2024	PH	1	0	100.0%
January 1–15, 2024	RO	9	0	100.0%
January 16–31, 2024	PH	0	0	--
January 16–31, 2024	RO	7	0	100.0%
February 1–15, 2024	PH	31	0	100.0%
February 1–15, 2024	RO	119	2	98.3%
February 16–29, 2024	PH	72	3	95.8%
February 16–29, 2024	RO	73	3	95.9%
March 1–15, 2024	PH	3	0	100.0%
March 1–15, 2024	RO	117	10	91.5%
March 16–31, 2024	PH	9	0	100.0%
March 16–31, 2024	RO	80	3	96.3%
April 1–15, 2024	PH	3	0	100.0%
April 1–15, 2024	RO	28	0	100.0%
April 16–30, 2024	PH	2	0	100.0%
April 16–30, 2024	RO	30	2	93.3%
May 1–15, 2024	PH	1	0	100.0%
May 1–15, 2024	RO	5	1	80.0%
May 16–31, 2024	PH	1	0	100.0%
May 16–31, 2024	RO	0	0	--
June 1–15, 2024	PH	28	4	85.7%
June 1–15, 2024	RO	0	0	--
June 16–30, 2024	PH	12	4	66.7%
June 16–30, 2024	RO	0	0	--

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 349 NOR juvenile Chinook salmon were PIT tagged and released at the Cougar Dam traps in the Spring of 2024. 2 PIT tags were redetected downstream in the Columbia River Estuary. The average travel time was 154 days. One Chinook salmon containing a PIT tag from Cougar Head of Reservoir was captured in the PH trap. No VIE marked fish were encountered at this site during sampling in the Spring of 2024. Table 55 shows a summary of the fish redetected at downstream sites. One Chinook PIT tag, 3DD.003BEE1074, was detected on 5 different days from 4/1/2024 to 4/14/2024 at the PD6 - Columbia River Estuary site. Information regarding PIT tags at the RST site can be found in Appendix C.

Table 55. Summary of redetections PIT tagged juvenile Chinook at the Cougar Dam sites.

PIT Tag #	Mark Date	Redetection Date	Recap Site	Travel Time (Days)
3DD.003BEE1074	11/1/2023	4/1/2024	PD6 - Columbia River Estuary rkm 68	152
3DD.003BEE13F6	11/1/2023	4/5/2024	TWX - Estuary Towed Array (Exp.)	156
3DD.003BE9F60D	3/21/2024	5/26/2024	TWX - Estuary Towed Array (Exp.)	66

Willamette Valley Projects Encounters

A total of 613 adipose clipped and PIT tagged Chinook were captured at the Cougar Dam traps in the Spring of 2024. These fish are a part of Cramer Fish Science's bulk mark release project. For information regarding bulk mark releases and detection data, refer to the *Bulk Marking and Reservoir Distribution Study Annual Report* (CFS 2024). One adult *O. mykiss* was encountered containing a PIT tag from a Chinook release by Cramer Fish Sciences. We believe this fish predated upon a juvenile Chinook. One Bull Trout was encountered containing a PIT tag. This fish had been tagged by EAS the month prior.

Non-Target Capture Data

A total of 1,383 non-target fish were captured at the Cougar Dam traps in the Spring of 2024. A summary of species and catch is provided below in Table 56. The most captured non-target species were dace, clipped Chinook salmon and sculpin. Additionally, three Bull Trout were encountered at this site and were reported to ODFW. One of these Bull Trout was tagged by EAS staff. More information regarding captured Bull Trout is provided in Appendix C.

Table 56. Summary of non-target fish capture for the Cougar Dam RSTs.

Species	Season Total	Season Total Mortality (subset of total)
Bull Trout	3	0
Chinook (clipped)	786	71
Cutthroat Trout	8	2
Lamprey	3	0
Pacific Lamprey	1	0
Dace	384	0
Largescale Sucker	1	0
Mountain Whitefish	25	1
O. mykiss	51	2
O. mykiss (adult)	22	1
Sculpin	60	0
Smallmouth Bass	36	0
Unknown Bass*	3	0
Totals	**1,383**	**77**

*Species denoted as "unknown" were too small and/or too decomposed to identify.

Fall Creek Head of Reservoir

A single 8-foot RST was deployed at the Fall Creek Head of Reservoir site on January 1, 2024, and continued sampling until June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Additionally, the RST was not sampled from January 9, 2024, to January 22, 2024, due to the RST being submerged from high flows, excessive debris, and a large incoming winter storm. During this outage, the RST was storm sampled, but high debris continued to warrant the trap being raised. Furthermore, the RST was not sampled from May 3, 2024, to May 9, 2024, due to increased flows and high levels of debris.

Trapping Efficiency Trials

A total of eight TE trials occurred from January 2, 2024, through June 13, 2024, at the Fall Creek Head of Reservoir site using hatchery reared Chinook salmon. Collectively, twelve TE trials have occurred at this site since May 5, 2023. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 57.

TEs ranged from 0.5% to 18.1% with a pooled average of 8.9% (95%CI ±3.5%, n=11) of all successful trials with five or more recaptures. One of the trials did not recapture enough fish to be used in the passage estimate calculation.

Table 57. Summary table of marked hatchery Chinook salmon releases at Fall Creek Head of Reservoir Site for trapping efficiency.

Release Location	Date of Release	Gauge Height at Release (ft)	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Fall Creek Head of Reservoir	5/5/2023	3.82	756	15	2.0%
Fall Creek Head of Reservoir	5/10/2023	3.78	750	23	3.1%
Fall Creek Head of Reservoir	5/18/2023	3.51	511	7	1.4%
Fall Creek Head of Reservoir	5/24/2023	3.28	760	4	0.5%
Fall Creek Head of Reservoir	1/2/2024	3.79	755	137	18.1%
Fall Creek Head of Reservoir	2/2/2024	4.12	751	51	6.8%
Fall Creek Head of Reservoir	3/5/2024	4.26	750	74	9.9%
Fall Creek Head of Reservoir	3/26/2024	4.17	998	99	9.9%
Fall Creek Head of Reservoir	4/15/2024	4.13	2,000	241	12.1%
Fall Creek Head of Reservoir	5/21/2024	3.5	749	24	3.2%
Fall Creek Head of Reservoir	5/29/2024	3.4	749	111	14.8%
Fall Creek Head of Reservoir	6/13/2024	3.35	750	124	16.5%

Run of River Trapping Efficiency Trials

No ROR trials occurred from January through June of 2024 due to insufficient numbers of fish captured. Past ROR trials have resulted in small numbers of fish recaptured, likely due to the limited number of fish released. Large numbers of fish are required for release in order to get enough recaptures for meaningful insight. Additional trials will be attempted in the future. A summary of ROR TE trials by month is provided in Table 58.

Table 58. Summary table of run of river releases at the Fall Creek HOR site for trapping efficiency.

Release Location	Date of Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Fall Creek Head of Reservoir	February 2023	3	0	0%
Fall Creek Head of Reservoir	March 2023	32	1	3.1%

Target Catch and Passage Timing

The trap at Fall Creek Head of Reservoir captured 7 juvenile Chinook salmon (Figure 48). Peak passage of Chinook salmon entering Fall Creek Reservoir occurred in February (n= 4, 57.1%% of total catch). Scale samples show that fish captured at this site consisted entirely of BY 2022 yearlings (Figure 49). Prior study above Fall Creek Reservoir found that most fish migrated into the reservoir December through the early summer months. Our observations are consistent with past monitoring efforts. We estimate that 41 (95% CI: 29 to 68) Chinook salmon migrated past the sample site into Fall Creek Reservoir during sampling in the Spring of 2024 (Figure 48). A summary of fork lengths and weight data is provided in Table 59.

In calendar year 2023, a total of 119 Adult Chinook were out planted above Fall Creek Reservoir. The Bedrock wildfire occurred in the drainage in July and was not fully contained until early October. Spawning surveys by ODFW and USACE staff, while limited, suggest that spawning success was very low for the out planted adults. No sub-yearling Chinook were captured in the RST in 2024 further suggesting that few, if any, Chinook were able to successfully spawn in Fall Creek above Fall Creek Reservoir in 2023. However, the trap was unable to sample during high flows events in late January and it is possible that some fry may have passed the trapping site at that time. Fall capture data from the Fall Creek Dam RST will be helpful in interpreting the success of the out planted adults in 2023.

Table 59. Summary of fork length and weight observed on juvenile Chinook salmon at the Fall Creek Head of Reservoir RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/2024–6/30/2024	22	7	121.9	114	134	121	20.5	13.6	25.7	21.2

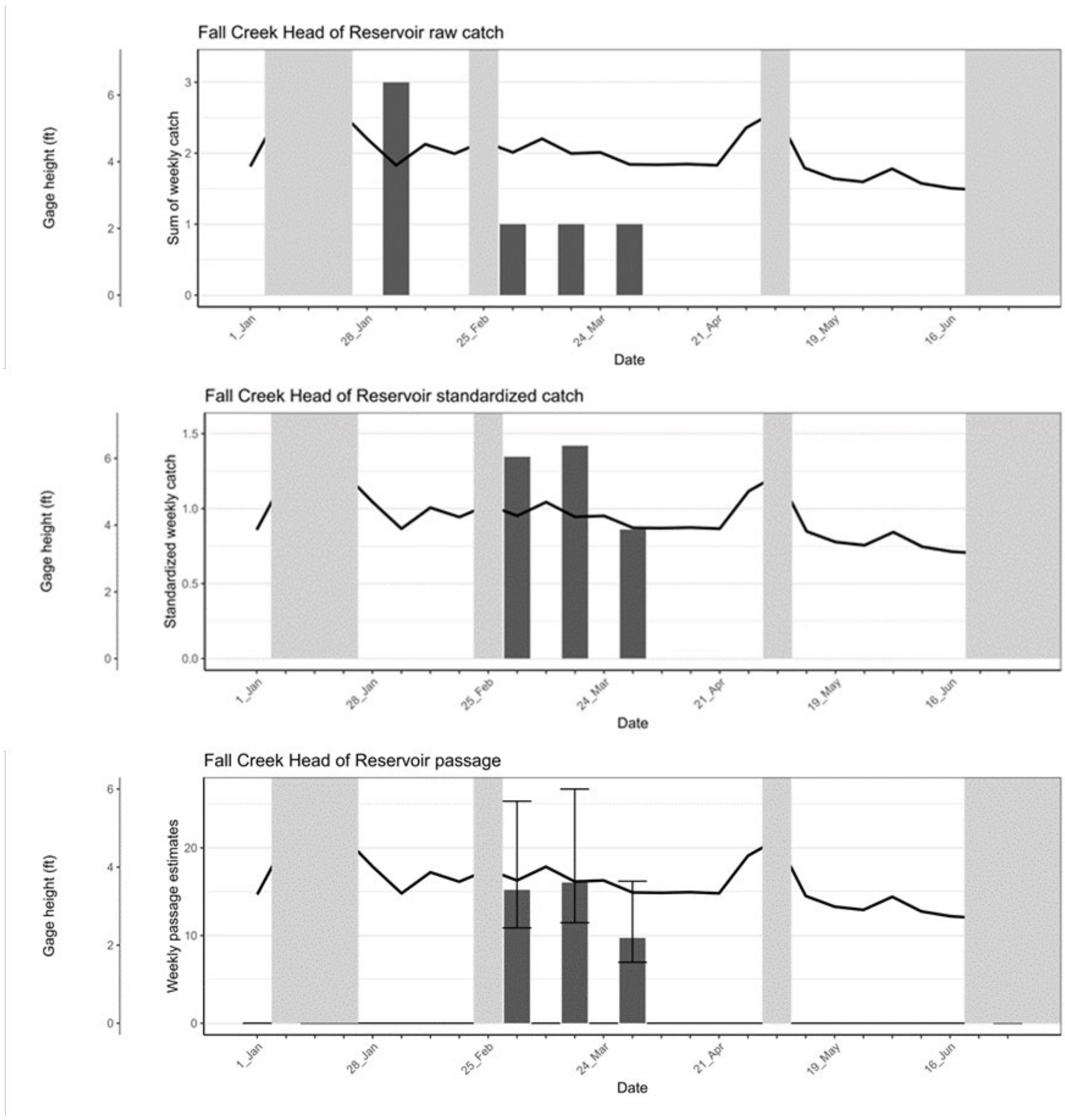

Figure 48. Raw catch (top panel), weekly standardized catch (middle panel), and weekly passage estimates (bottom panel) of NOR juvenile Chinook salmon at the Fall Creek Head of Reservoir site with stream flow (black line) and non-sampling weeks shaded out (gray).

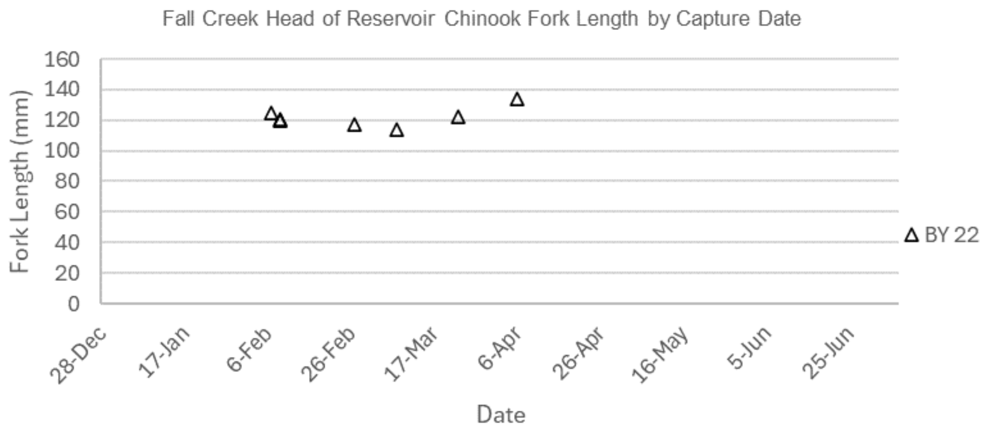

Figure 49. Length-Frequency of juvenile Chinook salmon at Fall Creek Head of Reservoir.

Injury Data

A total of seven juvenile Chinook salmon (100% of total Chinook salmon capture) captured at the Fall Creek Head of Reservoir site displayed injuries at the time of capture. These injuries were likely the result of contact with debris or trap surfaces upon capture. The injuries encountered within these juvenile Chinook salmon were descaling greater than 20%, fin damage, and tears (Table 60). TE hatchery Chinook salmon captured at this site exhibited higher percentages of descaling less than 20%, operculum damage, bruising, and fin damage when compared to NOR Chinook (Table 60).

No Chinook salmon were dead at the time of trap checks. No Chinook salmon were observed with copepods at the Fall Creek Head of Reservoir site in 2024. Additionally, no CFS bulk marked released Chinook salmon were found at this site by EAS personnel. A summary of injuries at this site can be found in Table 60.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Table 60. Summary of injuries observed on NOR and TE hatchery Chinook salmon at the Fall Creek Head of Reservoir RST site.

Injury Code	Chinook Injuries (NOR) (n=7)	Trapping Efficiency Hatchery Chinook (n=857)
NXI (no external injury)	0.0%	1.2%
MUNK	0.0%	0.0%
DS<2	0.0%	14.6%
DS>2	100.0%	81.2%
BLO	0.0%	0.0%
EYB	0.0%	0.6%
BVT	0.0%	0.0%
FVB	0.0%	0.1%
GBD	0.0%	0.0%
POP	0.0%	0.0%
HIN	0.0%	0.0%
OPD	0.0%	2.7%
TEA	14.3%	0.1%
BRU	0.0%	2.1%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	42.9%	92.4%
PRD	0.0%	0.0%
COP	0.0%	0.0%
BKD	0.0%	0.0%
FUN	0.0%	3.7%

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 7 NOR Chinook salmon were PIT tagged at the Fall Creek Head of Reservoir site in 2024. One PIT tagged Chinook was recaptured at the Fall Creek Dam Tailrace trap during the Spring 2024 monitoring period. The travel time was 8 days. No NOR Chinook salmon were VIE marked at the Fall Creek Head of Reservoir site in 2024. No VIE marked fish were redetected downstream at the Fall Creek Dam site. A summary of downstream PIT tag detections is provided in Table 61. Further information on tagged and VIE marked fish at this site is available in Appendix C.

Table 61. Summary of PIT tagged Chinook downstream redetections for the Fall Creek Head of Reservoir site.

PIT Tag #	Mark Date	Redetection Date	Recap Site	Travel Time (Days)
3DD.003BE9F184	2/7/2024	2/15/2024	Fall Creek Dam Tailrace	8

Non-Target Capture Data

The Fall Creek Head of Reservoir trap captured 634 non-target fish in addition to NOR juvenile Chinook salmon. The most commonly captured non-target species were dace, *O. mykiss*, and lamprey. A summary of species and numbers of fish caught are provided in Table 62.

Table 62. Summary of non-target fish catch at the Fall Creek Head of Reservoir RST.

Species	Season Total	Season Total Mortality (subset of total)
Cutthroat Trout	76	1
Chinook (clipped)	15	0
Dace	158	1
Largescale Sucker	2	0
Northern Pikeminnow	1	0
O. mykiss	201	1
O. mykiss (adult)	45	0
Pacific Lamprey	12	0
Sculpin	5	0
Lamprey	119	1
Totals	**634**	**4**

Fall Creek Dam Tailrace

A single 8-foot RST was deployed at Fall Creek Dam Tailrace RO channel on January 1, 2024, and continued sampling until June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Additionally, the RST was not sampled from January 1, 2024, to January 12, 2024, due to a sediment flush. The increased amount of sedimentation necessitated EAS to raise the cone due to the channel depth becoming too shallow to safely sample during this time. The trap was visited, and conditions checked daily to ensure a prompt return sampling once sediment loads decreased to safe levels.

Trapping Efficiency Trials

A total of five TE trials occurred from January 22, through April 8, 2024, in the Fall Creek Dam Tailrace using hatchery reared juvenile Chinook salmon. Collectively,13 trials have occurred at this site since June 8, 2022. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 63.

TEs ranged from 0.0% to 4.7% with a pooled average of 2.2% (95%CI ±1.3%, n=5) of all successful trials with five or more recaptures. Eight of the trials did not recapture enough fish to be used in the passage estimate calculation. Modeling results from the discharge and revolutions per hour analysis yielded a suite of models with high pseudo R^2 values, with a minimum of 0.832 for the model with discharge as a single variable. The full model with discharge, revolutions per hour, and their interaction had the highest pseudo R^2 of 0.942. The model with the lowest AICc score is the model with log-transformed discharge as a single variable, while still maintaining a pseudo R^2 of 0.859. Although the full model captures more of the variance in TE, it has a delta AICc score of 6.26 from the model using only log-transformed discharge. This indicates that the increasing complexity of adding multiple variables, and their interaction has greater disadvantages, relative to what is gained in increased pseudo R^2.

All five of the successful trials have occurred when flow was >950 cfs. TE trials performed during low flow did not yield any recaptures. This is likely due to the slow rotation speed of the trap and the subsequent flow levels allowing fish to easily avoid the trap. Low numbers of brood year 2023 Chinook from Willamette Hatchery will likely limit the number of fish available for TE trials in the Middle Fork Willamette basin. The combination of low flow and limited hatchery fish will result in fewer TE trials than expected for the remainder of the 2024 sampling period.

Table 63. Summary table of marked hatchery Chinook salmon releases at Fall Creek Dam Tailrace for trapping efficiency

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Fall Creek Dam Regulating Outlet	6/8/2022	957	517	11	2.1%
Fall Creek Dam Regulating Outlet	6/30/2022	231	513	0	0.0%
Fall Creek Dam Regulating Outlet	7/13/2022	228	498	0	0.0%
Fall Creek Dam Regulating Outlet	5/11/2023	83	998	0	0.0%
Fall Creek Dam Regulating Outlet	6/28/2023	89	992	0	0.0%
Fall Creek Dam Regulating Outlet	7/11/2023	48	1,006	0	0.0%
Fall Creek Dam Regulating Outlet	10/3/2023	60	1,020	0	0.0%
Fall Creek Dam Regulating Outlet	10/17/2023	2,630	1,011	14	1.4%
Fall Creek Dam Regulating Outlet	1/22/2024	1,028	999	12	1.2%
Fall Creek Dam Regulating Outlet	2/13/2024	1,700	1,004	47	4.7%
Fall Creek Dam Regulating Outlet	3/5/2024	1,000	1,001	14	1.4%
Fall Creek Dam Regulating Outlet	3/26/2024	55	1,600	0	0.0%
Fall Creek Dam Regulating Outlet	4/8/2024	124	2,000	0	0.0%

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Fall Creek Dam Tailrace in the Spring of 2024. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study and are not tagged. Sufficient numbers of NOR fish were not available to perform ROR TE trials.

Target Catch, Passage Estimates and Passage Timing

The trap in the Regulating Outlet Channel below Fall Creek Dam captured 9 juvenile Chinook salmon during sampling in the Spring of 2024. Capture of juvenile Chinook salmon occurred in February and March (Figure 50). Peak spring capture occurred in February (n=6, 66.7% of total Chinook salmon capture). This timing is consistent with previous monitoring efforts observed where Chinook salmon sub-yearlings and yearlings often migrated out of Fall Creek Dam in January and February (Keefer et al. 2012). Chinook catch in the spring occurred during periods of increased RO flow associated with significant storm events necessitating the release of water to refill and then maintain reservoir elevations. Only BY 2022 yearlings were captured at this site during the spring monitoring period (Figure 51). A summary of fork lengths and weights for Chinook salmon captured at Fall Creek Dam by BY is provided in Table 64. For raw weekly catch of Chinook at this site for sampling from 2022 and 2023, see Appendix I. Due to the low number of successful TE trials at this site (n=5), an estimate of passage at Fall Creek is not available at this time. Additional successful trials are needed to provide accurate estimates in the future.

In calendar year 2023, a total of 119 adult Chinook were out planted above Fall Creek Reservoir. The Bedrock wildfire occurred in the drainage in July and was not fully contained until early October. Spawning surveys by ODFW and USACE staff, while limited, suggest that spawning success was very low for the out planted adults. No sub-yearling Chinook were captured in the RSTs above and below Fall Creek Reservoir during the Spring of 2024, further suggesting that few, if any, Chinook were able to successfully spawn in Fall Creek above Fall Creek Reservoir in 2023. However, the trap was unable to sample the first two weeks in January due to high sediment loads flushing out of Fall Creek Dam Reservoir through the RO channel. It is possible that some Chinook fry passed the sampling site during that time. Fall sampling data will be necessary to help elucidate the success of out planted adult Chinook above Fall Creek Reservoir in 2023.

Table 64. Summary of fork length and weight observed on juvenile Chinook salmon of NOR at the Fall Creek Dam RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/2024–6/30/2024	22	9	129.6	112	146	130	26.1	15.5	24.7	26.5

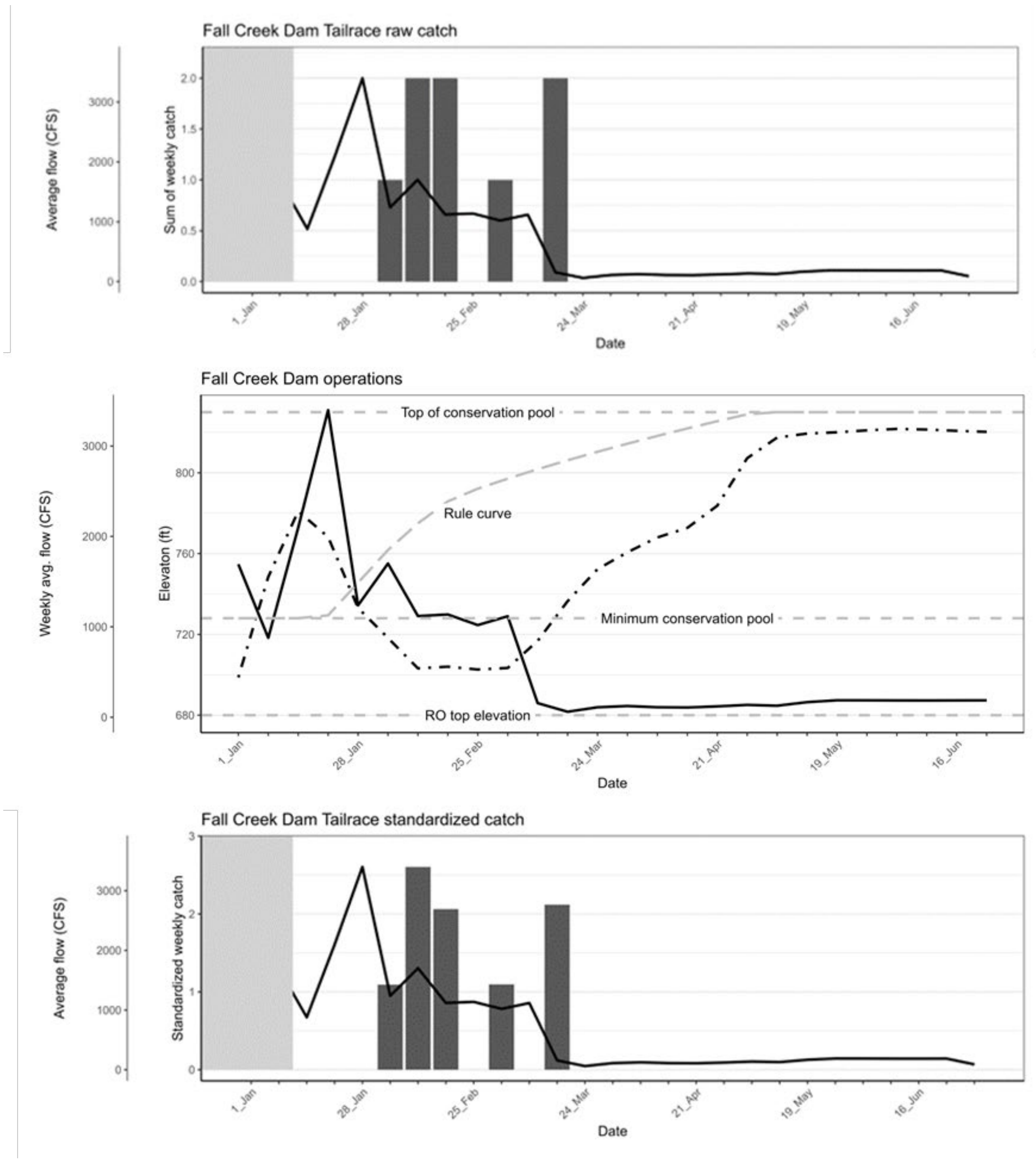

Figure 50. Raw catch (top panel) and weekly standardized catch (bottom panel) of NOR juvenile Chinook salmon at the Fall Creek Dam Tailrace site with RO outflow (black line) and non-sampling weeks shaded out (gray). Fall Creek Dam operations and features of interest (middle panel) with forebay elevation (black dot dash line) and outflow (black line)

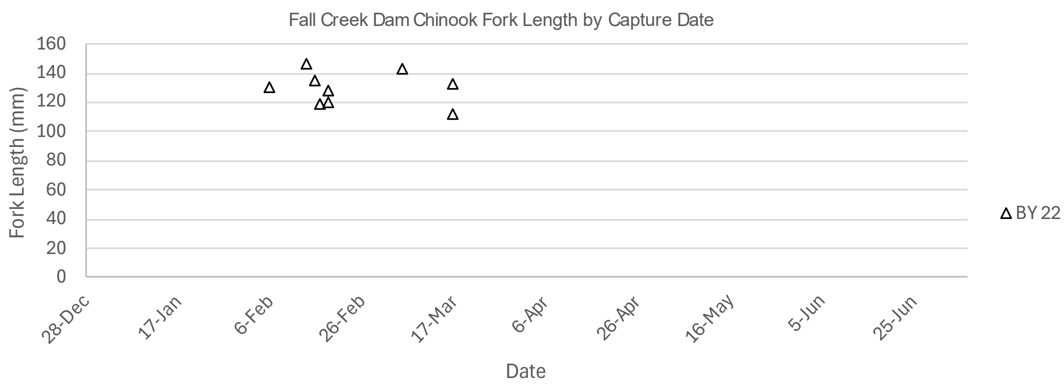

Figure 51. Length-frequency of juvenile Chinook salmon at the Fall Creek Dam Tailrace site.

Injury Data

In total, 9 juvenile Chinook salmon (100% of total Chinook salmon capture) captured at the Fall Creek Dam Tailrace site displayed injuries upon capture. The predominant injuries encountered within these juvenile Chinook salmon were descaling greater than 20%, operculum damage, and fin damage (Table 65).

Comparatively, juvenile Chinook salmon that were of NOR and were encountered at the Fall Creek Dam Tailrace site exhibited lower percentages of descaling greater than 20%, head injury, bruising, and fin damage when assessed against the PIT tagged bulk marked released Chinook salmon (Table 65). High percentages of descaling greater than 20% and fin damage were observed in captured TE hatchery fish. These findings are similar to many of those encountered when assessing hatchery raised fish among all sites.

No juvenile Chinook salmon that were encountered at the Fall Creek Dam Tailrace in the Spring of 2024 had copepods present upon removal from the RST, as seen in Figure 52. A total of one Chinook salmon was dead at the time of trap check (11.1% of total Chinook salmon capture). A summary of injuries by type is shown in Table 65. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Table 65. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Fall Creek Dam Tailrace RST site.

Injury Code	Chinook Injuries (NOR) (n=9)	Bulk Marked Released Chinook (n=215)	Trapping Efficiency Hatchery Chinook (n=74)
NXI (no external injury)	0.0%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	11.1%	4.2%	13.5%
DS>2	88.9%	95.8%	86.5%
BLO	0.0%	0.0%	1.4%
EYB	11.1%	1.4%	2.7%
BVT	0.0%	0.0%	1.4%
FVB	11.1%	0.0%	0.0%
GBD	0.0%	0.0%	6.8%
POP	0.0%	0.5%	0.0%
HIN	0.0%	1.9%	4.1%
OPD	33.3%	0.0%	4.1%
TEA	11.1%	0.0%	0.0%
BRU	0.0%	0.5%	2.7%
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	66.7%	99.5%	100.0%
PRD	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	1.4%

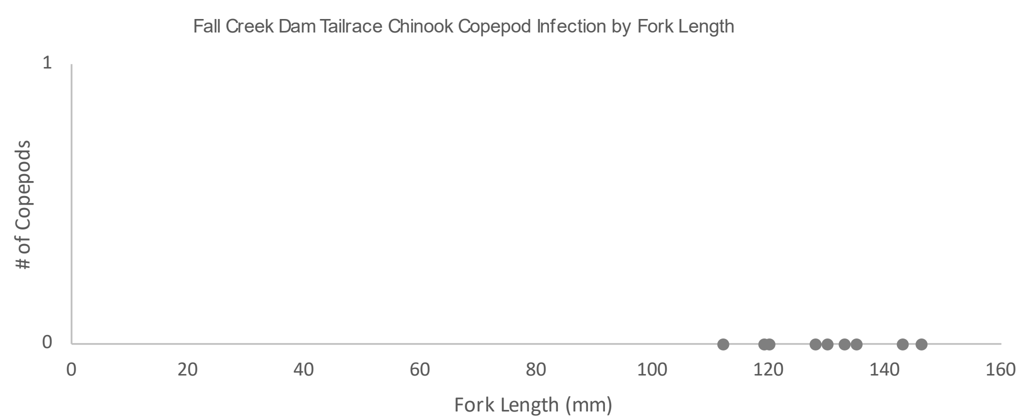

Figure 52. Copepod presence vs fork length on juvenile Chinook salmon captured at Fall Creek Dam Tailrace.

24-Hour Hold Trials

24-hour hold trials were performed on NOR juvenile Chinook salmon captured at Fall Creek Dam Tailrace to assess delayed mortality resulting from dam passage. A total of 8 Chinook salmon were held during the Spring 2024 monitoring period (Table 66). A total of 0 Chinook salmon died during hold (0.0%).

Table 66. Summary of 24-hour trials for fish captured in the RST at the Fall Creek Dam Tailrace site.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
January 1–15, 2024	Chinook	0	0	--
January 16–31, 2024	Chinook	0	0	--
February 1–15, 2024	Chinook	2	0	100.0%
February 16–29, 2024	Chinook	3	0	100.0%
March 1–15, 2024	Chinook	1	0	100.0%
March 16–31, 2024	Chinook	2	0	100.0%
April 1–15, 2024	Chinook	0	0	--
April 16–30, 2024	Chinook	0	0	--
May 1–15, 2024	Chinook	0	0	--
May 16–31, 2024	Chinook	0	0	--
June 1–15, 2024	Chinook	0	0	--
June 16–30, 2024	Chinook	0	0	--

PIT Tagged/VIE Marked Fish and Downstream Detections

No fish were PIT tagged at the Fall Creek Dam Tailrace site in the Spring of 2024 as all captured fish were placed into the 24-hour hold study. One PIT tagged fish from Fall Creek Head of Reservoir was recaptured at this site. The travel time for this fish was 8 days. No VIE marked Chinook salmon were detected at this site during the Spring 2024 sampling period. Further information on tagged fish at this site is available in Appendix C.

Willamette Valley Projects Encounters

A total of 214 adipose clipped and PIT tagged Chinook salmon were captured in the Fall Creek Dam RST in the Spring of 2024 that were associated with large bulk mark releases performed by Cramer Fish Sciences. For more information regarding release groups, dates, and other redetections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

The Fall Creek Dam Tailrace trap captured 570 non-target fish in addition to NOR juvenile Chinook salmon. A summary of species and numbers of fish caught is provided in Table 67. The most captured non-target species were clipped Chinook, cutthroat trout, and *O. mykiss*.

Table 67. Summary of non-target fish catch at the Fall Creek Dam Tailrace RST.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	348	1
Brown Bullhead	3	2
Cutthroat Trout	88	3
Dace	7	4
Largescale Sucker	4	3
Northern Pikeminnow	1	0
O. mykiss	80	7
O. mykiss (adult)	17	4
Pacific Lamprey	12	0
Sculpin	9	1
Unknown Salmonid*	1	1
Totals	**570**	**26**

*Species denoted as “unknown” were too small and/or too decomposed to identify.

Hills Creek Head of Reservoir – Middle Fork Willamette River

A single 5-foot RST was deployed in the Middle Fork Willamette River above Hills Creek Dam on February 1, 2024, and continued sampling until June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

In the calendar year 2022, a total of 468 adult spring Chinook salmon were out planted above Hills Creek Dam. This consisted of 198 females, 250 males, and 14 jack Chinook salmon (USACE 2022). No adult Chinook were out planted above Hills Creek Reservoir in 2023.

Trapping Efficiency Trials

A total of seven TE trials occurred from February 15, 2024, through June 20, 2024, at the Hills Creek Head of Reservoir – Middle Fork Willamette River site using hatchery reared Chinook salmon. Collectively, nine trials have occurred at this site since May 18, 2023. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 68.

TEs ranged from 0.1% to 8.5% with a pooled average of 2.6% (95% CI ±1.8%, n=8) of all successful trials with five or more recaptures. One of the trials did not recapture a sufficient number of fish to be used in the passage estimate calculation.

Table 68. Summary table of marked hatchery Chinook salmon releases at Hills Creek Head of Reservoir – Middle Fork Willamette River for trapping efficiency

Release Location	Date of Release	Gage Height at Release (ft)	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Hills Creek Head of Reservoir – Middle Fork Willamette River	5/18/2023	10.2	519	44	8.5%
Hills Creek Head of Reservoir – Middle Fork Willamette River	6/19/2023	8.9	760	6	0.8%
Hills Creek Head of Reservoir – Middle Fork Willamette River	2/15/2024	9.9	761	1	0.1%
Hills Creek Head of Reservoir – Middle Fork Willamette River	2/20/2024	10.05	749	18	2.4%
Hills Creek Head of Reservoir – Middle Fork Willamette River	3/20/2024	10.78	752	16	2.1%
Hills Creek Head of Reservoir – Middle Fork Willamette River	4/9/2024	9.5	2,001	9	0.4%
Hills Creek Head of Reservoir – Middle Fork Willamette River	5/1/2024	9.8	750	32	4.3%
Hills Creek Head of Reservoir – Middle Fork Willamette River	5/23/2024	9.6	749	11	1.5%
Hills Creek Head of Reservoir – Middle Fork Willamette River	6/20/2024	8.9	750	7	0.9%

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Hills Creek Head of Reservoir during the Spring of 2024 monitoring period. Sufficient numbers of NOR fish were not available to perform ROR TE trials.

Target Catch, Passage Estimates and Passage Timing

A total of 47 NOR juvenile Chinook salmon were captured in the RST above Hills Creek Dam during spring sampling 2024. Peak capture of juvenile Chinook salmon entering Hills Creek Reservoir occurred during February (n=26, 55.3% of total Chinook salmon catch) (Figure 53). Scale age analysis showed that all the Chinook salmon captured were BY 2022 yearlings (Figure 54). The first Chinook salmon yearling was captured on February 4, 2024, on the first day of sampling (Figure 53 and Figure 54). Based on this observation, it is possible that some fish migrated into Hills Creek Reservoir prior to the initiation of sampling. However, previous sampling at this location found that peak migration of juvenile Chinook into Hills Creek Reservoir occurred in March (Hansen et al 2017), later in the spring than was observed in 2024. A summary of fork length and weight data by brood year for Chinook salmon captured at this site in 2024 is provided in Table 69. No adults were out planted above Hills Creek Reservoir in 2023. For more information on adult out planting above Hills Creek Reservoir, please refer to Appendix I. Utilizing pooled averages of hatchery Chinook TE trials, EAS estimates that 2,016 (95% CI: 1,182 to 6,836) juvenile Chinook passed the sampling site during February to June 2024 monitoring period.

Table 69. Summary of fork length and weight observed on juvenile Chinook salmon of NOR at the Hills Creek Head of Reservoir RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	2/1/24–6/30/24	22	47	86.7	62	122	89	7.3	2.3	17.5	7.2

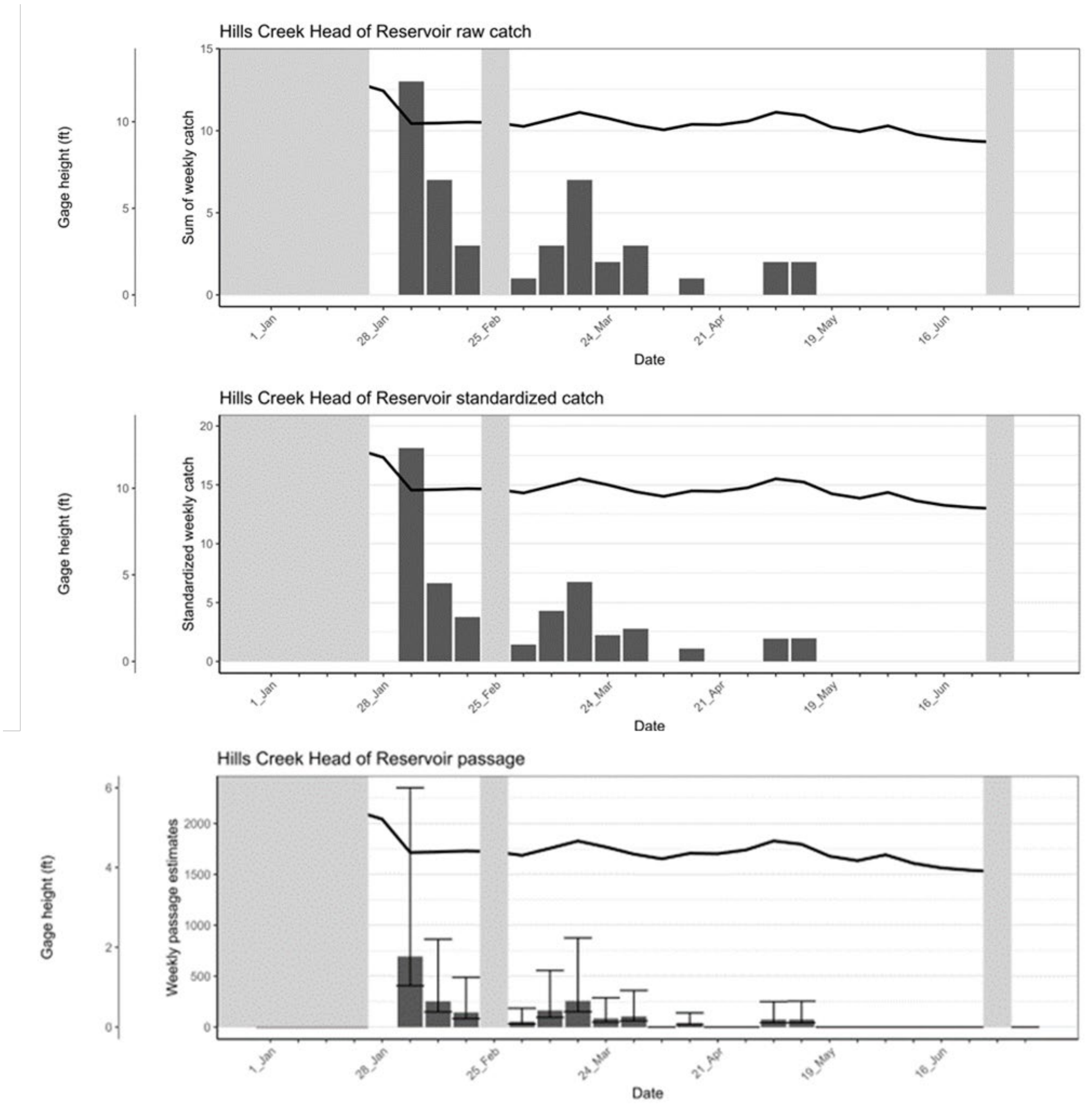

Figure 53. Raw catch (top panel) and weekly standardized catch (bottom panel) with stream gage height (black line) and non-sampling weeks shaded out (gray) for the Hills Creek Head of Reservoir – Middle Fork Willamette River RST.

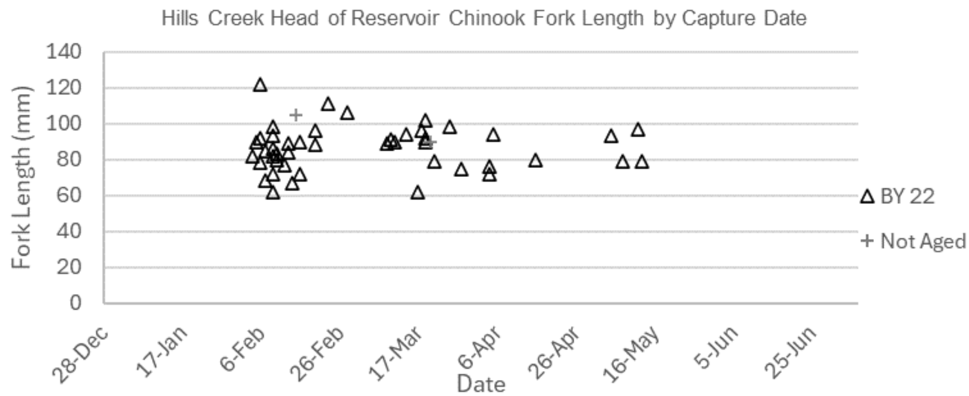

Figure 54. Length-frequency of juvenile Chinook salmon by brood year at the Hills Creek Head of Reservoir – Middle Fork Willamette River.

Injury Data

A total of 41 (87.2% of total Chinook salmon catch) juvenile Chinook salmon displayed at least one of the injury code conditions listed in Table 3. A summary of observed injuries can be found in Table 70.

The most common injuries exhibited at the Hills Creek Head of Reservoir RST site are descaling greater than 20% and fin damage. These injuries are frequently observed at the Head of Reservoir sites and can most likely be associated with contact from the RST itself. Captured TE hatchery Chinook salmon were found to have higher percentages of descaling greater than 20%, descaling less than 20%, fin damage, and fungus when compared to NOR Chinook (Table 70).

No copepods were observed attached to fish captured at this site in 2023. However, data through the Spring of 2024 illustrates that 14.9% of the Chinook salmon catch had copepods present (Figure 55). Copepod presence on Chinook salmon were only observed on fish with fork lengths greater than 60 mm and less than 100 mm. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally decreased from pre-release to recaptured observations at the Hills Creek Head of Reservoir RST site (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Table 70. Summary of injuries observed on NOR and TE hatchery Chinook salmon at the Hills Creek Head of Reservoir – Middle Fork Willamette River RST site.

Injury Code	Chinook Injuries (NOR) (n=47)	Trapping Efficiency Hatchery Chinook (n=93)
NXI (no external injury)	12.8%	0.0%
MUNK	0.0%	0.0%
DS<2	4.3%	14.0%
DS>2	78.7%	82.8%
BLO	0.0%	1.1%
EYB	0.0%	0.0%
BVT	0.0%	0.0%
FVB	0.0%	0.0%
GBD	0.0%	0.0%
POP	0.0%	0.0%
HIN	0.0%	0.0%
OPD	4.3%	2.2%
TEA	0.0%	0.0%
BRU	4.3%	1.1%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	34.0%	64.5%
PRD	2.1%	0.0%
COP	14.9%	0.0%
BKD	0.0%	0.0%
FUN	0.0%	1.1%

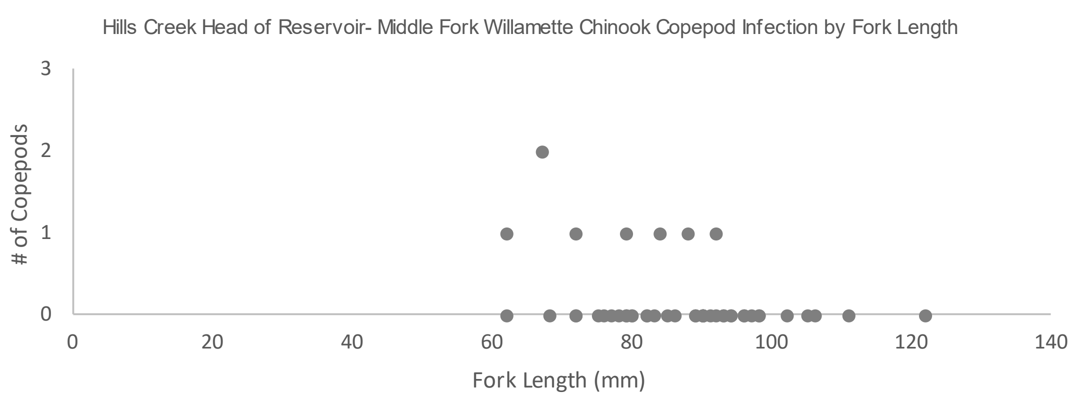

Figure 55. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Hills Creek Head of Reservoir.

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 45 NOR Chinook were PIT tagged and 2 fish were VIE marked during Spring 2024 sampling period. No PIT tagged or VIE marked fish were redetected downstream. Table 71 provides a summary of VIE marked fish at the Hills Creek Head of Reservoir – Middle Fork Willamette River site. Further information on tagged and VIE marked fish at this site is available in Appendix C.

Table 71. Summary table of VIE marked Chinook salmon at the Hills Creek Head of Reservoir – Middle Fork Willamette River RST site.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured
02/01/2024–02/15/2024	Left Dorsal	Yellow	1	0
02/16/2024–02/29/2024	Left Dorsal	Yellow	0	0
03/01/2024–03/15/2024	Left Dorsal	Red	0	0
03/16/2024–03/31/2024	Left Dorsal	Red	1	0
04/01/2024–04/15/2024	Left Dorsal	Blue	0	0
04/16/2024–04/30/2024	Left Dorsal	Blue	0	0
05/01/2024–05/15/2024	Left Dorsal	Orange	0	0
05/16/2024–05/31/2024	Left Dorsal	Orange	0	0
06/01/2024–06/15/2024	Left Dorsal	Pink	0	0
06/16/2024–06/30/2024	Left Dorsal	Pink	0	0

Non-Target Species

In addition to NOR juvenile Chinook salmon, a total of 197 non-target fish were captured. A summary of species and number of fish caught is provided in Table 72. The most captured non-target species were dace and *O. mykiss*. The Bull Trout captured at this site was tagged by EAS and reported to ODFW. Information regarding Bull Trout captures, fork lengths, and PIT tags is provided in Appendix C.

Table 72. Summary of non-target fish capture at the Hills Creek Head of Reservoir – Middle Fork Willamette River RST site.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	2	0
Bull Trout	1	0
Lamprey	9	1
Cutthroat Trout	9	1
Dace	56	0
Largescale Sucker	22	2
O. mykiss	51	0
O. mykiss (adult)	2	0
Redside Shiner	15	1
Sculpin	31	1
Totals	**198**	**6**

Hills Creek Dam Tailrace

One 5-foot RST and one 8-foot RST continued monitoring activities in the Middle Fork Willamette River in the Hills Creek Dam Tailrace and sampled from January 1, 2024, through June 30, 2024. The 5-foot RST is positioned below the confluence of the RO and PH outlet channels and is referred to as the RO trap. The 8-foot RST is positioned in the outlet of the PH and is referred to as the PH trap.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Additionally, the RSTs were not sampled from January 23, 2024, to February 6, 2024, due to flows increasing to unsafe thresholds, potentially putting EAS crew and fish safety at immediate risk.

For interpretation of results, it is important to note that no BY 2020 juvenile hatchery Chinook salmon (i.e. yearlings typically released in June 2021) or adult Chinook salmon in 2021 were out planted above Hills Creek Dam due to low adult returns (i.e., no production of BY 2021 juvenile Chinook salmon above Hills Creek Dam). In calendar year 2022, a total of 462 adult spring Chinook salmon were out planted above Hills Creek Dam. This consisted of 198 females, 250 males, and 14 jack Chinook salmon (USACE 2022). In calendar year 2023, no adult spring Chinook salmon were out planted above Hills Creek Dam. A total of 77,917 ad-clipped sub-yearling juvenile spring Chinook salmon were released into Hills Creek Reservoir in early July of 2023 by ODFW. Additionally, 20,000 PIT tagged juvenile hatchery Chinook Salmon were released at locations above Hills Creek Dam in 2023. For more information regarding these releases, please refer to the Willamette Valley Downstream Fish Passage Monitoring Annual Report (CFS 2024).

Trapping Efficiency Trials

A total of six TE trials occurred from January 23, 2024, to June 4, 2024, in the Hills Creek Dam Tailrace sites using hatchery reared Chinook salmon. Of these, five occurred in the powerhouse (PH) channel and one in the regulating outlet (RO) channel. Collectively, 28 TE trials have occurred at this site (18 in the PH channel and 10 in the RO channel) since January 6, 2022. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 73.

TEs ranged from 0.0% to 2.2% for the RO channel and 0.7% to 12.3% for the PH channel with a pooled average of 1.9% (95% CI ±0.8%, n=5) for the RO channel and a pooled average of 4.2% (95% CI ± 1.6%, n=18) for the PH channel for all successful trials with five or more recaptures. Five of the trials in the RO channel did not recapture enough fish to be used in the passage estimate calculation. For the RO channel, model results from the weekly average discharge and revolutions per hour analysis show that all models have low pseudo R^2 values (Table D-1). Of all the models for the RO channel, the model incorporating log-transformed discharge, trap revolutions per hour, and the interaction between the two covariates had the highest pseudo R^2 value ($R^2 = 0.089$). This model also had one the lowest AICc scores for the RO site (Table D-1). For the PH channel, the model incorporating log-transformed discharge, trap revolutions per hour, and the interaction between the two covariates had the highest pseudo R^2 value ($R^2 = 0.301$) as well. This model also had one the lowest AICc scores for the PH site (Table D-1). Full results and methods for the flow modeling are in Appendix E.

Table 73. Summary table of marked hatchery Chinook salmon releases below Hills Creek Dam for trapping efficiency

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Hills Creek Dam Powerhouse	1/6/2022	810	596	20	3.4%
Hills Creek Dam Powerhouse – RO Trial	1/6/2022	810	596	5	0.8%
Hills Creek Dam Regulating Outlet	1/6/2022	820	605	13	2.1%
Hills Creek Dam Powerhouse	2/16/2022	410	600	12	2.0%
Hills Creek Dam Powerhouse – RO Trial	2/16/2022	410	600	0	0.0%
Hills Creek Dam Regulating Outlet	2/16/2022	410	593	19	3.2%
Hills Creek Dam Powerhouse	2/25/2022	410	604	6	1.0%
Hills Creek Dam Powerhouse – RO Trial	2/25/2022	410	604	1	0.2%
Hills Creek Dam Regulating Outlet	2/25/2022	420	625	6	1.0%
Hills Creek Dam Powerhouse	12/7/2022	890	514	29	5.6%
Hills Creek Dam Powerhouse – RO Trial	12/7/2022	890	514	3	0.6%
Hills Creek Dam Regulating Outlet	12/13/2022	610	516	1	0.2%
Hills Creek Dam Powerhouse	2/25/2023	910	519	15	2.9%
Hills Creek Dam Powerhouse – RO Trial	2/25/2023	910	519	0	0.0%
Hills Creek Dam Regulating Outlet	2/25/2023	920	478	0	0.0%
Hills Creek Dam Powerhouse	4/26/2023	540	506	62	12.3%
Hills Creek Dam Powerhouse – RO Trial	4/26/2023	540	506	12	2.4%
Hills Creek Dam Powerhouse	5/17/2023	440	505	57	11.3%
Hills Creek Dam Powerhouse – RO Trial	5/17/2023	440	505	2	0.4%
Hills Creek Dam Powerhouse	6/3/2023	710	508	36	7.1%
Hills Creek Dam Powerhouse – RO Trial	6/3/2023	710	508	2	0.4%
Hills Creek Dam Regulating Outlet	6/13/2023	760	760	0	0.0%
Hills Creek Dam Powerhouse	6/27/2023	720	507	22	4.3%
Hills Creek Dam Powerhouse – RO Trial	6/27/2023	720	507	0	0.0%
Hills Creek Dam Powerhouse	9/27/2023	400	510	9	1.8%
Hills Creek Dam Powerhouse – RO Trial	9/27/2023	400	510	1	0.2%
Hills Creek Dam Powerhouse	10/17/2023	460	509	8	1.6%
Hills Creek Dam Powerhouse – RO Trial	10/17/2023	460	509	0	0.0%
Hills Creek Dam Powerhouse	10/31/2023	470	503	8	1.6%
Hills Creek Dam Powerhouse – RO Trial	10/31/2023	470	503	2	0.4%
Hills Creek Dam Powerhouse	11/15/2023	660	500	46	9.2%
Hills Creek Dam Powerhouse – RO Trial	11/15/2023	660	500	1	0.2%
Hills Creek Dam Regulating Outlet	11/21/2023	2420	503	3	0.6%

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Hills Creek Dam Powerhouse – RO Trial	5/17/2023	440	505	2	0.4%
Hills Creek Dam Regulating Outlet	11/29/2023	2130	504	2	0.4%
Hills Creek Dam Regulating Outlet	12/26/2023	750	505	10	2.0%
Hills Creek Dam Regulating Outlet	1/4/2024	100	503	5	1.0%
Hills Creek Dam Powerhouse	1/23/2024	910	505	8	1.6%
Hills Creek Dam Powerhouse	2/22/2024	420	1,473	31	2.1%
Hills Creek Dam Powerhouse	3/13/2024	450	1,494	11	0.7%
Hills Creek Dam Powerhouse	4/11/2024	830	3,996	74	1.9%
Hills Creek Dam Powerhouse	6/4/2024	200	1,250	51	4.1%

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Hills Creek Dam Tailrace in the Spring of 2024. Sufficient numbers of NOR fish were not available to perform ROR TE trials.

Target Catch, Passage Estimates and Passage Timing

A total of 60 juvenile Chinook salmon were captured in the Hills Creek Dam RSTs during spring sampling in 2024, 36 in the PH trap (60.0% of total catch) and 24 in the RO trap (40.0% of total catch) (Figure 56 and Figure 57). Peak capture of juvenile Chinook salmon occurred in January when 54 fish were captured (90.0% of total Chinook salmon catch). Scale age analysis showed that Chinook salmon captured from January 1, 2024, to June 30, 2024, consisted of two BYs: 2021 and 2022 (Figure 58). BY 2021 Chinook comprised a majority of the catch below Hills Creek Dam in the spring monitoring period (n= 42, 70.0% of total Chinook salmon catch). BY 21 Chinook were encountered from January 1, 2024, through the latter part of January while BY 2022 Chinook were captured throughout the entire reporting period. Fork length and weight data for Chinook salmon captured in the Hills Creek Dam Tailrace RSTs by BY is provided in Table 74.

Using pooled averages of Powerhouse channel released hatchery Chinook TE trials, we estimate that 316 (95% CI: 228 to 515) juvenile Chinook salmon passed through the PH during sampling in the Spring of 2024 (Figure 57). Additionally, using pooled hatchery Chinook TE trials for the RO trap from both powerhouse and RO releases, we estimate that 847 (95% CI: 567 to 1,674) juvenile Chinook passed the RO trap during sampling in the Spring of 2024 (Table 74). It is important to note that this estimate for the RO trap is not an estimate of RO passage but the combined passage of Chinook from both RO and Powerhouse routes. Each RST is only checked once in a 24 hour period; therefore, EAS cannot distinguish between daytime PH and nighttime RO operations for those fish captured in the RO trap. Thus, a NOR fish captured in the RO trap cannot be assigned to a specific route of passage.

Prior monitoring found that peak passage at Hills Creek Dam occurred November through January (Keefer et al. 2012). Similar to previous observations, no small sub-yearling Chinook salmon were observed in the RSTs below Hills Creek Dam in the Spring of 2024. This is likely a result of no adult Chinook salmon being out planted above Hills Creek Reservoir in 2023. Much like our data, previous catch at this site contained fish from multiple BYs suggesting that some Chinook salmon rear in the reservoir for multiple years or remain as adfluvial Chinook salmon in Hills Creek Reservoir. Capture of Chinook salmon in the RO and PWR RSTs in the spring monitoring period coincided with RO spill operations. Similar to previous observations from monitoring in 2022 and 2023, peak passage of Chinook occurred from November through January with the RO spill operations. However, many of the fish captured in each period were in the PH trap, suggesting that most fish passed through the PH instead of the RO. This implies that other factors such as pool elevation, depth to reservoir outlets or time of year may be influencing Chinook salmon movement out of Hills Creek Reservoir and that fish may pass through the RO channel at lower relative percentages, when compared directly to the PH. However, more clarity on passage estimates of fish coming through the RO is needed to draw conclusions on this matter. For raw weekly Chinook catch at the Hills Creek Dam RSTs for sampling from 2021 through 2023, refer to Appendix I.

Table 74. Summary of fork length and weight observed on juvenile Chinook salmon of NOR at the Hills Creek Dam Tailrace RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/2024–6/30/2024	21	42	199.7	155	237	199.5	90.5	41.7	136.9	91.6
Chinook	1/1/2024–6/30/2024	22	18	122.8	90	174	122	21.8	5.1	60.1	18.5

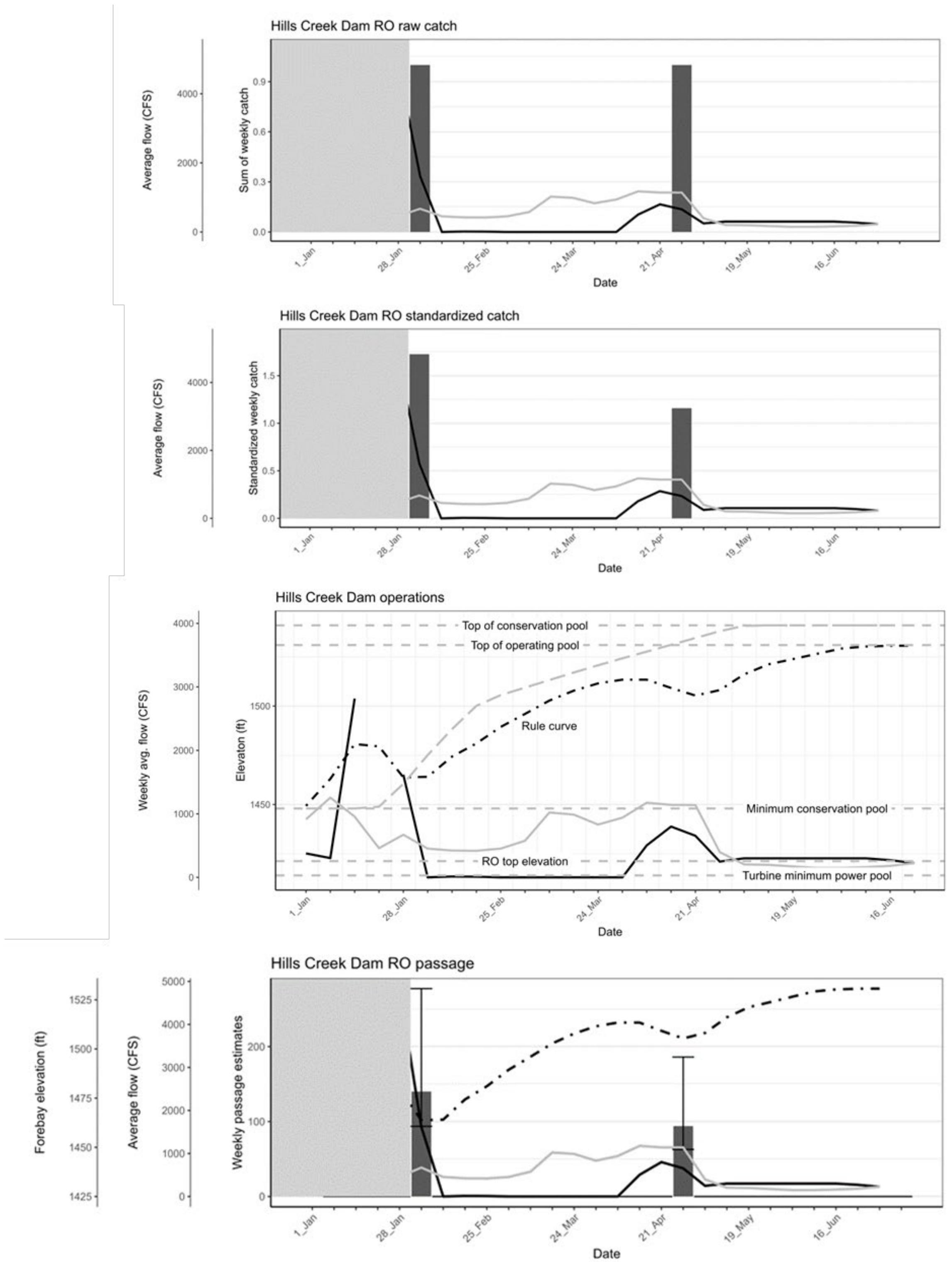

Figure 56. Raw catch (top panel), weekly standardized catch (second panel), and weekly passage estimates (bottom panel) overlayed with RO outflow (black line), Powerhouse outflow (gray line), and forebay elevation (black dot dash line) for the RO trap below Hills Creek Dam. The third panel shows Hills Creek Dam operations and features of interest with RO outflow (black line), Powerhouse outflow (gray line), and forebay elevation (black dot dash line).

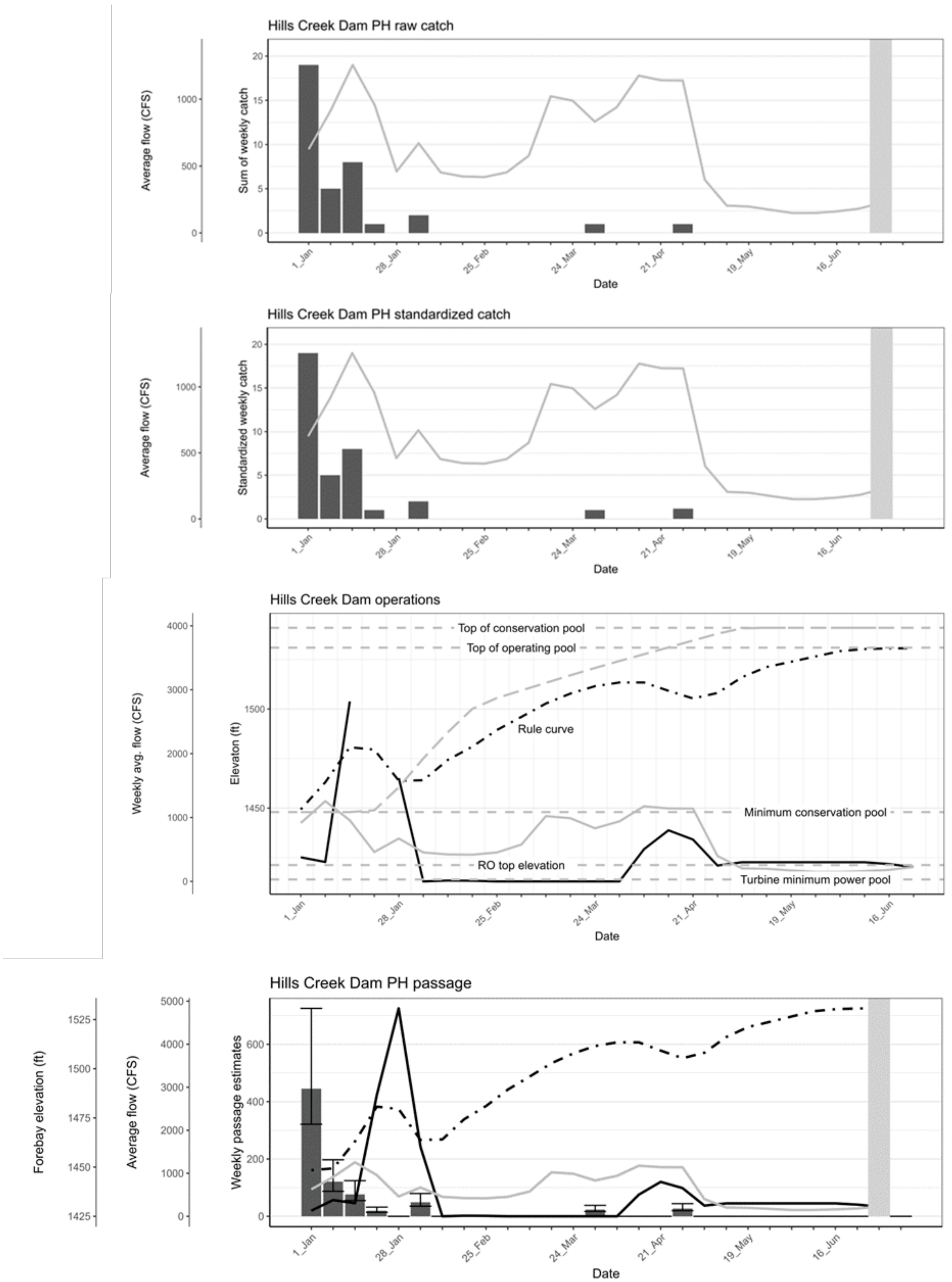

Figure 57. Raw catch (top panel), weekly standardized catch (second panel), Hills Creek Dam operations and features of interest (third panel), and weekly passage estimates (bottom panel) overlayed with Powerhouse outflow (gray line), RO outflow (black line), and forebay elevation (black dot dash line) for the PH trap below Hills Creek Dam.

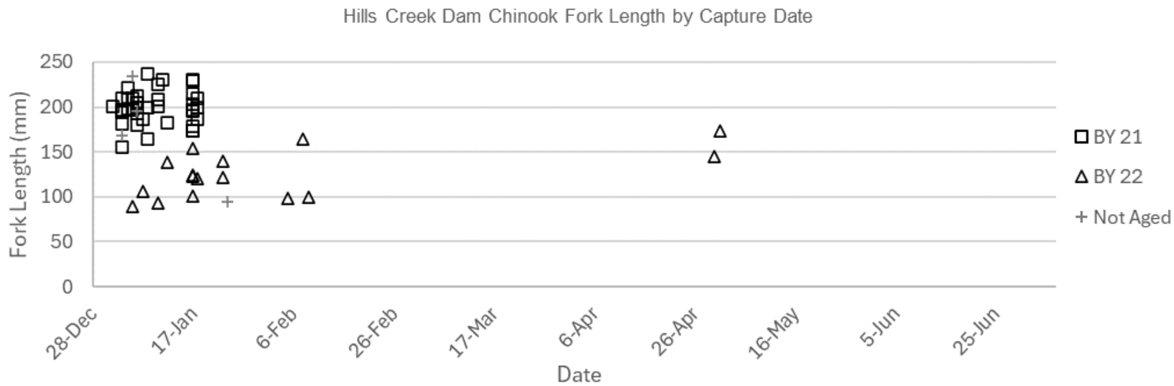

Figure 58. Length-frequency of juvenile Chinook salmon by brood year at the Hills Creek Dam site.

Injury Data

A total of 59 juvenile Chinook salmon (98.3% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 3. To provide insight on injuries associated with capture in a RST, injury data was collected from bulk marked released fish and hatchery fish utilized for TE trials.

The most common injuries observed at this site include descaling less than and greater than 20%, bleeding from vent, fin damage, and the presence of copepods (Table 75 and Table 76). 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 over time is displayed in Figure 59. Copepod presence on captured Chinook salmon at this site illustrated a positive correlation with the size of fish, like observations made by previous studies (CFS 2023a; Monzyk et al. 2015) (Figure 60).

Bulk marked release and TE hatchery Chinook salmon injuries were highly variable between the Hills Creek Dam PH and RO traps. Observed Chinook salmon injuries and bulk marking recapture injuries were more similarly related with the predominant injuries assessed being descaling, fin damage, the presence of copepods, bleeding from vent, fin blood vessels broken, and operculum damage (Table 75 and Table 76). TE hatchery Chinook salmon were found to have higher percentages of descaling greater than 20%, fin damage, and fungus, when compared to both NOR and bulk marked released Chinook.

There were 22 mortalities (36.1% of total Chinook salmon capture) at the time of trap check for this site: 13 in PH trap (59.1% of PH capture) and 9 in the RO trap (37.5% of RO capture). RO spill operations coincided with an increase in observed bodily injury, including descaling and the presence of copepods in Chinook salmon at the Hills Creek Dam site (Figure 59). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Table 75. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Hills Creek Dam Powerhouse RST.

Injury Code	Observed Chinook Injuries (n=36)	Bulk Marked Released Chinook (n=90)	Trapping Efficiency Hatchery Chinook (n=163)
NXI (no external injury)	2.8%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	41.7%	41.1%	22.1%
DS>2	55.6%	57.8%	77.9%
BLO	2.8%	5.6%	0.6%
EYB	27.8%	7.8%	0.6%
BVT	5.6%	7.8%	0.0%
FVB	22.2%	14.4%	0.0%
GBD	2.8%	3.3%	0.0%
POP	0.0%	2.2%	0.6%
HIN	13.9%	3.3%	0.0%
OPD	8.3%	12.2%	4.9%
TEA	2.8%	5.6%	1.2%
BRU	16.7%	22.2%	0.0%
HBP	0.0%	2.2%	0.0%
HO	0.0%	0.0%	0.0%
BO	2.8%	6.7%	0.0%
HBO	0.0%	0.0%	0.0%
FID	94.4%	97.8%	98.8%
PRD	0.0%	0.0%	0.0%
COP	88.9%	44.4%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	1.8%

Table 76. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Hills Creek Dam Regulatory Outlet RST.

Injury Code	Observed Chinook Injuries (n=24)	Bulk Marked Released Chinook (n=38)	Trapping Efficiency Hatchery Chinook (n=17)
NXI (no external injury)	0.0%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	33.3%	38.2%	11.8%
DS>2	62.5%	61.8%	88.2%
BLO	4.2%	5.9%	0.0%
EYB	20.8%	17.6%	0.0%
BVT	4.2%	11.8%	0.0%
FVB	33.3%	23.5%	0.0%
GBD	4.2%	11.8%	0.0%
POP	4.2%	0.0%	0.0%
HIN	12.5%	20.6%	0.0%
OPD	20.8%	11.8%	17.6%
TEA	4.2%	8.8%	0.0%
BRU	12.5%	17.6%	0.0%
HBP	4.2%	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	100.0%	97.1%	94.1%
PRD	0.0%	0.0%	0.0%
COP	75.0%	64.7%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	23.5%

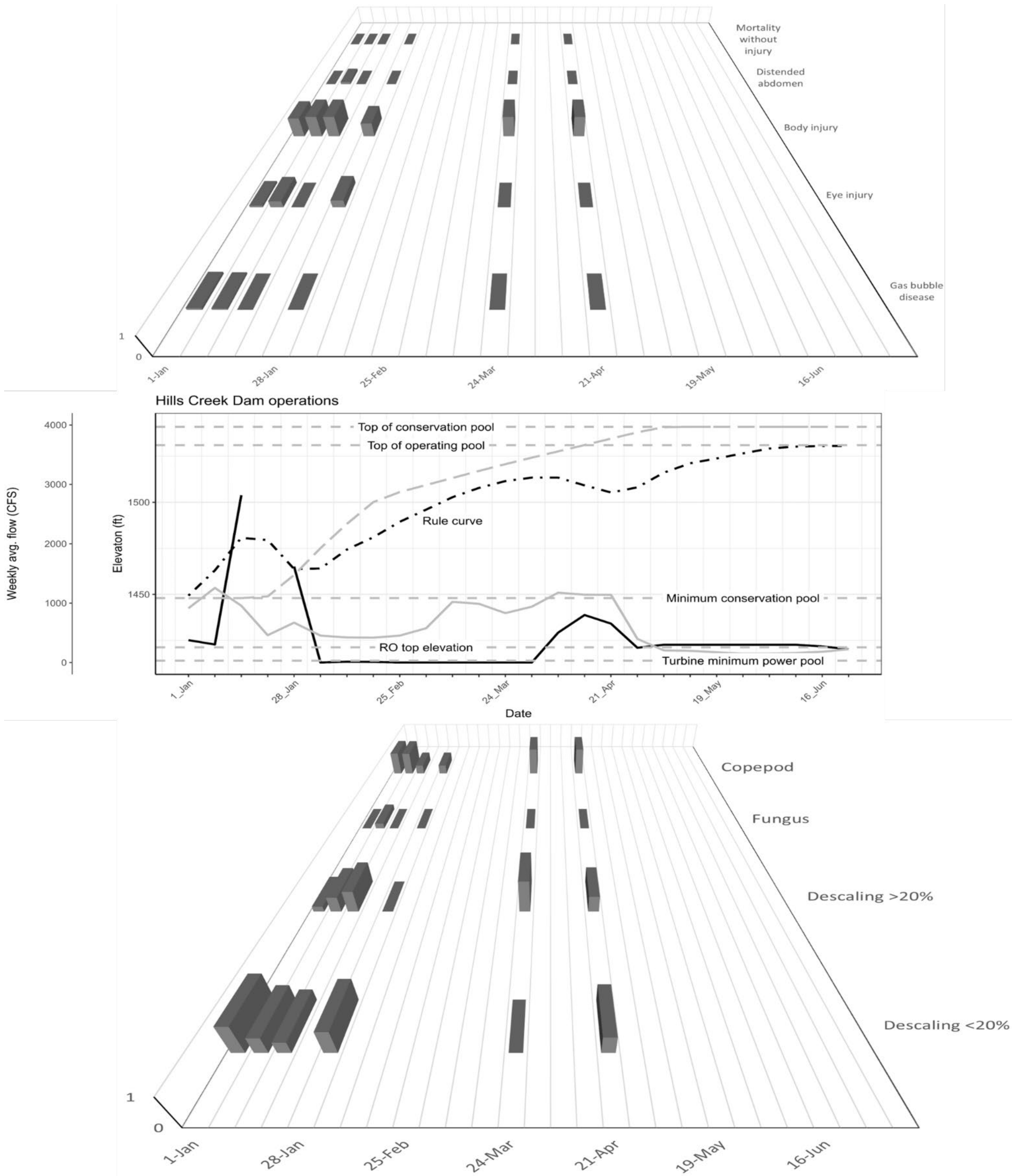

Figure 59. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data from the Hills Creek Dam (middle panel) showing spill flow (black line) and Powerhouse flow (gray line), and proportion of captured juvenile Chinook salmon displaying descaling injuries and copepods (bottom panel).

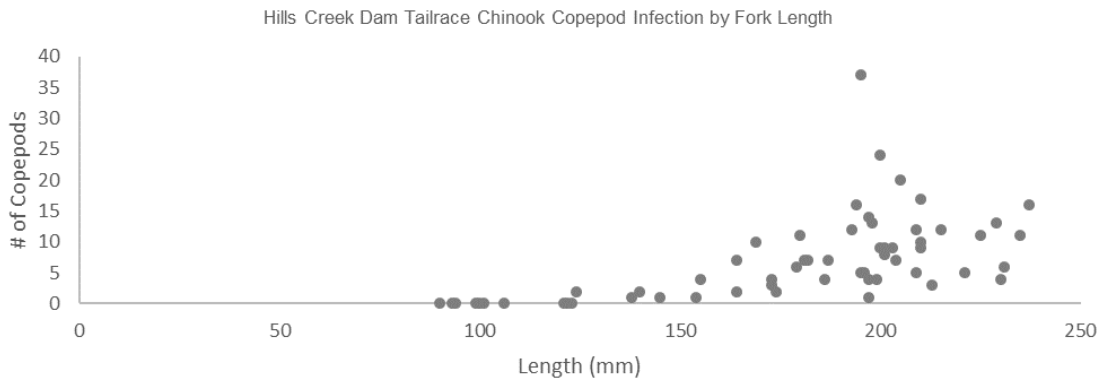

Figure 60. Copepod presence vs fork length on juvenile Chinook salmon captured at Hills Creek Dam Tailrace.

24-Hour Hold Trials

24-hour hold trials were performed on NOR juvenile Chinook salmon captured at Hills Creek Dam Tailrace to assess delayed mortality resulting from dam passage. A total of 28 fish, 10 from the RO and 18 from the PH traps, were held (Table 77). A total of 1 fish died during hold (3.6%). 1 of the 10 RO Chinook salmon died (10.0%) and 0 of the 18 PH Chinook salmon died (0.0%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 14.3%.

Table 77. Summary of 24-hour hold trials for Chinook salmon captured in the RST at the Hills Creek Dam site.

Hold Period	Trap	Number of Fish Held	Mortalities	% Survived
January 1–15, 2024	PH	15	0	100.0%
January 1–15, 2024	RO	7	1	85.7%
January 16–31, 2024	PH	1	0	100.0%
January 16–31, 2024	RO	2	0	100.0%
February 1–15, 2024	PH	2	0	100.0%
February 1–15, 2024	RO	1	0	100.0%
February 16–29, 2024	PH	0	0	--
February 16–29, 2024	RO	0	0	--
March 1–15, 2024	PH	0	0	--
March 1–15, 2024	RO	0	0	--
March 16–31, 2024	PH	0	0	--
March 16–31, 2024	RO	0	0	--
April 1–15, 2024	PH	0	0	--
April 1–15, 2024	RO	0	0	--
April 16–30, 2024	PH	0	0	--
April 16–30, 2024	RO	0	0	--
May 1–15, 2024	PH	0	0	--
May 1–15, 2024	RO	0	0	--
May 16–31, 2024	PH	0	0	--
May 16–31, 2024	RO	0	0	--
June 1–15, 2024	PH	0	0	--
June 1–15, 2024	RO	0	0	--
June 16–30, 2024	PH	0	0	--
June 16–30, 2024	RO	0	0	--

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 7 NOR Chinook salmon were PIT tagged and 0 were VIE marked at the Hills Creek Dam RST sites in the Spring of 2024. No VIE marked Chinook salmon were detected at this site. All other captured Chinook salmon were not tagged as they were prioritized for the 24-hour hold study. No PIT tagged fish were redetected downstream. A summary of VIE marked Chinook salmon by month at this site is provided in Table 78. Further information on tagged and VIE marked fish at this site is available in Appendix C.

Table 78. Summary of VIE tagged Chinook salmon at the Hills Creek Dam site.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured
N/A	Head	N/A	0	0

Willamette Valley Projects Encounters

A total of 124 adipose clipped and PIT tagged Chinook salmon were captured in the RSTs below Hills Creek Dam during the Spring 2024 monitoring period. These fish are a part of Cramer Fish Science's bulk mark release project. For more information on redetections of fish in the bulk mark release study, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Species

In addition to NOR juvenile Chinook salmon, a total of 1,084 non-target fish were captured. The most captured non-target species were clipped Chinook, crappie, and largescale sucker. A summary of species and numbers of fish caught is provided in Table 79.

Table 79. Summary of non-target catch for the RSTs in the Hills Creek Dam.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	270	98
Lamprey	8	0
Cutthroat Trout	3	1
Bluegill	65	44
Brown Bullhead	2	1
Crappie	251	208
Dace	67	6
Largescale Sucker	226	55
Mountain Whitefish	4	0
O. mykiss	13	0
O. mykiss (adult)	30	1
Redside Shiner	2	0
Sculpin	141	3
Spotted Bass	1	0
Unknown*	1	1
Totals	**1,084**	**418**

*Species denoted as "unknown" were too small and/or too decomposed to identify.

Lookout Point Head of Reservoir – Middle Fork Willamette River

A single 5-foot RST in the Middle Fork Willamette River above Lookout Point Reservoir continued monitoring activities and sampled from January 1, 2024, through June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Additionally, the RST was raised to its non-sampling position from January 23, 2024, to February 6, 2024, due to high debris loads from increased flows which caused severe damage to the trap.

Trapping Efficiency Trials

A total of eight TE trials occurred from January 3, 2024, to June 19, 2024, in the Lookout Point Head of Reservoir site using hatchery reared Chinook salmon. Collectively, 26 TE trials have occurred at this site since April 5, 2022. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 80.

TEs ranged from 0.0% to 12.5% with a pooled average of 2.7% (95% CI ±1.6%, n=14) of all successful trials with five or more recaptures. Twelve of the trials did not recapture enough fish to be used in the passage estimate calculation. Modeling results from the discharge and revolutions per hour analysis showed a suite of models with pseudo R^2 values ranging from 0.219 to 0.462. Typically, increasing complexity increased pseudo R^2 while also decreasing AICc scores. The full model with discharge, revolutions per hour and their interaction as covariates had the highest pseudo R^2 value of 0.462, while also having the lowest AICc score. The model with the second highest pseudo R^2 value (0.417), has a delta AICc score of 5.806.

Table 80. Summary table of marked hatchery Chinook salmon releases on the Middle Fork Willamette above Lookout Point Dam for trapping efficiency

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
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	4,100	1,004	125	12.5%
Lookout Point Head of Reservoir	7/20/2022	1,110	1,005	9	0.9%
Lookout Point Head of Reservoir	10/27/2022	1,680	506	9	1.8%
Lookout Point Head of Reservoir	11/17/2022	1,520	510	0	0.0%
Lookout Point Head of Reservoir	12/12/2022	1,510	510	0	0.0%
Lookout Point Head of Reservoir	1/13/2023	2,940	516	10	1.9%
Lookout Point Head of Reservoir	6/2/2023	2,605	760	15	2.0%
Lookout Point Head of Reservoir	6/15/2023	1,610	765	6	0.8%
Lookout Point Head of Reservoir	6/29/2023	1,340	769	2	0.3%
Lookout Point Head of Reservoir	7/19/2023	1,180	765	0	0.0%
Lookout Point Head of Reservoir	8/22/2023	1,470	677	13	1.9%
Lookout Point Head of Reservoir	8/31/2023	1,660	751	0	0.0%
Lookout Point Head of Reservoir	9/20/2023	776	787	1	0.1%
Lookout Point Head of Reservoir	10/26/2023	1,190	755	0	0.0%
Lookout Point Head of Reservoir	11/15/2023	1,630	755	3	0.4%
Lookout Point Head of Reservoir	11/29/2023	3,020	760	2	0.3%
Lookout Point Head of Reservoir	12/19/2023	5,680	1,504	9	0.6%
Lookout Point Head of Reservoir	1/3/2024	2,010	1,505	2	0.1%
Lookout Point Head of Reservoir	2/14/2024	2,120	761	2	0.3%
Lookout Point Head of Reservoir	3/13/2024	3,170	1,498	15	1.0%
Lookout Point Head of Reservoir	4/8/2024	2,670	1,997	7	0.4%
Lookout Point Head of Reservoir	4/15/2024	4,130	2,002	20	1.0%
Lookout Point Head of Reservoir	5/1/2024	4,620	751	35	4.7%
Lookout Point Head of Reservoir	5/23/2024	2,440	751	14	1.9%
Lookout Point Head of Reservoir	6/19/2024	1,300	756	0	0%

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Lookout Point Head of Reservoir during the Spring 2024 monitoring period. Sufficient numbers of NOR fish were not available to perform ROR TE trials.

Target Catch, Passage Estimates, and Passage Timing

The trap captured 49 juvenile Chinook salmon during spring sampling in 2024. Peak capture of juvenile Chinook salmon entering Lookout Point Reservoir occurred in March (n= 19, 38.8%). This timing is consistent with past observations from sampling in 2022 (see Appendix I) and from previous study by Romer (2015). Figure 61 shows raw and standardized catch overlayed with flow at the Lookout Point Head of Reservoir site.

Chinook salmon catch consisted of two BY classes, BY 2022 yearlings (n= 15, 30.6% of total catch) and BY 2023 sub-yearlings (n= 34, 75.6%) (Figure 62). The first BY 2023 sub-yearling captured at the trap occurred on February 27, 2024. This timing was considerably later than was observed in previous years by EAS (EAS 2023). Chinook catch at this site in the Spring of 2024 was lower than the observed catch in previous studies. This is likely tied to the lower number of adult out plants that occurred in 2023. For more information on adult out plants in the Willamette basin, please refer to Appendix I. Fork length and weight data by BY for Chinook salmon captured at this site is provided in Table 81. Using pooled averages of hatchery Chinook TEs, EAS estimate that 1,929 (95% CI: 1,200 to 4,914) juvenile Chinook salmon passed the sampling site during the spring monitoring period (Figure 61). This estimate is likely low as it does not include any fish that may have passed the site when the RST was raised for high flow for extended periods of time in which catch cannot be standardized across the outage period.

Table 81. Summary of fork length and weight observed on juvenile Chinook salmon of NOR at the Lookout Point Head of Reservoir RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/24–6/30/24	22	15	96.2	75	112	95	9.6	4.6	13.8	9.2
Chinook	1/1/24–6/30/24	23	34	59.3	32	89	56.5	3.6	1.0	8.0	3.5

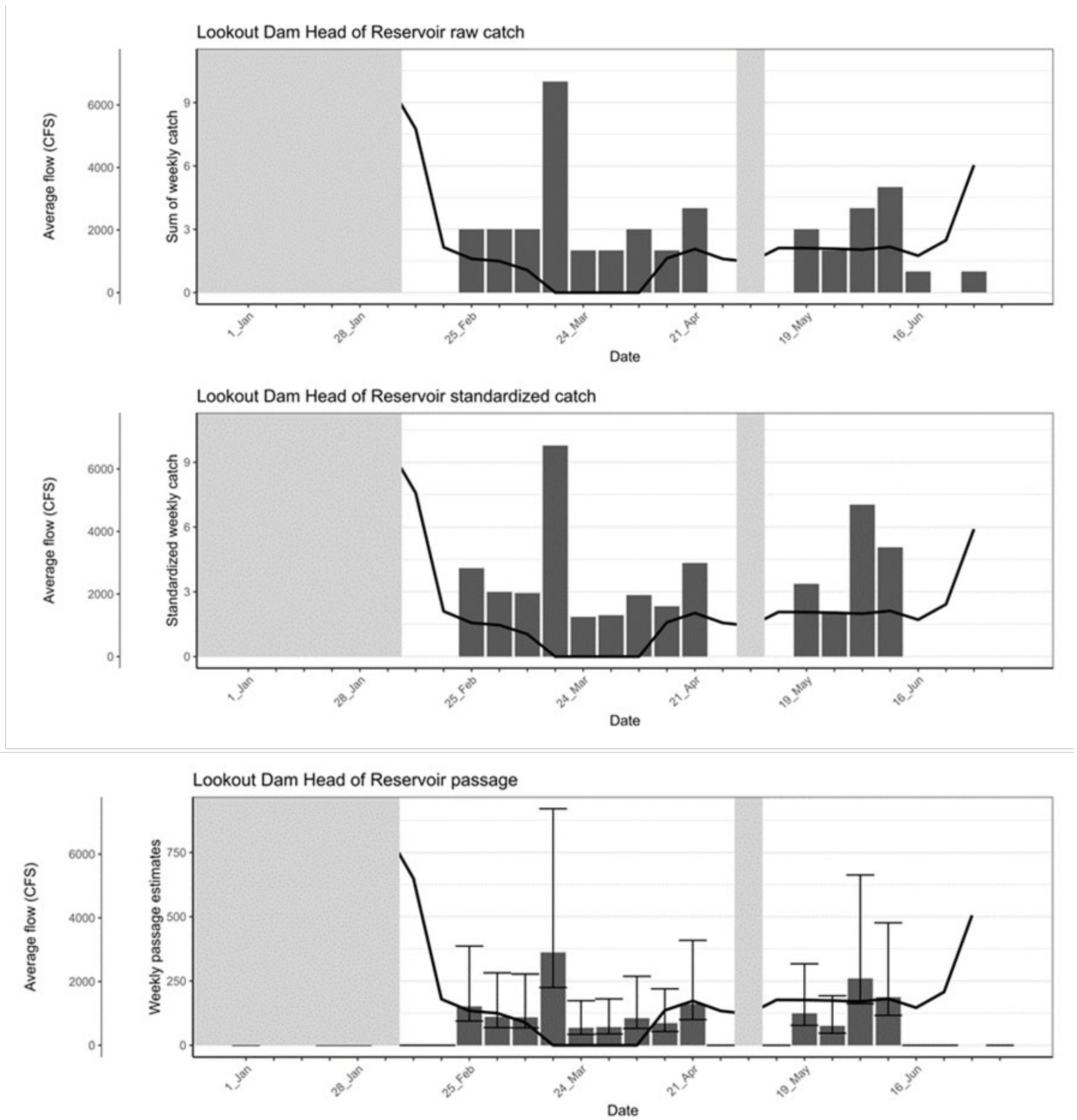

Figure 61. Raw catch (top panel), standardized catch (middle panel), and weekly passage estimates (bottom panel) of NOR juvenile Chinook salmon at the Lookout Point Head of Reservoir site with stream flow (black line) and non-sampling weeks shaded out (gray).

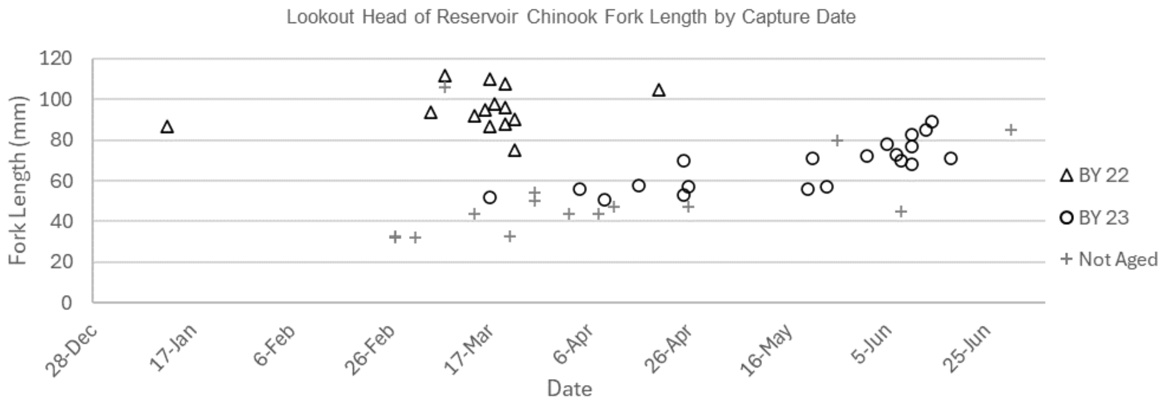

Figure 62. Length-frequency of juvenile Chinook salmon at the Lookout Point Head of Reservoir site.

Injury Data

A total of 28 juvenile Chinook salmon (57.1% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 3. The most common injuries observed at this site include descaling greater than 20% and fin damage (Table 82).

Copepod presence on captured Chinook salmon within our studies generally showed a positive correlation with the size of fish, similar to observations made by previous studies (CFS 2023a; Monzyk et al. 2015). However, at the Lookout Point Head of Reservoir RST site, zero fish were observed with copepods present on their fins or within their gills (Figure 63). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

There were no mortalities (0.0% of total Chinook salmon catch) observed upon trap check during the reporting period. Documented injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. Bulk marked released Chinook salmon at the Lookout Point Head of Reservoir RST site were found to exhibit a higher percentage of descaling greater than 20%, tears, fin damage, and the presence of copepods. It should be noted that there was only one recaptured bulk marked released Chinook salmon at this site. Furthermore, TE hatchery Chinook salmon were observed having higher percentages of descaling, operculum damage, fin damage, and fungus when compared to NOR fish (Table 82). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally decreased from pre-release to recaptured observations at the Lookout Point Head of Reservoir RST site (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Similar to other sites detailed within this report, results illustrated that Chinook salmon less than 60 mm were more likely to have less significant external injuries than those above 60 mm (Appendix D, Table D-7). Additionally, 100% of the Chinook salmon encountered that were above 60 mm had at least one injury denoted. The most common of these injuries was descaling and fin damage (Appendix D, Table D-7).

Table 82. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Lookout Point Head of Reservoir RST site.

Injury Code	Chinook Injuries (NOR) (n=49)	Bulk Marked Released Chinook (n=1)	Trapping Efficiency Hatchery Chinook (n=95)
NXI (no external injury)	42.9%	0.0%	2.1%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	0.0%	11.6%
DS>2	53.1%	100.0%	85.3%
BLO	0.0%	0.0%	0.0%
EYB	0.0%	0.0%	0.0%
BVT	2.0%	0.0%	0.0%
FVB	0.0%	0.0%	1.1%
GBD	0.0%	0.0%	0.0%
POP	0.0%	0.0%	0.0%
HIN	0.0%	0.0%	0.0%
OPD	2.0%	0.0%	3.2%
TEA	2.0%	100.0%	1.1%
BRU	4.1%	0.0%	0.0%
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	30.6%	100.0%	62.1%
PRD	0.0%	0.0%	0.0%
COP	0.0%	100.0%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	2.1%

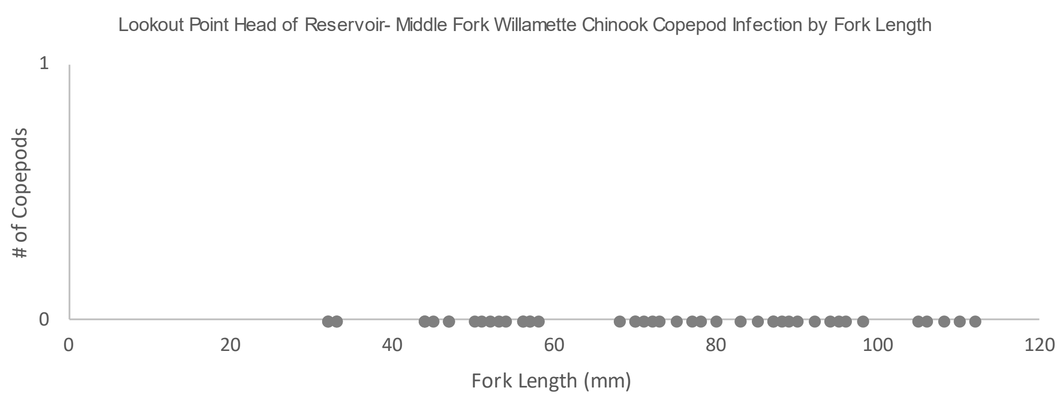

Figure 63. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Lookout Point Head of Reservoir.

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 29 juvenile Chinook salmon were PIT tagged and 16 were VIE marked at the Lookout Point Head of Reservoir site during sampling in the Spring of 2024. Fish that were not tagged were either still sac-fry or below minimum length requirements for tagging. One PIT tagged fish was recaptured at the Lookout Dam Tailrace traps in May of 2024. The travel time was 78 days. No VIE marked fish have been redetected at downstream sites through the Spring of 2024. A summary of downstream PIT tag detections is provided in Table 83 and a summary of VIE marked Chinook salmon by month at this site is provided in Table 84. Further information on tagged and VIE marked fish at this site is available in Appendix C.

Table 83. Summary of redetections of PIT tagged Chinook at the Lookout Point Head of Reservoir site.

PIT Tag #	Mark Date	Redetection Date	Recap Site	Travel Time (Days)
3DD.003BD22E41	3/5/2024	5/22/2024	Lookout Dam Tailrace	78
3DD.003BD22E45	5/26/2024	7/18/2024	Lookout Dam Tailrace	53

Table 84. Summary of VIE tagged Chinook salmon at the Lookout Point Head of Reservoir site.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured
01/01/2024–01/15/2024	Left Dorsal	Green	0	0
01/16/2024–01/31/2024	Left Dorsal	Green	0	0
02/01/2024–02/15/2024	Left Dorsal	Yellow	0	0
02/16/2024–02/29/2024	Left Dorsal	Yellow	0	0
03/1/2024–03/15/2024	Left Dorsal	Red	1	0
03/16/2024–03/31/2024	Left Dorsal	Red	3	0
04/01/2024–04/15/2024	Left Dorsal	Blue	5	0
04/16/2024–04/30/2024	Left Dorsal	Blue	4	0
05/01/2024–05/15/2024	Left Dorsal	Orange	0	0
05/16/2024–05/31/2024	Left Dorsal	Orange	2	0
06/01/2024–06/15/2024	Left Dorsal	Pink	1	0
06/01/2024–06/15/2024	Left Dorsal	Pink	0	0

Willamette Valley Projects Encounters

A total of one adipose clipped and PIT tagged Chinook salmon was captured at the Lookout Point Head of Reservoir trap during the Spring 2024 sampling period. This fish was a part of the Cramer Fish Science's bulk mark release project. For information regarding bulk mark releases, dates of release, and redetections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

A total of 276 non-target fish were captured at the Lookout Point Head of Reservoir site in addition to NOR juvenile Chinook salmon. A summary of species and numbers of fish caught is provided in Table 85. The most captured non-target species were largescale sucker and dace.

Table 85. Summary of non-target fish capture at the Lookout Point Head of Reservoir site.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	41	1
Oregon Chub	1	0
Lamprey	7	0
Cutthroat Trout	6	0
Dace	59	0
Largescale Sucker	67	0
Mountain Whitefish	4	0
Northern Pikeminnow	27	1
O. mykiss	42	0
O. mykiss (adult)	5	1
Redside Shiner	1	0
Sculpin	14	2
Unknown Bass*	1	0
Unknown*	1	0
Totals	**276**	**5**

*Species denoted as “unknown” were too small and/or too decomposed to identify.

Lookout Dam Tailrace

Three 8-foot RSTs in the Middle Fork Willamette River in the Lookout Dam Tailrace continued monitoring activities and sampled from January 1, 2024, through June 30, 2024. Within the tailrace below Lookout Dam, there are two RSTs located in the channel downstream of the PH Outlet, referred to as PH1 and PH2, and one RST in the channel on the south side of the island, referred to as the RO, or Spill.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Additionally, the RSTs were not sampled from February 1, 2024, to February 13, 2024, due to high flows which exceeded EAS' predefined safety thresholds for flow. During this period, all 3 of the RSTs were safety checked from shore to ensure any issues could be addressed in a timely manner.

Trapping Efficiency Trials

A total of three TE trials occurred below Lookout Point Dam tailrace from January 10, 2024, through April 3, 2024, using hatchery reared Chinook salmon. Collectively, 17 TE trials have occurred at this site since April 13, 2022. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 86.

The trapping efficiencies at this site are poor and complex. One trap is located in a spill channel, occasionally catching fish from the powerhouse (PH) route, though only in very low abundances under specific conditions. Two additional traps are positioned on the PH side channel. Prior to September 5, 2023, these two traps were set up in the PH channel: one upstream near the north shore and the other downstream, offset to the south. To enhance personnel safety while checking the traps, a decision was made to reorient them side by side. This new setup was expected to maintain, if not improve, the traps' effectiveness, as the adjacent positioning allows them to sample more efficiently compared to the previous setup, which could be affected by changing flow conditions.

Spill TE from the spill route ranged from 0.0% - 1.8% and had a pooled average TE of 0.7% (95%CI ± 1.0%, n = 3). Six of the nine trials were not successful in capturing the minimum number of fish (five) to be included in the passage estimate. Spill TE from the PH route ranged from 0.0% - 0.2% and had a pooled average TE of 0.1% (95%CI ±1.0%, n = 2). Seven of the nine trials were not successful in capturing the minimum number of fish to be included in the passage estimate. Model results from the discharge and revolutions per hour analysis indicate that two to three models had a modest fit for the site. The full model incorporating flow, trap revolutions per hour, and the interaction between the covariates had the highest pseudo R^2 (R^2 = 0.42) as well as the lowest AICc score. This suggests that while this model explains the most variation in the data, its complexity improved the fit when compared to the more simplistic models. Full results and methods for the flow modeling are located in Appendix E.

PH1 TE from the PH route ranged from 0.0% - 0.1% and had only two successful trials out of six. The pooled average of all trials (regardless if recaptures were <5) is <0.01% (95%CI ± 0.1%, n = 6). PH1 TE from the spill route ranged from 0.0% - 0.1% and had only three successful trials out of eleven. The pooled average of those three trials is 0.2% (95%CI ± 0.1%, n = 3). Model results from the discharge and revolutions per hour analysis indicate that six of eight models had a modest fit for the site. The full model incorporating flow, trap revolutions per hour, and the interaction between the covariates had the highest pseudo R^2 (R^2 = 0.52). However, this model also had the highest AICc score, suggesting that the increased complexity of the model only provided modest improvements in fit relative to the simpler models included in the comparison. Full results and methods for the flow modeling are located in Appendix E.

PH2 TE from the PH route ranged from 0.0% - 0.1% and had only three successful trials out of seven. The pooled average of all trials regardless of recapture numbers is 0.01% (95%CI ±0.02%, n = 7). PH2 TE from the spill route ranged from 0.0% - 0.01% and did not have a successful trial. The pooled average of all of the trials (regardless if recaptures were <5) is <0.01% (95%CI ±0.02%, n = 7). Model results from the discharge and revolutions per hour analysis indicate that all models had a poor fit for the site. The full model incorporating flow, trap revolutions per hour, and the interaction between the covariates had the highest pseudo R^2 (R^2 = 0.24). However, this model also had the second highest AICc score, suggesting that the increased complexity of the model only provided modest improvements in fit relative to the simpler models included in the comparison. Full results and methods for the flow modeling are located in Appendix E.

These TEs are extremely low and to get accurate estimates for PH fish caught via spill route and spill fish caught via PH route it is likely impossible to release enough fish to determine TE with any accuracy. Recaptures were pooled by release location in the below table. Even with the new configuration of the PH1 and PH2 traps and large release groups, passage estimates could not be calculated for this site and more trials across a wide range of flows will be needed in the future.

Table 86. Summary table of marked hatchery Chinook salmon releases below Lookout Point Dam for trapping efficiency

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Lookout Dam Powerhouse	4/13/2022	2,925	998	0	0.0%
Lookout Dam Powerhouse	5/23/2023	2,920	3,999	32	0.8%
Lookout Dam Powerhouse	6/1/2023	2,950	4,011	6	0.1%
Lookout Dam Powerhouse	6/14/2023	3,130	4,010	4	0.1%
Lookout Dam Powerhouse	6/28/2023	3,160	4,010	3	0.1%
Lookout Dam Powerhouse	7/18/2023	2,700	4,012	9	0.2%
Lookout Dam Spillway	9/13/2023	1,850	3,636	0	0.0%
Lookout Dam Spillway	9/14/2003	1,850	3,998	0	0.0%
Lookout Dam Spillway	10/25/2023	1,730	4,042	0	0.0%
Lookout Dam Spillway	11/16/2023	1,600	4,005	12	0.3%
Lookout Dam Spillway	12/6/2023	2,100	8,007	18	0.2%
Lookout Dam Spillway	12/13/2023	6,000	8,011	148	1.8%
Lookout Dam Powerhouse	12/20/2023	4,910	16,007	29	0.2%
Lookout Dam Powerhouse*	1/10/2024	6,986	17,553	3	0.02%
Lookout Dam Spillway	3/27/2024	3,600	7,800	11	0.1%
Lookout Dam Spillway	4/3/2024	3,100	6,599	7	0.1%

*5 separate releases on this day, but all are counted as one trial. The numbers reflect the total number of fish released on 1/10/2024, and the average flow was taken.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Lookout Point Dam during this reporting period. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study and are not tagged. Sufficient numbers of NOR fish were not available to perform ROR TE trials.

Target Catch and Passage Timing

A total of 87 juvenile Chinook salmon were captured in the Lookout Dam Tailrace during the 2024 spring sampling period, 63 in the PH traps (72.4% of total catch, 21 in PH1, 42 in PH2) (Figure 64 and Figure 65) and 24 in the Spill trap (27.6% of total catch) (Figure 66). Chinook salmon capture in the spring was comprised of individuals from BY 2021 (n=2, 12.3% of spring Chinook salmon catch) and BY 2022 (n=85, 97.7% of spring Chinook salmon catch) (Figure 67). No BY 2023 sub-yearlings were encountered at this site during sampling in the spring of 2024. Peak capture of Chinook below Lookout Point Dam occurred in January (n= 60, 69.0% of total Chinook catch). A summary of fork length and weight data for Chinook salmon captured in the Lookout Dam Tailrace RSTs by BY is provided in Table 87.

Our trapping rate in the Lookout Dam Tailrace was approximately 0.5 fish per day. This is slightly higher than rates observed from sampling in 2022, 2023, and those reported for sampling conducted from 2011 to 2015, in which the traps averaged roughly 0.3 fish per day (Romer et al. 2012–2016; EAS 2023). However, these rates are all lower than those observed from sampling by Keefer et al. from 2007 to 2010 which had a capture rate of 0.7 fish per day. Adult out planting above Lookout Reservoir have often been low in recent years which may result in the decreased rate of catch in the Lookout Dam Tailrace RST's. For more information on adult Chinook out planting in the Middle Fork Willamette basin, please refer to Appendix I.

Due to the low number of successful TE trials and low efficiency of the RSTs at this location, we are unable to create passage estimates for fish exiting Lookout Dam at this time. However, we were able to provide passage estimates for the trap in the tailrace of Dexter Dam and as Dexter Reservoir and Dexter Dam are immediately below Lookout Dam, estimates from Dexter can be used to provide some insight on passage at Lookout Dam.

Observations from sampling in 2012 and 2013 found that fish passed in the summer when spill occurred at the Lookout Dam Tailrace (Keefer et al. 2013). On years when no spring/summer spill occurred and water primarily passed through the turbines, Chinook salmon passage occurred predominantly in the fall months (Romer et al. 2013). Peak catch in the spring of 2024 occurred in January during a high flow event prior to the initiation of spill. However, an increase in catch was observed in late April and May during spill operations. Using the raw passage counts to infer relative passage timing, this change in peak capture could be a result of the decreased number of adult Chinook out planted at locations above Lookout Point Reservoir in 2023 and the resulting change in proportion of yearling and sub-yearling Chinook passing through Lookout Dam in the spring. Previous monitoring by EAS found that relatively few fry exited Lookout Reservoir in the spring (EAS 2024). This is similar to results from other studies and suggests that fry either enter the reservoir later in the year or rear in the reservoir upon entry. For raw weekly catch of Chinook at the Lookout Dam RST sites for sampling from 2021 to 2023, refer to Appendix I.

Table 87. Summary of fork length and weight observed on juvenile Chinook salmon of NOR at the Lookout Point Dam Tailrace RST sites by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/2024–6/30/2024	21	2	208.5	208	209	N/A	95.7	95.7	96	N/A
Chinook	1/1/2024–6/30/2024	22	85	124.1	82	180	115	24.6	4.8	78.4	18.5

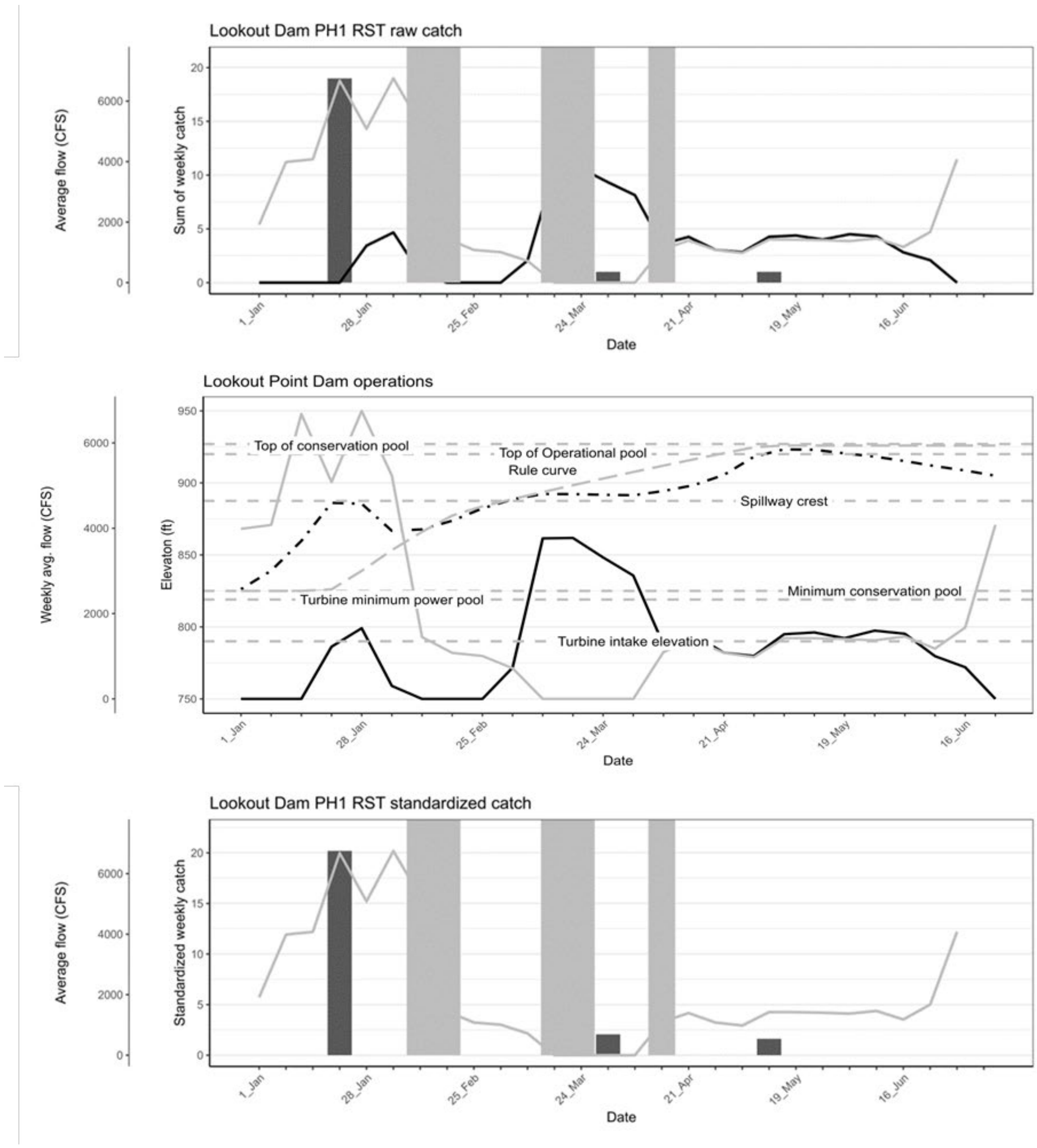

Figure 64. Raw catch (top panel), Lookout Point Dam operations and features of interest (middle panel), and weekly standardized catch (bottom panel) of NOR juvenile Chinook salmon at Lookout Point Dam Tailrace PH1 trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), and intake elevations (gray dash line).

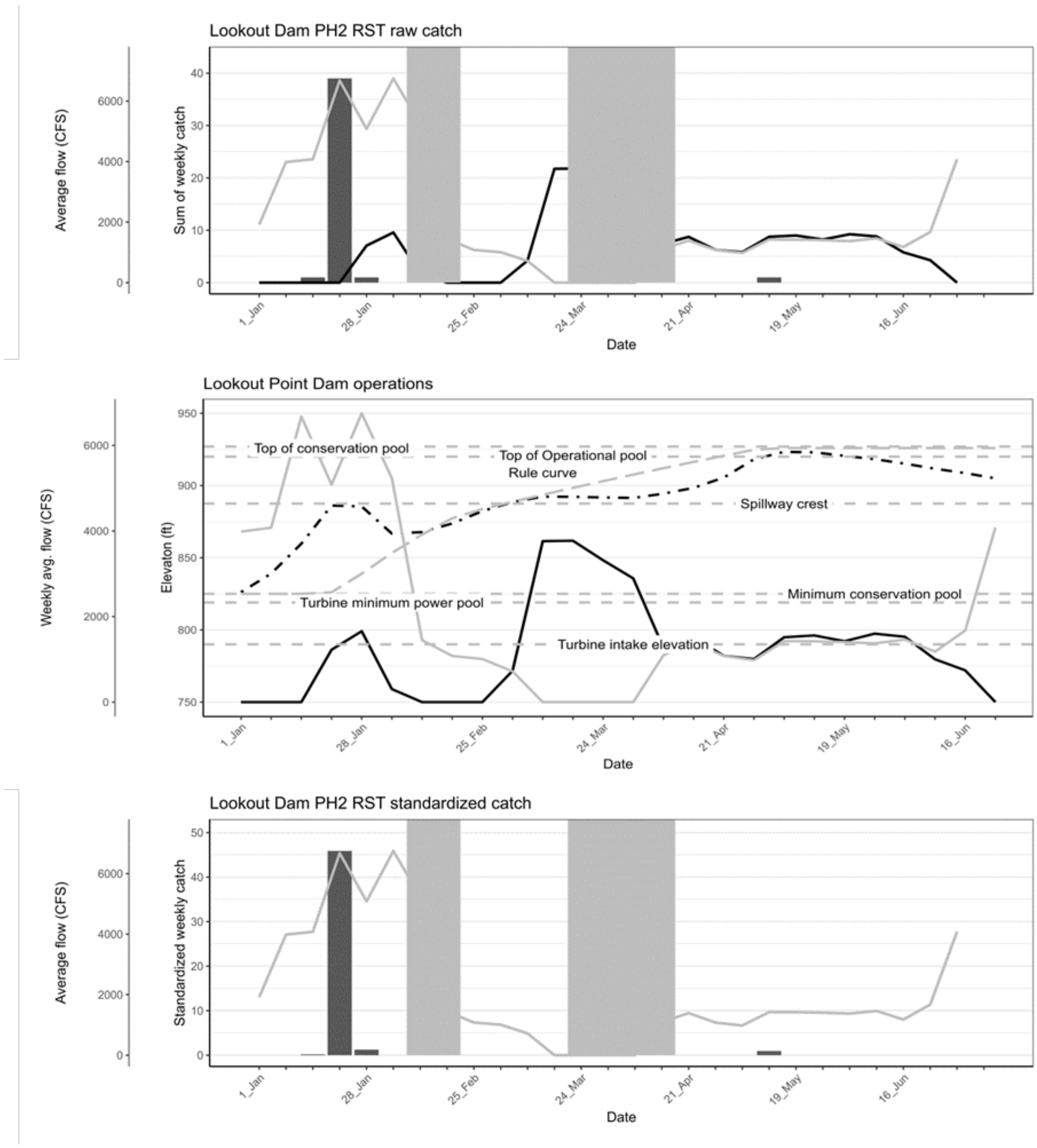

Figure 65. Raw catch (top panel), Lookout Point Dam operations and features of interest (middle panel), and weekly standardized catch (bottom panel) of NOR juvenile Chinook salmon at Lookout Dam Tailrace PH2 trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), and intake elevations (gray dash line).

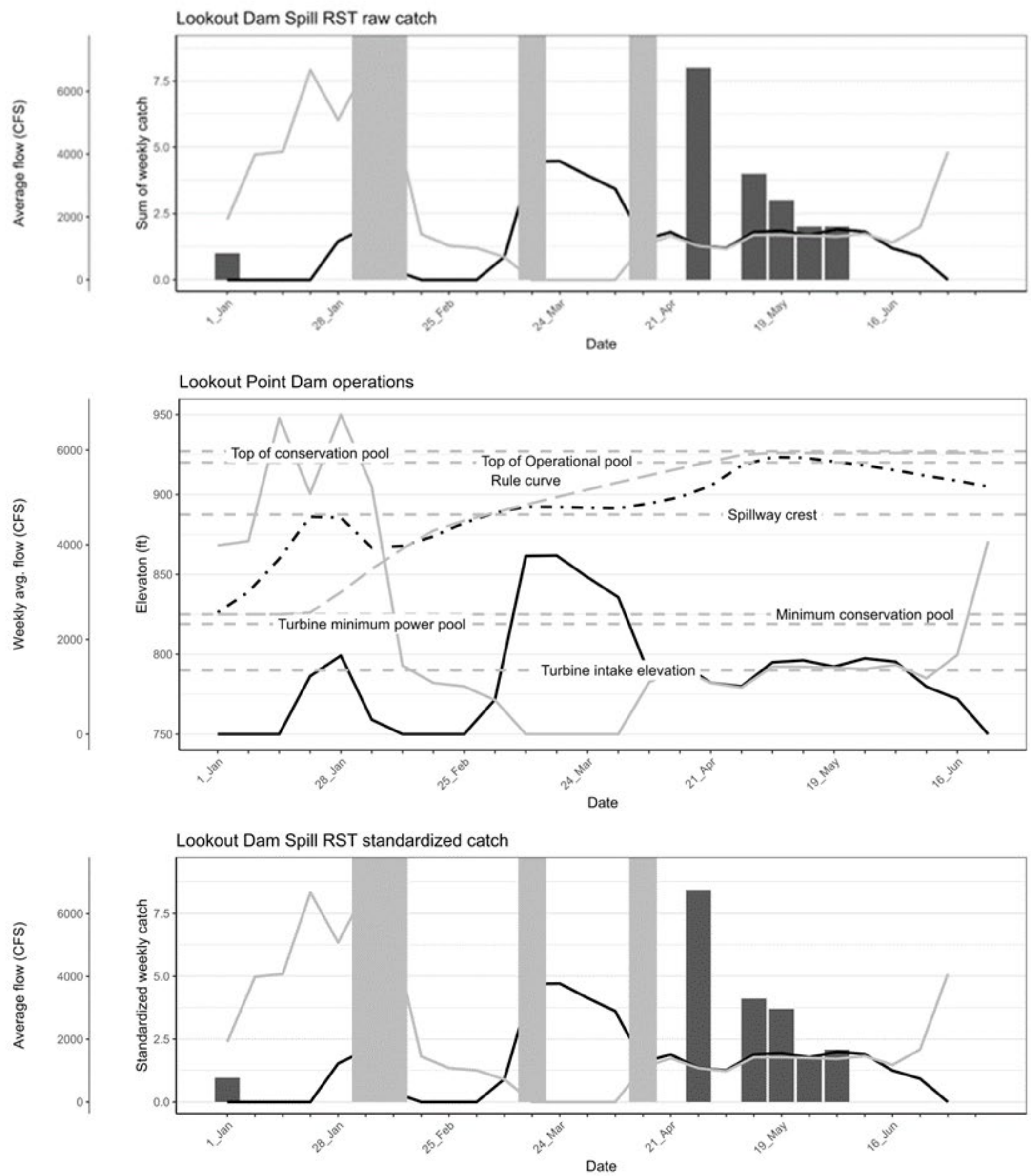

Figure 66. Raw catch (top panel), Lookout Point Dam operations and features of interest (middle panel), and weekly standardized catch (bottom panel) of NOR juvenile Chinook salmon at Lookout Point Dam Tailrace Spill trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), and intake elevations (gray dash line).

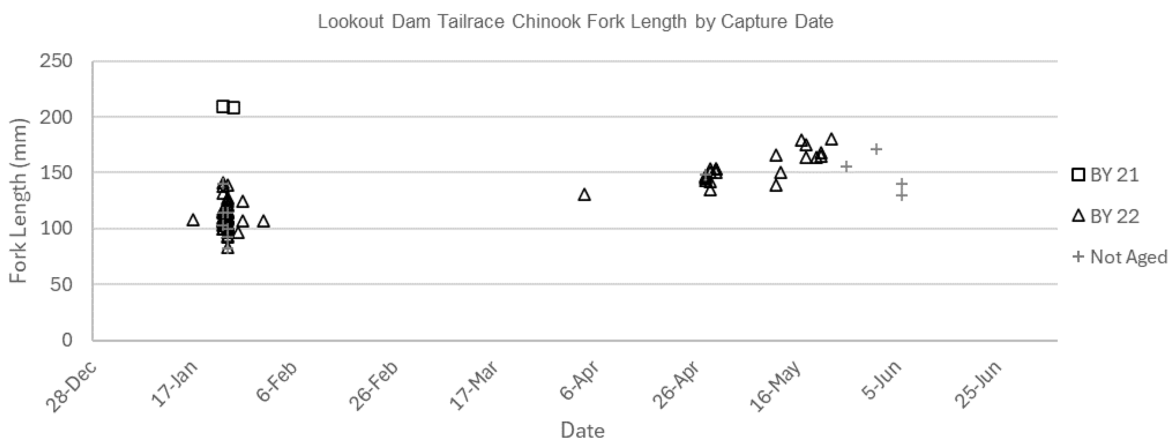

Figure 67. Length-frequency analysis for age of juvenile Chinook salmon captured below Lookout Point Dam.

Injury Data

A total of 87 juvenile Chinook salmon (100.0% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 3. All observed injuries from capture at all traps are combined for reporting purposes due to the uncertainty of a fish's route of passage based on which trap it was captured in. A total of 45 juvenile Chinook salmon (32.8% of total Chinook salmon catch) were found dead at the time of trap check (11 in PH1, 15 in PH2, and 19 in Spill).

The most common injuries observed at this site include descaling less than 20%, descaling greater than 20%, and fin damage (Table 88). At the Lookout Point Dam RST site, NOR juvenile Chinook salmon and PIT tagged bulk mark released recaptures exhibited many similar injuries (Table 88). The most observed injuries with these bulk marked released fish were descaling greater than 20% and fin damage (Table 88). TE hatchery Chinook salmon exhibited similar injuries to their NOR and bulk marked released counterparts. However, as was illustrated across a significant portion of the monitored RST sites, descaling, fin damage, and fungus were the most commonly observed injuries.

Figure 68 shows the proportion of captured Chinook salmon and bulk marked Chinook salmon, from Cramer releases, displaying injuries by type over the sampling period. Injury rates were highest during spill operations across all traps. 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 showed a positive correlation with increasing size of fish as has been observed here and at other sites in the past (Figure 69). Additional information regarding injuries by size and average injuries per fish is available in Appendix D. Surface spill periods are displayed in Table 89 and denoted in Figure 68.

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally decreased from pre-release to recaptured observations at the Lookout Point Dam RST site (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Like other sites detailed within this report, results illustrated that Chinook salmon less than 60 mm in length were more likely to have less significant external injuries than those above 60 mm in length (Appendix D, Table D-7). Additionally, 100% of the Chinook salmon encountered that were above 60 mm in length had at least one injury denoted. The most common of these injuries was descaling and fin damage (Appendix D, Table D-7).

Table 88. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Lookout Point Dam Tailrace.

Injury Code	Chinook Injuries (NOR) (n=87)	Bulk Marked Released Chinook (n=220)	Trapping Efficiency Hatchery Chinook (n=23)
NXI (no external injury)	0.0%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	10.3%	18.6%	30.4%
DS>2	87.4%	81.4%	69.6%
BLO	0.0%	0.5%	0.0%
EYB	1.1%	5.9%	8.7%
BVT	3.4%	0.5%	0.0%
FVB	6.9%	10.9%	8.7%
GBD	14.9%	10.0%	21.7%
POP	0.0%	0.9%	8.7%
HIN	5.7%	8.2%	4.3%
OPD	10.3%	12.3%	13.0%
TEA	2.3%	3.6%	4.3%
BRU	9.2%	14.5%	0.0%
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%	4.3%
FID	73.6%	99.5%	100.0%
PRD	1.1%	2.7%	13.0%
COP	20.7%	8.6%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	43.5%

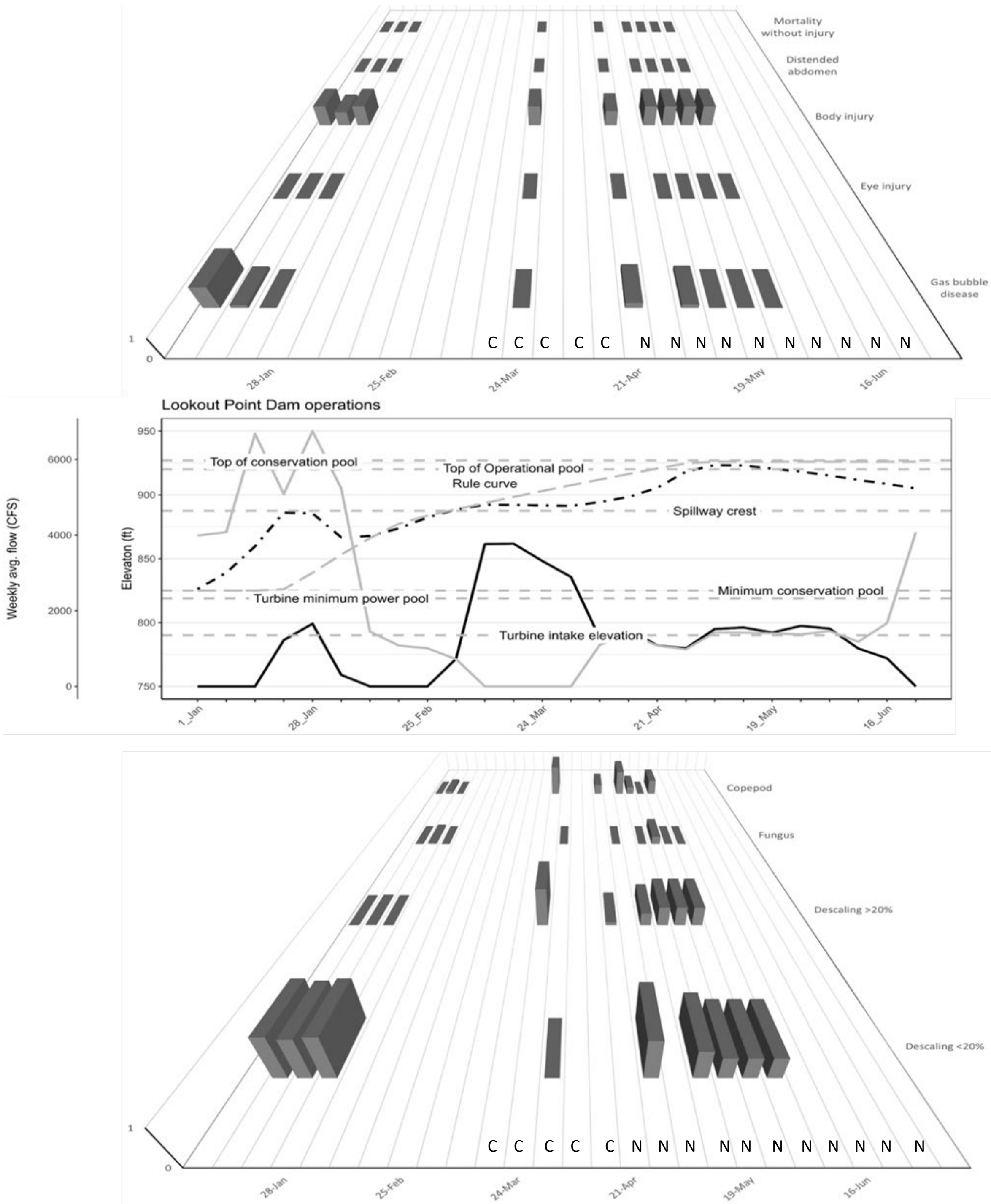

Figure 68. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations and features of interest at Lookout Dam with spill (black line) and Powerhouse (gray line) outflow (middle panel), and proportion of captured juvenile Chinook salmon displaying descaling injuries and copepod presence (bottom panel). Bars denoted with "C" show weeks in which Continuous Ungated Surface Spill occurred while those denoted with "N" show weeks in which Gated Nighttime Spill Operations occurred.

Table 89. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Lookout Dam Tailrace RST site.

Site	Dates	Description
Lookout Dam	3/18/2024 – 4/15/2024	Continuous Ungated Surface Spill
Lookout Dam	4/15/2024 – 6/27/2024	Nighttime Gated Surface Spill Operations

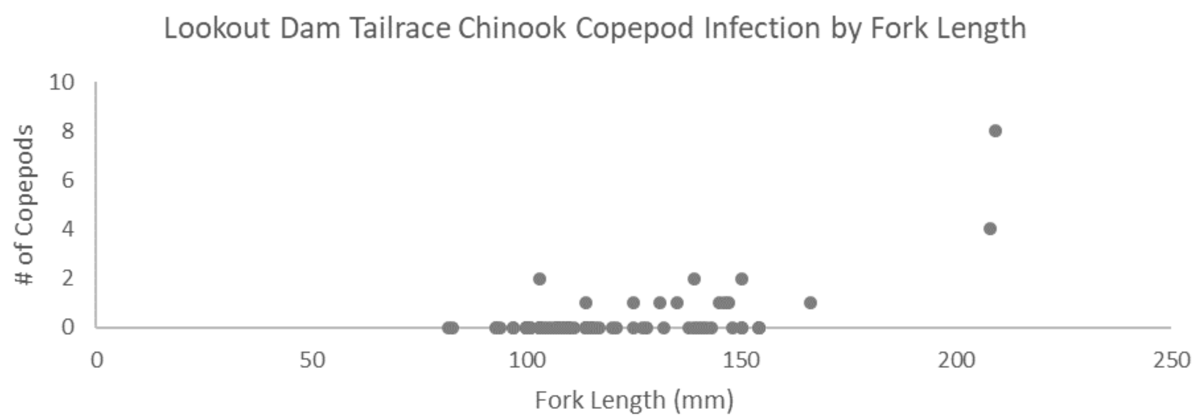

Figure 69. Copepod prevalence vs fork length on juvenile Chinook salmon captured at the Lookout Point Dam Tailrace.

24-Hour Hold Trials

24-hour hold trials were performed on NOR juvenile Chinook salmon captured at Lookout Dam Tailrace to assess delayed mortality resulting from dam passage. A total of 79 fish, 15 from the Spill and 64 from the PH traps, were held (Table 90). A total of 7 fish died during hold (8.9%), 6 of the 15 Spill Chinook salmon died (40.0%) and 1 of the 64 PH Chinook salmon died (0.2%). Mortality rates across the two-week periods in which fish were held ranged from 0.0% to 100%.

Table 90. Summary of 24-hour trials for Chinook salmon captured in the RSTs at the Lookout Dam Tailrace sites.

Hold Period	Route	Number of Fish Held	Mortalities	% Survived
January 1–15, 2024	PH	0	0	--
January 1–15, 2024	Spill	0	0	--
January 16–31, 2024	PH	56	0	100.0%
January 16–31, 2024	Spill	0	0	--
February 1–15, 2024	PH	0	0	--
February 1–15, 2024	Spill	0	0	--
February 16–29, 2024	PH	0	0	--
February 16–29, 2024	Spill	0	0	--
March 1–15, 2024	PH	0	0	--
March 1–15, 2024	Spill	0	0	--
March 16–31, 2024	PH	0	0	--
March 16–31, 2024	Spill	0	0	--
April 1–15, 2024	PH	0	0	--
April 1–15, 2024	Spill	0	0	--
April 16–30, 2024	PH	0	0	--
April 16–30, 2024	Spill	11	3	72.7%
May 1–15, 2024	PH	1	1	0.0%
May 1–15, 2024	Spill	1	1	0.0%
May 16–31, 2024	PH	0	0	--
May 16–31, 2024	Spill	7	0	100.0%
June 1–15, 2024	PH	0	0	--
June 1–15, 2024	Spill	3	2	33.3%
June 16–30, 2024	PH	0	0	--
June 16–30, 2024	Spill	0	0	--

PIT Tagged/VIE Marked Fish and Downstream Detections

One juvenile Chinook salmon was PIT tagged at the RST sites below Lookout Point Dam in this reporting period. All other captured fish were placed into the 24-hour hold study. No fish were VIE marked at this location during the Spring 2024 monitoring period as fish were prioritized for the 24-hour hold study and no VIE marked fish from upstream sites were detected. The single PIT tagged NOR Chinook has not been redetected downstream through the Spring of 2024. One PIT tagged Chinook that was tagged at the Lookout Point Head of Reservoir RST was recaptured at this site during this reporting period 2024. The travel time was 78 days. Further information on tagged and VIE marked fish at this site is available in Appendix C.

Willamette Valley Projects Encounters

A total of 220 adipose clipped and PIT tagged Chinook salmon were encountered below Lookout Point Dam in the Spring of2024. Two of these Chinook were also encountered downstream in the Dexter Dam Tailrace RST by EAS crew. These fish were associated with bulk mark fish releases performed by Cramer Fish Sciences. For more information regarding bulk mark releases and detections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Species

A total of 503 non-target fish were captured in the RSTs below Lookout Point Dam during the reporting period (Table 91). The most common non-target species encountered were clipped Chinook and walleye.

Table 91. Summary of non-target fish capture below Lookout Point Dam.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	2	0
Chinook (clipped)	300	16
Crappie	18	8
Largescale Sucker	4	4
Northern Pikeminnow	1	1
O. mykiss	2	0
O. mykiss (adult)	3	1
Sculpin	25	1
Smallmouth Bass	28	7
Unknown Bass*	22	16
Unknown*	1	1
Walleye	97	12
Totals	**503**	**67**

*Species denoted as “unknown” were too small and/or too decomposed to identify.

Dexter Dam Tailrace

A single 5-foot RST in the Dexter Dam Tailrace continued monitoring activities and sampled from January 1, 2024, through June 30, 2024.

Sampling outages resulting from high flows, excessive debris, severe weather, localized flood evacuations, and additional issues are listed in Appendix B. Non-sampling periods illustrated in the figures below are further detailed in Appendix B.

Trapping Efficiency Trials

Due to construction improvements of the Dexter hatchery being undertaken adjacent to Dexter Dam, EAS relocated the Dexter Dam Tailrace RST on November 6, 2023. The RST stayed on the north side of the river but moved over 300 yards downstream. Because of this, TE, weekly passage estimates and weekly discharge and revolution per hour modeling include only TE trial data after the RST was moved. A total of six TE trials occurred from January 9, 2024, through April 10, 2024, in the Dexter Dam Tailrace using hatchery reared juvenile Chinook salmon. Collectively, 15 TE trials have occurred at this site since the site RST was moved. A summary of the fish release numbers, recaptures, and flow level for each trial is provided in Table 92.

TEs ranged from 0.0% to 0.9% with a pooled average of 0.5% (95%CI ±0.2%, n=6) of all successful trials with five or more recaptures. Eight of the trials did not recapture enough fish to be used in the passage estimate calculation, and one trial was discounted due to an ODFW fish release upstream of Dexter Dam. For this site, the model incorporating log-transformed average weekly discharge and trap revolutions per hour had the highest pseudo R^2 value (R^2 = 0.293). The AICc score for this model fell out in the middle of the range for all AICc scores for the site (Table D-1). Full results and methods for the flow modeling are in Appendix E.

Table 92. Summary table of marked hatchery Chinook salmon releases at Dexter Dam Tailrace for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent 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	1018	67	6.6%
Dexter Dam Powerhouse	7/21/2022	1,560	976	2	0.2%
Dexter Dam Powerhouse	10/26/2022	2,950	1007	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	1010	10	1.0%
Dexter Dam Powerhouse	12/15/2022	1,540	1025	1	0.1%
Dexter Dam Powerhouse	3/16/2023	1,550	1,200	2	0.2%
Dexter Dam Spillway	3/29/2023	1,280	1,199	5	0.4%
Dexter Dam Powerhouse	5/25/2023	3,030	4,003	14	0.3%
Dexter Dam Powerhouse	6/7/2023	3,200	4,010	4	0.1%
Dexter Dam Powerhouse	6/21/2023	2,720	4,028	15	0.4%
Dexter Dam Powerhouse	7/6/2023	2,640	4,000	5	0.1%
Dexter Dam Powerhouse	8/2/2023	2,240	1,505	3	0.2%
Dexter Dam Powerhouse	8/23/2023	1,710	4,012	14	0.3%
Dexter Dam Powerhouse	9/6/2023	1,800	4,037	13	0.3%
Dexter Dam Powerhouse	10/4/2023	1,720	4,001	5	0.1%
Dexter Dam Spillway	10/24/2023	1,590	1,514	18	1.2%
Dexter Dam Spillway	11/1/2023	1,450	1,506	9	0.6%
Dexter Dam Spillway	11/22/2023	3,480	1,516	0	0.0%
Dexter Dam Spillway	12/5/2023	2,050	4,006	10	0.2%
Dexter Dam Spillway	12/12/2023	4,050	4,001	13	0.3%
Dexter Dam Spillway and Powerhouse	12/21/2023	4,850	4,005	3	0.1%
Dexter Dam Powerhouse	12/28/2023	1,990	8,032	46	0.6%
Dexter Dam Powerhouse	1/9/2024	3,360	4,004	6	0.1%
Dexter Dam Spillway	2/8/2024	8,500	2,067	0	0.0%
Dexter Dam Spillway	2/28/2024	1,200	1,959	11	0.6%
Dexter Dam Spillway	3/6/2024	1,250	2,000	4	0.2%
Dexter Dam Spillway	4/2/2024	3,370	1,962	0	0.0%
Dexter Dam Spillway*	4/10/2024	2,800	6,000	9	0.2%

*ODFW mistakenly released fish above Dexter Dam instead of downstream in February, March, and April of 2024. The TE trial in April had only marked fish with an ad-clip, so these fish cannot be distinguished from the ODFW release.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Dexter Dam Tailrace during this reporting period. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study and are not tagged. Sufficient numbers of NOR fish were not available to perform ROR TE trials.

Target Catch, Passage Estimates and Passage Timing

The trap captured 28 juvenile Chinook salmon during the Spring 2024 monitoring period (Figure 70). Chinook salmon catch below Dexter Dam was primarily composed of BY 2022 yearlings (n=27, 96.4% of total catch). A single BY 2021 Chinook salmon was also captured at the site on January 29, 2024 (Figure 72). No BY 2023 sub-yearlings were encountered at this site in the spring monitoring period. Data summarizing fork lengths and weights of Chinook salmon captured at Dexter Dam can be found in Table 93.

Peak capture of juvenile Chinook salmon leaving Dexter Reservoir occurred in January (n= 10, 35.7%). Previously, peak capture at Dexter Dam in the spring showed an association with the concurrent surface spill events at Lookout and Dexter Dams. Catch in the spring of 2024 was spread throughout the sampling period and surface spill was the only route of passage available to fish after the powerhouse went offline in early January (Figure 71). No clear association with spill at Lookout Dam and catch below Dexter was observed during sampling in the spring. We estimate that during sampling in the Spring of 2024, 5,321 (95% CI: 3,982 to 8,017) juvenile Chinook salmon migrated past the trapping site (Figure 71). For figures displaying raw weekly catch of Chinook at this site for sampling in 2022 and 2023, refer to Appendix I.

Table 93. Summary of fork length and weight observed on juvenile Chinook salmon of NOR at the Dexter Dam Tailrace RST site by brood year.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)	Average Weight (g)	Min. Weight (g)	Max Weight (g)	Median Weight (g)
Chinook	1/1/2024–6/30/2024	21	1	227	227	227	N/A	101.5	101.5	101.5	N/A
Chinook	1/1/2024–6/30/2024	22	27	130.3	77	177	129	26.9	7.7	60.1	24.6

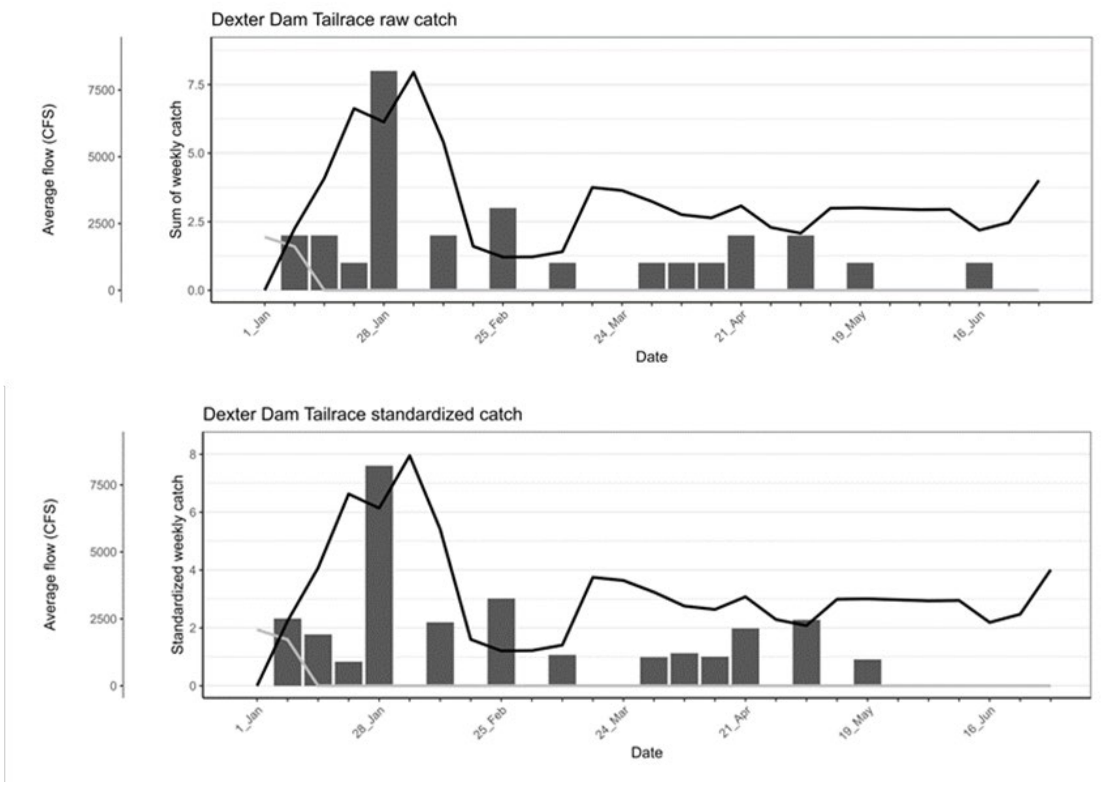

Figure 70. Raw catch Dexter Dam (top panel) and weekly standardized catch (bottom panel) of NOR juvenile Chinook salmon at the Dexter Dam Tailrace site with spill (black line) and Powerhouse outflow (gray line).

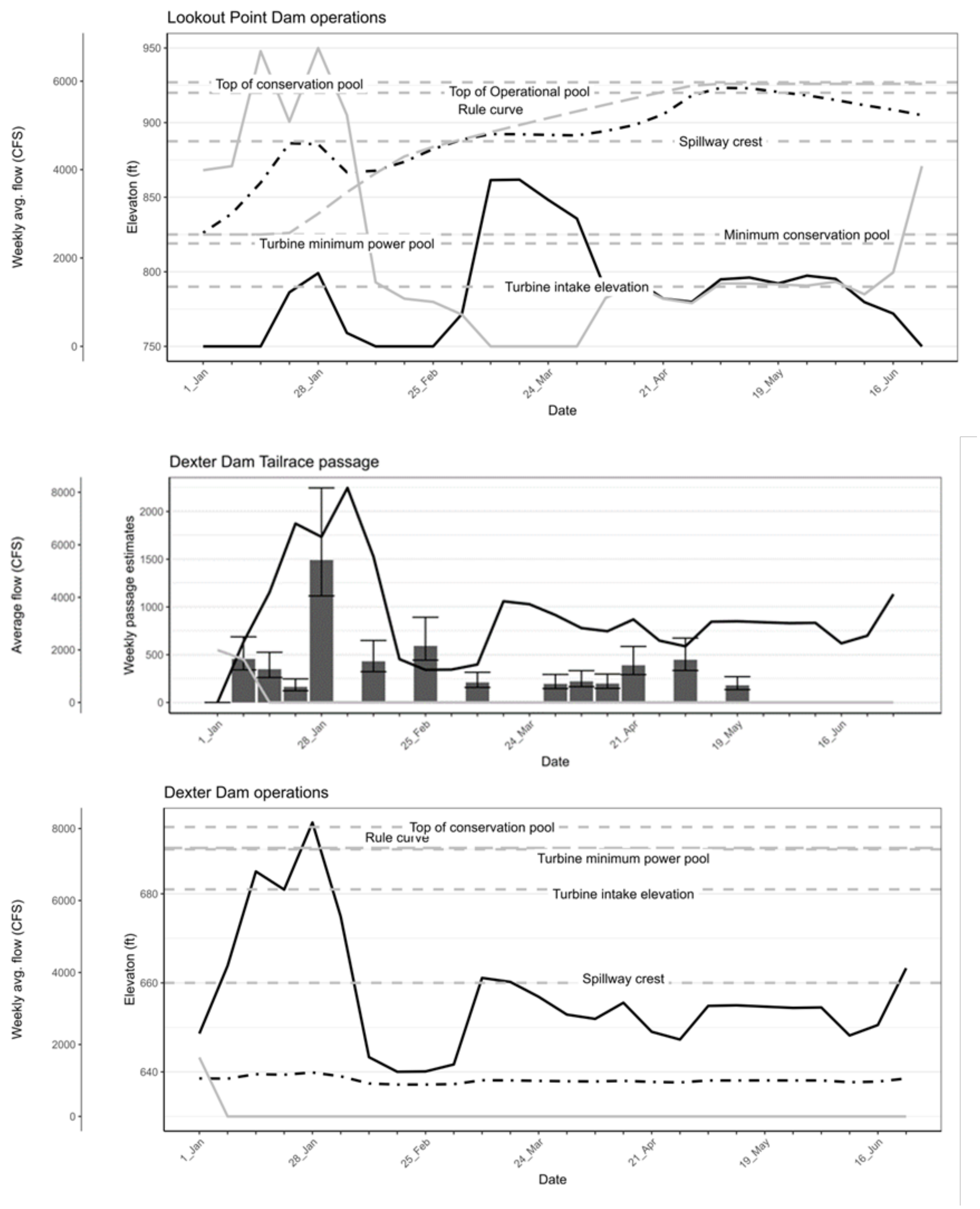

Figure 71. Lookout Dam (top panel) and Dexter Dam (bottom panel) operations with forebay elevation (black dot dash line), spill/RO outflow (black line) and Powerhouse outflow (gray line). Weekly passage estimates with 95% confidence for juvenile Chinook salmon at Dexter Dam (middle panel) with spill (black line) and Powerhouse outflow (gray line).

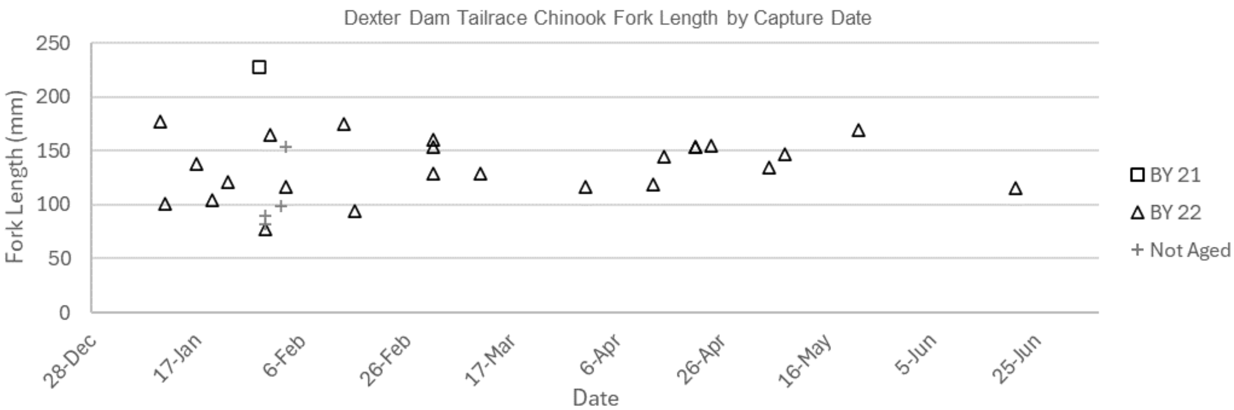

Figure 72. Length-frequency of juvenile Chinook salmon by brood year at the Dexter Dam Tailrace site.

Injury Data

A total of 27 juvenile Chinook salmon (96.4% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 3. One mortality was observed during the spring monitoring period (3.6% of total Chinook salmon catch).

To provide insight on injuries associated with capture in a RST, injury data was collected from bulk marked release and hatchery fish utilized for TE trials. The most common injuries observed at this site include descaling less than and greater than 20% and fin damage for NOR Chinook (Table 94). It is also worth noting that Chinook salmon at this site exhibited higher percentages of gas bubble disease and copepod presence as compared to other sites with a similar sample size. Additionally, more Chinook salmon were found to have gas bubble disease following the downstream relocation of the RST. It is worth noting that the overall sample size of Chinook salmon being discussed at the Dexter Dam Tailrace is relatively small and additional data will be collected in 2024 to provide further clarity regarding injuries at this location.

Bulk marked released and TE hatchery Chinook salmon exhibited higher percentages of descaling less than 20% and fin damage as compared to NOR fish (Table 94). Dissimilarly to other sites, the TE hatchery Chinook at Dexter Dam were not observed as having fungus. These Chinook salmon also had a lower gas bubble disease percentage (2.7%), when compared to both NOR and bulk marked released Chinook (27.6% and 26.0%), respectively (Table 94).

Figure 73 illustrates the proportion of fish displaying injuries by type over the sampling period. Observed injury rates at this site increased during spill operations. However, relatively few fish were captured during this reporting period and more data is needed to draw more accurate conclusions. 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 74). It is likely that observations of gas bubble disease are higher for RST captured fish than those not captured in an RST, as these fish are often captured and held in areas of higher dissolved gas. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Almost identical to other sites detailed within this report, results illustrated that Chinook salmon less than 60 mm in length were more likely to have no external injuries than those measuring above 60 mm (Appendix D, Table D-6). Additionally, 100% of the Chinook salmon encountered that were measured above 60 mm had at least one injury denoted. The most common of these injuries was descaling and fin damage (Appendix D, Table D-6).

Data collected on the injury rates of TE hatchery fish illustrated that both the percentage of fish with injuries and the average number of injuries per fish generally increased from pre-release to recaptured observations (Appendix D). Detailed findings on injury type are further presented in Appendix D.

Table 94. Summary of injuries observed on NOR, bulk marked, and TE hatchery Chinook salmon at the Dexter Dam RST.

Injury Code	Chinook Injuries (NOR) (n=28)	Bulk Marked Released Chinook (n=77)	Trapping Efficiency Hatchery Chinook (n=37)
NXI (no external injury)	3.4%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	17.2%	19.5%	43.2%
DS>2	75.9%	80.5%	56.8%
BLO	0.0%	0.0%	0.0%
EYB	3.4%	5.2%	0.0%
BVT	0.0%	2.6%	0.0%
FVB	0.0%	3.9%	2.7%
GBD	27.6%	26.0%	2.7%
POP	0.0%	0.0%	0.0%
HIN	6.9%	6.5%	0.0%
OPD	6.9%	16.9%	5.4%
TEA	3.4%	3.9%	0.0%
BRU	6.9%	9.1%	0.0%
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	79.3%	92.2%	97.3%
PRD	0.0%	0.0%	0.0%
COP	27.6%	11.7%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%

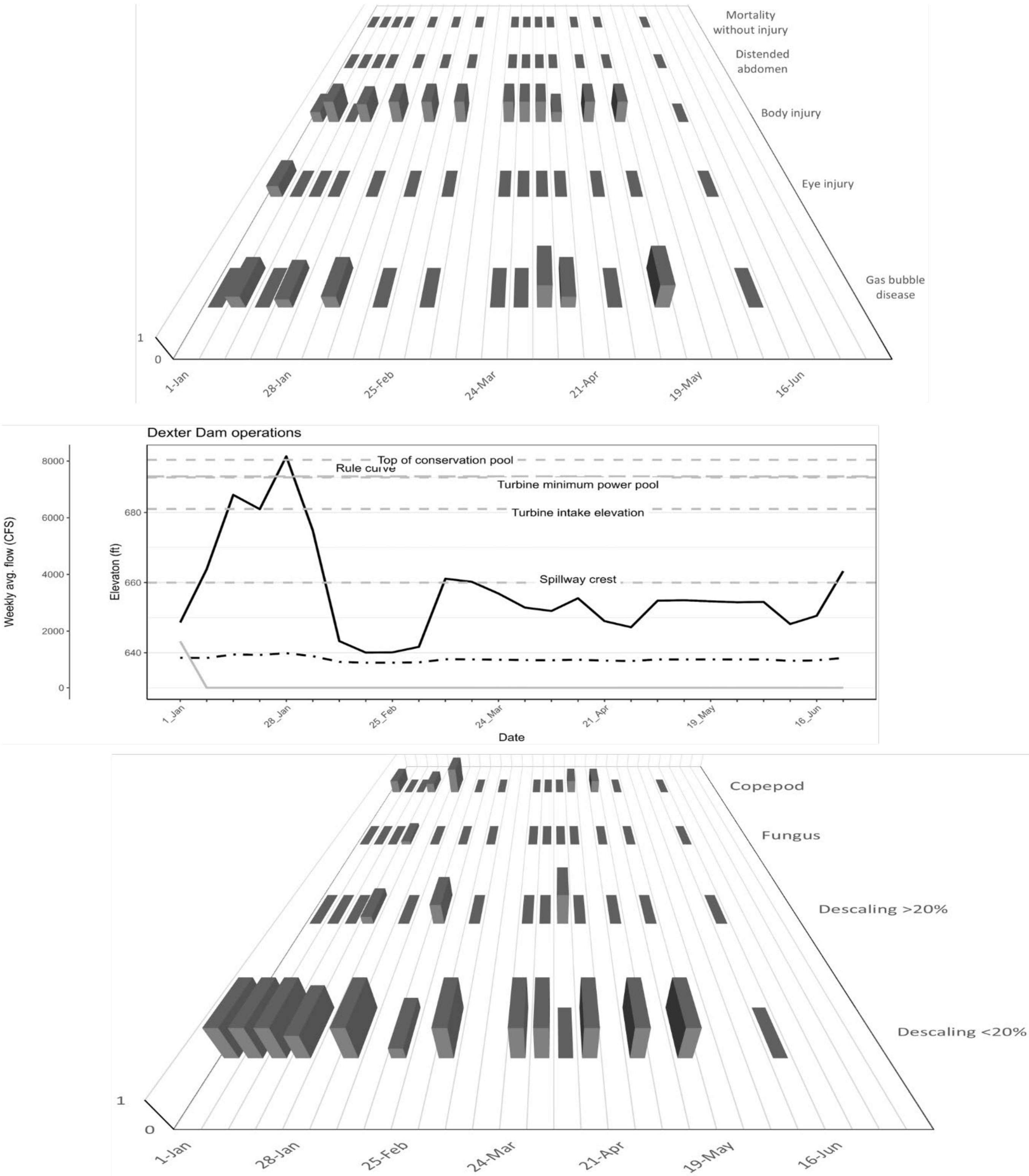

Figure 73. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data and features of interest for Dexter Dam Tailrace (middle panel) with spill outflow (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), and proportion of captured juvenile Chinook salmon displaying descaling injuries and copepods (bottom panel).

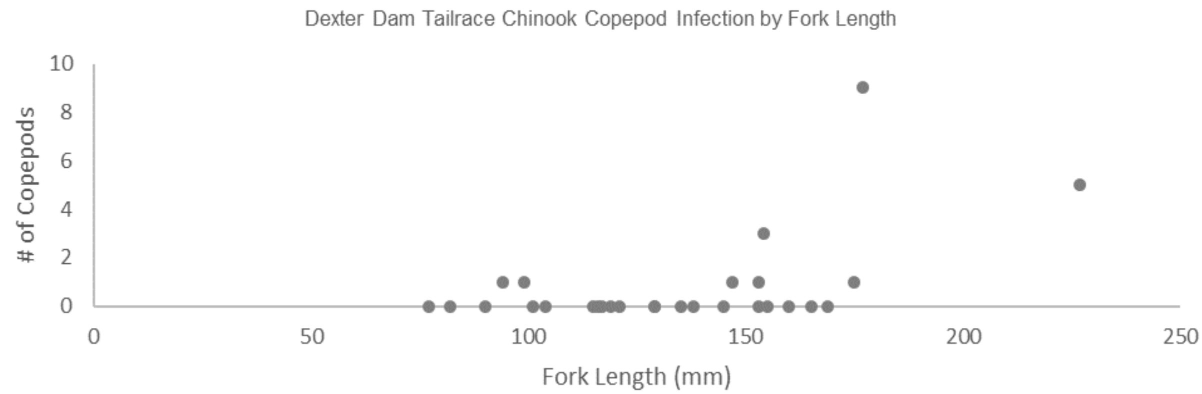

Figure 74. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Dexter Dam Tailrace.

24-Hour Hold Trials

24-hour hold trials were performed on NOR juvenile Chinook salmon captured at Dexter Dam Tailrace to assess delayed mortality resulting from dam passage. 28 Chinook salmon were held during this reporting period (Table 95). A total of 1 Chinook salmon died during hold (3.6%). Mortality rates between the two-week reporting periods ranged from 0.0% to 25.0%.

Table 95. Summary of 24-hour hold trials for Chinook salmon captured in the RST at the Dexter Dam Tailrace site.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
January 1–15, 2024	Chinook	2	0	100.0%
January 16–31, 2024	Chinook	7	0	100.0%
February 1–15, 2024	Chinook	3	0	100.0%
February 16–29, 2024	Chinook	1	0	100.0%
March 1–15, 2024	Chinook	4	0	100.0%
March 16–31, 2024	Chinook	1	0	100.0%
April 1–15, 2024	Chinook	2	0	100.0%
April 16–30, 2024	Chinook	4	1	75.0%
May 1–15, 2024	Chinook	2	0	100.0%
May 16–31, 2024	Chinook	1	0	100.0%
June 1–15, 2024	Chinook	0	0	--
June 16–30, 2024	Chinook	1	0	100.0%

PIT Tagged/VIE Marked Fish and Downstream Detections

One Chinook salmon was PIT tagged at the Dexter Dam Tailrace site during this reporting period. All other fish captured were placed into the 24-hour hold study. No VIE marked fish from upstream sites were detected at the Dexter Dam Tailrace RST site. The single PIT tagged NOR Chinook has not been redetected at downstream sites through the Spring of 2024. Further information on tagged and VIE marked fish at this site is available in Appendix C.

Willamette Valley Projects Encounters

A total of 77 adipose clipped and PIT tagged Chinook salmon were captured at the Dexter Dam Tailrace site during this monitoring period. Two of these Chinook were also encountered in the Lookout Dam Tailrace RSTs by EAS crew prior to their recapture at the Dexter Dam Tailrace RST. For more information regarding bulk mark releases and detections, refer to the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

A total of 1,328 non-target fish were captured during this reporting period in addition to NOR juvenile Chinook salmon. A summary of species and numbers of fish caught are provided in Table 96. The most commonly captured non-target species were crappie, sculpin, and clipped Chinook salmon (escapees from the Dexter Fish Facility or from ODFW liberation releases).

Table 96. Summary of non-target fish captured in the RST at the Dexter Dam Tailrace site.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	25	2
Chinook (clipped)	696	7
Crappie	153	19
Lamprey	3	0
Pacific Lamprey	1	0
Cutthroat Throat	2	0
Dace	17	0
Largescale Sucker	2	1
O. mykiss	6	0
O. mykiss (adult)	5	0
Sculpin	376	70
Smallmouth Bass	1	0
Northern Pikeminnow	5	0
Unknown*	1	1
Unknown Salmonid*	1	1
Walleye	34	12
Totals	**1,328**	**113**

*Species denoted as “unknown” were too small and/or too decomposed to identify.

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Appendix A –
Locations of Rotary Screw Traps

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Appendix A: Locations of Rotary Screw Traps

Figures and Tables

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FIGURE A-1
Breitenbush River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-2
North Santiam Above Detroit

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-3
Big Cliff Dam Tailrace

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-4
Green Peter Head of Reservoir-
Middle Santiam River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-5
Green Peter Tailrace - Middle Santiam River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-6 Foster Dam Head of Reservoir -South Santiam River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES

Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-7
Cougar Dam Head of Reservoir

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-8
Cougar Dam Tailrace

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-9
Fall Creek Head of Reservoir

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-10
Fall Creek Dam Tailrace

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-11
Middle Fork Willamette Above Hills Creek

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-12
Hills Creek Dam

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-13
Lookout Point Head of Reservoir

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES

Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-14
Lookout Dam Tailrace

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-15
Dexter Dam Tailrace

● RST location prior to 11/6/2023

▲ RST location after 11/6/2023

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES

Wholly Owned Subsidiary of Natives of Kodiak

Table A-1. RST locations at sampling sites for previous and current monitoring efforts

RST Location	Previous Monitoring Effort Location (lat. long.)	Historic RST Size (5ft or 8ft)	Current Monitoring Effort Location (lat. long.)	Current RST Size (5ft or 8ft)
Breitenbush River	44.75168, -122.131006	One 5ft (2010–2013)	44.76769, -122.09685	One 5ft
Big Cliff Dam Tailrace	44.75269, -122.28713	One 5ft (2014–2016)	44.75269, -122.28713	One 8ft
Detroit Head of Reservoir- North Santiam	44.69251, -122.05029	One 5ft (2010–2016)	44.69251, -122.05029	One 5ft
Green Peter Head of Reservoir- Middle Santiam River	N/A	N/A	44.51444, -122.37605	One 5ft
Green Peter Dam Tailrace	N/A	N/A	44.44756, -122.55153	One 8ft
Foster Head of Reservoir- South Santiam River	44.391496, -122.499065	One 5ft (2010–2016)	44.39085, -122.50114	One 5ft
Cougar Head of Reservoir	44.048185, -122.217893	One 5ft (2010–2016)	44.048185, -122.217893	One 5ft
Cougar Dam Tailrace	44.12871, -122.24396	PWR two 8ft, RO two 5ft (2011) PWR two 8ft, RO one 5ft (2012–2016)	44.12871, -122.24396	PWR two 8ft, RO one 5ft
Fall Creek Head of Reservoir	43.96467, -122.61917	One 8ft (2005–2008)	43.96467, -122.61917	One 8ft
Fall Creek Dam Tailrace	43.945477, -122.760329	One 8ft (2006–2009, 2015-2016)	43.945477, -122.760329	One 8ft
Hills Creek Head of Reservoir- Middle Fork Willamette River	43.60359, -122.45622	One 5ft	43.60359, -122.45622	One 5ft
Hills Creek Dam Tailrace RO	43.71208, -122.42340	One 5ft	43.71304, -122.42497	One 5ft
Hills Creek Dam Tailrace	43.71113, -122.42464	One 8ft (2003–2004)	43.71113, -122.42464	One 8ft
Lookout Point Head of Reservoir- Middle Fork Willamette River	43.76669, -122.53139	One 8ft (2007–2008, 2010–2016)	43.76669, -122.53139	One 5ft
Lookout Dam Tailrace	43.91442, -122.75658	One 8ft (2007–2008, 2011–2016) Two 8ft (2009-2010)	43.91442, -122.75658	Three 8ft
Dexter Dam Tailrace	N/A	N/A	43.92527, -122.81147	One 5ft

Appendix B –
Sampling Outages by Site

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Appendix B: Sampling Outages by Site

Site	Date(s) of Trap Outage*	Reason for Outage
Fall Creek Dam Tailrace	1/1/2024-1/12/2024	The RST cone was raised to its non-sampling position due to increased sediment, logs, and debris. The RST attempted to fish multiple times over this time period, but silt was constantly covering the perf panel, and excessive amounts of mud were shoveled from within the cone.
Fall Creek Head of Reservoir	1/9/2024-1/22/2024	The RST cone was raised to its non-sampling position because the trap was physically submerged due to high flows. Although there was a large incoming winter storm, EAS personnel storm sampled the RST on multiple occasions, resulting in excessive amounts of debris accumulation.
Lookout Point Head of Reservoir	1/9/2024-1/11/2024	The RST cone was raised to its non-sampling position as it was observed to be full of large, woody debris by EAS personnel. Additionally, there was an incoming winter storm that had severely increased projections in flow.
Big Cliff Dam Tailrace Green Peter Head of Reservoir Green Peter Dam Tailrace Cougar Dam Tailrace Fall Creek Head of Reservoir Fall Creek Dam Tailrace Hills Creek Dam Tailrace Lookout Point Head of Reservoir Lookout Dam Tailrace Dexter Dam Tailrace	1/13/2024	The RST was not monitored and/or sampled due to a severe ice storm which resulted in the declaration of an Oregon State of Emergency. During this time, roads were inaccessible, power lines and trees were down, and travel was extremely unsafe given the conditions.
Big Cliff Dam Tailrace	1/14/2024	The RST was not monitored and/or sampled due to a severe ice storm which resulted in the declaration of an Oregon State of Emergency. During this time, roads were inaccessible, power lines and trees were down, and travel was extremely unsafe given the conditions. When EAS personnel observed the RST on 1/14/2024, it was fully covered in ice and was completely inaccessible.
Dexter Dam Tailrace	1/14/2024	The RST was not monitored and/or sampled due to a severe ice storm which resulted in the declaration of an Oregon State of Emergency. During this time, roads were inaccessible, power lines and trees were down, and travel was extremely unsafe given the conditions. EAS personnel observed the Dexter Dam RST on 1/14/2024 and left it fishing.
Lookout Point Head of Reservoir	1/14/2024	The RST was not monitored and/or sampled due to a severe ice storm which resulted in the declaration of an Oregon State of Emergency. During this time, roads were inaccessible, power lines and trees were down, and travel was extremely unsafe given the conditions. EAS personnel were unable to raise the LOPHOR RST due to excessive amounts of debris and a broken winch on the trap.
Green Peter Head of Reservoir Green Peter Dam Tailrace Cougar Dam Tailrace Fall Creek Head of Reservoir Fall Creek Dam Tailrace Hills Creek Dam Tailrace Lookout Dam Tailrace	1/14/2024	The RST was not monitored and/or sampled due to a severe ice storm which resulted in the declaration of an Oregon State of Emergency. During this time, roads were inaccessible, power lines and trees were down, and travel was extremely unsafe given the conditions.
Green Peter Dam Tailrace	1/15/2024	The RST was observed from afar, but due to the severe ice storm, EAS personnel were unable to safely access the RST. Flows were high, ice covered rocks and kayaks, and EAS personnel did not feel safe kayaking to the trap. Furthermore, trees and power lines had fallen along the roads, making conditions unsafe.
Big Cliff Dam Tailrace Green Peter Head of Reservoir Green Peter Dam Tailrace Cougar Dam Tailrace Fall Creek Head of Reservoir Fall Creek Dam Tailrace Hills Creek Dam Tailrace Lookout Point Head of	1/15/2024	The RST was not monitored and/or sampled due to a severe ice storm which resulted in the declaration of an Oregon State of Emergency. During this time, roads were inaccessible, power lines and trees were down, and travel was extremely unsafe given the conditions.

Site	Date(s) of Trap Outage*	Reason for Outage
Reservoir Lookout Dam Tailrace Dexter Dam Tailrace		
Big Cliff Dam Tailrace Green Peter Head of Reservoir Green Peter Dam Tailrace Cougar Dam Tailrace Fall Creek Head of Reservoir Fall Creek Dam Tailrace Hills Creek Dam Tailrace Lookout Point Head of Reservoir Lookout Dam Tailrace Dexter Dam Tailrace	1/16/2024	The RST was not monitored and/or sampled due to a severe ice storm which resulted in the declaration of an Oregon State of Emergency. During this time, roads were inaccessible, power lines and trees were down, and travel was extremely unsafe given the conditions.
Big Cliff Dam Tailrace	1/17/2024-2/9/2024	The RST was not monitored and/or sampled, and the cone was raised to its non-sampling position due to high flows resulting from localized flood evacuations.
Lookout Point Head of Reservoir	1/17/2024-2/7/2024	The RST cone was raised to its non-sampling position due to an increased amount of debris which resulted in damage to the RST winch and difficulties in raising and lowering the cone.
Cougar Dam Tailrace	1/19/2024-1/20/2024	The RST cone was grounded out due to low flow from the Powerhouse Channel and was therefore, not operating and/or spinning.
Green Peter Dam Tailrace	1/19/2024-2/9/2024	The RST cone was raised to its non-sampling position due to elevated flows that had the potential to make sampling unsafe to fish and travel to the RST via kayak unsafe for EAS personnel.
Hills Creek Dam Tailrace	1/23/2024-2/6/2024	The RST cone was raised to its non-sampling position due to elevated flows subsequently increasing water levels to an unsafe height for EAS personnel.
Hills Creek Head of Reservoir	2/1/2024-2/2/2024	The RST cone was raised to its non-sampling position because the loop line auxiliary tree had severely sagged, and the ground was starting to give way. Initially, EAS personnel were unable to lower the cone due to tension from the tree and concerns of its foundational support. However, EAS personnel went back to the RST on 2/2/2024 and were able to consolidate cables and fish the trap safely.
Lookout Dam Tailrace	2/1/2024-2/7/2024	The RST cone positioned in the Spill was raised to its non-sampling position due to severely increased flows. These flows exceeded the preset 10,000 cubic feet per second threshold, and in doing so, traps were safety checked from the shoreline to ensure there was no visible damage to cables and associated lines, while prioritizing EAS safety.
Lookout Dam Tailrace	2/1/2024-2/13/2024	The RST cones positioned in Powerhouse 1 and Powerhouse 2 flows were raised to their non-sampling position due to severely increased flows. These flows exceeded the preset 10,000 cubic feet per second threshold, and in doing so, traps were safety checked from the shoreline to ensure there was no visible damage to cables and associated lines, while prioritizing EAS safety.
Hills Creek Head of Reservoir	2/7/2024-2/8/2024	The RST cone was raised to its non-sampling position due to the loop line actively snapping on the trap. The cone was therefore raised for repairs and a new loop line was added.
Lookout Dam Tailrace	2/9/2024-2/13/2024	The RST cone positioned in the Spill was raised to its non-sampling position due to severely increased flows. These flows exceeded the preset 10,000 cubic feet per second threshold, and in doing so, traps were safety checked from the shoreline to ensure there was no visible damage to cables and associated lines, while prioritizing EAS safety.
Green Peter Dam Tailrace	2/12/2024-2/12/2024	The RST was not checked due to extremely high flows, making it difficult and unsafe for EAS personnel to monitor and/or sample the trap via kayak.
Lookout Point Head of Reservoir	2/12/2024-2/13/2024	The RST cone was raised to its non-sampling position due to necessary winch and collar repairs on the trap. Without these repairs being made, it could have caused potential safety issues to both fish and EAS personnel.
Breitenbush River	2/27/2024-3/2/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.

Site	Date(s) of Trap Outage*	Reason for Outage
Detroit Head of Reservoir	2/27/2024-3/3/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Green Peter Head of Reservoir	2/27/2024-3/4/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Foster Dam Head of Reservoir	2/27/2024-3/1/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Fall Creek Head of Reservoir	2/28/2024-3/4/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Cougar Head of Reservoir	2/28/2024-3/3/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Lookout Point Head of Reservoir	2/28/2024-3/1/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Hills Creek Head of Reservoir	2/28/2024-3/4/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Green Peter Dam Tailrace	2/29/2024-3/4/2024	The RST cone was raised to its non-sampling position because the Green Peter Dam Operator informed EAS staff of potential flows resulting from an incoming storm exceeding preset safety thresholds.
Detroit Head of Reservoir	3/2/2024-3/3/2024	The RST cone was raised to its non-sampling position because the foam collar sheared, and the RST was unable to operate safely and without additional mechanical damage.
Foster Dam Head of Reservoir	3/12/2024-3/13/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Green Peter Dam Tailrace	3/13/2024-3/14/2024	The RST cone was raised to its non-sampling position because Spill flow had commenced and there was a subsequent flush of debris.
Hills Creek Head of Reservoir	3/11/2024-3/13/2024	The RST cone was raised to its non-sampling position because of an incoming storm. The storm caused severe increases in expected flow and led to uncertainties surrounding travel and weather, potentially causing safety concerns to both EAS staff and fish being monitored.
Green Peter Dam Tailrace	3/15/2024-3/19/2024	The RST cone was raised to its non-sampling position because Spill flow had commenced on 3/13/2024 and there was a subsequent flush of debris. The high levels of debris made operating and accessing the RST unsafe for both fish and EAS personnel.
Lookout Dam Tailrace	3/15/2024-3/20/2024	The RST cone of the Powerhouse 1 trap was raised to its non-sampling position due to high levels of debris. The heightened levels of debris made operating and accessing the RST unsafe for both fish and EAS personnel.
Lookout Dam Tailrace	3/15/2024-3/20/2024	The RST cone of the Powerhouse 2 trap was raised to its non-sampling position due to high levels of debris. The heightened levels of debris made operating and accessing the RST unsafe for both fish and EAS personnel.
Lookout Dam Tailrace	3/15/2024-3/20/2024	The RST cone of the Spill trap was raised to its non-sampling position due to high levels of debris. The heightened levels of debris made operating and accessing the RST unsafe for both fish and EAS personnel.
Lookout Dam Tailrace	3/29/2024-3/30/2024	The RST cone of the Powerhouse 1 trap was raised to its non-sampling position due to necessary repairs being made to ensure the traps operational capabilities related to catch and safety.
Fall Creek Head of Reservoir	4/25/2024-4/28/2024	The RST cone was raised to its non-sampling position due to a flow spike which resulted in a high debris load.

Site	Date(s) of Trap Outage*	Reason for Outage
Fall Creek Head of Reservoir	5/3/2024–5/9/2024	The RST cone was raised to its non-sampling position due to a flow spike which resulted in a high debris load.
Lookout Point Head of Reservoir	5/3/2024–5/8/2024	The RST cone was raised to its non-sampling position due to a flow spike which resulted in a high debris load.
Breitenbush River	5/9/2024–5/10/2024	The RST cone was raised to its non-sampling position due to a localized windstorm resulting in falling trees both upstream and within the immediate vicinity of the RST. This was a significant safety concern to EAS staff, fish, and the RST itself.
Big Cliff Dam Tailrace	5/9/2024–5/10/2024	The RST cone was raised to its non-sampling position due to excessive amounts of debris from a debris flush subsequent of Spill operations. Additionally, localized windstorms were causing trees to fall upstream of the RST and within its immediate vicinity.
Lookout Dam Tailrace	5/16/2024–5/18/2024	The RST cone of the Powerhouse 1 trap was raised to its non-sampling position because sealant was utilized to remove gaps (voids) between the RST panel and fins. The sealant needed to cure and dry for 24 hours.
Breitenbush River	6/2/2024–6/5/2024	The RST cone was raised to its non-sampling position because excessive rain and ongoing snowmelt was forecasted to cause increased flow events. These flow events have the potential to surpass preset safety thresholds, and/or cause localized debris flushes resulting in RST damage.
Detroit Head of Reservoir	6/2/2024–6/4/2024	The RST cone was raised to its non-sampling position because excessive rain and ongoing snowmelt was forecasted to cause increased flow events. These flow events have the potential to surpass preset safety thresholds, and/or cause localized debris flushes resulting in RST damage.
Green Peter Head of Reservoir	6/2/2024–6/4/2024	The RST cone was raised to its non-sampling position because excessive rain and ongoing snowmelt was forecasted to cause increased flow events. These flow events have the potential to surpass preset safety thresholds, and/or cause localized debris flushes resulting in RST damage.
Foster Dam Head of Reservoir	6/2/2024–6/4/2024	The RST cone was raised to its non-sampling position because excessive rain and ongoing snowmelt was forecasted to cause increased flow events. These flow events have the potential to surpass preset safety thresholds, and/or cause localized debris flushes resulting in RST damage.
Cougar Head of Reservoir	6/2/2024–6/4/2024	The RST cone was raised to its non-sampling position because excessive rain and ongoing snowmelt was forecasted to cause increased flow events. These flow events have the potential to surpass preset safety thresholds, and/or cause localized debris flushes resulting in RST damage.
Fall Creek head of Reservoir	6/2/2024–6/4/2024	The RST cone was raised to its non-sampling position because excessive rain and ongoing snowmelt was forecasted to cause increased flow events. These flow events have the potential to surpass preset safety thresholds, and/or cause localized debris flushes resulting in RST damage.
Lookout Point Head of Reservoir	6/2/2024–6/4/2024	The RST cone was raised to its non-sampling position because excessive rain and ongoing snowmelt was forecasted to cause increased flow events. These flow events have the potential to surpass preset safety thresholds, and/or cause localized debris flushes resulting in RST damage.
Hills Creek Head of Reservoir	6/2/2024–6/4/2024	The RST cone was raised to its non-sampling position because excessive rain and ongoing snowmelt was forecasted to cause increased flow events. These flow events have the potential to surpass preset safety thresholds, and/or cause localized debris flushes resulting in RST damage.
Dexter Dam Tailrace	6/11/2024	The RST cone was not monitored and/or sampled due to a miscommunication with EAS crew and personnel.
Fall Creek Dam Tailrace	6/11/2024	The RST cone was not monitored and/or sampled due to a miscommunication with EAS crew and personnel.
Lookout Dam Tailrace	6/12/2024–6/13/2024	The RST cone of the Powerhouse 1 trap was raised to its non-sampling position because sealant was utilized to remove gaps (voids) between the RST panel and fins. The sealant needed to cure and dry for 24 hours.
Fall Creek Head of Reservoir	6/26/2024–6/30/2024	The RST cone was raised to its non-sampling position due to severely decreased flows leading to the RST grounding out. The cone was raised to prevent any damage. Additionally, the cone was raised due to issues with personnel residing at the Fall Creek Head of Reservoir access point and being disruptive.

*The outages table detailed above is a comprehensive list of all sites sampled throughout the 2024 monitoring year. While the report does not include all the dates that are listed within the table above, all outages for 2024 are included to help better visualize survey effort and outages related to environmental variables. It includes every outage documented and the subsequent reason for it.

Appendix C – PIT Tags and VIE Tagging

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Appendix C: PIT Tags and VIE Tagging

Sections

Figures and Tables

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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.

Site	UDF	MRR Site/Release Site
Breitenbush River	BRT	BREITR
Detroit Head of Reservoir- North Santiam River	DTA	NSANTR
Big Cliff Dam Tailrace	BCL	BCLTAL
Green Peter Head of Reservoir – Middle Santiam River	GPA	MSANTR
Green Peter Dam Tailrace – Middle Santiam River	GPR	GPD
Foster Head of Reservoir – South Santiam	SAN	SSANTR
Cougar Head of Reservoir	SMK	MCKESF
Cougar Dam Tailrace	CGR	CGRTAL
Fall Creek Head of Reservoir	FCA	FALL2C
Fall Creek Dam Tailrace	FCR	FALTAL
Hills Creek Head of Reservoir – Middle Fork Willamette River	HCA	WILRMF
Hills Creek Dam Tailrace	HCR	HCRREG
Lookout Point Dam Head of Reservoir	LOA	WILRMF
Lookout Dam Tailrace	LOP	LOPTAL
Dexter Dam Tailrace	DEX	DEXTAL
Species	**SRR Code**	
Wild Spring Chinook	11W	
Hatchery Spring Chinook	11H	
Wild Winter Steelhead	34W	

Conditional Comments	
AI	Adipose intact
AD	Adipose clipped
RE	Recapture

Table C-2. Summary of Chinook and *O. mykiss* PIT tagged and VIE marked at RST from January 1, 2024, through June 30, 2024.

Tagging Site	Species	Total PIT Tagged	Total VIE Marked
Breitenbush River	Chinook	32	2,360
	O. mykiss	43	3
Detroit Head of Reservoir- North Santiam	Chinook	49	20,289
	O. mykiss	40	11
Big Cliff Dam Tailrace	Chinook	288	0
	O. mykiss	6	0
Green Peter Head of Reservoir –Middle Santiam	Chinook	6	601
	O. mykiss	21	0
Green Peter Dam Tailrace – Middle Santiam	Chinook	0	0
	O. mykiss	0	0
Foster Dam Head of Reservoir – South Santiam	Chinook	4	1*
	O. mykiss	43	0
Cougar Head of Reservoir	Chinook	25	159
Cougar Dam Tailrace	Chinook	349	0
Fall Creek Head of Reservoir	Chinook	7	0
Fall Creek Dam Tailrace	Chinook	0	0
Hills Creek Head of Reservoir – Middle Fork Willamette	Chinook	45	2
Hills Creek Dam Tailrace	Chinook	7	0
Lookout Point Head of Reservoir – Middle Fork Willamette	Chinook	29	16
Lookout Dam Tailrace	Chinook	1	0
Dexter Dam Tailrace	Chinook	1	0

*Denotes incorrect protocol

Table C-3. List of downstream redetections for fish PIT tagged at RST sites from January 1, 2024, through June 30, 2024.

PIT Tag #	Mark Date	Mark Site	Recap Date	Travel Time	Recap Site
3DD.003BEE0FF3	6/21/2023	Breitenbush River	1/1/2024	194	Big Cliff Dam
3DD.003BE9F184	2/7/2024	Fall Creek Head of Reservoir	2/15/2024	8	Fall Creek Dam Tailrace
3DD.003BD224C5	11/4/2023	Cougar Dam Head of Reservoir	3/1/2024	118	Cougar Dam
3DD.003BEE1074	11/1/2023	Cougar Dam Tailrace	4/1/2024	178	PD6 - Columbia River Estuary rkm 68
3DD.003BEE13F6	11/1/2023	Cougar Dam Tailrace	4/5/2024	156	TWX - Estuary Towed Array (Exp.)
3DD.003BD397FF	10/6/2023	Breitenbush River	4/17/2024	194	Big Cliff Dam
3DD.003BD397FC	10/6/2023	Breitenbush River	4/23/2024	200	Big Cliff Dam
3DD.003BD22B76	10/12/2023	Foster Dam Head of Reservoir	4/25/2024	196	PD5 – Columbia River Estuary rkm 62
3DD.003E5283EC	4/4/2024	Breitenbush River	5/2/2024	28	Big Cliff Dam
3DD.003BEE1AA8	9/6/2023	Detroit Head of Reservoir	5/2/2024	239	PD5 - Columbia River Estuary rkm 62
3DD.003BEE1AB2	9/13/2023	Breitenbush River	5/3/2024	233	Big Cliff Dam
3DD.003BEE11EF	11/5/2023	Detroit Head of Reservoir	5/6/2024	183	Big Cliff Dam
3DD.003BD395E4	6/21/2023	Foster Dam Head of Reservoir	5/6/2024	320	PD8 - Columbia River Estuary rkm 82
3DD.003BEE1373	10/18/2023	Breitenbush River	5/7/2024	202	Big Cliff Dam
3DD.003BE9F161	5/4/2024	Big Cliff Dam Tailrace	5/9/2024	5	PD7 - Columbia River Estuary rkm 70
3DD.003BE9FE5C	4/26/2024	Big Cliff Dam Tailrace	5/10/2024	14	TWX - Estuary Towed Array (Exp.)
3DD.003BD22E41	3/5/2024	Lookout Point Head of Reservoir	5/22/2024	78	Lookout Dam Tailrace
3DD.003BE9F60D	3/21/2024	Cougar Dam Tailrace	5/26/2024	66	TWX - Estuary Towed Array (Exp.)
3DD.003BD22603	11/2/2023	Detroit Head of Reservoir	6/8/2024	219	PD8 - Columbia River Estuary rkm 82
3DD.003BD22E45	5/26/2024	Lookout Point Head of Reservoir	7/18/2024	53	Lookout Dam Tailrace

Table C-4. List of Bull Trout captured at RST sites and collected data from January 1, 2024, through June 30, 2024.

Site	Date	Length (est. mm)	Tag(s)	Condition
Cougar Dam	2/4/2024	340	N/A	Injured
Cougar Dam Head of Reservoir	2/13/2024	75	N/A	Unharmed
Hills Creek Head of Reservoir	2/15/2024	271	EAS tagged: 132592690	Injured
Cougar Dam Head of Reservoir	3/29/2024	135	N/A	Unharmed
Cougar Dam Head of Reservoir	4/1/2024	115	N/A	Unharmed
Cougar Dam	4/4/2024	295	EAS tagged: 132589913	Injured
Cougar Dam Head of Reservoir	4/26/2024	160	N/A	Unharmed
Cougar Dam	5/3/2024	300	132589913	Injured

Table C-5. Summary of fish containing PIT tags encountered by EAS at RST sites from January 1, 2024, through June 30, 2024.

Site	Trap	Species	# Fish Encountered
Breitenbush River	5 ft	Chinook	6
Breitenbush River	5 ft	*O. mykiss*	0
Detroit Head of Reservoir – North Santiam	5 ft	Chinook	13
Detroit Head of Reservoir – North Santiam	5 ft	*O. mykiss*	0
Big Cliff Dam Tailrace	8 ft	Chinook	81
Big Cliff Dam Tailrace	8 ft	*O. mykiss*	1
Green Peter Head of Reservoir – Middle Santiam	5 ft	Chinook	52
Green Peter Head of Reservoir – Middle Santiam	5 ft	*O. mykiss*	0
Green Peter Tailrace	8 ft	Chinook	88
Green Peter Tailrace	8 ft	*O. mykiss*	0
Foster Dam Head of Reservoir – South Santiam	5 ft	Chinook	28
Foster Dam Head of Reservoir – South Santiam	5 ft	*O. mykiss*	0
Cougar Head of Reservoir	5 ft	Chinook	0
Cougar Dam Tailrace	PH	Chinook	89
Cougar Dam Tailrace	RO	Chinook	526
Fall Creek Head of Reservoir	8 ft	Chinook	0
Fall Creek Dam Tailrace	8 ft	Chinook	215
Hills Creek Head of Reservoir- Middle Fork Willamette	5 ft	Chinook	0
Hills Creek Dam Tailrace	RO	Chinook	34
Hills Creek Dam Tailrace	PH	Chinook	90
Lookout Point Head of Reservoir- Middle Fork Willamette	5 ft	Chinook	1
Lookout Dam Tailrace	Spill	Chinook	72
Lookout Dam Tailrace	PH	Chinook	149
Dexter Dam Tailrace	5 ft	Chinook	77

Table C-6. List of radio tagged Chinook captured at RST sites from January 1, 2024, through June 30, 2024.

Site	Trap	PIT Tag Number	Date	Species
Green Peter Tailrace - Middle Santiam River	8 ft	3DD.003BD57AC1	3/29/2024	Chinook*
Green Peter Tailrace - Middle Santiam River	8 ft	3DD.003BD2BDC1	4/23/2024	Chinook*
Green Peter Tailrace - Middle Santiam River	8 ft	3DD.003BD2BC34	4/25/2024	Chinook*
Green Peter Tailrace - Middle Santiam River	8 ft	3DD.003BD2BD53	5/7/2024	Chinook*

*Denotes fish encountered with both Radio and PIT tags. These fish were tagged by PNNL for studies in Green Peter Reservoir.

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Appendix D – Additional Injury Information

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Appendix D: Additional Injury Information

Tables

Table D-1. Big Cliff Dam Tailrace injuries for Chinook by size.

Total Chinook (n=924)	<60mm (n=5)	>60mm and <110mm (n=55)	>110mm (n=864)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	60.0%	0.0%	0.1%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	12.7%	24.2%
DS>2	0.0%	74.5%	74.3%
BLO	0.0%	0.0%	2.5%
EYB	0.0%	5.5%	10.3%
BVT	0.0%	3.6%	5.9%
FVB	0.0%	14.5%	10.8%
GBD	0.0%	0.0%	3.4%
POP	20.0%	7.3%	2.3%
HIN	40.0%	3.6%	12.5%
OPD	20.0%	7.3%	20.8%
TEA	20.0%	7.3%	4.1%
BRU	20.0%	3.6%	15.5%
HBP	0.0%	1.8%	1.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.2%
FID	20.0%	69.1%	86.6%
PRD	0.0%	0.0%	0.1%
COP	0.0%	47.3%	85.5%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	2.4%
Total (%) of captured fish with injuries	**40.0%**	**100.0%**	**99.9%**
Average number of injuries per fish (non NXI)	**2.0**	**2.6**	**3.6**

Table D-2. Green Peter Dam Tailrace injuries for Chinook by size.

Total Chinook (n=128)	<60mm (n=2)	>60mm and <110mm (n=40)	>110mm (n=86)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	50.0%	5.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	5.0%	47.7%
DS>2	0.0%	77.5%	52.3%
BLO	0.0%	0.0%	3.5%
EYB	0.0%	5.0%	24.4%
BVT	0.0%	2.5%	3.5%
FVB	0.0%	15.0%	47.7%
GBD	0.0%	30.0%	58.1%
POP	0.0%	0.0%	4.7%
HIN	0.0%	5.0%	24.4%
OPD	50.0%	15.0%	27.9%
TEA	0.0%	0.0%	8.1%
BRU	0.0%	10.0%	22.1%
HBP	0.0%	2.5%	1.2%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	0.0%	72.5%	93.0%
PRD	0.0%	0.0%	0.0%
COP	0.0%	2.5%	5.8%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	2.5%	4.7%
Total (%) of captured fish with injuries	**50.0%**	**95.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**1.0**	**2.5**	**4.3**

Table D-3. Cougar Dam Powerhouse route injuries for Chinook by size.

<60mm (n=13)	>60mm and <110mm (n=137)	>110mm (n=151)	<60mm (n=13)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	69.2%	4.4%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	7.7%	5.1%	16.6%
DS>2	7.7%	83.9%	80.1%
BLO	0.0%	1.5%	1.3%
EYB	0.0%	2.9%	7.3%
BVT	0.0%	2.9%	2.6%
FVB	0.0%	6.6%	15.9%
GBD	0.0%	1.5%	6.0%
POP	7.7%	2.2%	1.3%
HIN	0.0%	2.2%	6.0%
OPD	7.7%	10.2%	19.9%
TEA	7.7%	10.9%	3.3%
BRU	0.0%	7.3%	8.6%
HBP	0.0%	0.0%	6.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.7%
FID	23.1%	49.6%	76.2%
PRD	0.0%	0.0%	0.7%
COP	15.4%	49.6%	81.5%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	2.9%	5.3%
Total (%) of captured fish with injuries	**30.8%**	**95.6%**	**100.0%**
Average number of injuries per fish (non NXI)	**1.5**	**2.4**	**3.4**

Table D-4. Cougar Dam Regulatory Outlet route injuries for Chinook by size.

Total Chinook (n=826)	<60mm (n=21)	>60mm and <110mm (n=320)	>110mm (n=485)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	66.7%	1.9%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	2.2%	31.1%
DS>2	4.8%	35.9%	66.2%
BLO	0.0%	0.6%	1.9%
EYB	23.8%	1.3%	19.8%
BVT	0.0%	1.3%	3.3%
FVB	4.8%	2.8%	18.4%
GBD	0.0%	0.6%	54.2%
POP	0.0%	0.9%	3.5%
HIN	4.8%	0.9%	5.8%
OPD	0.0%	4.4%	24.1%
TEA	0.0%	4.7%	3.3%
BRU	0.0%	3.1%	10.1%
HBP	0.0%	0.0%	1.6%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	0.0%	21.3%	85.2%
PRD	0.0%	0.0%	0.4%
COP	0.0%	21.3%	88.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	1.3%	7.8%
Total (%) of captured fish with injuries	**33.3%**	**98.1%**	**100.0%**
Average number of injuries per fish (non NXI)	**1.0**	**1.0**	**4.2**

Table D-5. Fall Creek Dam Tailrace injuries for Chinook by size.

Total Chinook (n=9)	<60mm (n=0)	>60mm and <110mm (n=0)	>110mm (n=9)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	---	---	0.0%
MUNK	---	---	0.0%
DS<2	---	---	11.1%
DS>2	---	---	88.9%
BLO	---	---	0.0%
EYB	---	---	11.1%
BVT	---	---	0.0%
FVB	---	---	11.1%
GBD	---	---	0.0%
POP	---	---	0.0%
HIN	---	---	0.0%
OPD	---	---	33.3%
TEA	---	---	11.1%
BRU	---	---	0.0%
HBP	---	---	0.0%
HO	---	---	0.0%
BO	---	---	0.0%
HBO	---	---	0.0%
FID	---	---	66.7%
PRD	---	---	0.0%
COP	---	---	0.0%
BKD	---	---	0.0%
FUN	---	---	22.2%
Total (%) of captured fish with injuries	**---**	**---**	**100.0%**
Average number of injuries per fish (non NXI)	**---**	**---**	0.0%

Note: "---" stands for not applicable

Table D-6. Dexter Dam Tailrace injuries for Chinook by size.

Total Chinook (n=56)	<60mm (n=28)	>60mm and <110mm (n=7)	>110mm (n=21)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	0.0%	0.0%	4.8%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	0.0%	23.8%
DS>2	0.0%	100.0%	71.4%
BLO	0.0%	0.0%	0.0%
EYB	0.0%	0.0%	4.8%
BVT	0.0%	0.0%	0.0%
FVB	0.0%	0.0%	0.0%
GBD	0.0%	14.3%	33.3%
POP	0.0%	0.0%	0.0%
HIN	0.0%	0.0%	9.5%
OPD	0.0%	0.0%	9.5%
TEA	0.0%	14.3%	0.0%
BRU	0.0%	28.6%	0.0%
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	0.0%	85.7%	81.0%
PRD	0.0%	0.0%	0.0%
COP	0.0%	28.6%	28.6%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	4.8%
Total (%) of captured fish with injuries	**100.0%**	**100.0%**	**95.2%**
Average number of injuries per fish (non NXI)	**0.0**	**2.7**	**2.7**

Table D-7. Lookout Dam Tailrace (RO and PH) injuries for Chinook by size.

Total Chinook (n=106)	<60mm (n=20)	>60mm and <110mm (n=30)	>110mm (n=56)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	90.0%	10.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	0.0%	14.3%
DS>2	5.0%	80.0%	83.9%
BLO	0.0%	0.0%	0.0%
EYB	0.0%	0.0%	0.0%
BVT	0.0%	3.3%	3.6%
FVB	0.0%	0.0%	10.7%
GBD	0.0%	0.0%	14.3%
POP	0.0%	0.0%	0.0%
HIN	0.0%	0.0%	8.9%
OPD	5.0%	0.0%	14.3%
TEA	0.0%	3.3%	1.8%
BRU	0.0%	6.7%	10.7%
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	5.0%	43.3%	80.4%
PRD	0.0%	0.0%	1.8%
COP	0.0%	0.0%	30.4%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	3.6%
Total (%) of captured fish with injuries	**10.0%**	**90.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**1.1**	**1.5**	**2.8**

Table D-8. Hills Creek Dam Powerhouse route injuries for Chinook by size.

Total Chinook (n=35)	<60mm (n=0)	>60mm and <110mm (n=4)	>110mm (n=31)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	---	25.0%	0.0%
MUNK	---	0.0%	0.0%
DS<2	---	0.0%	25.8%
DS>2	---	75.0%	38.7%
BLO	---	0.0%	3.2%
EYB	---	0.0%	12.9%
BVT	---	0.0%	3.2%
FVB	---	0.0%	25.8%
GBD	---	0.0%	0.0%
POP	---	0.0%	3.2%
HIN	---	0.0%	9.7%
OPD	---	0.0%	16.1%
TEA	---	0.0%	3.2%
BRU	---	0.0%	6.5%
HBP	---	0.0%	3.2%
HO	---	0.0%	0.0%
BO	---	0.0%	0.0%
HBO	---	0.0%	0.0%
FID	---	75.0%	67.7%
PRD	---	0.0%	0.0%
COP	---	0.0%	58.1%
BKD	---	0.0%	0.0%
FUN	---	0.0%	6.5%
Total (%) of captured fish with injuries	**---**	**75.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**---**	**1.8**	**2.8**

Note: “---“ stands for not applicable

Table D-9. Hills Creek Dam Regulatory Outlet route injuries for Chinook by size.

Total Chinook (n=24)	<60mm (n=0)	>60mm and <110mm (n=3)	>110mm (n=21)
Injury Code	**Injuries (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI (no external injury)	---	0.0%	0.0%
MUNK	---	0.0%	0.0%
DS<2	---	0.0%	38.1%
DS>2	---	100.0%	57.1%
BLO	---	0.0%	4.8%
EYB	---	33.3%	19.0%
BVT	---	0.0%	4.8%
FVB	---	0.0%	38.1%
GBD	---	33.3%	0.0%
POP	---	0.0%	4.8%
HIN	---	0.0%	14.3%
OPD	---	0.0%	23.8%
TEA	---	0.0%	4.8%
BRU	---	33.3%	9.5%
HBP	---	0.0%	4.8%
HO	---	0.0%	0.0%
BO	---	0.0%	0.0%
HBO	---	0.0%	0.0%
FID	---	100.0%	100.0%
PRD	---	0.0%	0.0%
COP	---	0.0%	85.7%
BKD	---	0.0%	0.0%
FUN	---	0.0%	9.5%
Total (%) of captured fish with injuries	**---**	**100.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**---**	**3.0**	**4.2**

Note: "---" stands for not applicable

Table D-10. Injury rates of hatchery Trapping Efficiency pre-release and after capture for Breitenbush, North Santiam HOR, Green Peter HOR, and Foster HOR RST sites.

Injury Code	Breitenbush		Detroit HOR		Green Peter HOR		Foster HOR	
	Pre-release Injury (%) (n=300)	Recapture Injury (%) (n=287)	Pre-release Injury (%) (n=250)	Recapture Injury (%) (n=270)	Pre-release Injury (%) (n=50)	Recapture Injury (%) (n=54)	Pre-release Injury (%) (n=250)	Recapture Injury (%) (n=109)
NXI (no external injury)	32.7%	4.9%	37.6%	21.5%	6.0%	5.6%	4.4%	0.0%
MUNK	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DS<2	4.3%	1.0%	5.2%	0.4%	0.0%	7.4%	3.6%	0.0%
DS>2	61.0%	85.4%	56.0%	76.7%	88.0%	50.0%	90.8%	99.1%
BLO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
EYB	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%
BVT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FVB	0.0%	0.3%	0.0%	0.0%	0.0%	3.7%	0.0%	1.8%
GBD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%
POP	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HIN	0.0%	0.3%	0.0%	1.9%	0.0%	1.9%	0.0%	0.0%
OPD	1.7%	3.1%	1.6%	2.2%	2.0%	9.3%	0.0%	11.9%
TEA	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%
BRU	0.0%	0.3%	0.0%	0.0%	0.0%	5.6%	0.4%	0.0%
HBP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FID	66.7%	87.5%	58.8%	77.4%	76.0%	83.3%	58.0%	85.3%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	21.3%	0.0%	8.5%	0.0%	0.0%	0.8%	0.0%
Total (%) of captured fish with injuries	**67.3%**	**95.1%**	**62.4%**	**78.5%**	**94.0%**	**94.4%**	**95.6%**	**100.0%**
Average number of injuries per fish (non NXI)	**1.7**	**2.0**	**1.6**	**1.9**	**1.7**	**1.7**	**1.6**	**2.0**

Table D-11. Injury rates of hatchery Trapping Efficiency pre-release and after capture for Cougar HOR, Fall Creek Dam HOR, Lookout Point Dam HOR, and Hills Creek Dam HOR RST sites.

Injury Code	Cougar HOR		Fall Creek HOR		Lookout HOR		Hills Creek HOR	
	Pre-release Injury (%) (n=250)	Recapture Injury (%) (n=161)	Pre-release Injury (%) (n=400)	Recapture Injury (%) (n=857)	Pre-release Injury (%) (n=400)	Recapture Injury (%) (n=95)	Pre-release Injury (%) (n=350)	Recapture Injury (%) (n=93)
NXI (no external injury)	0.0%	13.7%	3.5%	1.2%	11.0%	2.1%	8.0%	0.0%
MUNK	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DS<2	3.6%	8.1%	11.3%	14.6%	8.3%	11.6%	12.6%	14.0%
DS>2	96.4%	71.4%	83.0%	81.2%	76.5%	85.3%	78.6%	82.8%
BLO	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	1.1%
EYB	1.2%	0.0%	0.5%	0.6%	0.8%	0.0%	0.0%	0.0%
BVT	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%
FVB	0.4%	0.0%	0.3%	0.1%	1.3%	1.1%	0.3%	0.0%
GBD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
POP	0.4%	0.6%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%
HIN	0.0%	0.6%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%
OPD	0.8%	13.0%	0.5%	2.7%	1.3%	3.2%	1.4%	2.2%
TEA	0.8%	0.0%	0.0%	0.1%	0.3%	1.1%	0.9%	0.0%
BRU	0.4%	2.5%	0.3%	2.1%	0.5%	0.0%	0.9%	1.1%
HBP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FID	98.0%	75.2%	88.3%	92.4%	88.0%	62.1%	85.4%	64.5%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.8%	4.3%	4.0%	3.7%	4.3%	2.1%	4.0%	1.1%
Total (%) of captured fish with injuries	**100.0%**	**86.3%**	**96.5%**	**98.8%**	**89.0%**	**97.9%**	**92.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**2.0**	**1.9**	**1.9**	**2.0**	**1.9**	**1.7**	**1.9**	**1.7**

Table D-12. Injury rates of hatchery Trapping Efficiency pre-release and after capture for Big Cliff dam, Green Peter Dam, Cougar Dam powerhouse and regulatory routes.

Injury Code	Big Cliff Dam		Green Peter Dam		Cougar Dam Powerhouse		Cougar Dam Regulatory Outlet	
	Pre-release Injury (%) (n=300)	Recapture Injury (%) (n=123)	Pre-release Injury (%) (n=400)	Recapture Injury (%) (n=20)	Pre-release Injury (%) (n=300)	Recapture Injury (%) (n=319)	Pre-release Injury (%) (n=200)	Recapture Injury (%) (n=142)
NXI (no external injury)	31.3%	10.6%	3.3%	0.0%	0.3%	3.4%	1.0%	0.0%
MUNK	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DS<2	11.3%	17.9%	7.5%	10.0%	10.0%	10.0%	7.5%	14.1%
DS>2	56.7%	66.7%	87.5%	90.0%	89.7%	73.0%	91.5%	85.9%
BLO	0.0%	0.0%	0.0%	0.0%	0.0%	1.3%	0.0%	4.9%
EYB	0.0%	6.5%	0.0%	5.0%	0.0%	1.6%	0.0%	2.8%
BVT	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%
FVB	0.0%	1.6%	0.0%	5.0%	0.3%	0.9%	0.5%	0.7%
GBD	0.0%	0.0%	0.0%	20.0%	0.0%	2.2%	0.0%	11.3%
POP	0.0%	0.0%	0.3%	0.0%	0.3%	0.6%	0.0%	4.2%
HIN	0.0%	0.0%	0.0%	5.0%	0.3%	1.6%	0.0%	3.5%
OPD	1.7%	9.8%	0.5%	25.0%	1.3%	6.6%	0.0%	10.6%
TEA	0.0%	0.0%	0.5%	0.0%	0.3%	1.6%	0.5%	3.5%
BRU	0.0%	0.0%	0.8%	0.0%	1.7%	0.9%	0.0%	0.0%
HBP	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.7%
HO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FID	60.0%	88.6%	66.5%	75.0%	98.0%	80.6%	95.5%	100.0%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	2.1%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	1.6%	0.0%	0.0%	1.0%	11.9%	1.5%	7.7%
Total (%) of captured fish with injuries	**68.7%**	**89.4%**	**96.8%**	**100.0%**	**99.7%**	**96.6%**	**99.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**1.6**	**2.0**	**1.2**	**2.4**	**2.0**	**2.0**	**2.0**	**2.5**

Table D-13. Injury rates of hatchery Trapping Efficiency pre-release and after capture for Hills Creek Powerhouse and Regulatory routes, Fall Creek Dam, and Dexter Dam.

Injury Code	Hills Creek Dam Powerhouse		Hills Creek Dam Regulatory Outlet		Fall Creek Dam		Dexter Dam	
	Pre-release Injury (%) (n=250)	Recapture Injury (%) (n=163)	Pre-release Injury (%) (n=250)	Pre-release Injury (%) (n=300)	Pre-release Injury (%) (n=300)	Pre-release Injury (%) (n=250)	Pre-release Injury (%) (n=50)	Recapture Injury (%) (n=17)
NXI (no external injury)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DS<2	18.4%	22.1%	16.8%	11.7%	11.7%	16.8%	0.0%	11.8%
DS>2	78.8%	77.9%	83.2%	88.3%	88.3%	83.2%	100.0%	88.2%
BLO	0.4%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
EYB	0.8%	0.6%	2.0%	0.3%	0.3%	2.0%	0.0%	0.0%
BVT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FVB	0.4%	0.0%	0.4%	1.3%	1.3%	0.4%	4.0%	0.0%
GBD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
POP	0.4%	0.6%	0.4%	0.0%	0.0%	0.4%	0.0%	0.0%
HIN	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
OPD	0.0%	4.9%	0.0%	0.0%	0.0%	0.0%	2.0%	17.6%
TEA	0.0%	1.2%	0.4%	0.0%	0.0%	0.4%	0.0%	0.0%
BRU	0.4%	0.0%	0.4%	1.0%	1.0%	0.4%	0.0%	0.0%
HBP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FID	99.2%	98.8%	98.4%	99.7%	99.7%	98.4%	100.0%	94.1%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	9.2%	1.8%	8.0%	5.0%	5.0%	8.0%	2.0%	23.5%
Total (%) of captured fish with injuries	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**2.1**	**2.1**	**2.1**	**2.1**	**2.1**	**2.1**	**2.1**	**2.4**

Table D-14. Injury rates of hatchery Trapping Efficiency pre-release and after capture for Lookout Dam.

Injury Code	Lookout Dam	
	Pre-release Injury (%) (n=300)	Recapture Injury (%) (n=23)
NXI (no external injury)	0.0%	0.0%
MUNK	0.0%	0.0%
DS<2	15.3%	30.4%
DS>2	84.7%	69.6%
BLO	0.0%	0.0%
EYB	0.0%	8.7%
BVT	0.0%	0.0%
FVB	0.0%	8.7%
GBD	0.0%	21.7%
POP	0.0%	8.7%
HIN	0.0%	4.3%
OPD	0.7%	13.0%
TEA	0.0%	4.3%
BRU	0.3%	0.0%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	4.3%
FID	100.0%	100.0%
PRD	0.0%	13.0%
COP	0.0%	0.0%
BKD	0.0%	0.0%
FUN	3.7%	43.5%
Total (%) of captured fish with injuries	**89.0%**	**97.9%**
Average number of injuries per fish (non NXI)	**1.9**	**1.7**

Table D-15. Injury rates by year on NOR Chinook captured in the Big Cliff Dam Tailrace RST by injury type. Barotrauma injuries include Chinook with BLO, EYB, BVT, FVB, GBD, or POP injury codes. Mechanical injuries include Chinook with HIN, OPD, TEA, BRU, HBP, DS>2, HO, BO, and HBO injury codes. Other injuries include Chinook with FID, PRD, COP, BKD, and FUN injury codes. Mortalities represents all Chinook found dead in the RST at time of trap check.

Year	Site	Trap Location	NOR Chinook Assessed for Injury	Barotrauma Injuries	Mechanical Injuries	Other Injuries	Mortalities
2024	**Big Cliff Dam**	**Tailrace**	**937**	**25.8%**	**47.1%**	**96.3%**	**15.5%**
2023	**Big Cliff Dam**	**Tailrace**	**704**	**18.8%**	**35.9%**	**80.0%**	**7.4%**
2022	**Big Cliff Dam**	**Tailrace**	**1234**	**18.5%**	**38.5%**	**88.4%**	**12.6%**
2021	**Big Cliff Dam**	**Tailrace**	**611**	**4.6%**	**14.4%**	**82.2%**	**6.5%**

Data represents all fish captured in the RST for the entire year except for 2024 which only includes data from January 1st to June 30th.

Table D-16. Injury rates by year on NOR Chinook captured in the Green Peter Dam Tailrace RST by injury type. Barotrauma injuries include Chinook with BLO, EYB, BVT, FVB, GBD, or POP injury codes. Mechanical injuries include Chinook with HIN, OPD, TEA, BRU, HBP, DS>2, HO, BO, and HBO injury codes. Other injuries include Chinook with FID, PRD, COP, BKD, and FUN injury codes. Mortalities represents all Chinook found dead in the RST at time of trap check.

Year	Site	Trap Location	NOR Chinook Assessed for Injury	Barotrauma Injuries	Mechanical Injuries	Other Injuries	Mortalities
2024	Green Peter Dam	Tailrace	128	70.3%	53.9%	87.5%	11.7%
2023	Green Peter Dam	Tailrace	107	49.5%	37.4%	67.3%	19.6%

Data represents all fish captured in the RST for the entire year except for 2024 which only includes data from January 1st to June 30th.

Table D-17. Injury rates by year on NOR Chinook captured in the Cougar Dam Tailrace RSTs by injury type. Barotrauma injuries include Chinook with BLO, EYB, BVT, FVB, GBD, or POP injury codes. Mechanical injuries include Chinook with HIN, OPD, TEA, BRU, HBP, DS>2, HO, BO, and HBO injury codes. Other injuries include Chinook with FID, PRD, COP, BKD, and FUN injury codes. Mortalities represents all Chinook found dead in the RST at time of trap check.

Year	Site	Trap Location	NOR Chinook Assessed for Injury	Barotrauma Injuries	Mechanical Injuries	Other Injuries	Mortalities
2024	Cougar Dam	Powerhouse	305	20.0%	33.1%	80.7%	10.5%
2024	Cougar Dam	RO	826	66.0%	46.2%	91.3%	16.7%
2023	Cougar Dam	Powerhouse	427	14.8%	23.2%	78.5%	11.2%
2023	Cougar Dam	RO	5273	47.0%	38.8%	97.9%	9.5%
2022	Cougar Dam	Powerhouse	1178	10.1%	16.1%	86.7%	9.8%
2022	Cougar Dam	RO	1776	40.8%	43.0%	95.4%	17.7%
2021	Cougar Dam	Powerhouse	361	1.1%	5.5%	45.7%	1.7%
2021	Cougar Dam	RO	2889	5.8%	33.2%	80.9%	8.7%

Data represents all fish captured in the RST for the entire year except for 2024 which only includes data from January 1st to June 30th.

Table D-18. Injury rates by year on NOR Chinook captured in the Fall Creek Dam Tailrace RST by injury type. Barotrauma injuries include Chinook with BLO, EYB, BVT, FVB, GBD, or POP injury codes. Mechanical injuries include Chinook with HIN, OPD, TEA, BRU, HBP, DS>2, HO, BO, and HBO injury codes. Other injuries include Chinook with FID, PRD, COP, BKD, and FUN injury codes. Mortalities represents all Chinook found dead in the RST at time of trap check.

Year	Site	Trap Location	NOR Chinook Assessed for Injury	Barotrauma Injuries	Mechanical Injuries	Other Injuries	Mortalities
2024	Fall Creek Dam	RO	9	22.2%	33.3%	88.9%	11.1%
2023	Fall Creek Dam	RO	150	22.7%	42.7%	60.7%	21.3%
2022	Fall Creek Dam	RO	1	0.0%	100.0%	100.0%	0.0%

Data represents all fish captured in the RST for the entire year except for 2024 which only includes data from January 1st to June 30th.

Table D-19. Injury rates by year on NOR Chinook captured in the Hills Creek Dam Tailrace RSTs by injury type. Barotrauma injuries include Chinook with BLO, EYB, BVT, FVB, GBD, or POP injury codes. Mechanical injuries include Chinook with HIN, OPD, TEA, BRU, HBP, DS>2, HO, BO, and HBO injury codes. Other injuries include Chinook with FID, PRD, COP, BKD, and FUN injury codes. Mortalities represents all Chinook found dead in the RST at time of trap check.

Year	Site	Trap Location	NOR Chinook Assessed for Injury	Barotrauma Injuries	Mechanical Injuries	Other Injuries	Mortalities
2024	Hills Creek Dam	PH	36	41.7%	52.8%	97.2%	36.1%
2024	Hills Creek Dam	Tailrace*	24	50.0%	66.7%	100.0%	37.5%
2023	Hills Creek Dam	PH	397	30.0%	35.8%	45.1%	29.2%
2023	Hills Creek Dam	Tailrace*	247	25.9%	34.0%	47.0%	21.1%
2022	Hills Creek Dam	PH	42	57.1%	64.3%	78.6%	59.5%
2022	Hills Creek Dam	Tailrace*	28	60.7%	71.4%	92.9%	32.1%
2021	Hills Creek Dam	PH	14	35.7%	57.1%	92.9%	57.1%
2021	Hills Creek Dam	Tailrace*	56	37.5%	44.6%	83.9%	57.1%

*Tailrace refers to the "RO" trap that captures fish from both the Powerhouse and Regulatory Outlet.
Data represents all fish captured in the RST for the entire year except for 2024 which only includes data from January 1st to June 30th.

Table D-20. Injury rates by year on NOR Chinook captured in the Lookout Dam Tailrace RSTs by injury type. Barotrauma injuries include Chinook with BLO, EYB, BVT, FVB, GBD, or POP injury codes. Mechanical injuries include Chinook with HIN, OPD, TEA, BRU, HBP, DS>2, HO, BO, and HBO injury codes. Other injuries include Chinook with FID, PRD, COP, BKD, and FUN injury codes. Mortalities represents all Chinook found dead in the RST at time of trap check.

Year	Site	Trap Location	NOR Chinook Assessed for Injury	Barotrauma Injuries	Mechanical Injuries	Other Injuries	Mortalitie s
2024	Lookout Dam	Tailrace	87	23.0%	26.4%	78.2%	3.4%
2023	Lookout Dam	Tailrace	139	56.8%	54.7%	85.6%	30.9%
2022	Lookout Dam	Tailrace	78	34.6%	52.6%	67.9%	19.2%
2021	Lookout Dam	Tailrace	18	0.0%	0.0%	16.7%	0.0%

Data represents all fish captured in the RST for the entire year except for 2024 which only includes data from January 1st to June 30th.

Table D-21. Injury rates by year on NOR Chinook captured in the Dexter Dam Tailrace RST by injury type. Barotrauma injuries include Chinook with BLO, EYB, BVT, FVB, GBD, or POP injury codes. Mechanical injuries include Chinook with HIN, OPD, TEA, BRU, HBP, DS>2, HO, BO, and HBO injury codes. Other injuries include Chinook with FID, PRD, COP, BKD, and FUN injury codes. Mortalities represents all Chinook found dead in the RST at time of trap check.

Year	Site	Trap Location	NOR Chinook Assessed for Injury	Barotrauma Injuries	Mechanical Injuries	Other Injuries	Mortalitie s
2024	Dexter Dam	Tailrace	28	32.1%	49.1%	89.3%	3.6%
2023	Dexter Dam	Tailrace	57	31.6%	29.3%	80.7%	8.8%
2022	Dexter Dam	Tailrace	99	25.3%	42.5%	54.5%	9.1%

Data represents all fish captured in the RST for the entire year except for 2024 which only includes data from January 1st to June 30th.

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Appendix E –
Trap Efficiency Analysis

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Appendix E: Trap Efficiency Plots

Sections

Figures and Tables

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TRAP EFFICIENCY ANALYSES

Introduction

Rotary screw traps (RSTs) are commonly used by fisheries biologists to gather data on juvenile salmonids as they migrate downstream through freshwater habitats. Mark-recapture techniques are frequently employed at RSTs to estimate juvenile abundances. This involves marking and releasing fish upstream of the RST and then capturing both marked and unmarked fish in subsequent days. A simple Lincoln-Petersen (L-P) model can be used to estimate the number of unmarked fish passing the RST.

Lincoln-Petersen model:

U=u∗nm$U=u*nm$

Where:

UU = the number of unmarked fish passing the RST
Uu = the unmarked fish captured at the RST
Nn = the number of marked fish available for recapture
Mm = the number of marked fish recaptured.

A key component of the L-P model, and all mark-recapture models, is the efficiency of the traps and the variables that can potentially impact this efficiency. We investigate the effect of average weekly discharge, trap revolution speed, and the interaction between these variables on RST efficiencies at sites within the Willamette River Basin. Ultimately, the results of this analysis will help inform our future modeling efforts aimed at exploring the potential impact of fish size (fork length) on trap efficiencies.

Methods

Correlation analysis

A correlation analysis was conducted to identify potential issues associated with multicollinearity and model assumption violations that could arise from fitting models with both discharge and trap revolution speed if they were highly correlated. We examined the correlation between the weekly discharge (the average of the average daily discharge for the following seven days) following a trap efficiency (TE) trial and the average revolutions per hour for the following three days following a TE trial by site, using data from 2021-2024. Correlation values were calculated using the `cor()` function implemented in R (R Core Team, 2024).

Trap efficiency analysis

A suite of models was developed to explore the effect of weekly discharge, trap revolutions per hour, and their interaction on trap efficiencies by site. This was done by fitting a series of beta regression models using a combination of weekly discharge, log-weekly discharge, revolutions per hour, and their interactions with the `betareg()` function from the `betareg` package in R (Cribari-Neto and Zeileis 2010). The general structure of the full model is described below:

TEj,i=β0+β1Qj,i+β2Rj,i+ β3Qj,iRj,i+εj,i$TE_{j,i}=\beta_0+\beta_1 Q_{j,i}+\beta_2 R_{j,i}+ \beta_3 Q_{j,i} R_{j,i}+\varepsilon_{j,i}$

Where:

TEj,i$TE_{j,i}$ = the beta-distributed trap efficiency at site *j* for efficiency trial *i*.
Qj,i$Q_{j,i}$ = average daily flow (or log average daily flow) at site *j* during the seven-day trap efficiency trial window for trial *i*.
Rj,i$R_{j,i}$ = is average revolutions per hour at site *j* during the following three days from TE trial release *i.*
Qj,iRj,i$Q_{j,i}R_{j,i}$ = is the interaction term between average weekly flow and average revolutions per hour.
β0, β1,β2,β3$\beta_0, \beta_1, \beta_2, \beta_3$ = are coefficients estimated by the model representing the relationship between the predictors and the trap efficiency.
εj,i$\varepsilon_{j,i}$ = is the error term accounting for the variability not explained by the model.

Additionally, each model was fitted with both a log-link and a logit-link function to investigate the performance of these links between the response variable (trap efficiency) and the predictor variables (average weekly flow and average revolutions per hour).

Below is a summary of models used for comparison:

- **model_null:** No covariates
- **model_q:** Weekly average discharge
- **model_logq**: Log-transformed weekly average discharge
- **model_rph**: Average revolutions per hour
- **model_q_rph**: Weekly average discharge and average revolutions per hour
- **model_logq_rph**: Log-transformed weekly average discharge and average revolutions per hour
- **model_full**: Weekly average discharge and average revolutions per hour with interaction
- **model_full_log**: Log-transformed weekly average discharge and average revolutions per hour with interaction

Model outputs were assessed through model fit, residual statistics, AICc, examination of coefficient estimates, and visual inspection of model diagnostic plots.

Results

Correlation results

The correlations range from weak to extremely strong, with most sites showing a positive correlation, suggesting that in most cases, higher discharge was associated with higher revolutions per hour (Table D-1). A few sites exhibit weak or negligible correlations, indicating that the relationship between discharge and revolutions per hour was not consistent across all locations. Based on these results, we proceeded to the TE analysis and applied the same models across all sites, recognizing that the correlation between covariates should be considered when interpreting model results.

Table E-1. Summary table with the correlation between weekly average discharge (cfs) following TE trial release and average revolutions per hour of RST over the three days following TE trial release for each rotary screw trap site within the Willamette River Basin, Washington, December 2021 – June 2024.

RST Site	Correlation	Sample Size
Big Cliff Dam	-0.23811	34
Breitenbush River	0.888868	14
Cougar Head of Reservoir	0.034156	23
Cougar Dam Powerhouse	-0.16224	19
Cougar Dam Regulating Outlet	-0.18596	22
Detroit Head of Reservoir	0.805025	15
Dexter Dam	0.889227	15
Fall Creek Dam	0.931064	13
Foster Head of Reservoir	0.721129	24
Green Peter Dam	0.905342	22
Hills Creek Powerhouse	0.431782	18
Hills Creek Regulating Outlet	0.910347	10
Lookout Point Head of Reservoir	0.69203	26
Lookout Dam PH1	0.786772	17
Lookout Dam PH2	0.828993	18
Lookout Dam Spillway	0.941199	18

Trap efficiency results

Model results from the log-link and logit-link beta functions were nearly identical between models across sites. Consequently, we opted to use the logit-link function for proceeding analyses due to easier interpretation and better application to the datasets. For most sites, the full models consistently emerged as the best-fitting, as indicated by the highest pseudo R^2 values (Cragg and Uhler's R-squared). In some instances, simpler models using only discharge or revolutions per hour performed well but typically did not outperform the more complex models that included both variables and their interaction.

Sites such as Fall Creek Dam and Foster Head of Reservoir exhibited particularly high pseudo R^2 values ($R^2 = 0.942$ and 0.799, respectively) with their best models, indicating a very strong fit. Conversely, Cougar Dam Regulating Outlet and Hills Creek Regulating Outlet had extremely poor model fits (pseudo $R^2 < 0.10$) across all models tested.

Notably, several of the best-fit models based on pseudo R^2 also had some of the highest (worst) AICc scores compared to simpler models within the same site. This suggests that while the more complex models typically explained more variance in the data, in some cases, the additional complexity only marginally improved model performance relative to simpler models.

Overall, the analysis indicates that although the best-fitting model varies by site, those models incorporating a combination of weekly discharge (or log-transformed weekly discharge), revolutions per hour, and an interaction term tend to provide the best fit.

Table E-2. Summary of beta regression model fit results with a logit-link function for each rotary screw trap site within the Willamette River Basin, Washington, December 2021 – June 2024. The models include no covariates (model_null), weekly average discharge (cfs; model_q), log of weekly average discharge (model_logq), average revolutions per hour (model_rph), weekly average discharge and average revolutions per hour (model_q_rph), log of weekly average discharge and average revolutions per hour (model_logq_rph), interaction between average weekly discharge and average revolutions per hour (model_full), and interaction between log of average weekly discharge and average revolutions per hour (model_full_log).

RST Site	Sample Size	Model	AICc Fit	Delta AICc	LogLik	Pseudo R^2
Big Cliff Dam	34	model_full_log	-121.661	4.008	66.902	0.277
Big Cliff Dam	34	model_logq_rph	-123.106	2.562	66.243	0.25
Big Cliff Dam	34	model_logq	-125.668	0	66.234	0.248
Big Cliff Dam	34	model_full	-120.247	5.422	66.195	0.231
Big Cliff Dam	34	model_q_rph	-121.92	3.749	65.649	0.2
Big Cliff Dam	34	model_q	-124.394	1.275	65.597	0.193
Big Cliff Dam	34	model_rph	-115.985	9.683	61.393	0.048
Big Cliff Dam	34	model_null	-116.806	8.863	60.596	NA
Breitenbush River	14	model_full_log	-37.225	7.156	27.362	0.396
Breitenbush River	14	model_full	-36.943	7.438	27.222	0.325
Breitenbush River	14	model_logq_rph	-40.318	4.063	26.381	0.281
Breitenbush River	14	model_logq	-43.849	0.532	26.125	0.266
Breitenbush River	14	model_q_rph	-38.818	5.564	25.631	0.17
Breitenbush River	14	model_q	-42.751	1.63	25.576	0.162
Breitenbush River	14	model_rph	-42.799	1.582	25.6	0.16
Breitenbush River	14	model_null	-44.381	0	24.736	NA
Cougar Dam Powerhouse	19	model_q_rph	-174.219	3.07	92.538	0.179
Cougar Dam Powerhouse	19	model_q	-177.29	0	92.445	0.171
Cougar Dam Powerhouse	19	model_full	-171.063	6.227	92.839	0.167
Cougar Dam Powerhouse	19	model_logq_rph	-173.134	4.156	91.996	0.134
Cougar Dam Powerhouse	19	model_logq	-176.236	1.053	91.918	0.125
Cougar Dam Powerhouse	19	model_full_log	-169.732	7.558	92.174	0.122
Cougar Dam Powerhouse	19	model_rph	-174.292	2.997	90.946	0.024
Cougar Dam Powerhouse	19	model_null	-176.824	0.466	90.787	NA

RST Site	Sample Size	Model	AICc Fit	Delta AICc	LogLik	Pseudo R^2
Cougar Dam Regulating Outlet	22	model_full_log	-73.144	8.506	43.447	0.027
Cougar Dam Regulating Outlet	22	model_q_rph	-76.705	4.945	43.529	0.026
Cougar Dam Regulating Outlet	22	model_full	-73.462	8.189	43.606	0.024
Cougar Dam Regulating Outlet	22	model_q	-79.641	2.009	43.487	0.022
Cougar Dam Regulating Outlet	22	model_logq_rph	-76.307	5.343	43.33	0.013
Cougar Dam Regulating Outlet	22	model_rph	-79.149	2.502	43.241	0.009
Cougar Dam Regulating Outlet	22	model_logq	-79.167	2.483	43.25	0.007
Cougar Dam Regulating Outlet	22	model_null	-81.65	0	43.141	NA
Cougar Head of Reservoir	23	model_full	-283.636	5.505	148.583	0.323
Cougar Head of Reservoir	23	model_q	-289.141	0	148.202	0.273
Cougar Head of Reservoir	23	model_q_rph	-286.208	2.933	148.215	0.271
Cougar Head of Reservoir	23	model_full_log	-282.357	6.784	147.943	0.27
Cougar Head of Reservoir	23	model_logq	-288.209	0.932	147.736	0.253
Cougar Head of Reservoir	23	model_logq_rph	-285.292	3.849	147.757	0.252
Cougar Head of Reservoir	23	model_rph	-282.429	6.712	144.846	0.001
Cougar Head of Reservoir	23	model_null	-285.063	4.078	144.831	NA
Detroit Head of Reservoir	15	model_full	-42.605	8.879	29.636	0.212
Detroit Head of Reservoir	15	model_q_rph	-46.928	4.556	29.464	0.183
Detroit Head of Reservoir	15	model_full_log	-42.273	9.211	29.47	0.181
Detroit Head of Reservoir	15	model_logq_rph	-46.316	5.168	29.158	0.13
Detroit Head of Reservoir	15	model_rph	-49.664	1.82	28.923	0.1
Detroit Head of Reservoir	15	model_logq	-48.668	2.816	28.425	0.034
Detroit Head of Reservoir	15	model_q	-48.365	3.119	28.274	0.006
Detroit Head of Reservoir	15	model_null	-51.484	0	28.242	NA
Dexter Dam	15	model_logq_rph	-135.31	3.807	73.655	0.293
Dexter Dam	15	model_full	-130.662	8.455	73.664	0.292
Dexter Dam	15	model_logq	-139.117	0	73.649	0.29
Dexter Dam	15	model_full_log	-130.819	8.297	73.743	0.28
Dexter Dam	15	model_q_rph	-135.074	4.043	73.537	0.255
Dexter Dam	15	model_q	-138.887	0.229	73.535	0.252
Dexter Dam	15	model_rph	-138.027	1.089	73.105	0.244
Dexter Dam	15	model_null	-138.299	0.818	71.65	NA
Fall Creek Dam	13	model_full	-101.153	6.26	59.862	0.942
Fall Creek Dam	13	model_logq_rph	-103.296	4.118	58.148	0.878
Fall Creek Dam	13	model_q_rph	-100.97	6.444	56.985	0.873
Fall Creek Dam	13	model_full_log	-98.108	9.306	58.34	0.87
Fall Creek Dam	13	model_logq	-107.413	0	58.04	0.859
Fall Creek Dam	13	model_rph	-104.138	3.275	56.403	0.853
Fall Creek Dam	13	model_q	-102.741	4.672	55.704	0.832
Fall Creek Dam	13	model_null	-94.415	12.999	49.807	NA
Foster Head of Reservoir	24	model_full_log	-120.999	0	67.166	0.799
Foster Head of Reservoir	24	model_q_rph	-119.811	1.188	64.958	0.722
Foster Head of Reservoir	24	model_full	-116.677	4.322	65.005	0.714
Foster Head of Reservoir	24	model_logq_rph	-111.335	9.664	60.72	0.602
Foster Head of Reservoir	24	model_rph	-99.031	21.968	53.115	0.338
Foster Head of Reservoir	24	model_logq	-94.368	26.631	50.784	0.052
Foster Head of Reservoir	24	model_q	-93.683	27.316	50.442	0.001
Foster Head of Reservoir	24	model_null	-96.296	24.703	50.434	NA
Green Peter Dam	22	model_q_rph	-156.4	2.544	83.377	0.107
Green Peter Dam	22	model_full	-153.019	5.925	83.385	0.106

RST Site	Sample Size	Model	AICc Fit	Delta AICc	LogLik	Pseudo R^2
Green Peter Dam	22	model_full_log	-152.55	6.393	83.15	0.101
Green Peter Dam	22	model_q	-158.232	0.712	82.783	0.08
Green Peter Dam	22	model_logq	-157.252	1.691	82.293	0.051
Green Peter Dam	22	model_logq_rph	-154.233	4.71	82.293	0.051
Green Peter Dam	22	model_rph	-156.978	1.966	82.156	0.035
Green Peter Dam	22	model_null	-158.944	0	81.788	NA
Hills Creek Powerhouse	18	model_full_log	-71.885	4.097	43.443	0.301
Hills Creek Powerhouse	18	model_full	-71.34	4.643	43.17	0.265
Hills Creek Powerhouse	18	model_logq_rph	-72.737	3.245	41.907	0.107
Hills Creek Powerhouse	18	model_logq	-74.351	1.632	41.033	0.102
Hills Creek Powerhouse	18	model_q_rph	-72.554	3.429	41.815	0.094
Hills Creek Powerhouse	18	model_rph	-75.814	0.169	41.764	0.085
Hills Creek Powerhouse	18	model_q	-73.897	2.085	40.806	0.067
Hills Creek Powerhouse	18	model_null	-75.983	0	40.391	NA
Hills Creek Regulating Outlet	10	model_full_log	-45.905	18.161	35.453	0.089
Hills Creek Regulating Outlet	10	model_full	-45.727	18.34	35.363	0.079
Hills Creek Regulating Outlet	10	model_logq_rph	-54.385	9.681	35.193	0.054
Hills Creek Regulating Outlet	10	model_logq	-60.385	3.681	35.193	0.054
Hills Creek Regulating Outlet	10	model_rph	-60.171	3.895	35.086	0.044
Hills Creek Regulating Outlet	10	model_q_rph	-54.184	9.883	35.092	0.043
Hills Creek Regulating Outlet	10	model_q	-60.119	3.947	35.06	0.035
Hills Creek Regulating Outlet	10	model_null	-64.066	0	34.89	NA
Lookout Dam PH1	17	model_full	-192.897	6.004	104.176	0.515
Lookout Dam PH1	17	model_full_log	-192.179	6.723	103.817	0.473
Lookout Dam PH1	17	model_q_rph	-195.941	2.961	103.637	0.446
Lookout Dam PH1	17	model_logq_rph	-195.493	3.408	103.413	0.394
Lookout Dam PH1	17	model_rph	-198.902	0	103.374	0.378
Lookout Dam PH1	17	model_logq	-195.453	3.449	101.649	0.14
Lookout Dam PH1	17	model_q	-195.103	3.798	101.475	0.101
Lookout Dam PH1	17	model_null	-195.877	3.025	100.367	NA
Lookout Dam PH2	18	model_full	-187.791	7.875	101.395	0.243
Lookout Dam PH2	18	model_q_rph	-191.312	4.354	101.195	0.211
Lookout Dam PH2	18	model_full_log	-187.589	8.077	101.294	0.207
Lookout Dam PH2	18	model_logq_rph	-191.289	4.378	101.183	0.196
Lookout Dam PH2	18	model_rph	-194.262	1.404	100.988	0.15
Lookout Dam PH2	18	model_q	-193.165	2.501	100.44	0.033
Lookout Dam PH2	18	model_logq	-193.116	2.55	100.415	0.031
Lookout Dam PH2	18	model_null	-195.666	0	100.233	NA
Lookout Dam Spillway	16	model_full	-179.035	0	97.018	0.42
Lookout Dam Spillway	16	model_full_log	-177.472	1.563	96.236	0.385
Lookout Dam Spillway	16	model_logq_rph	-175.334	3.701	93.206	0.325
Lookout Dam Spillway	16	model_q_rph	-169.384	9.652	90.23	0.243
Lookout Dam Spillway	16	model_rph	-165.163	13.873	86.439	0.085
Lookout Dam Spillway	16	model_q	-161.291	17.744	84.503	0.006
Lookout Dam Spillway	16	model_logq	-161.217	17.818	84.466	0
Lookout Dam Spillway	16	model_null	-164.131	14.904	84.466	NA
Lookout Point Head of Reservoir	26	model_full	-181.892	0	97.446	0.462
Lookout Point Head of Reservoir	26	model_full_log	-176.085	5.806	94.543	0.417
Lookout Point Head of Reservoir	26	model_logq_rph	-167.162	14.73	88.533	0.341
Lookout Point Head of Reservoir	26	model_q_rph	-167.211	14.681	88.558	0.339
Lookout Point Head of Reservoir	26	model_rph	-169.349	12.542	88.22	0.329
Lookout Point Head of Reservoir	26	model_logq	-167.228	14.664	87.159	0.283

RST Site	Sample Size	Model	AICc Fit	Delta AICc	LogLik	Pseudo R^2
Lookout Point Head of Reservoir	26	model_q	-165.692	16.199	86.392	0.219
Lookout Point Head of Reservoir	26	model_null	-165.157	16.734	84.84	NA

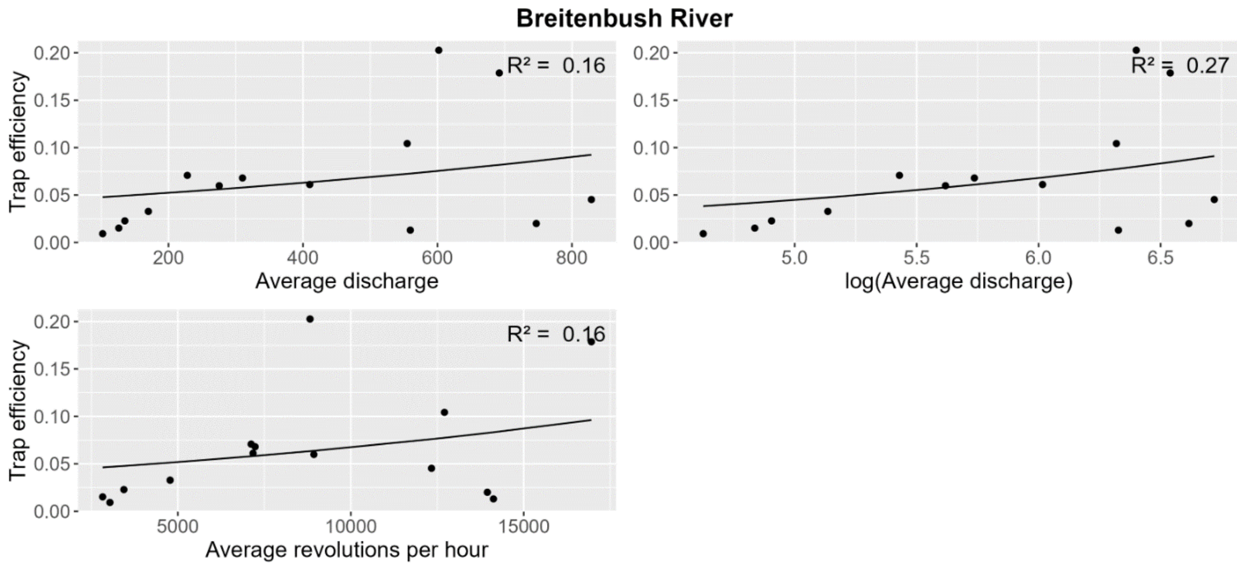

Figure E-1. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Breitenbush River. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

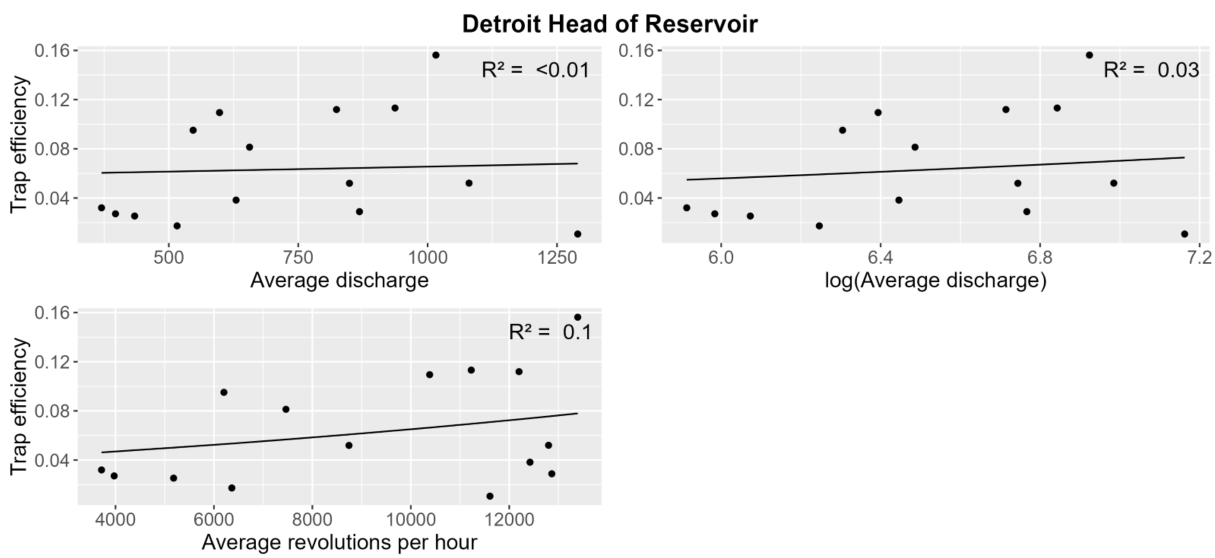

Figure E-2. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Detroit Head of Reservoir. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

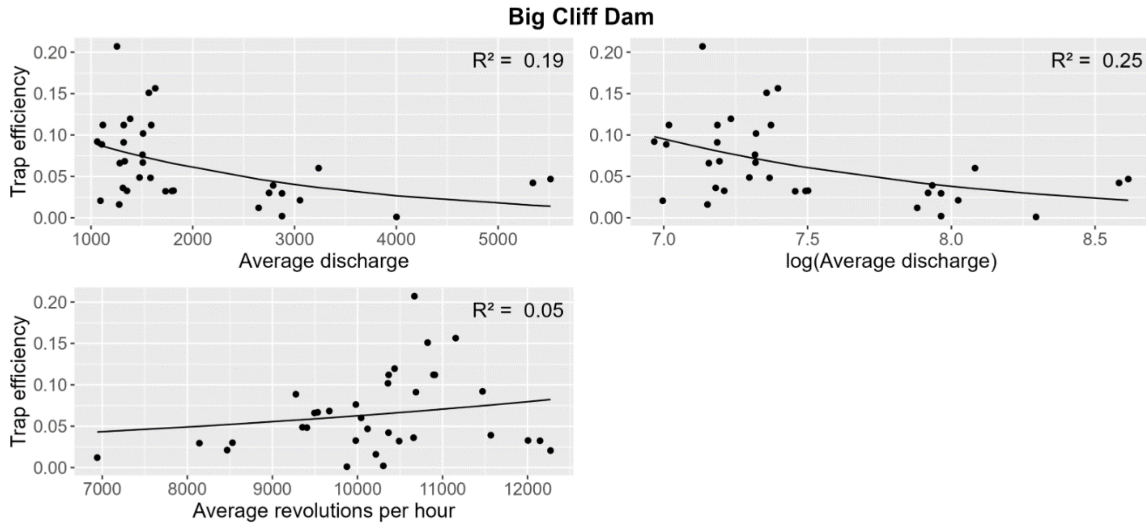

Figure E-3. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Big Cliff Dam. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

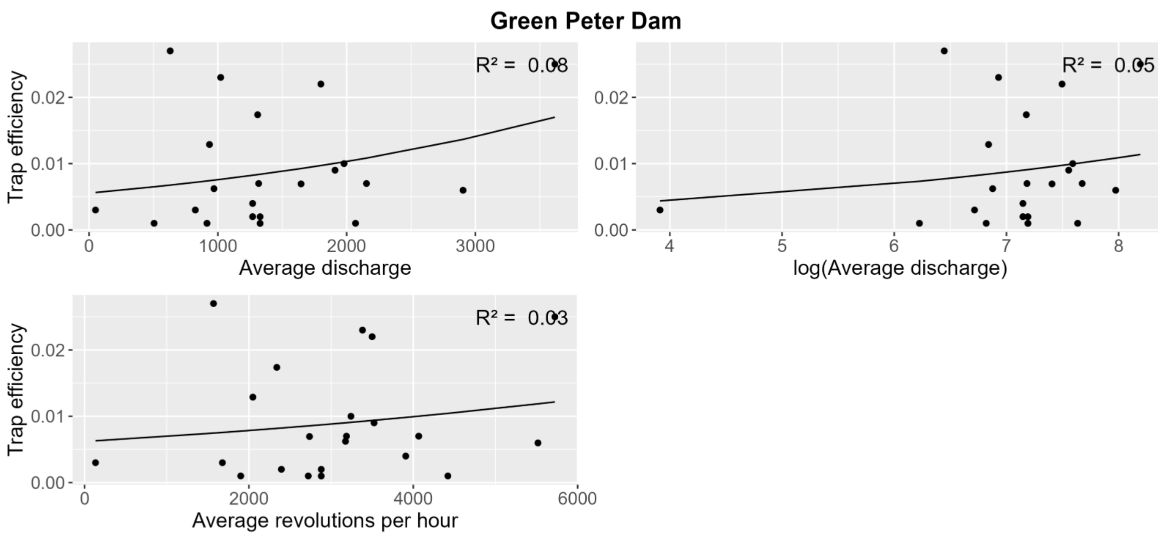

Figure E-4. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Green Peter Dam. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

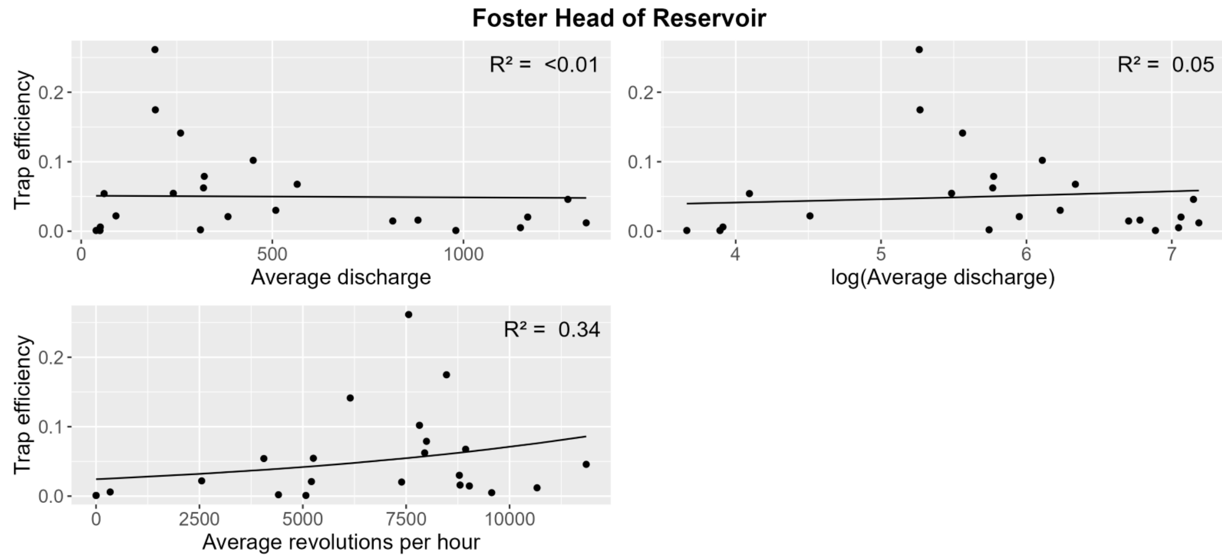

Figure E-5. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Foster Head of Reservoir. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

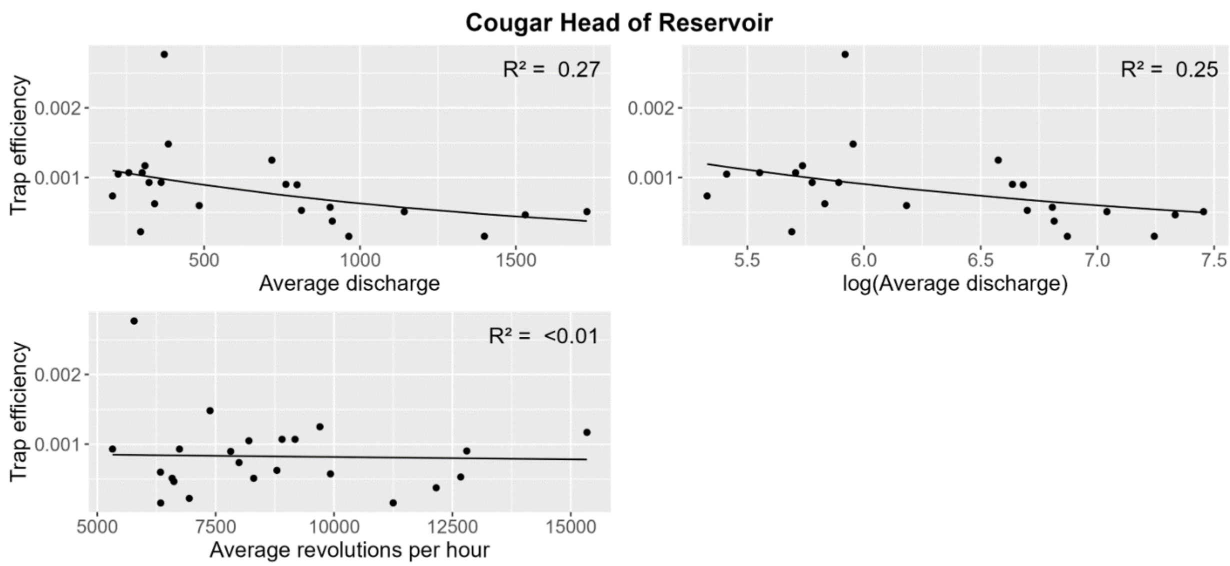

Figure E-6. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Cougar Head of Reservoir. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

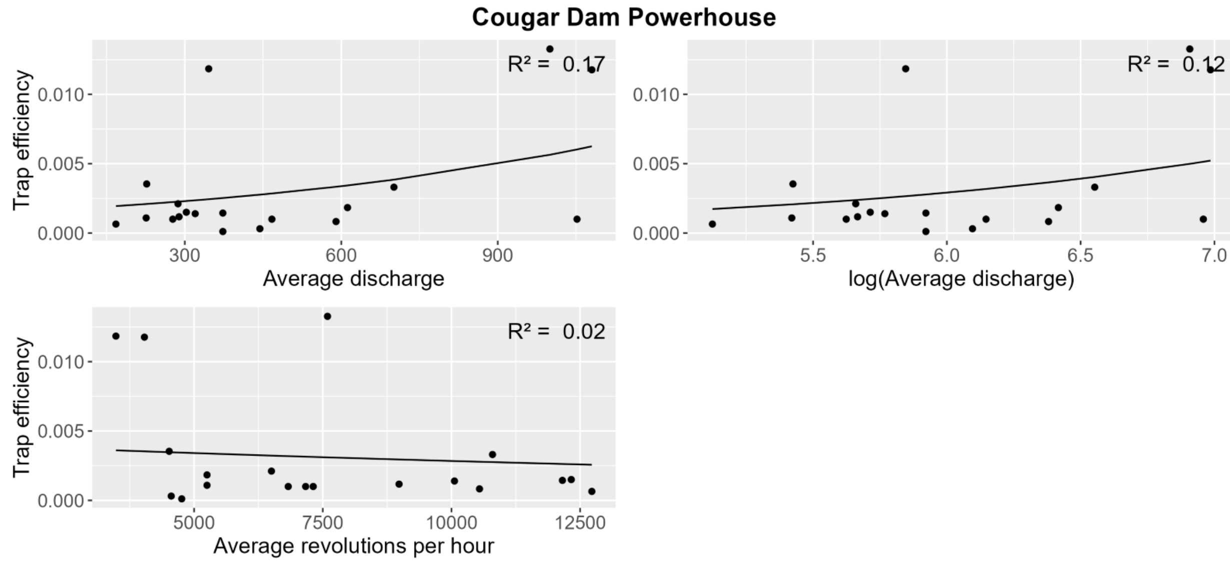

Figure E-7. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Cougar Dam powerhouse. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

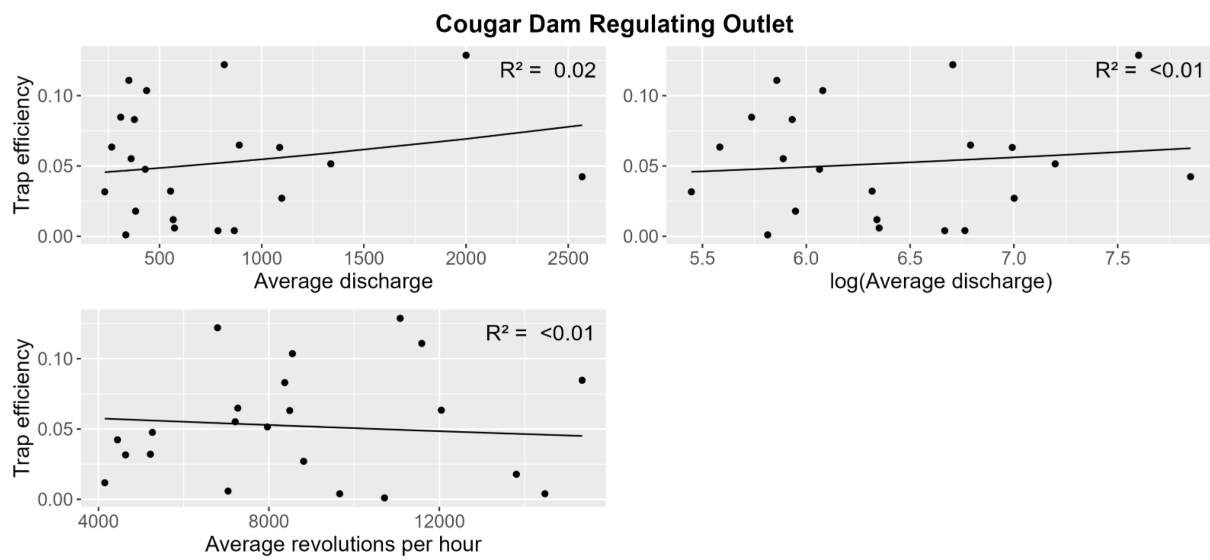

Figure E-8. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Cougar Dam regulating outlet. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

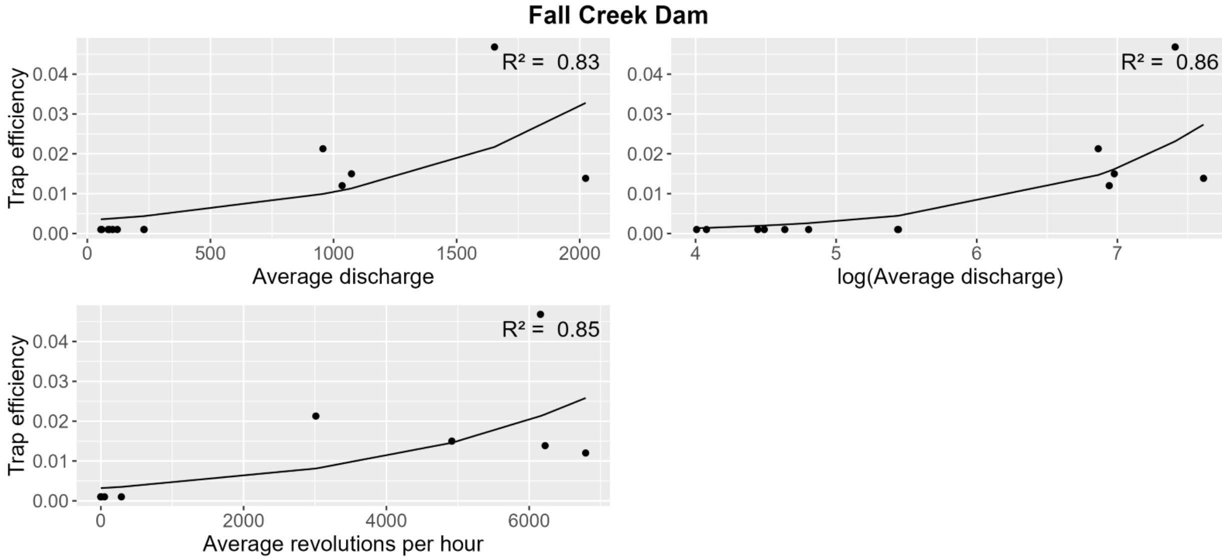

Figure E-9. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Fall Creek Dam. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

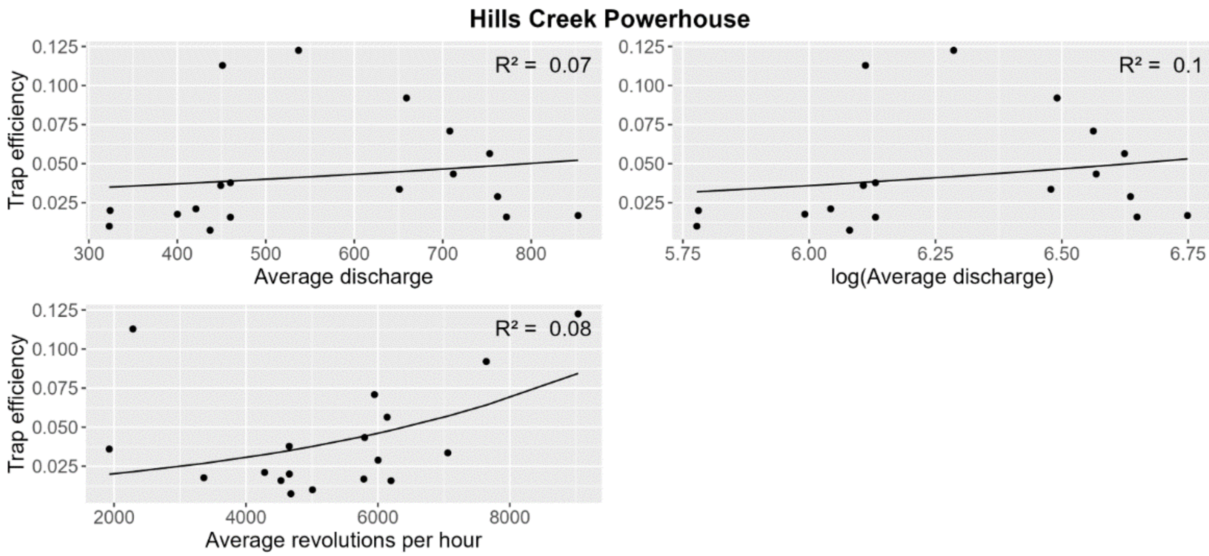

Figure E-10. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Hills Creek powerhouse. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

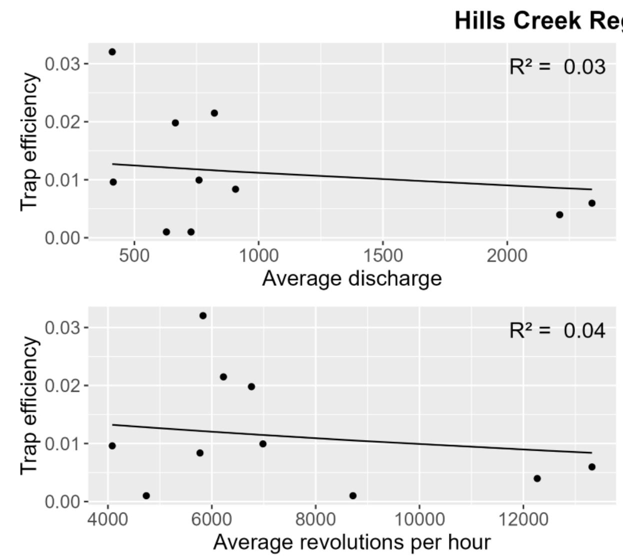

Figure E-11. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Hills Creek regulating Outlet. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

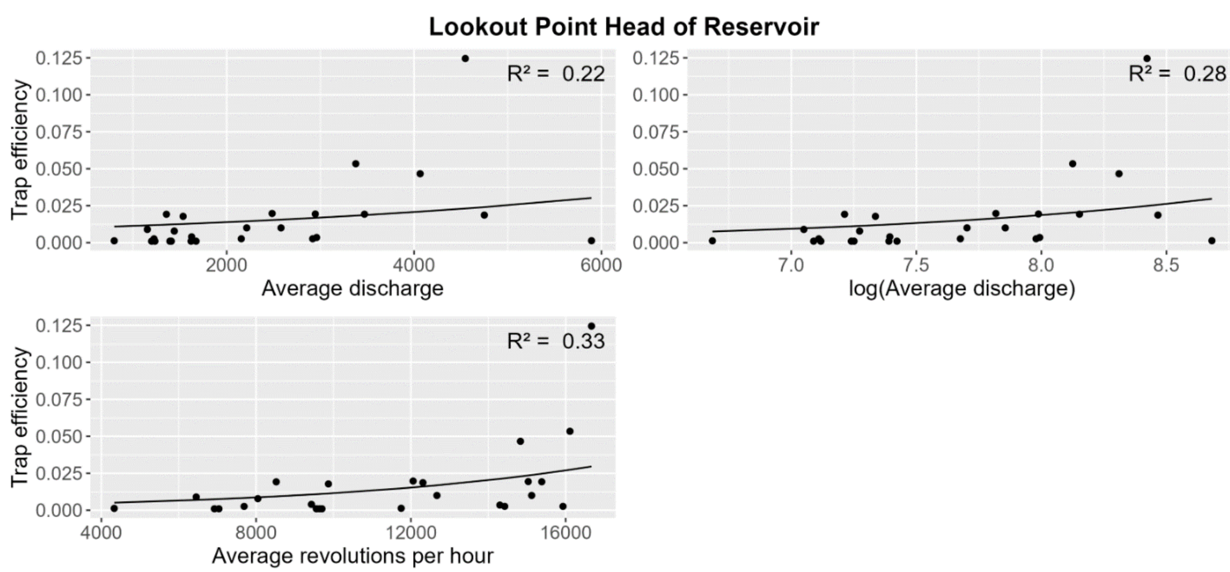

Figure E-12. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Lookout Point Head of Reservoir. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

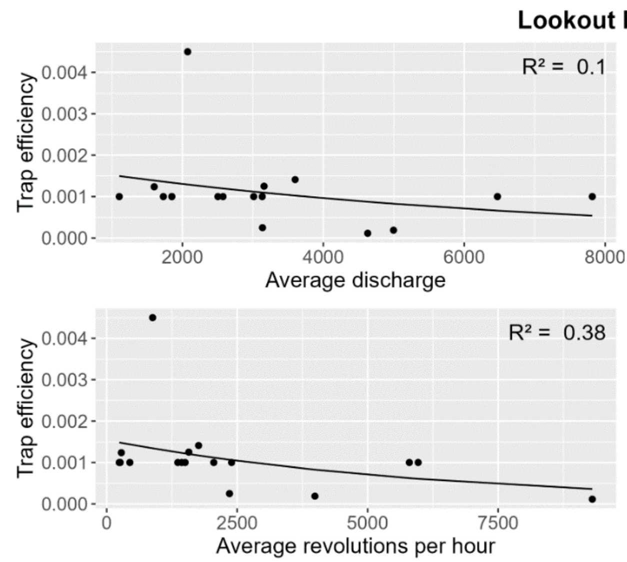

Figure E-13. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Lookout Dam powerhouse 1. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

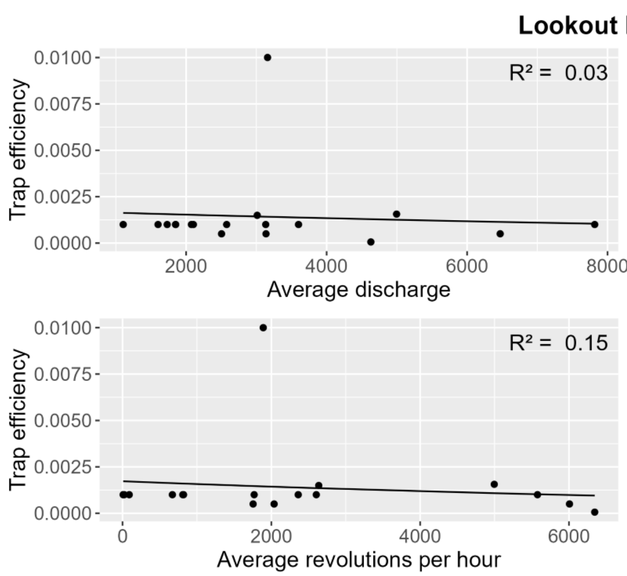

Figure E-14. Scatter plot of trap efficiency in relation to weekly average discharge (cfs) following TE trial release (top left), log of weekly average discharge (cfs) following TE trial release (top right), and average revolutions per hour of RST over the three days preceding TE trial release (bottom), at Lookout Dam powerhouse 2. Best fit lines are plotted to each scatter plot using a beta regression model with corresponding pseudo R^2 values indicated.

Discussion

The primary goal of TE trials is to investigate the efficiency of rotary screw traps (RSTs) using a mark-recapture technique and applying a Lincoln-Petersen (L-P) model to estimate the number of wild fish passing the RSTs. The efficiency of these traps is crucial as it impacts the accuracy and precision of juvenile salmonid abundance estimates. We explored the effects of various environmental and operational factors, specifically average weekly discharge and trap revolution speed, on the efficiency of these traps across different sites in the Willamette River Basin.

Our initial correlation analysis indicated that the relationship between weekly discharge and trap revolution speed varied considerably among the sites. While some sites exhibited strong positive correlations (e.g., Breitenbush River and Fall Creek Dam), others showed weak or even negative correlations (e.g., Big Cliff Dam and Cougar Dam Powerhouse). This variability suggests that the interplay between discharge and trap speed is influenced by site-specific factors, which could include variations in river morphology, local hydrodynamics, and trap placement. These findings highlight the necessity of site-specific analyses when evaluating RST efficiencies.

We developed a series of beta regression models to assess the impact of weekly discharge, trap revolutions per hour, and their interaction on trap efficiencies. The models were fitted with both logit-link and log-link functions to evaluate their performance. The logit-link function was ultimately preferred due to its easier interpretation and better fit to the data.

Across most sites, the full models that included both discharge (or log-transformed discharge) and revolutions per hour, as well as their interaction, consistently provided the best fit as indicated by the highest pseudo R^2 values. This suggests that the interaction between discharge and trap speed plays a significant role in determining trap efficiency. Notably, sites like Fall Creek Dam and Foster Head of Reservoir demonstrated exceptionally high model fits (pseudo $R^2 = 0.942$ and 0.799, respectively), indicating a strong influence of the included variables on trap efficiency at these locations.

However, it is important to note that some sites exhibited poor model fits across all tested models (e.g., Cougar Dam Regulating Outlet and Hills Creek Regulating Outlet), with pseudo R^2 values below 0.10. This could be attributed to additional unaccounted factors influencing trap efficiency or inherent variability in trap performance at these sites.

The findings from this study underscore the importance of considering both environmental and operational variables when modeling trap efficiencies. The strong performance of models incorporating both discharge and trap speed suggests that these factors should be routinely included in future analyses. Moreover, the identified site-specific differences highlight the need for tailored approaches rather than a one-size-fits-all model.

Future research should aim to extend the study period and incorporate additional variables to develop more comprehensive models. Conducting semi-controlled experiments, where possible, to isolate the effects of individual variables could also help refine our understanding of the mechanisms driving trap efficiency. Additionally, we intend to build off these results by investigating the impact fish size (fork length) has on trap efficiencies in the following analysis.

This study provides an initial analysis of the factors influencing RST efficiency in the Willamette River Basin. By highlighting the importance of both discharge and trap revolution speed, and recognizing the variability across different sites, we have laid the groundwork for more accurate and site-specific modeling efforts. These insights are crucial for fisheries biologists and managers aiming to improve the precision of juvenile salmonid abundance estimates and enhance the effectiveness of RSTs in monitoring fish populations.

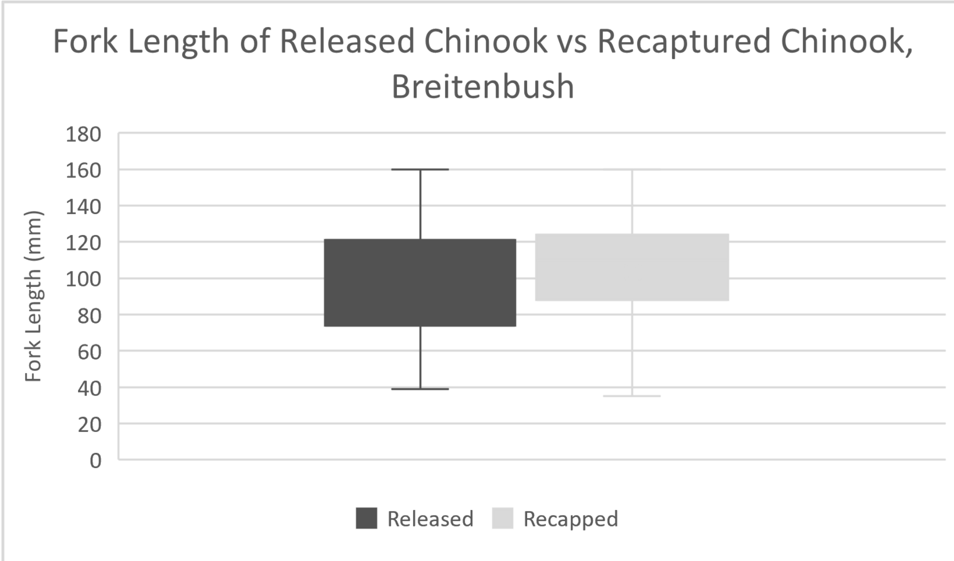

Figure E-15. Fork length of released Chinook versus recaptured Chinook at the Breitenbush site.

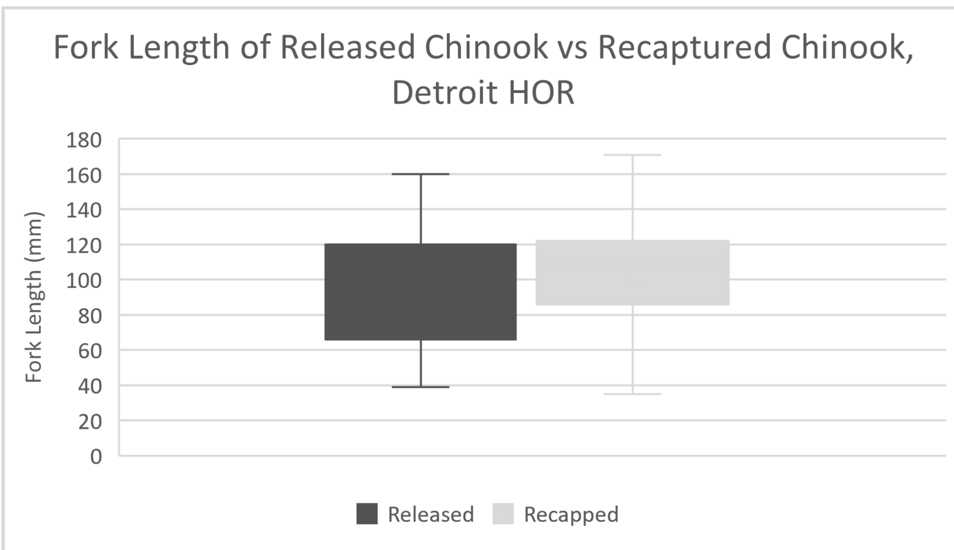

Figure E-16. Fork length of released Chinook versus recaptured Chinook at the Detroit Head of Reservoir site.

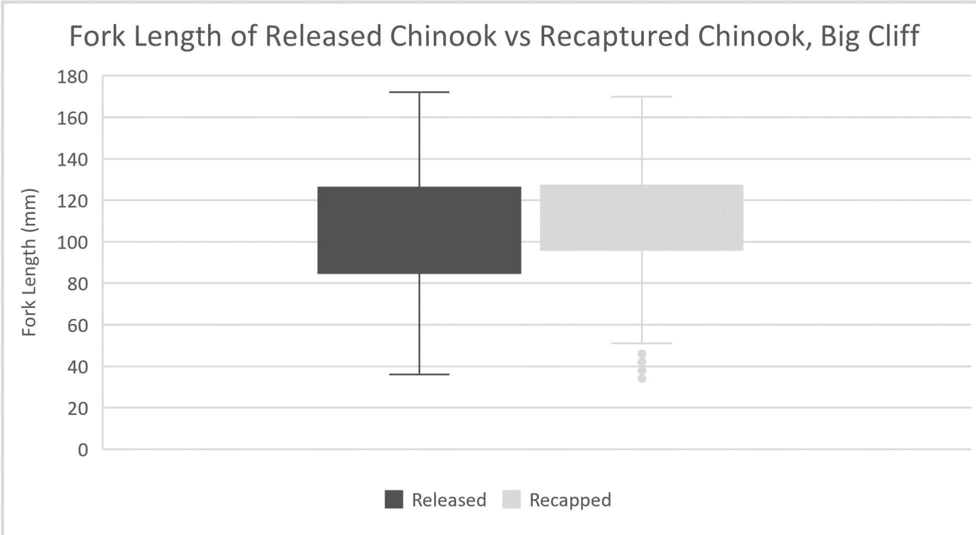

Figure E-17. Fork length of released Chinook versus recaptured Chinook at the Big Cliff Dam site.

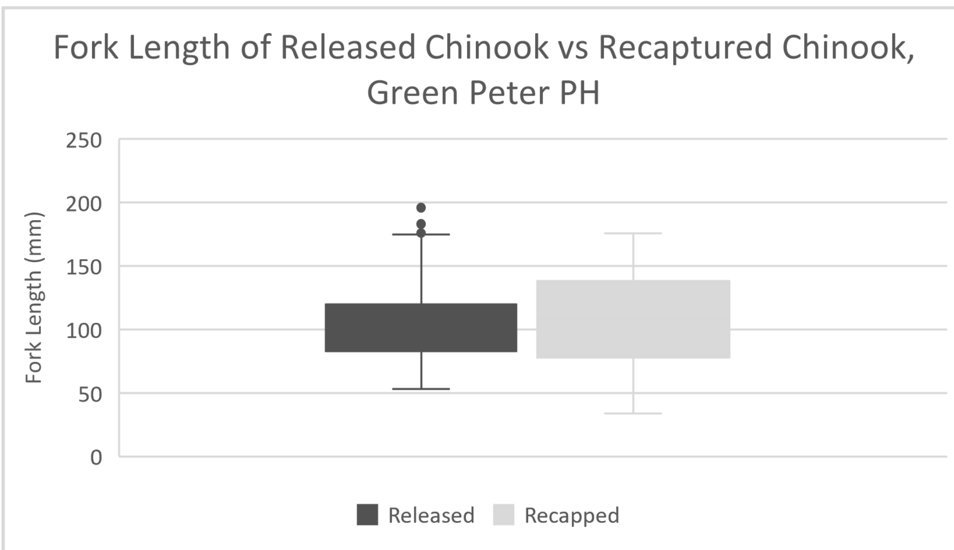

Figure E-18. Fork length of released Chinook versus recaptured Chinook at the Green Peter Dam PH site.

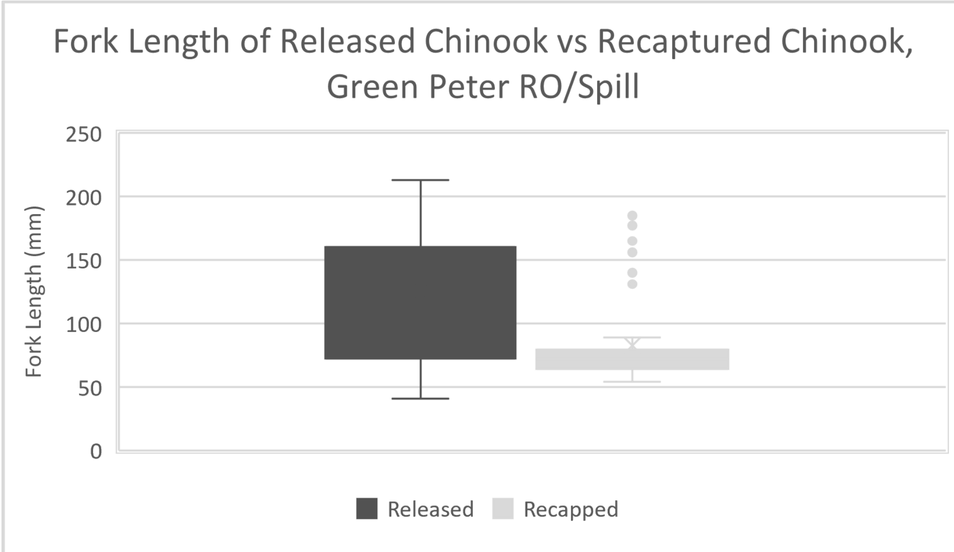

Figure E-19. Fork length of released Chinook versus recaptured Chinook at the Green Peter Dam RO site.

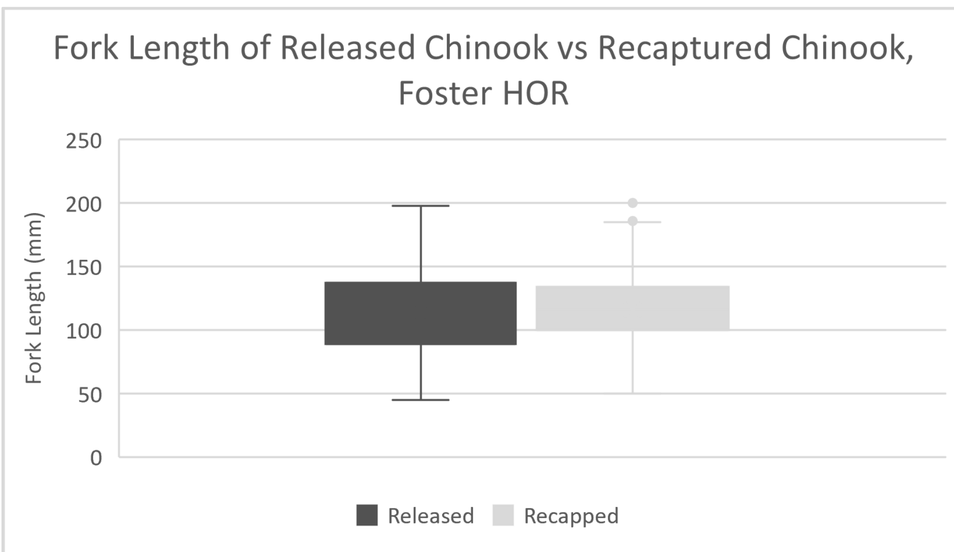

Figure E-20. Fork length of released Chinook versus recaptured Chinook at the Foster Head of Reservoir site.

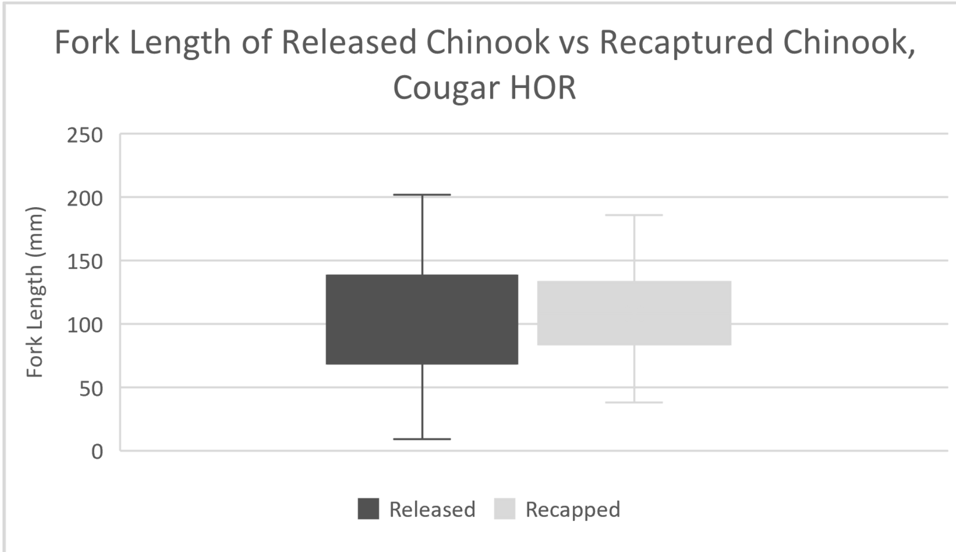

Figure E-21. Fork length of released Chinook versus recaptured Chinook at the Cougar Head of Reservoir site.

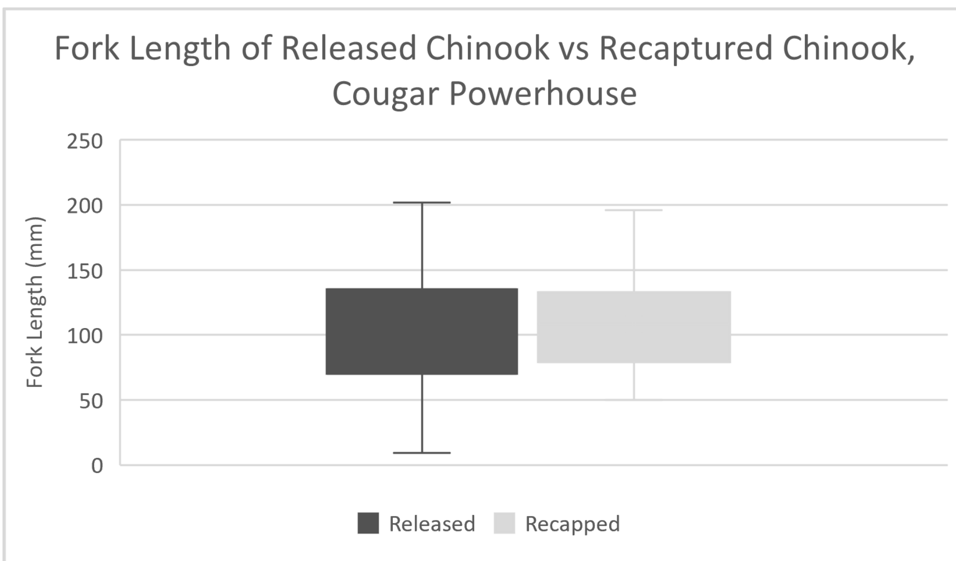

Figure E-22. Fork length of released Chinook versus recaptured Chinook at the Cougar Dam PH site.

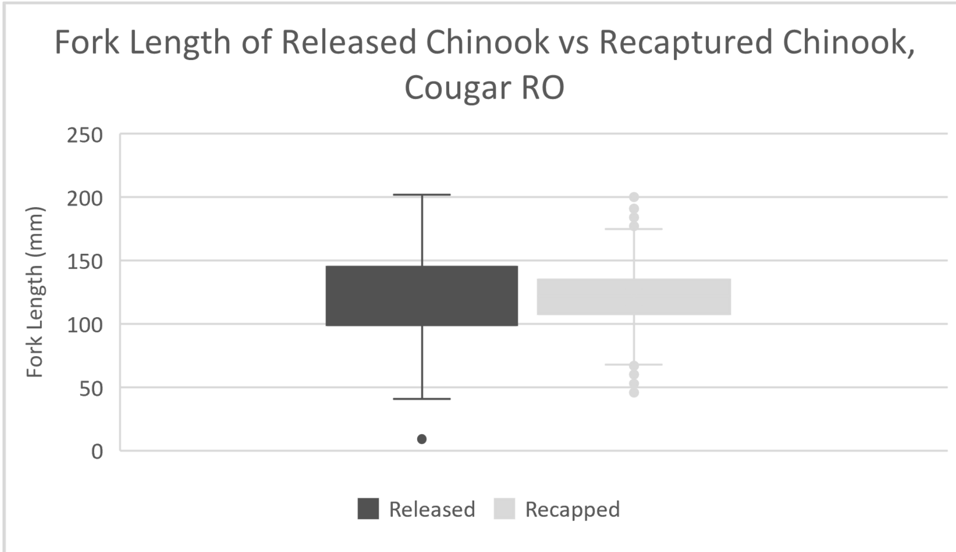

Figure E-23. Fork length of released Chinook versus recaptured Chinook at the Cougar Dam RO site.

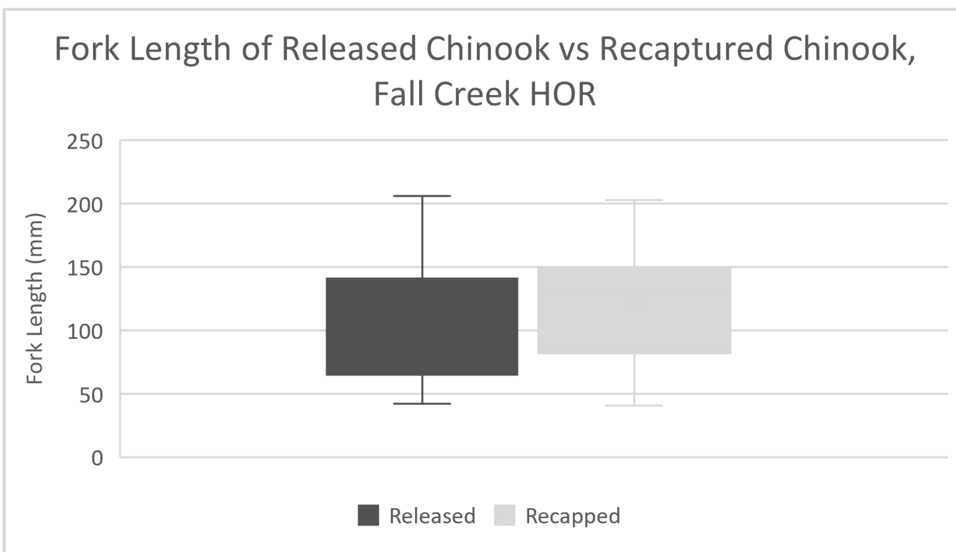

Figure E-24. Fork length of released Chinook versus recaptured Chinook at the Fall Creek Head of Reservoir site.

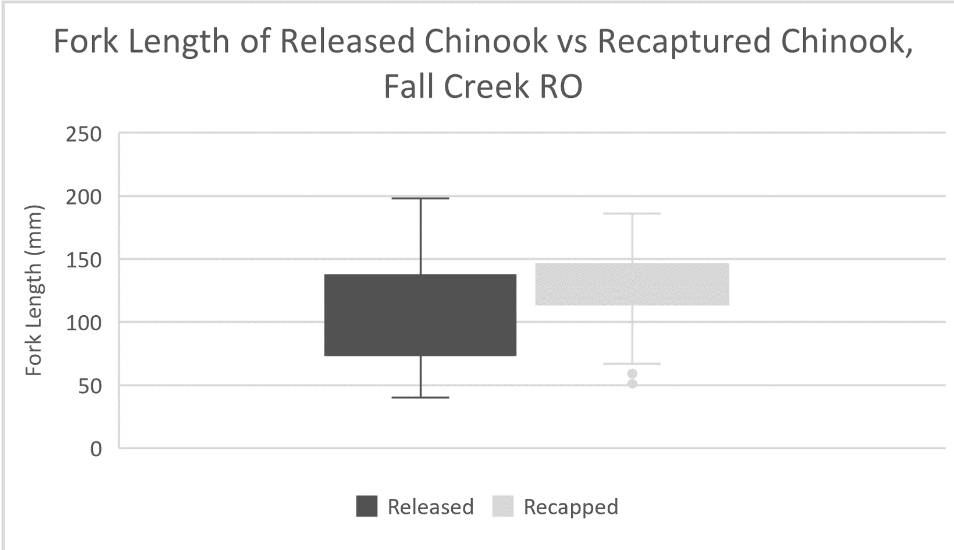

Figure E-25. Fork length of released Chinook versus recaptured Chinook at the Fall Creek Dam RO site.

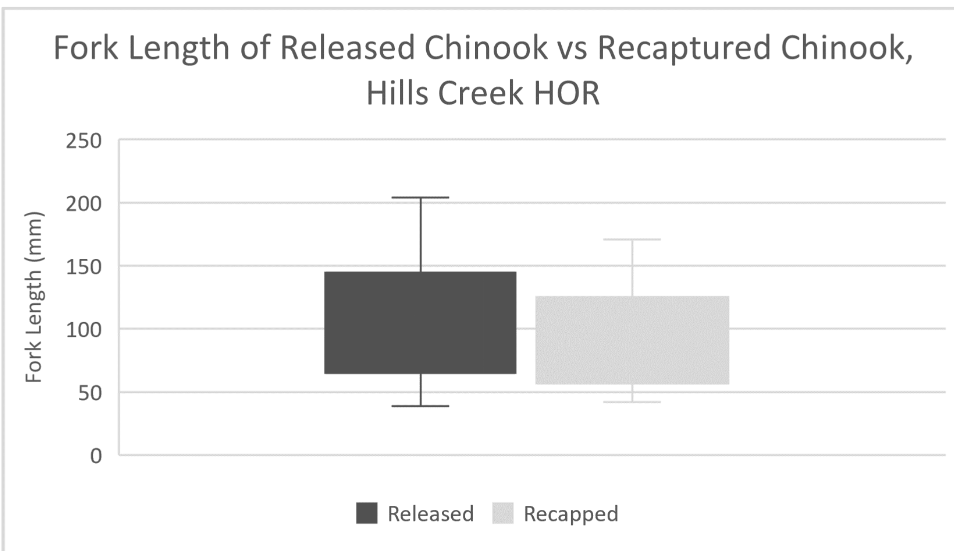

Figure E-26. Fork length of released Chinook versus recaptured Chinook at the Hills Creek Head of Reservoir site.

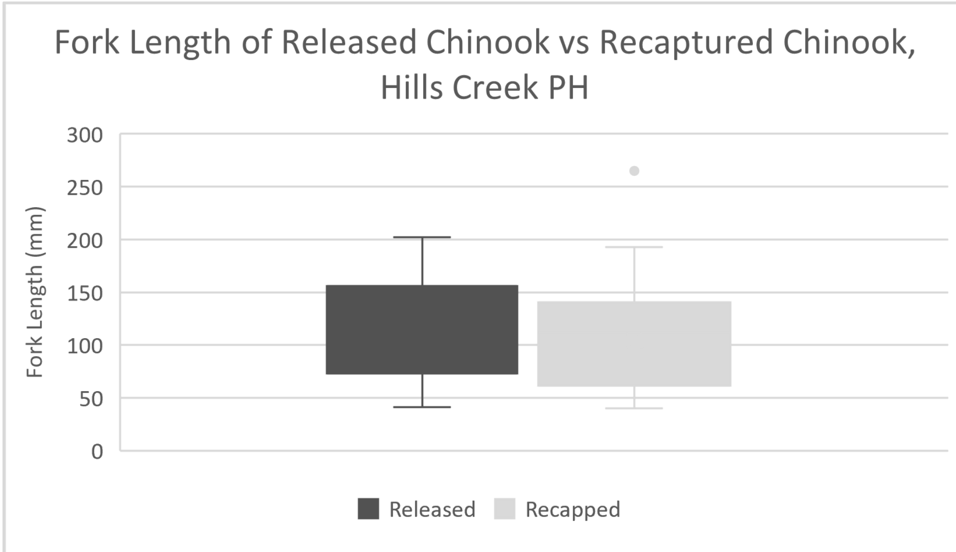

Figure E-27. Fork length of released Chinook versus recaptured Chinook at the Hills Creek Dam PH site.

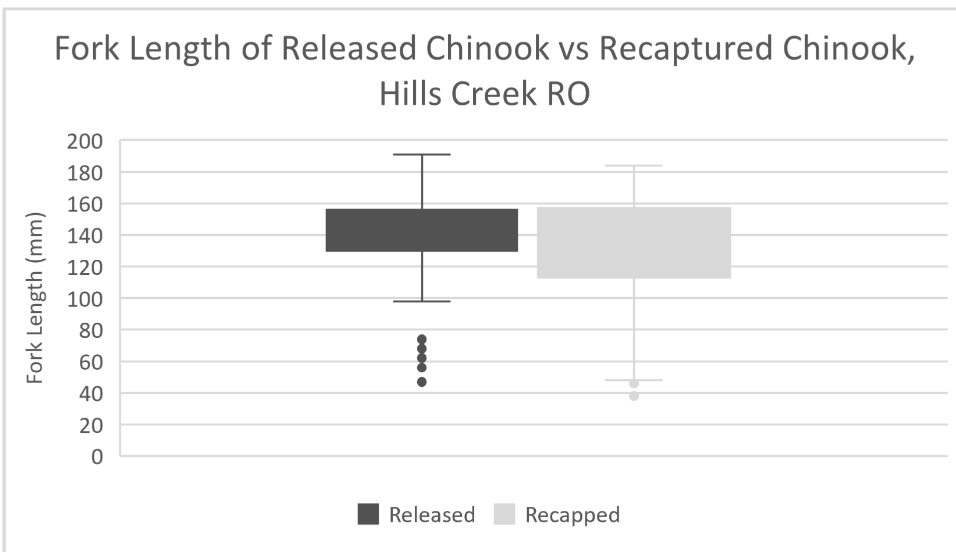

Figure E-28. Fork length of released Chinook versus recaptured Chinook at the Hills Creek Dam RO site.

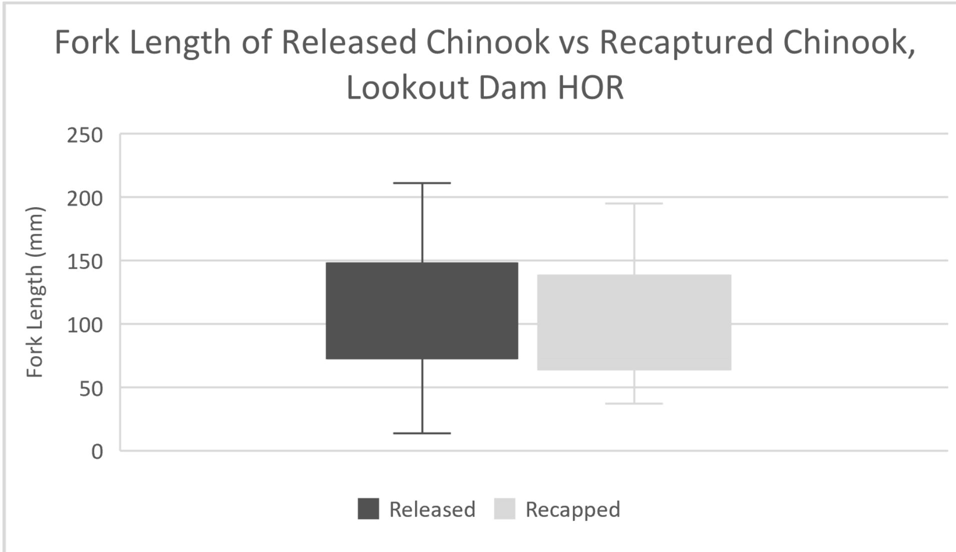

Figure E-29. Fork length of released Chinook versus recaptured Chinook at the Lookout Head of Reservoir site.

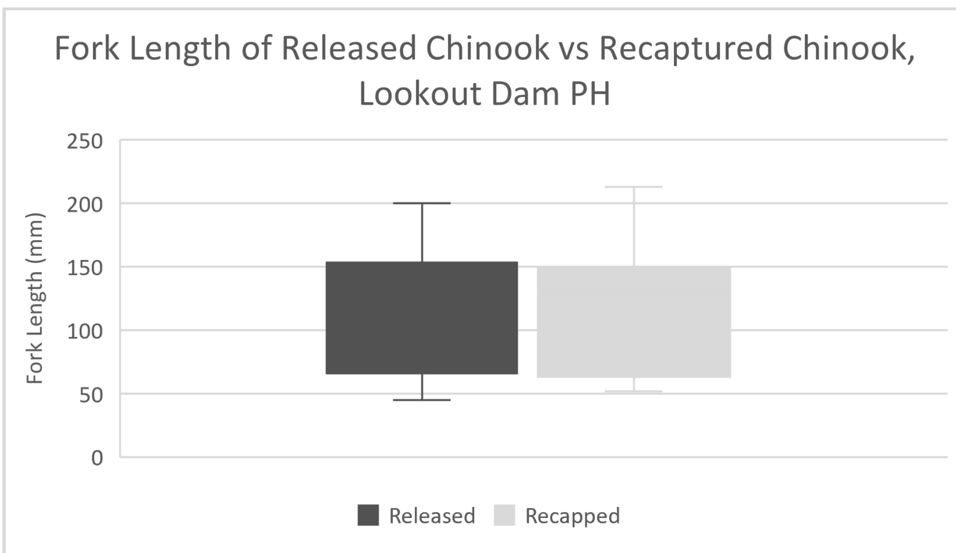

Figure E-30. Fork length of released Chinook versus recaptured Chinook at the Lookout Dam PH site.

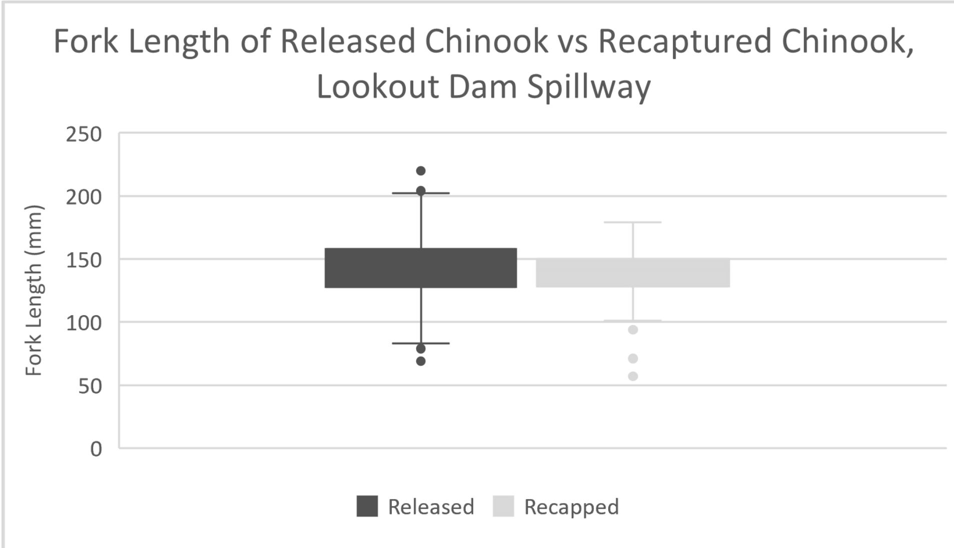

Figure E-31. Fork length of released Chinook versus recaptured Chinook at the Lookout Dam RO site.

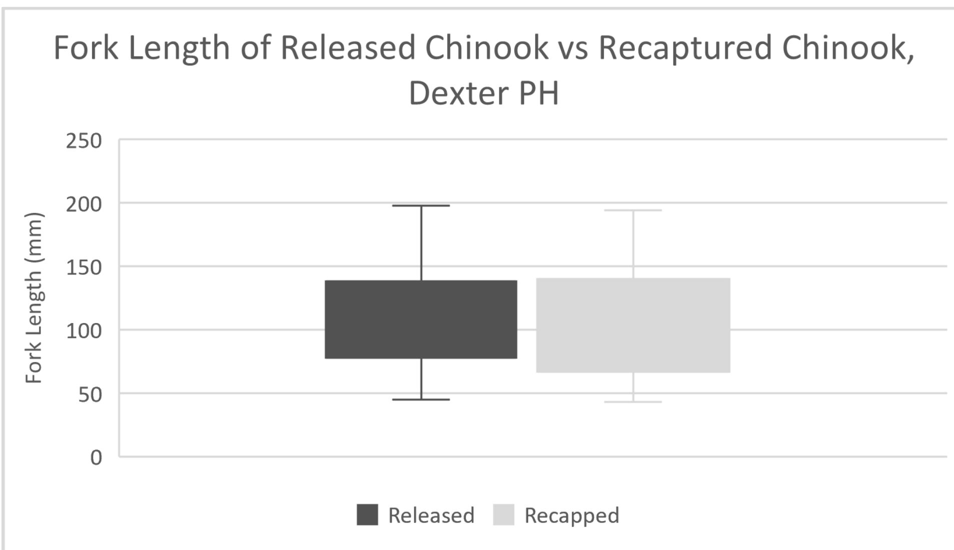

Figure E-32. Fork length of released Chinook versus recaptured Chinook at the Dexter Dam PH site.

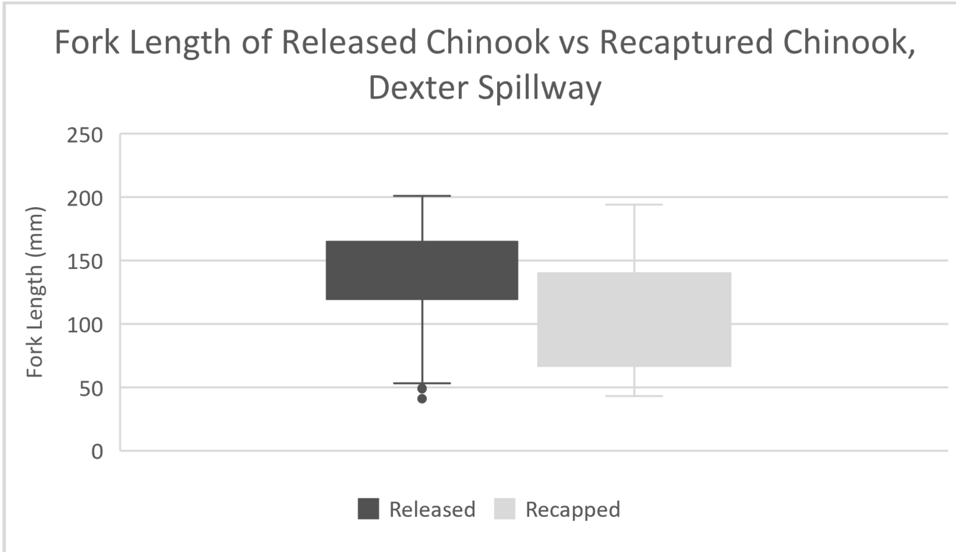

Figure E-33. Fork length of released Chinook versus recaptured Chinook at the Dexter Dam RO site.

Table E-3. Summary table of marked hatchery Chinook released in the Willamette Valley for trapping efficiency trials since 2021.

Release Location	Date of Release	Flow at Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Breitenbush River	6/21/2023	231	749	53	7.1%
Breitenbush River	7/6/2023	173	763	25	3.3%
Breitenbush River	8/2/2023	133	791	12	1.5%
Breitenbush River	9/20/2023	114	756	7	0.9%
Breitenbush River	10/5/2023	131	789	18	2.3%
Breitenbush River	10/25/2023	289	750	51	6.8%
Breitenbush River	11/10/2023	578	750	152	20.3%
Breitenbush River	11/21/2023	405	900	55	6.1%
Breitenbush River	2/7/2024	730	750	15	2.0%
Breitenbush River	2/21/2024	715	750	134	17.9%
Breitenbush River	3/6/2024	540	748	78	10.4%
Breitenbush River	3/25/2024	822	243	11	4.5%
Breitenbush River	5/15/2024	819	692	9	1.3%
Breitenbush River	6/25/2024	297	752	45	6.0%
Detroit Head of Reservoir – North Santiam River	6/6/2023	833	539	28	5.2%
Detroit Head of Reservoir – North Santiam River	6/20/2023	629	750	61	8.1%
Detroit Head of Reservoir – North Santiam River	7/6/2023	512	750	13	1.7%
Detroit Head of Reservoir – North Santiam River	8/2/2023	422	750	19	2.5%
Detroit Head of Reservoir – North Santiam River	9/6/2023	379	700	19	2.7%
Detroit Head of Reservoir – North Santiam River	10/5/2023	370	750	24	3.2%
Detroit Head of Reservoir – North Santiam River	10/25/2023	539	757	72	9.5%
Detroit Head of Reservoir – North Santiam River	11/10/2023	820	813	91	11.2%
Detroit Head of Reservoir – North Santiam River	11/21/2023	601	1,014	111	10.9%
Detroit Head of Reservoir – North Santiam River	2/7/2024	1,270	749	8	1.1%
Detroit Head of Reservoir – North Santiam River	2/21/2024	1,020	749	117	15.6%
Detroit Head of Reservoir – North Santiam River	3/6/2024	923	751	85	11.3%
Detroit Head of Reservoir – North Santiam River	5/15/2024	1,400	749	39	5.2%
Detroit Head of Reservoir – North Santiam River	6/6/2024	1,200	450	13	2.9%
Detroit Head of Reservoir – North Santiam River	6/18/2024	786	836	32	3.8%
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%

Release Location	Date of Release	Flow at Release	# of Fish Released	# of Fish Recaptured	% Efficiency
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%
Big Cliff Dam Tailrace	1/25/2023	1,320	500	56	11.2%
Big Cliff Dam Tailrace	2/17/2023	1,470	499	38	7.6%
Big Cliff Dam Tailrace	3/7/2023	1,260	2,968	61	2.1%
Big Cliff Dam Tailrace	3/10/2023	1,320	541	112	20.7%
Big Cliff Dam Tailrace	4/28/2023	2,440	498	34	6.8%
Big Cliff Dam Tailrace	5/23/2023	1,080	500	6	1.2%
Big Cliff Dam Tailrace	6/21/2023	1,270	500	8	1.6%
Big Cliff Dam Tailrace	7/5/2023	1,260	500	33	6.6%
Big Cliff Dam Tailrace	8/3/2023	1,080	474	42	8.9%
Big Cliff Dam Tailrace	9/19/2023	1,580	424	64	15.1%
Big Cliff Dam Tailrace	10/6/2023	1,590	500	56	11.2%
Big Cliff Dam Tailrace	10/25/2023	1,630	633	99	15.6%
Big Cliff Dam Tailrace	11/16/2023	4,200	527	0	0.0%
Big Cliff Dam Tailrace	11/21/2023	3,750	500	30	6.0%
Big Cliff Dam Tailrace	12/28/2023	1,520	550	56	10.2%
Big Cliff Dam Tailrace	2/14/2024	1,550	500	16	3.2%
Big Cliff Dam Tailrace	2/21/2024	1,060	464	52	11.2%
Big Cliff Dam Tailrace	3/6/2024	1,810	556	18	3.2%
Big Cliff Dam Tailrace	3/7/2024	1,820	1,959	1	0.05%
Big Cliff Dam Tailrace	3/12/2024	1,780	550	18	3.3%
Big Cliff Dam Tailrace	5/7/2024	3,310	493	1	0.2%
Big Cliff Dam Tailrace	6/18/2024	1,440	499	18	3.6%
Green Peter Head of Reservoir – Middle Santiam	6/7/2023	2.0	750	0	0%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	6/7/2023	2.0	1,000	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	7/28/2023	1.02	750	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	8/30/2023	0.9	749	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	9/27/2023	1.29	741	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	10/11/2023	2.69	750	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	10/31/2023	1.45	750	0	0.0%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	10/31/2023	1.45	1,000	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	11/15/2023	2.53	749	1	0.1%
Green Peter Head of Reservoir – Middle Santiam	2/8/2024	3.21	753	4	0.5%

Release Location	Date of Release	Flow at Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Green Peter Head of Reservoir – Middle Santiam	3/14/2024	3.43	800	4	0.5%
Green Peter Head of Reservoir – Middle Santiam	4/2/2024	3.35	754	2	0.3%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	4/2/2024	3.35	1,002	1	0.1%
Green Peter Head of Reservoir – Middle Santiam	4/12/2024	3.04	2,500	23	0.9%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	4/19/2024	2.63	1,000	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	5/15/2024	3.17	998	35	3.5%
Green Peter Head of Reservoir – Middle Santiam	6/5/2024	3.52	1,083	10	0.9%
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%
Green Peter Dam Tailrace – Spill (dead fish)	5/11/2023	1,910	1,001	0	0.0%
Green Peter Dam Tailrace – Spill	5/11/2023	1,910	999	9	0.9%
Green Peter Dam Tailrace – PWR	5/25/2023	1,980	1,000	10	1.0%
Green Peter Dam Tailrace – Powerhouse (dead fish)	6/30/2023	2,190	1,000	9	0.9%
Green Peter Dam Tailrace – Powerhouse	6/30/2023	1980	1,000	23	2.3%
Green Peter Dam Tailrace – PWR	7/27/2023	50	1,009	13	1.3%
Green Peter Dam Tailrace – PWR	8/16/2023	50	1,008	7	0.7%
Green Peter Dam Tailrace – PWR	8/31/2023	1,970	1,000	8	0.8%
Green Peter Dam Tailrace – PWR	10/4/2023	2,930	1,005	0	0.0%
Green Peter Dam Tailrace*	11/1/2023	1,800	1,000	22	2.2%
Green Peter Dam Tailrace*	11/14/2023	1,300	1,000	7	0.7%
Green Peter Dam Tailrace – Spill	11/29/2023	630	1,000	28	2.8%
Green Peter Dam Tailrace – Spill (dead fish)	11/29/2023	630	3,999	11	0.3%
Green Peter Dam Tailrace	12/8/2023	3,700	1,000	25	2.5%
Green Peter Dam Tailrace – Spill	12/19/2023	50	1,000	3	0.3%
Green Peter Dam Tailrace –PWR	1/9/2024	3,590	1,003	6	0.6%
Green Peter Dam Tailrace –Spill	2/16/2024	50	1,000	1	0.1%
Green Peter Dam Tailrace –PWR	3/26/2024	50	1,014	1	0.1%
Green Peter Dam Tailrace –Spill (dead)	3/26/2024	1,100	3,000	0	0.0%
Green Peter Dam Tailrace –Spill	3/26/2024	50	1,004	2	0.2%
Green Peter Dam Tailrace –Spill	4/18/2024	1,270	1,011	4	4.0%
Green Peter Dam Tailrace –Spill (dead)	4/24/2024	1,270	3,000	2	0.1%
Green Peter Dam Tailrace –Spill	4/24/2024	1,270	1,000	2	0.2%
Green Peter Dam Tailrace –PWR	6/11/2024	1,890	1,000	3	0.3%
Green Peter Dam Tailrace –PWR	6/18/2024	2,010	1,001	1	0.1%
Foster Dam Head of Reservoir	9/29/2022	51	1,063	0	0.0%
Foster Dam Head of Reservoir	10/25/2022	211	821	116	14.1%
Foster Dam Head of Reservoir	11/1/2022	261	1006	263	26.1%
Foster Dam Head of Reservoir	11/9/2022	560	1007	68	6.8%
Foster Dam Head of Reservoir	11/15/2022	240	1009	55	5.5%
Foster Dam Head of Reservoir	11/22/2022	165	933	163	17.5%
Foster Dam Head of Reservoir	2/27/2023	376	1,002	21	2.1%

Release Location	Date of Release	Flow at Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Foster Dam Head of Reservoir	3/9/2023	313	995	62	6.2%
Foster Dam Head of Reservoir	3/15/2023	966	1,025	0	0.0%
Foster Dam Head of Reservoir	5/11/2023	1,130	985	20	2.0%
Foster Dam Head of Reservoir	6/2/2023	313	1,003	2	0.2%
Foster Dam Head of Reservoir	6/29/2023	93	1,000	22	2.2%
Foster Dam Head of Reservoir	7/27/2023	49	989	0	0.0%
Foster Dam Head of Reservoir	8/31/2023	35	1,000	0	0.0%
Foster Dam Head of Reservoir	9/26/2023	50	1,000	6	0.6%
Foster Dam Head of Reservoir	10/10/2023	52	1,016	55	5.4%
Foster Dam Head of Reservoir	11/14/2023	431	1,000	102	10.2%
Foster Dam Head of Reservoir	11/22/2023	321	1,001	79	7.9%
Foster Dam Head of Reservoir	2/2/2024	1,270	1,005	46	4.6%
Foster Dam Head of Reservoir	3/19/2024	1,320	1,000	12	1.2%
Foster Dam Head of Reservoir	4/3/2024	923	1,003	16	1.6%
Foster Dam Head of Reservoir	4/4/2024	774	1,909	28	1.5%
Foster Dam Head of Reservoir	5/15/2024	753	999	30	3.0%
Foster Dam Head of Reservoir	6/5/2024	1,160	1,000	5	0.5%
Cougar Dam Head of Reservoir	3/18/2022	774	806	40	5.0%
Cougar Dam Head of Reservoir	5/19/2022	1380	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%
Cougar Dam Head of Reservoir	4/14/2023	980	506	10	2.0%
Cougar Dam Head of Reservoir	5/10/2023	1,170	508	7	1.4%
Cougar Dam Head of Reservoir	5/16/2023	1,700	497	23	4.6%
Cougar Dam Head of Reservoir	6/8/2023	503	510	23	4.5%
Cougar Dam Head of Reservoir	7/27/2023	223	758	27	3.6%
Cougar Dam Head of Reservoir	9/21/2023	194	745	41	5.5%
Cougar Dam Head of Reservoir	10/19/2023	211	750	42	5.6%
Cougar Dam Head of Reservoir	11/14/2023	340	756	21	2.8%
Cougar Dam Head of Reservoir	11/28/2023	261	760	67	8.8%
Cougar Dam Head of Reservoir	2/6/2024	899	768	53	6.9%
Cougar Dam Head of Reservoir	3/12/2024	849	756	26	3.4%
Cougar Dam Head of Reservoir	4/1/2024	751	754	24	3.2%
Cougar Dam Head of Reservoir	5/22/2024	859	760	41	5.4%
Cougar Dam Head of Reservoir	6/12/2024	445	750	17	2.3%
Cougar Dam Powerhouse Channel	1/19/2022	925	997	37	3.7%
Cougar Dam Powerhouse Channel	4/20/2022	860	1,000	67	6.7%
Cougar Dam Powerhouse Channel	7/19/2022	310	535	148	27.7%
Cougar Dam Powerhouse Channel	8/11/2022	700	949	29	3.1%
Cougar Dam Powerhouse Channel	1/12/2023	500	843	159	18.9%
Cougar Dam Powerhouse Channel	3/23/2023	500	500	49	9.8%
Cougar Dam Powerhouse Channel	3/30/2023	490	497	95	19.1%
Cougar Dam Powerhouse Channel	4/18/2023	580	297	14	4.7%

Release Location	Date of Release	Flow at Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Cougar Dam Powerhouse Channel	5/10/2023	710	499	5	1.0%
Cougar Dam Powerhouse Channel	6/6/2023	370	507	65	12.8%
Cougar Dam Powerhouse Channel	7/26/2023	370	510	63	12.4%
Cougar Dam Powerhouse Channel	9/21/2023	340	500	53	10.6%
Cougar Dam Powerhouse Channel	10/11/2023	290	500	83	16.6%
Cougar Dam Powerhouse Channel	1/30/2024	1,040	502	70	13.9%
Cougar Dam Powerhouse Channel	2/7/2024	1,040	493	43	8.7%
Cougar Dam Powerhouse Channel	3/11/2024	650	499	33	6.6%
Cougar Dam Powerhouse Channel	4/4/2024	1,010	501	33	6.6%
Cougar Dam Powerhouse Channel	5/22/2024	330	500	38	7.6%
Cougar Dam Powerhouse Channel	6/12/2024	500	501	102	20.4%
Cougar Dam Regulating Outlet Channel	1/19/2022	1,000	995	26	2.6%
Cougar Dam Regulating Outlet Channel	4/20/2022	400	995	16	1.6%
Cougar Dam Regulating Outlet Channel	5/15/2022	2,570	500	64	12.8%
Cougar Dam Regulating Outlet Channel	10/14/2022	890	509	49	9.6%
Cougar Dam Regulating Outlet Channel	11/22/2022	350	504	24	4.8%
Cougar Dam Regulating Outlet Channel	12/13/2022	430	502	42	8.4%
Cougar Dam Regulating Outlet Channel	12/15/2022	360	1,010	56	5.5%
Cougar Dam Regulating Outlet Channel	12/20/2022	360	1,014	61	6.0%
Cougar Dam Regulating Outlet Channel	12/28/2022	900	704	14	2.0%
Cougar Dam Regulating Outlet Channel	1/30/2023	350	509	6	1.2%
Cougar Dam Regulating Outlet Channel	3/23/2023	800	511	3	0.6%
Cougar Dam Regulating Outlet Channel	3/30/2023	300	491	31	6.3%
Cougar Dam Regulating Outlet Channel	4/18/2023	800	501	2	0.4%
Cougar Dam Regulating Outlet Channel	5/10/2023	600	499	0	0.0%
Cougar Dam Regulating Outlet Channel	10/11/2023	350	518	14	2.7%
Cougar Dam Regulating Outlet Channel	11/8/2023	1,100	508	43	8.5%
Cougar Dam Regulating Outlet Channel	11/30/2023	310	505	26	5.1%
Cougar Dam Regulating Outlet Channel	12/18/2023	1,200	505	2	0.4%
Cougar Dam Regulating Outlet Channel	1/11/2024	890	505	65	12.9%
Cougar Dam Regulating Outlet Channel	2/7/2024	2,000	505	9	1.8%
Cougar Dam Regulating Outlet Channel	3/12/2024	720	499	16	3.2%
Cougar Dam Regulating Outlet Channel	4/1/2024	950	502	52	10.4%
Fall Creek Head of Reservoir	5/5/2023	3.82	756	15	2.0%
Fall Creek Head of Reservoir	5/10/2023	3.78	750	23	3.1%
Fall Creek Head of Reservoir	5/18/2023	3.51	511	7	1.4%
Fall Creek Head of Reservoir	5/24/2023	3.28	760	4	0.5%
Fall Creek Head of Reservoir	1/2/2024	3.79	755	137	18.1%
Fall Creek Head of Reservoir	2/2/2024	4.12	751	51	6.8%
Fall Creek Head of Reservoir	3/5/2024	4.26	750	74	9.9%
Fall Creek Head of Reservoir	3/26/2024	4.17	998	99	9.9%
Fall Creek Head of Reservoir	4/15/2024	4.13	2,000	241	12.1%
Fall Creek Head of Reservoir	5/21/2024	3.5	749	24	3.2%
Fall Creek Head of Reservoir	5/29/2024	3.4	749	111	14.8%
Fall Creek Head of Reservoir	6/13/2024	3.35	750	124	16.5%
Fall Creek Dam Regulating Outlet	6/8/2022	957	517	11	2.1%
Fall Creek Dam Regulating Outlet	6/30/2022	231	513	0	0.0%
Fall Creek Dam Regulating Outlet	7/13/2022	228	498	0	0.0%

Release Location	Date of Release	Flow at Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Fall Creek Dam Regulating Outlet	5/11/2023	83	998	0	0.0%
Fall Creek Dam Regulating Outlet	6/28/2023	89	992	0	0.0%
Fall Creek Dam Regulating Outlet	7/11/2023	48	1,006	0	0.0%
Fall Creek Dam Regulating Outlet	10/3/2023	60	1,020	0	0.0%
Fall Creek Dam Regulating Outlet	10/17/2023	2,630	1,011	14	1.4%
Fall Creek Dam Regulating Outlet	1/22/2024	1,028	999	12	1.2%
Fall Creek Dam Regulating Outlet	2/13/2024	1,700	1,004	47	4.7%
Fall Creek Dam Regulating Outlet	3/5/2024	1,000	1,001	14	1.4%
Fall Creek Dam Regulating Outlet	3/26/2024	55	1,600	0	0.0%
Fall Creek Dam Regulating Outlet	4/8/2024	124	2,000	0	0.0%
Hills Creek Head of Reservoir – Middle Fork Willamette River	5/18/2023	10.2	519	44	8.5%
Hills Creek Head of Reservoir – Middle Fork Willamette River	6/19/2023	8.9	760	6	0.8%
Hills Creek Head of Reservoir – Middle Fork Willamette River	2/15/2024	9.9	761	1	0.1%
Hills Creek Head of Reservoir – Middle Fork Willamette River	2/20/2024	10.05	749	18	2.4%
Hills Creek Head of Reservoir – Middle Fork Willamette River	3/20/2024	10.78	752	16	2.1%
Hills Creek Head of Reservoir – Middle Fork Willamette River	4/9/2024	9.5	2,001	9	0.4%
Hills Creek Head of Reservoir – Middle Fork Willamette River	5/1/2024	9.8	750	32	4.3%
Hills Creek Head of Reservoir – Middle Fork Willamette River	5/23/2024	9.6	749	11	1.5%
Hills Creek Head of Reservoir – Middle Fork Willamette River	6/20/2024	8.9	750	7	0.9%
Hills Creek Dam Powerhouse	9/27/2023	400	510	9	1.8%
Hills Creek Dam Powerhouse	10/17/2023	460	509	8	1.6%
Hills Creek Dam Powerhouse	10/31/2023	470	503	8	1.6%
Hills Creek Dam Powerhouse	11/15/2023	660	500	46	9.2%
Hills Creek Dam Powerhouse	1/23/2024	910	505	8	1.6%
Hills Creek Dam Powerhouse	2/22/2024	420	1,473	31	2.1%
Hills Creek Dam Powerhouse	3/13/2024	450	1,494	11	0.7%
Hills Creek Dam Powerhouse	4/11/2024	830	3,996	74	1.9%
Hills Creek Dam Powerhouse	6/4/2024	200	1,250	51	4.1%
Hills Creek Dam Powerhouse	1/6/2022	810	596	20	3.4%
Hills Creek Dam Powerhouse	2/16/2022	410	600	12	2.0%
Hills Creek Dam Powerhouse	2/25/2022	410	604	6	1.0%
Hills Creek Dam Powerhouse	12/7/2022	890	514	29	5.6%
Hills Creek Dam Powerhouse	2/25/2023	910	519	15	2.9%
Hills Creek Dam Powerhouse	4/26/2023	540	506	62	12.3%
Hills Creek Dam Powerhouse	5/17/2023	440	505	57	11.3%
Hills Creek Dam Powerhouse	6/3/2023	710	508	36	7.1%
Hills Creek Dam Powerhouse	6/27/2023	720	507	22	4.3%
Hills Creek Dam Powerhouse – RO Trial	9/27/2023	400	510	1	0.2%
Hills Creek Dam Powerhouse – RO Trial	10/17/2023	460	509	0	0.0%
Hills Creek Dam Powerhouse – RO Trial	10/31/2023	470	503	2	0.4%
Hills Creek Dam Powerhouse – RO Trial	11/15/2023	660	500	1	0.2%

Release Location	Date of Release	Flow at Release	# of Fish Released	# of Fish Recaptured	% Efficiency
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	0.0%
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%
Hills Creek Dam Powerhouse – RO Trial	2/25/2023	910	519	0	0.0%
Hills Creek Dam Powerhouse – RO Trial	4/26/2023	540	506	12	2.4%
Hills Creek Dam Powerhouse – RO Trial	5/17/2023	440	505	2	0.4%
Hills Creek Dam Powerhouse – RO Trial	6/3/2023	710	508	2	0.4%
Hills Creek Dam Powerhouse – RO Trial	6/27/2023	720	507	0	0.0%
Hills Creek Dam Powerhouse – RO Trial	5/17/2023	440	505	2	0.4%
Hills Creek Dam Powerhouse – RO Trial	9/27/2023	400	510	1	0.2%
Hills Creek Dam Powerhouse – RO Trial	10/17/2023	460	509	0	0.0%
Hills Creek Dam Powerhouse – RO Trial	10/31/2023	470	503	2	0.4%
Hills Creek Dam Regulating Outlet	11/21/2023	2420	503	3	0.6%
Hills Creek Dam Regulating Outlet	11/29/2023	2130	504	2	0.4%
Hills Creek Dam Regulating Outlet	12/26/2023	750	505	10	2.0%
Hills Creek Dam Regulating Outlet	1/4/2024	100	503	5	1.0%
Hills Creek Dam Regulating Outlet	1/6/2022	820	605	13	2.1%
Hills Creek Dam Regulating Outlet	2/16/2022	410	593	19	3.2%
Hills Creek Dam Regulating Outlet	2/25/2022	420	625	6	1.0%
Hills Creek Dam Regulating Outlet	12/13/2022	610	516	1	0.2%
Hills Creek Dam Regulating Outlet	2/25/2023	920	478	0	0.0%
Hills Creek Dam Regulating Outlet	6/13/2023	760	760	0	0.0%
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	4,100	1,004	125	12.5%
Lookout Point Head of Reservoir	7/20/2022	1,110	1,005	9	0.9%
Lookout Point Head of Reservoir	10/27/2022	1,680	506	9	1.8%
Lookout Point Head of Reservoir	11/17/2022	1,520	510	0	0.0%
Lookout Point Head of Reservoir	12/12/2022	1,510	510	0	0.0%
Lookout Point Head of Reservoir	1/13/2023	2,940	516	10	1.9%
Lookout Point Head of Reservoir	6/2/2023	2,605	760	15	2.0%
Lookout Point Head of Reservoir	6/15/2023	1,610	765	6	0.8%
Lookout Point Head of Reservoir	6/29/2023	1,340	769	2	0.3%
Lookout Point Head of Reservoir	7/19/2023	1,180	765	0	0.0%
Lookout Point Head of Reservoir	8/22/2023	1,470	677	13	1.9%
Lookout Point Head of Reservoir	8/31/2023	1,660	751	0	0.0%
Lookout Point Head of Reservoir	9/20/2023	776	787	1	0.1%
Lookout Point Head of Reservoir	10/26/2023	1,190	755	0	0.0%
Lookout Point Head of Reservoir	11/15/2023	1,630	755	3	0.4%
Lookout Point Head of Reservoir	11/29/2023	3,020	760	2	0.3%
Lookout Point Head of Reservoir	12/19/2023	5,680	1,504	9	0.6%
Lookout Point Head of Reservoir	1/3/2024	2,010	1,505	2	0.1%
Lookout Point Head of Reservoir	2/14/2024	2,120	761	2	0.3%
Lookout Point Head of Reservoir	3/13/2024	3,170	1,498	15	1.0%
Lookout Point Head of Reservoir	4/8/2024	2,670	1,997	7	0.4%
Lookout Point Head of Reservoir	4/15/2024	4,130	2,002	20	1.0%
Lookout Point Head of Reservoir	5/1/2024	4,620	751	35	4.7%

Release Location	Date of Release	Flow at Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Lookout Point Head of Reservoir	5/23/2024	2,440	751	14	1.9%
Lookout Point Head of Reservoir	6/19/2024	1,300	756	0	0%
Lookout Dam Powerhouse	4/13/2022	2,925	998	0	0.0%
Lookout Dam Powerhouse	5/23/2023	2,920	3,999	32	0.8%
Lookout Dam Powerhouse	6/1/2023	2,950	4,011	6	0.1%
Lookout Dam Powerhouse	6/14/2023	3,130	4,010	4	0.1%
Lookout Dam Powerhouse	6/28/2023	3,160	4,010	3	0.1%
Lookout Dam Powerhouse	7/18/2023	2,700	4,012	9	0.2%
Lookout Dam Powerhouse	12/20/2023	4,910	16,007	29	0.2%
Lookout Dam Powerhouse	1/10/2024	6,986	17,553	3	0.02%
Lookout Dam Spillway	9/13/2023	1,850	3,636	0	0.0%
Lookout Dam Spillway	9/14/2003	1,850	3,998	0	0.0%
Lookout Dam Spillway	10/25/2023	1,730	4,042	0	0.0%
Lookout Dam Spillway	11/16/2023	1,600	4,005	12	0.3%
Lookout Dam Spillway	12/6/2023	2,100	8,007	18	0.2%
Lookout Dam Spillway	12/13/2023	6,000	8,011	148	1.8%
Lookout Dam Spillway	3/27/2024	3,600	7,800	11	0.1%
Lookout Dam Spillway	4/3/2024	3,100	6,599	7	0.1%
Dexter Dam Powerhouse	7/21/2022	1,560	976	2	0.2%
Dexter Dam Powerhouse	10/26/2022	2,950	1007	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	1010	10	1.0%
Dexter Dam Powerhouse	12/15/2022	1,540	1025	1	0.1%
Dexter Dam Powerhouse	3/16/2023	1,550	1,200	2	0.2%
Dexter Dam Powerhouse	5/25/2023	3,030	4,003	14	0.3%
Dexter Dam Powerhouse	6/7/2023	3,200	4,010	4	0.1%
Dexter Dam Powerhouse	6/21/2023	2,720	4,028	15	0.4%
Dexter Dam Powerhouse	7/6/2023	2,640	4,000	5	0.1%
Dexter Dam Powerhouse	8/2/2023	2,240	1,505	3	0.2%
Dexter Dam Powerhouse	8/23/2023	1,710	4,012	14	0.3%
Dexter Dam Powerhouse	9/6/2023	1,800	4,037	13	0.3%
Dexter Dam Powerhouse	10/4/2023	1,720	4,001	5	0.1%
Dexter Dam Powerhouse	1/9/2024	3,360	4,004	6	0.1%
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	1018	67	6.6%
Dexter Dam Spillway	3/29/2023	1,280	1,199	5	0.4%
Dexter Dam Spillway	10/24/2023	1,590	1,514	18	1.2%
Dexter Dam Spillway	11/1/2023	1,450	1,506	9	0.6%
Dexter Dam Spillway	11/22/2023	3,480	1,516	0	0.0%
Dexter Dam Spillway	12/5/2023	2,050	4,006	10	0.2%
Dexter Dam Spillway	12/12/2023	4,050	4,001	13	0.3%
Dexter Dam Spillway	12/21/2023	4,850	4,005	3	0.1%
Dexter Dam Spillway	2/8/2024	8,500	2,067	0	0.0%
Dexter Dam Spillway	2/28/2024	1,200	1,959	11	0.6%
Dexter Dam Spillway	3/6/2024	1,250	2,000	4	0.2%
Dexter Dam Spillway	4/2/2024	3,370	1,962	0	0.0%

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Appendix F – Images of Injuries

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Appendix F: Example of Injury Photos

Figures

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Figure F-1. Live fish with no external injuries (NXI)

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

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

Figure F-4. Bleeding from Vent (BVT)

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

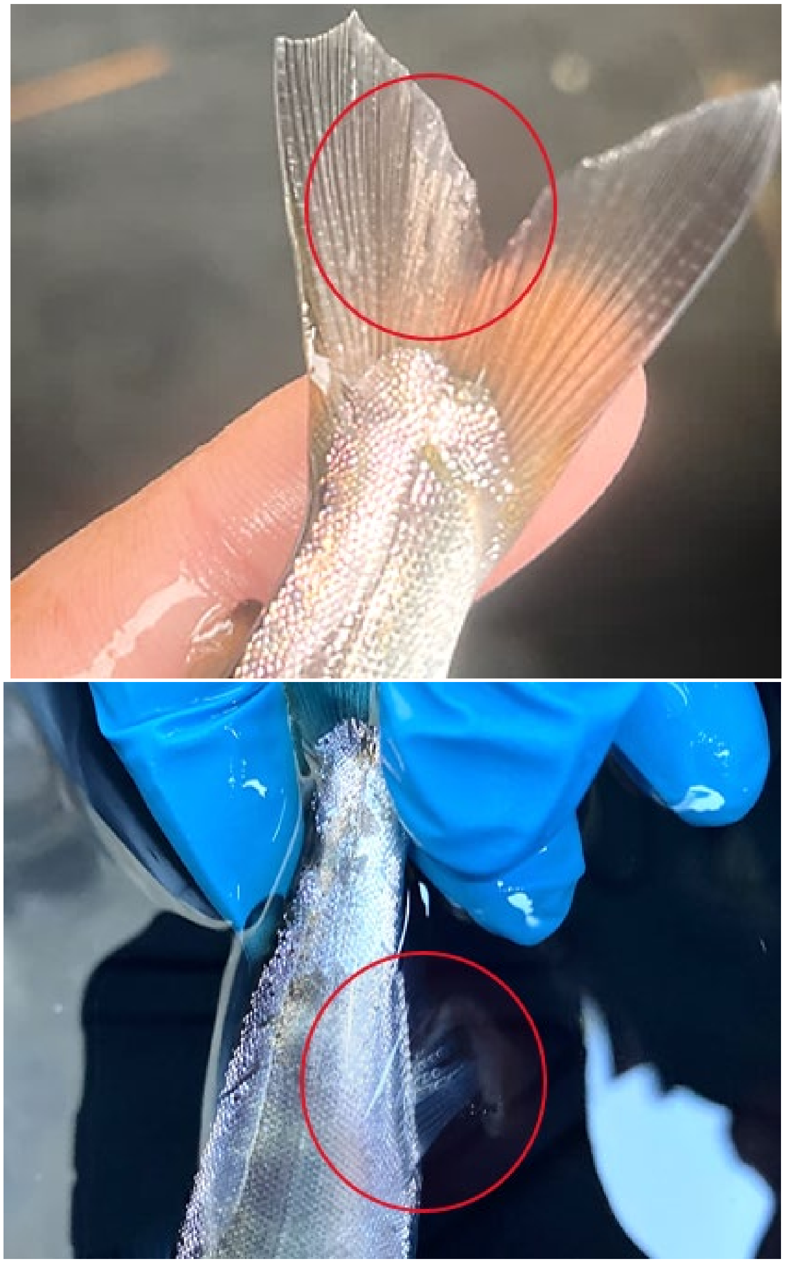

Figure F-6. Gas Bubble Disease (fin ray/eye inclusions) (GBD)

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

Figure F-8. Head Injury (HIN)

Figure F-9. Operculum Damage (OPD)

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

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

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

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

Figure F-14. Head Only (HO)

Figure F-15. Body Only (BO)

Figure F-16. Head Barely Connected (HBO)

Figure F-17. Fin Damage (FID)

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

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

Figure F-20. Fungus (FUN)

Appendix G –
Images of Non-Target Species

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Appendix G: Images of Non-Target Species

Figures

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Figure G-1. Bluegill

Figure G-2. Juvenile Lamprey (Many juvenile lamprey cannot accurately be identified to species in the field)

Figure G-3. Brown Bullhead

Figure G-4. Bull Trout

Figure G-5. Crappie

Figure G-6. Cutthroat Trout

Figure G-7. Longnose Dace

Figure G-8. Kokanee

Figure G-9. Sculpin

Figure G-10. Smallmouth Bass

Figure G-11. Spotted Bass

Figure G-12. Walleye

Figure G-13. Western Mosquitofish

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Appendix H –
Images of Traps Sampling in Various Conditions

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Appendix H: Images of Traps Sampling in Various Conditions

Figures and Tables

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

Figure H-2. RST sampling at the Breitenbush River site in low flow.

Figure H-3. RST sampling at the Detroit Head of Reservoir site in medium flow.

Figure H-4. RST sampling at the Big Cliff Dam at low flow (left) and high flow (right).

Figure H-5. RST sampling at the Green Peter Head of Reservoir – Middle Santiam site in low flow.

Figure H-6. Green Peter Dam Tailrace – Middle Santiam River at low flow, not sampling, (left) and high flow (right).

Figure H-7. Foster Dam Head of Reservoir – South Santiam River at low (left), medium (middle), and high, not sampling (right) flow.

Figure H-8. Cougar Dam Head of Reservoir not sampling at high flow.

Figure H-9. Cougar Dam – Regulating Outlet at medium (left) and high (right) flow.

Figure H-10. Cougar Dam – Powerhouse Channel when not sampling (above) and when sampling with high debris (right).

Figure H-11. Fall Creek Head of Reservoir at low (left), medium (middle), and high not sampling (right) flow.

Figure H-12. Fall Creek Dam Tailrace at low (left) and high (right) flow.

Figure H-13. RST sampling at the Hills Creek Head of Reservoir – Middle Fork Willamette River site in medium flow.

Figure H-14. Hills Creek Dam – Regulating Outlet sampling at high (top) and medium (bottom) flow.

Figure H-15. Hills Creek Dam – Powerhouse Channel sampling at low flow.

Figure H-16. Lookout Point Head of Reservoir sampling at medium (top) and high (bottom) flow.

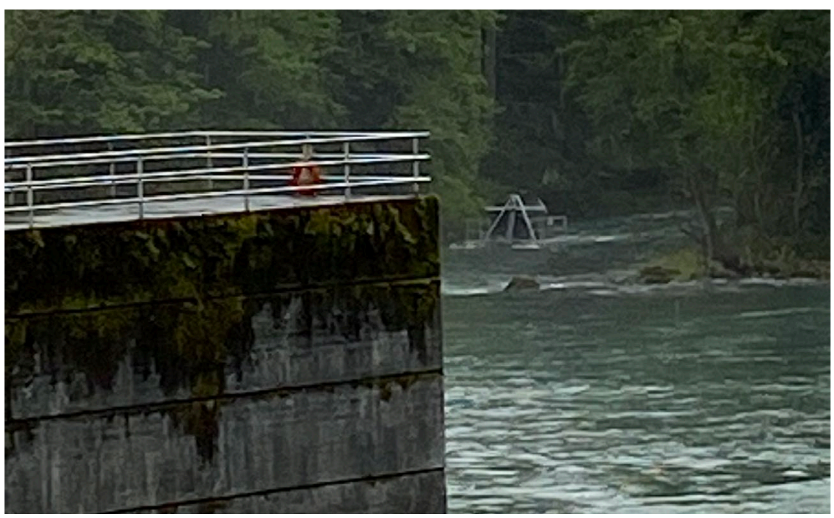

Figure H-17. Lookout Dam Tailrace – Spillway.

Figure H-18. Lookout Dam Tailrace – Powerhouse Channel in the old orientation where one trap was staggered behind the other (top) and in the new orientation side by side (bottom).

Figure H-19. Dexter Dam Tailrace at the old location (top) and the new location (bottom).

Table H-1. RST sampling constraints by flow/river level and other considerations at sampling sites.

RST Sampling Site	Flow Level Necessitating RST to be Raise to Non-sampling Position	Other Factors Observed That Result in Sampling Outages
Breitenbush River	Unknown at this time.	Rapid increase in flow results in large amounts of debris causing damage to the RST and captured fish. These increases require the RST to be raised and secured.
Big Cliff Dam Tailrace	Flows exceeding 5,000 cfs	Debris passage events require the trap to be raised and secured.
Detroit Head of Reservoir- North Santiam River	Unknown at this time.	Rapid increase in flow results in large amounts of debris causing damage to the RST and captured fish. These increases require the RST to be raised and secured.
Green Peter Dam Tailrace	Flows exceeding 4,000 cfs	Surface spill has resulted in significant amounts of woody debris stopping the RST and creating hazardous conditions for captured fish.
Cougar Dam Tailrace RO	Flows exceeding 4,000 cfs	Adjustments need to be made for flow changes above 2,500 cfs in order for sampling above that level to occur.
Fall Creek Dam	Flows exceeding 3,500 cfs	Sediment and woody debris have resulted in conditions that the RST cannot sample in. These conditions typically occur during drawdown.
Dexter Dam	Unknown at this time.	Trap is sampling in a new location and other factors impacting sampling are still to be determined.
Lookout Dam	Flows exceeding 10,000 cfs	High debris loads can impact RST sampling. This usually occurs with surface spill.
Lookout Point Head of Reservoir	Flows exceeding 5,000 cfs	High debris loads can impact RST sampling and damage captured fish.
Hills Creek Dam Tailrace RO	Flows exceeding 3,000 cfs	N/A
Hills Creek Dam Tailrace PH	Unknown at this time.	High debris loads have been observed but have not been severe enough to impede sampling to date.
Hills Creek Head of Reservoir- Middle Fork Willamette	Unknown at this time.	Rapid increase in flow results in large amounts of debris causing damage to the RST and captured fish. These increases require the RST to be raised and secured.

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Appendix I – Adult Chinook Out planting Above Willamette Valley Projects 2010 to 2023 and Multi-year Figures and Length Tables of Weekly Chinook Capture for Sites Sampling During the 2021 to 2024 Seasons

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Appendix I: Adult Chinook Out planting Above Willamette Valley Projects 2010 to 2023 and Multi-year Figures and Length Tables of Weekly Chinook Capture for Sites Sampling During the 2021 to 2024 Seasons

Figures and Tables

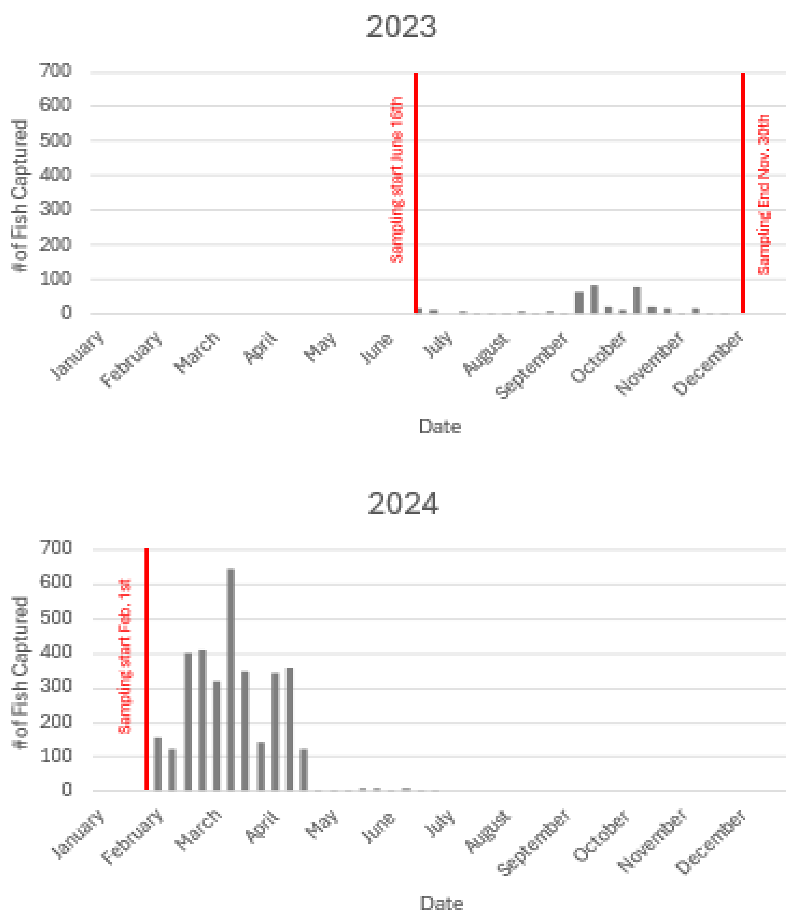
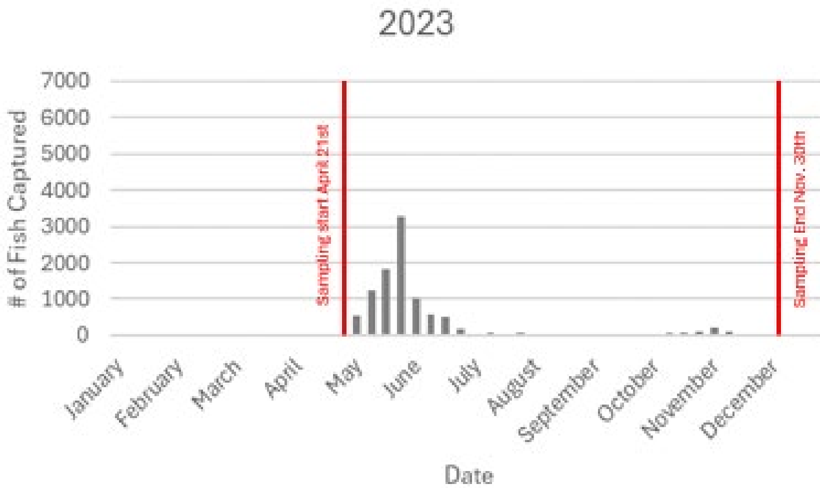


Figure I-1. Weekly Chinook capture at the Breitenbush River RST for 2023 and 2024 sampling.



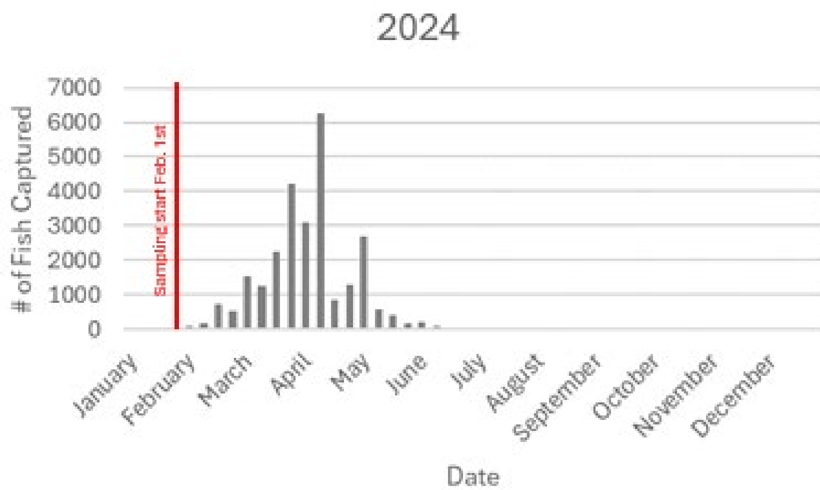


Figure I-2. Weekly Chinook capture at the Detroit Head of Reservoir- North Santiam RST for 2023 and 2024 sampling.

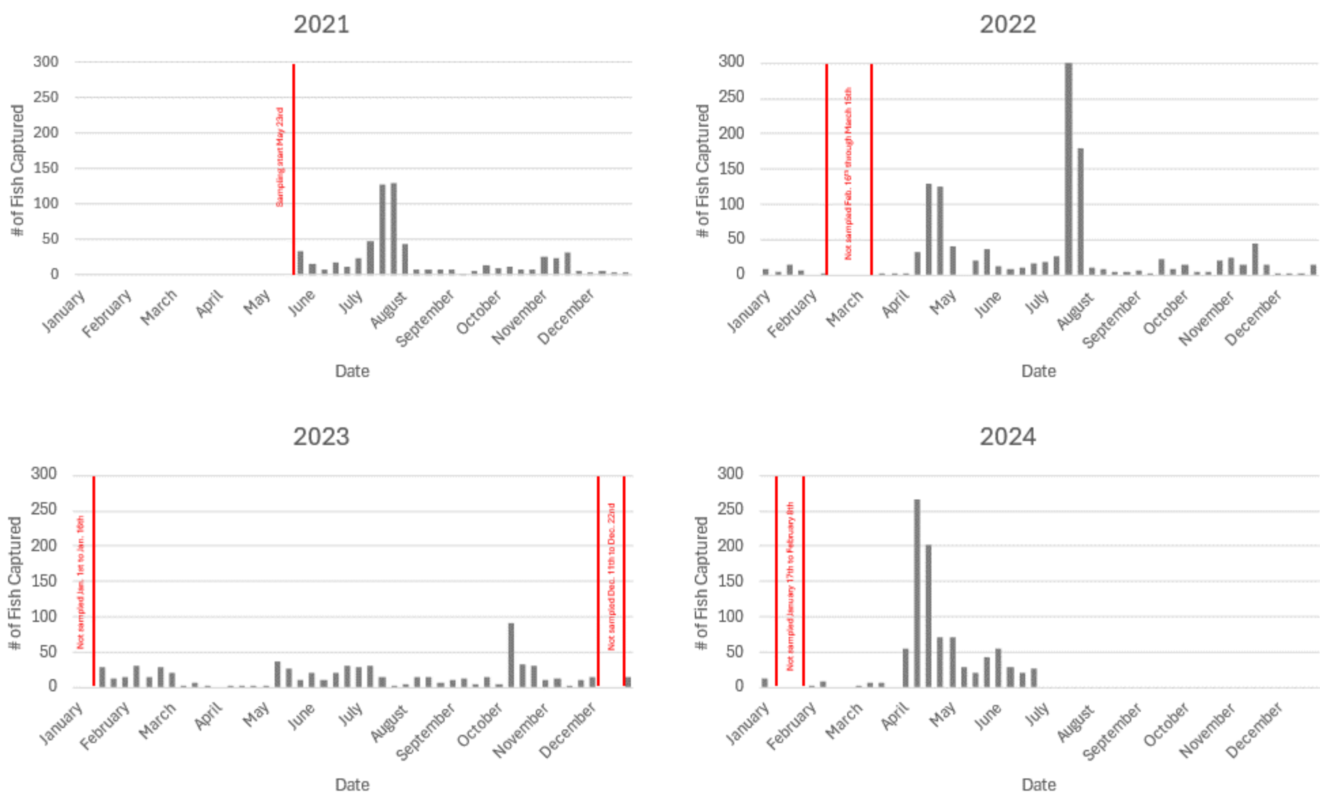


Figure I-3. Weekly Chinook capture at the Big Cliff Dam RST for 2021 through 2024 sampling.

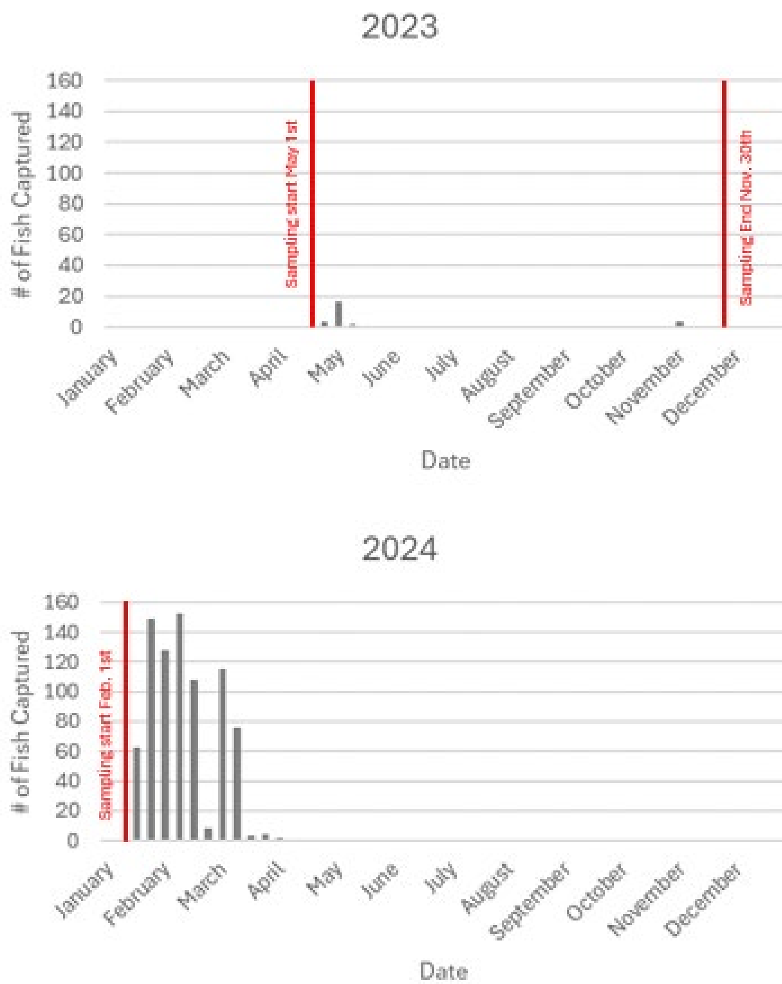
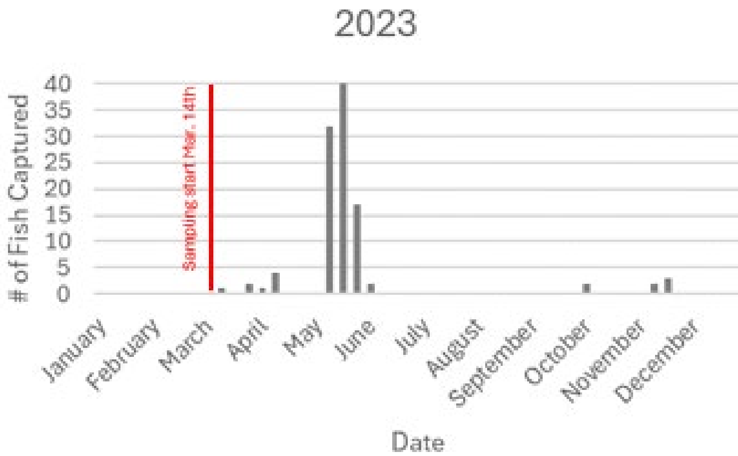


Figure I-4. Weekly Chinook capture at the Green Peter Head of Reservoir RST for 2023 and 2024 sampling.



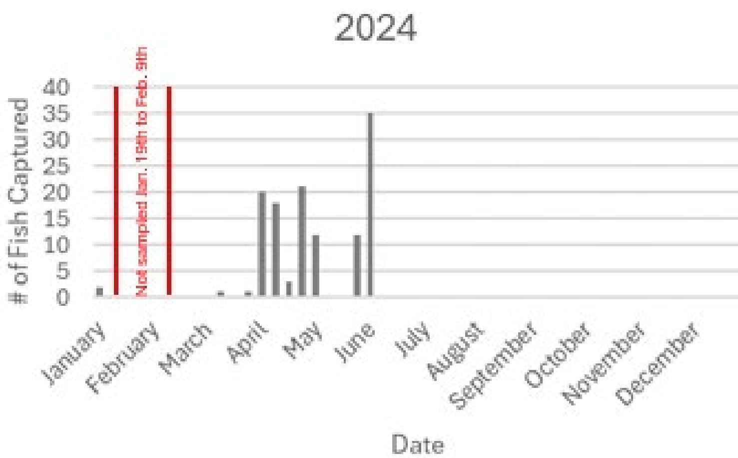


Figure I-5. Weekly Chinook capture at the Green Peter Dam Tailrace RST for 2023 and 2024 sampling.

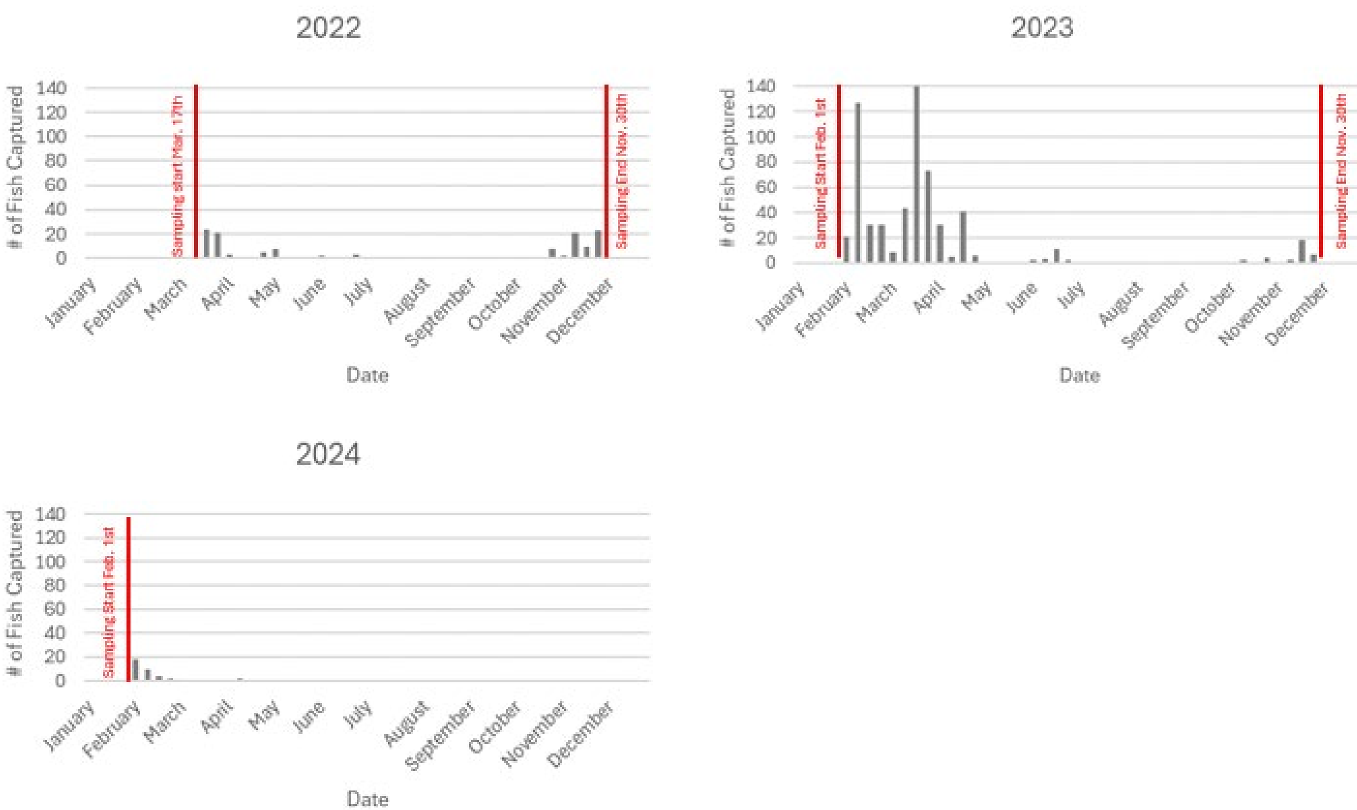


Figure I-6. Weekly Chinook capture at the Foster Head of Reservoir- South Santiam RST for 2022 through 2024 sampling.

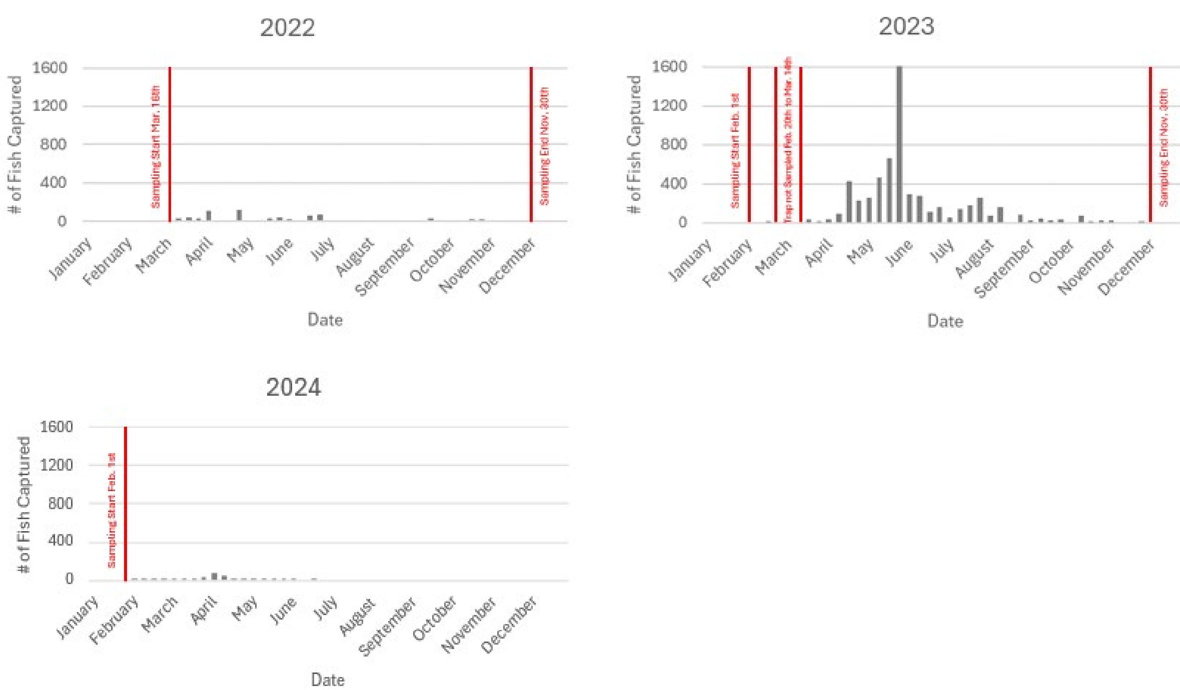


Figure I-7. Weekly Chinook capture at the Cougar Head of Reservoir RST for 2022 through 2024 sampling.

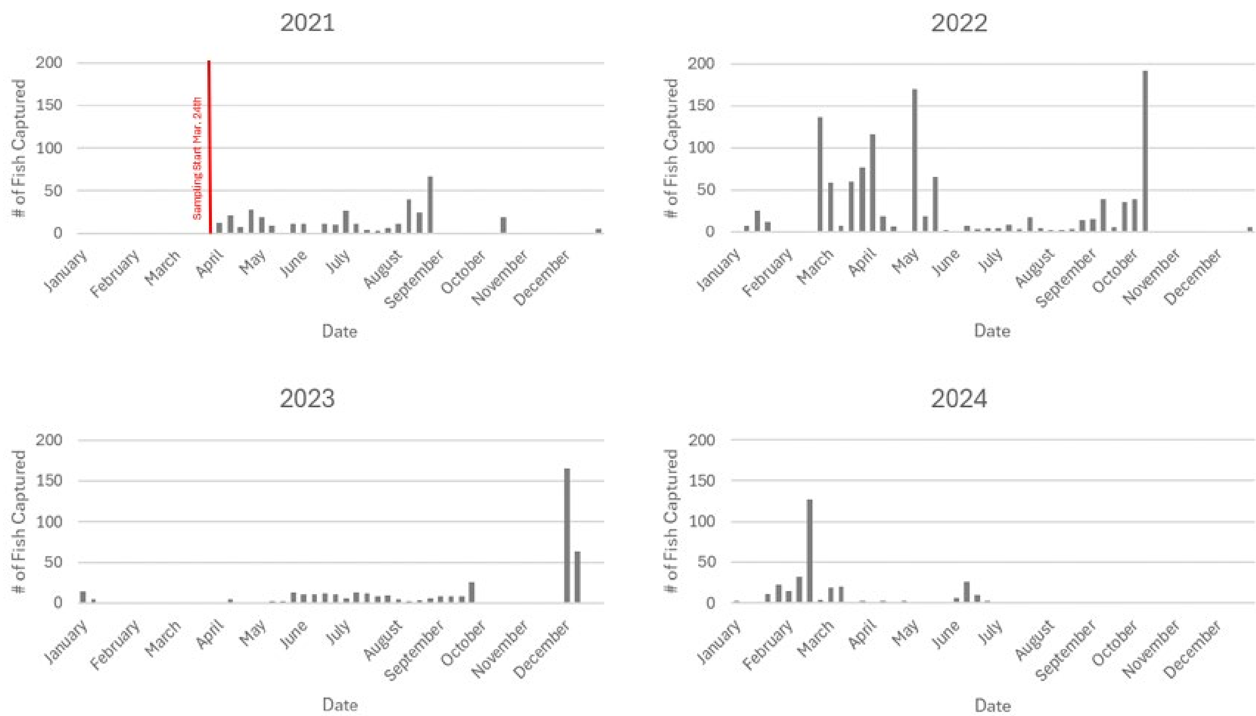


Figure I-8. Weekly Chinook capture at the Cougar Dam PH RSTs for 2021 through 2023 sampling.

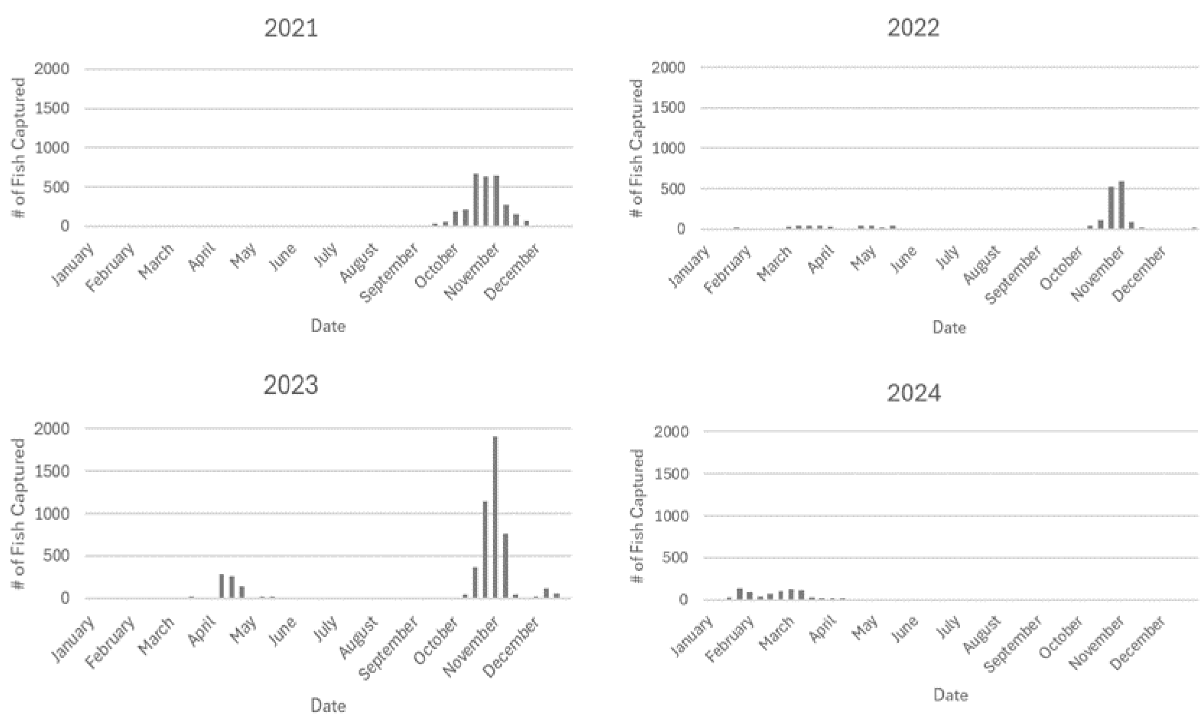


Figure I-9. Weekly Chinook capture at the Cougar Dam RO RST for 2021 through 2023 sampling.

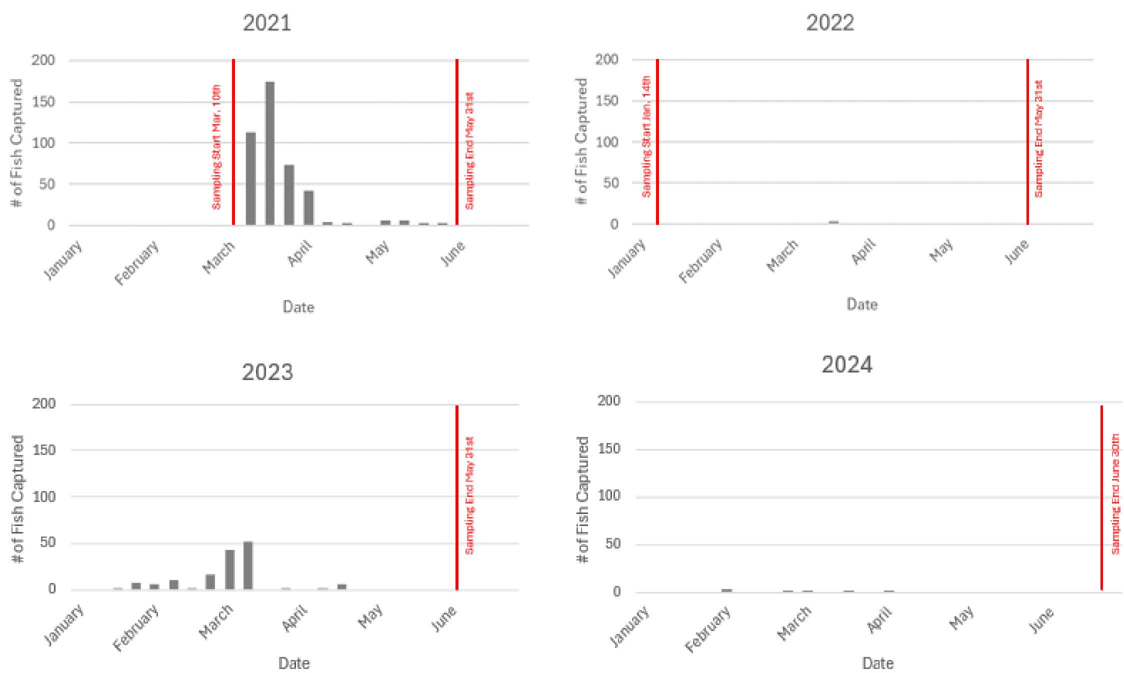


Figure I-10. Weekly Chinook catch at the Fall Creek Head of Reservoir RST for 2021 through 2024 sampling.

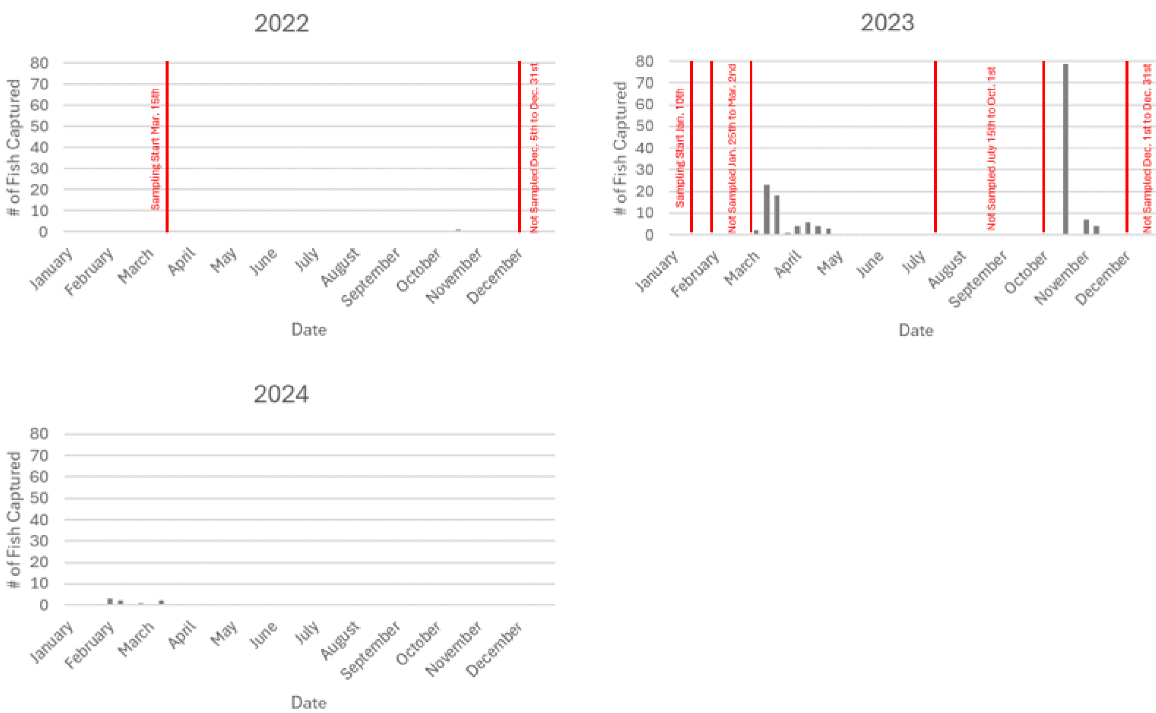


Figure I-11. Weekly Chinook capture at the Fall Creek Dam RST for 2022 through 2024 sampling.

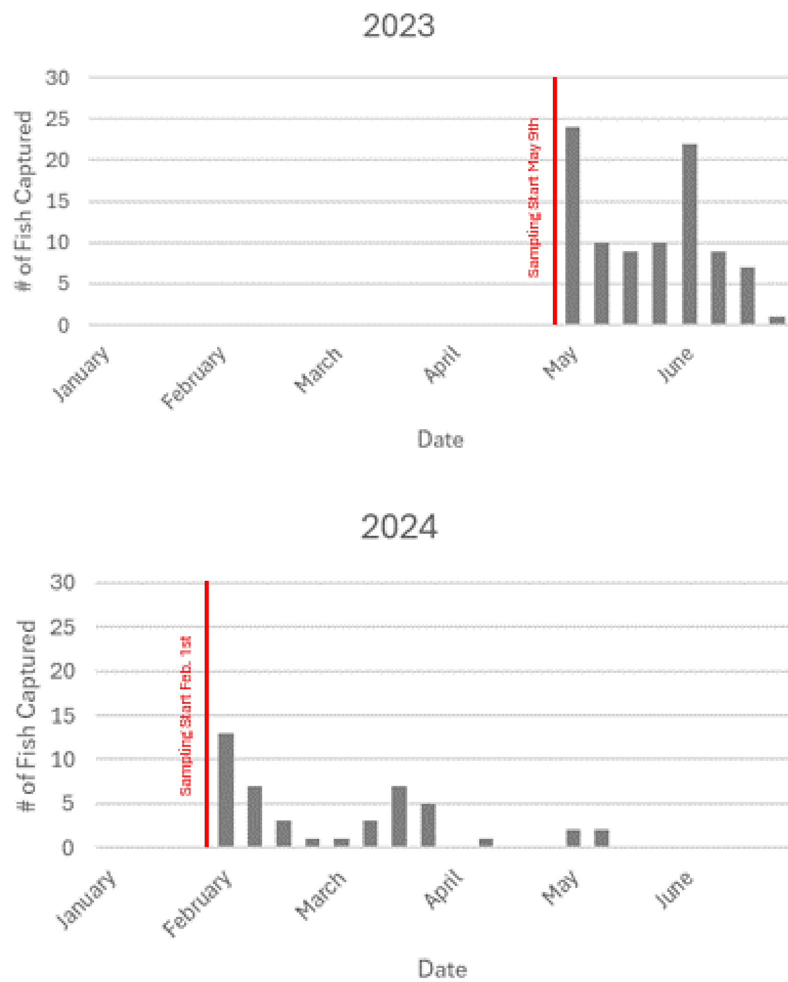


Figure I-12. Weekly Chinook capture at the Hills Creek Head of Reservoir- Middle Fork Willamette RST for 2023 and 2024 sampling.

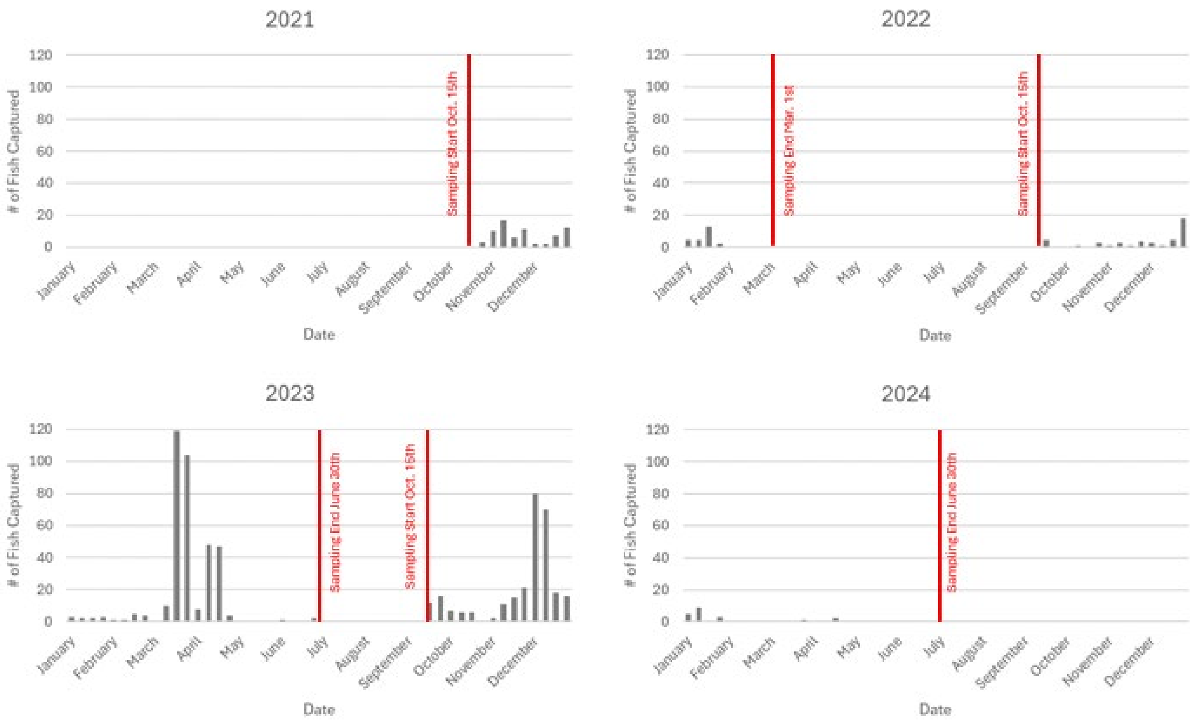


Figure I-13. Weekly Chinook capture at the Hills Creek Dam RSTs for 2021 through 2024 sampling.

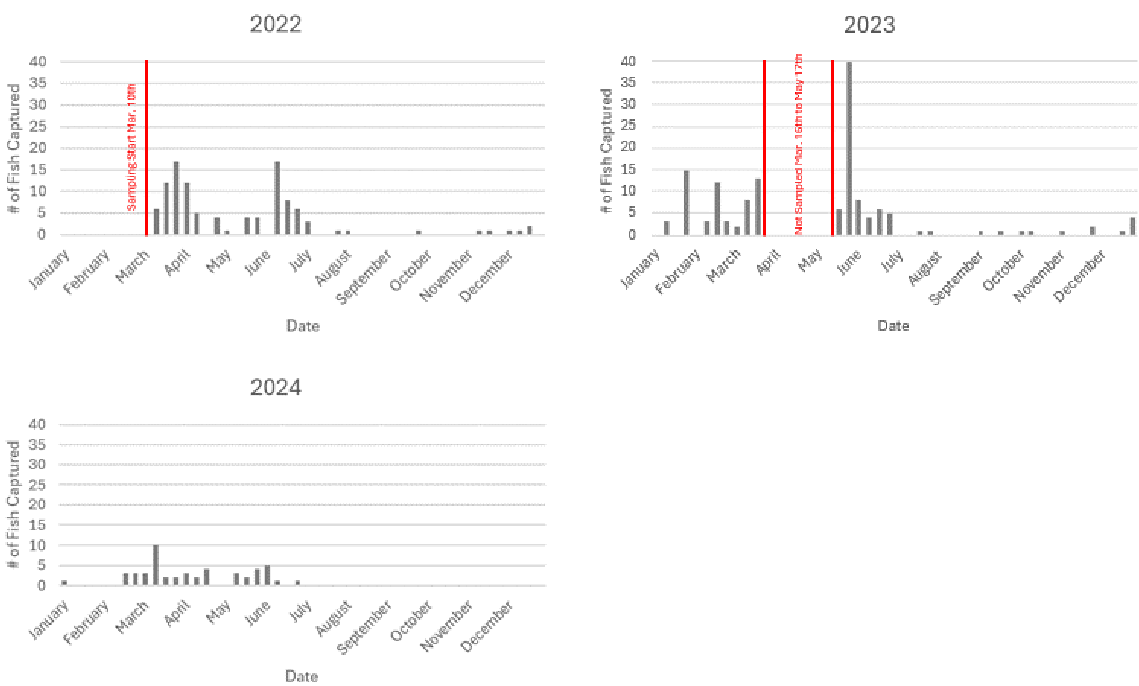


Figure I-14. Weekly Chinook capture at the Lookout Point Head of Reservoir RST for 2022 through 2024 sampling.

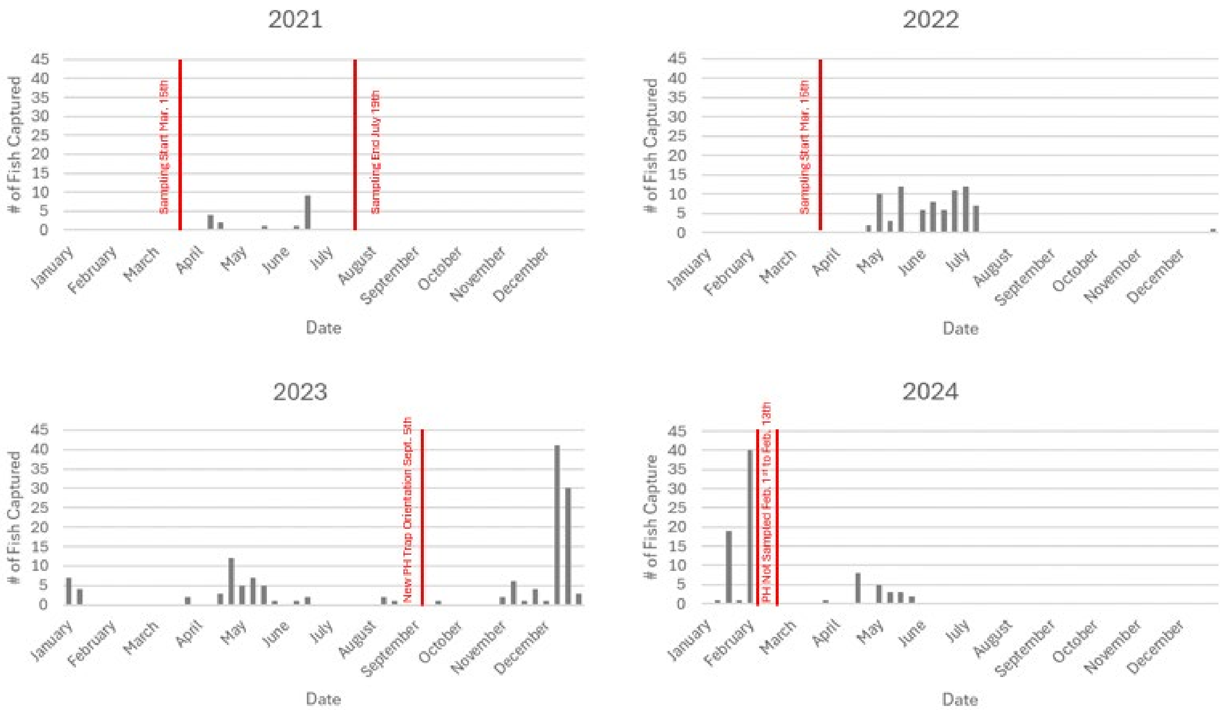


Figure I-15. Weekly Chinook capture at the Lookout Dam Tailrace RSTs for 2021 through 2024 sampling.

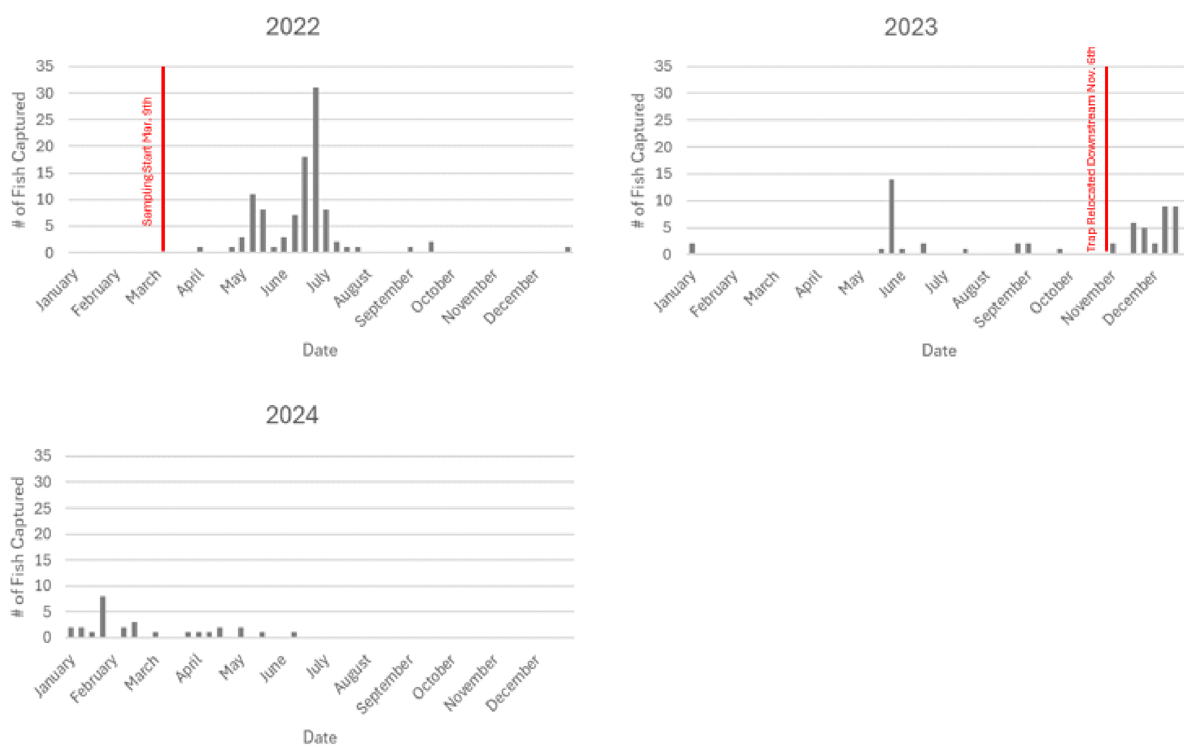


Figure I-16. Weekly Chinook capture at the Dexter Dam Tailrace RST for 2022 through 2024 sampling.

Table I-1. Adult Chinook Out planting Above Willamette Valley Projects 2010 to 2023.

Sub-Basin	Location	Year	Total Females Out planted	Total Males Out planted	Total Chinook Outplants
North Santiam	Above Detroit Reservoir	2010	1143	1341	2484
North Santiam	Above Detroit Reservoir	2011	63	85	148
North Santiam	Above Detroit Reservoir	2012	121	132	253
North Santiam	Above Detroit Reservoir	2013	524	579	1103
North Santiam	Above Detroit Reservoir	2014	299	573	872
North Santiam	Above Detroit Reservoir	2015	689	829	1518
North Santiam	Above Detroit Reservoir	2016	804	434	1238
North Santiam	Above Detroit Reservoir	2017	732	883	1615
North Santiam	North Santiam Above Detroit Reservoir	2018	392	387	779
North Santiam	Breitenbush River Above Detroit Reservoir	2018	104	121	225
North Santiam	North Santiam Above Detroit Reservoir	2019	315	350	665
North Santiam	Breitenbush River Above Detroit Reservoir	2019	143	222	365
North Santiam	North Santiam Above Detroit Reservoir	2020	798	1085	1883
North Santiam	Breitenbush River Above Detroit Reservoir	2020	341	350	691
North Santiam	North Santiam Above Detroit Reservoir	2021	288	466	754
North Santiam	Breitenbush River Above Detroit Reservoir	2021	127	433	560
North Santiam	North Santiam Above Detroit Reservoir	2022	1417	1543	2960
North Santiam	Breitenbush River Above Detroit Reservoir	2022	540	508	1048
North Santiam	North Santiam Above Detroit Reservoir	2023	720	708	1428
North Santiam	Breitenbush River Above Detroit Reservoir	2023	300	296	596
South Santiam	South Santiam above Foster Reservoir	2010	232	488	720
South Santiam	South Santiam above Foster Reservoir	2011	597	618	1215
South Santiam	South Santiam above Foster Reservoir	2012	417	545	962
South Santiam	South Santiam above Foster Reservoir	2013	428	476	904
South Santiam	South Santiam above Foster Reservoir	2014	195	185	380
South Santiam	South Santiam above Foster Reservoir	2015	270	347	617
South Santiam	South Santiam above Foster Reservoir	2016	109	168	277
South Santiam	South Santiam above Foster Reservoir	2017	109	146	255
South Santiam	South Santiam above Foster Reservoir	2018	25	62	87
South Santiam	South Santiam above Foster Reservoir	2019	58	78	136
South Santiam	South Santiam above Foster Reservoir	2020	142	211	353
South Santiam	South Santiam above Foster Reservoir	2021	64	115	179

Sub-Basin	Location	Year	Total Females Out planted	Total Males Out planted	Total Chinook Outplants
South Santiam	South Santiam above Foster Reservoir	2022	68	150	218
South Santiam	South Santiam above Foster Reservoir	2023	116	164	280
South Santiam	Above Green Peter Reservoir-Middle Santiam River	2022	300	300	600
South Santiam	Above Green Peter Reservoir-Quartzville Creek	2022	100	100	200
South Santiam	Above Green Peter Reservoir-Middle Santiam River	2023	300	300	600
South Santiam	Above Green Peter Reservoir-Quartzville Creek	2023	100	100	200
McKenzie	South Fork McKenzie above Cougar Reservoir	2010	318	444	762
McKenzie	South Fork McKenzie above Cougar Reservoir	2011	339	391	730
McKenzie	South Fork McKenzie above Cougar Reservoir	2012	447	504	951
McKenzie	South Fork McKenzie above Cougar Reservoir	2013	338	294	632
McKenzie	South Fork McKenzie above Cougar Reservoir	2014	462	235	697
McKenzie	South Fork McKenzie above Cougar Reservoir	2015	456	301	757
McKenzie	South Fork McKenzie above Cougar Reservoir	2016	410	309	719
McKenzie	South Fork McKenzie above Cougar Reservoir	2017	376	235	611
McKenzie	South Fork McKenzie above Cougar Reservoir	2018	404	211	615
McKenzie	South Fork McKenzie above Cougar Reservoir	2019	261	198	459
McKenzie	South Fork McKenzie above Cougar Reservoir	2020	202	204	406
McKenzie	South Fork McKenzie above Cougar Reservoir	2021	121	249	370
McKenzie	South Fork McKenzie above Cougar Reservoir	2022	384	680	1064
McKenzie	South Fork McKenzie above Cougar Reservoir	2023	27	65	92
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2010	Unknown	Unknown	1422
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2011	Unknown	Unknown	1741
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2012	Unknown	Unknown	2520
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2013	Unknown	Unknown	1966
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2014	Unknown	Unknown	1065
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2015	Unknown	Unknown	1086

Sub-Basin	Location	Year	Total Females Out planted	Total Males Out planted	Total Chinook Outplants
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2016	Unknown	Unknown	687
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2017	Unknown	Unknown	741
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2018	137	245	382
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2019	358	422	780
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2020	371	519	890
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2021	193	283	476
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2022	386	426	812
Middle Fork	North Fork Middle Fork Willamette above Lookout Point Reservoir	2023	21	50	71
Middle Fork	Middle Fork Willamette above Hills Creek Reservoir	2018	110	225	335
Middle Fork	Middle Fork Willamette above Hills Creek Reservoir	2019	142	159	301
Middle Fork	Middle Fork Willamette above Hills Creek Reservoir	2020	252	275	527
Middle Fork	Middle Fork Willamette above Hills Creek Reservoir	2021	0	0	0
Middle Fork	Middle Fork Willamette above Hills Creek Reservoir	2022	198	264	462
Middle Fork	Middle Fork Willamette above Hills Creek Reservoir	2023	0	0	0
Fall Creek	Fall Creek above Fall Creek Reservoir	2013	Unknown	Unknown	467
Fall Creek	Fall Creek above Fall Creek Reservoir	2014	Unknown	Unknown	456
Fall Creek	Fall Creek above Fall Creek Reservoir	2015	Unknown	Unknown	259
Fall Creek	Fall Creek above Fall Creek Reservoir	2016	Unknown	Unknown	425
Fall Creek	Fall Creek above Fall Creek Reservoir	2017	Unknown	Unknown	294
Fall Creek	Fall Creek above Fall Creek Reservoir	2018	Unknown	Unknown	94
Fall Creek	Fall Creek above Fall Creek Reservoir	2019	58	191	249
Fall Creek	Fall Creek above Fall Creek Reservoir	2020	310	524	834
Fall Creek	Fall Creek above Fall Creek Reservoir	2021	41	55	96
Fall Creek	Fall Creek above Fall Creek Reservoir	2022	58	81	139
Fall Creek	Fall Creek above Fall Creek Reservoir	2023	56	63	119

Table I-2. Length tables of Chinook salmon captured at the Breitenbush RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	2/1/23–6/30/23	22	30	55.5	44	68	55
Chinook	7/1/23–11/30/23	22	347	89.7	51	114	91
Chinook	2/1/24–6/30/24	23	3,079	36.4	29	69	36
Chinook	2/1/24–6/30/24	22	29	96.7	81	147	95

Table I-3. Length tables of *O. mykiss* captured at the Breitenbush RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
O. mykiss	2/1/23–6/30/23	23	2	51.5	27	76	N/A
O. mykiss	2/1/23–6/30/23	22	2	113.5	107	120	N/A
O. mykiss	7/1/23–11/30/23	21	2	169.0	139	192	N/A
O. mykiss	7/1/23–11/30/23	22	8	125.1	85	151	132
O. mykiss	7/1/23–11/30/23	23	347	31.1	21	165	27
O. mykiss	2/1/24–6/30/24	24	8	28.9	26	31	29
O. mykiss	2/1/24–6/30/24	23	48	101.3	33	193	90
O. mykiss	2/1/24–6/30/24	22	1	270.0	270	270	N/A

Table I-4. Length tables of Chinook salmon captured at the Detroit Head of Reservoir RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	1/1/23-6/30/23	21	1	61.0	61	61	N/A
Chinook	1/1/23-6/30/23	22	9,125	35.6	28	70	35
Chinook	7/1/23-11/30/23	22	1,015	76.0	33	117	79
Chinook	2/1/24–6/30/24	22	49	86.6	69	107	86
Chinook	2/1/24–6/30/24	23	26,808	36.6	28	72	36

Table I-5. Length tables of *O. mykiss* captured at the Detroit Head of Reservoir RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
O. mykiss	1/1/23-6/30/23	19	1	408.0	408	408	N/A
O. mykiss	1/1/23-6/30/23	21	1	188.0	188	188	N/A
O. mykiss	1/1/23-6/30/23	22	7	79.4	49	99	82
O. mykiss	1/1/23-6/30/23	23	484	35.5	25	46	35
O. mykiss	7/1/23-11/30/23	21	2	199.5	169	230	N/A
O. mykiss	7/1/23-11/30/23	22	1	112.0	112	112	N/A
O. mykiss	7/1/23-11/30/23	23	94	35.8	20	90	26
O. mykiss	2/1/24–6/30/24	21	1	315.0	315	315	N/A
O. mykiss	2/1/24–6/30/24	22	12	170.3	142	197	170
O. mykiss	2/1/24–6/30/24	23	40	72.8	34	115	74
O. mykiss	2/1/24–6/30/24	24	10	30.1	22	39	28.5

Table I-6. Length tables of Chinook salmon captured at the Big Cliff Dam RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	12/1/21–6/30/22	20	290	165.2	100	260	160
Chinook	5/1/22–12/31/22	20 and 21	897	137.1	31	283	131
Chinook	1/1/23–6/30/23	20	42	202.8	157	340	195
Chinook	1/1/23–6/30/23	21	125	155.8	72	199	160
Chinook	1/1/23–6/30/23	22	156	51.8	29	130	37
Chinook	7/1/23–12/31/23	20	4	234.8	199	300	220
Chinook	7/1/23–12/31/23	21 and 22	377	137.0	91	191	137
Chinook	1/1/24–6/30/24	21 and 22	895	144.8	80	231	142
Chinook	1/1/23–6/30/23	23	42	98.4	35	121	107

Table I-7. Length tables of *O. mykiss* captured at the Big Cliff Dam RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
O. mykiss	1/1/23–6/30/23	21	3	297.0	274	335	282
O. mykiss	1/1/23–6/30/23	22	27	200.4	155	269	194
O. mykiss	1/1/23–6/30/23	23	47	29.7	25	71	28
O. mykiss	7/1/23–12/31/23	21	1	295.0	295	295	N/A
O. mykiss	7/1/23–12/31/23	22	2	151.0	145	157	N/A
O. mykiss	7/1/23–12/31/23	23	171	31.8	24	120	29
O. mykiss	1/1/24–6/30/24	21	1	275.0	275	275	N/A
O. mykiss	1/1/24–6/30/24	22	39	199.4	154	260	195
O. mykiss	1/1/24–6/30/24	23	8	78.8	34	124	79
O. mykiss	1/1/24–6/30/24	24	26	30.4	25	39	29

Table I-8. Length tables of Chinook salmon captured at the Green Peter Head of Reservoir RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	1/1/23–6/30/23	22	21	36.4	33	45	36
Chinook	7/1/23–11/30/23	22	4	105.5	98	114	105
Chinook	2/1/24–6/30/24	22	5	91.6	81	104	92
Chinook	2/1/24–6/30/24	23	806	36.2	32	70	36

Table I-9. Length tables of *O. mykiss* captured at the Green Peter Head of Reservoir RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
O. mykiss	1/1/23–6/30/23	23	1	36.0	36	36	N/A
O. mykiss	2/1/24–6/30/24	21	1	255.0	255	255	N/A
O. mykiss	2/1/24–6/30/24	22	3	174	139	215	168
O. mykiss	2/1/24–6/30/24	23	18	95.2	75	115	92
O. mykiss	2/1/24–6/30/24	24	2	23.5	20	27	N/A

Table I-10. Length tables of Chinook salmon captured at the Green Peter Dam RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	1/1/23–6/30/23	22	100	66.8	33	98	66
Chinook	7/1/23–12/31/23	22	7	112.1	89	155	103
Chinook	1/1/24–6/30/24	22	51	146.6	98	173	149
Chinook	1/1/24–6/30/24	23	77	105.3	36	141	107

Table I-11. Length tables of *O. mykiss* salmon captured at the Green Peter Dam RST by brood year from 2023-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
O. mykiss	1/1/23–6/30/23	21	5	271.4	240	318	268
O. mykiss	1/1/23–6/30/23	22	5	185.8	174	195	185
O. mykiss	1/1/23–6/30/23	23	1	29.0	29	29	N/A
O. mykiss	7/1/23–12/31/23	22	1	125.0	125	125	N/A
O. mykiss	1/1/24–6/30/24	23	8	188.9	162	225	187.5

Table I-12 Length tables of Chinook salmon captured at the Foster Head of Reservoir RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	5/7/22–6/30/22	20	5	124.4	108	138	127
Chinook	5/7/22–6/30/22	21	61	39.7	31	80	35
Chinook	7/1/22–11/30/22	20 and 21	62	104.5	81	161	142.5
Chinook	2/1/23–6/30/23	21	21	108.6	93	134	109
Chinook	2/1/23–6/30/23	22	555	37.8	30	95	36
Chinook	7/1/23–11/30/23	22	33	105.3	63	123	107
Chinook	2/1/24–6/30/24	22	3	100.7	79	120	103
Chinook	2/1/24–6/30/24	23	36	40.3	35	86	38

Table I-13. . Length tables of *O. mykiss* salmon captured at the Foster Head of Reservoir RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
O. mykiss	5/7/22–6/30/22	22	32	35.5	28	65	35
O. mykiss	5/7/22–6/30/22	21	16	110.5	88	132	111
O. mykiss	5/7/22–6/30/22	20	42	172.3	141	213	170
O. mykiss	7/1/23–11/30/23	22	65	88.2	68	117	85
O. mykiss	7/1/23–11/30/23	21	68	148.1	125	205	145
O. mykiss	2/1/24–6/30/24	22	19	180.1	135	232	186
O. mykiss	2/1/24–6/30/24	23	25	97.3	71	132	98
O. mykiss	2/1/24–6/30/24	24	159	31.1	24	51	30

Table I-14. Length tables of Chinook salmon captured at the Cougar Head of Reservoir RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	3/7/22–6/30/22	20	34	91.6	64	150	76
Chinook	3/7/22–6/30/22	21	542	39	27	77	37
Chinook	7/1/22–11/30/22	21	134	78.6	60	99	78
Chinook	2/1/23- 6/30/23	21	32	88.2	73	106	89
Chinook	2/1/23–6/30/23	22	4,592	36.2	25	64	36
Chinook	7/1/23–11/30/23	21	1	104	104	104	N/A
Chinook	7/1/23–11/30/23	22	1,228	58.4	36	98	56
Chinook	2/1/24–6/30/24	22	28	79.6	51	95	82.5
Chinook	2/1/24–6/30/24	23	226	36.1	31	70	36

Table I-15. Length tables of Chinook salmon captured at the Cougar Dam RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	12/1/21–6/30/22	20	290	165.2	100	260	160
Chinook	1/1/22–6/30/22	21	408	38.4	27	64	37
Chinook	7/1/22–11/30/22	20 and 21	1,802	142.9	53	247	144
Chinook	1/1/23–6/30/23	21	802	144.1	76	196	149
Chinook	1/1/23–6/30/23	22	62	57.3	33	102	54.5
Chinook	7/1/23–11/30/23	20	141	211.0	182	286	209
Chinook	7/1/23–11/30/23	21 and 22	4,695	114.3	47	176	115
Chinook	1/1/24–6/30/24	21 and 22	1,091	116.2	57	207	118
Chinook	1/1/24–6/30/24	23	40	48.5	35	80	39.5

Table I-16. Length tables of Chinook salmon captured at the Fall Creek Head of Reservoir RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	1/11/22–5/31/22	19	1	255.0	255	255	N/A
Chinook	1/11/22–5/31/22	20	6	128.3	119	139	128.5
Chinook	1/1/23–5/31/23	22	148	36.7	31	86	34
Chinook	1/1/24–6/30/24	22	7	121.9	114	134	121

Table I-17. Length tables of Chinook salmon captured at the Fall Creek Dam RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	10/15/22–12/31/22	20	1	230.0	230	230	N/A
Chinook	1/1/23–6/30/23	22	61	36.8	33	60	37
Chinook	7/1/23–12/31/23	21	85	181.0	142	203	185
Chinook	7/1/23–12/31/23	22	4	100	94	106	100
Chinook	1/1/24–6/30/24	22	9	129.6	112	146	130

Table I-18. Length tables of Chinook salmon captured at the Hills Creek Head of Reservoir RST by brood year from 202-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	2/1/23–6/30/23	22	93	43.7	30	76	44
Chinook	2/1/24–6/30/24	22	47	86.7	62	122	89

Table I-19. Length tables of Chinook salmon captured at the Hills Creek Dam RST by brood year from 2021-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	10/15/21–3/1/22	19	68	239.1	201	265	245
Chinook	10/15/21–3/1/22	20	20	118.3	69	159	120.5
Chinook	9/15/22–12/31/22	20	45	228.4	188	280	225
Chinook	1/1/23–6/30/23	19	1	314.0	314	314	N/A
Chinook	1/1/23–6/30/23	20	12	255.1	234	285	251.5
Chinook	1/1/23–6/30/23	21	1	122.0	122	122	N/A
Chinook	1/1/23–6/30/23	22	346	36.0	31	61	35
Chinook	1/1/23–6/30/23	N/A	4	N/A	N/A	N/A	N/A
Chinook	7/1/23–12/31/23	20	1	298.0	298	298	N/A
Chinook	7/1/23–12/31/23	21	261	188.4	129	233	193
Chinook	7/1/23–12/31/23	22	18	96.1	69	121	96
Chinook	1/1/24–6/30/24	21	42	199.7	155	237	199.5
Chinook	1/1/24–6/30/24	22	18	122.8	90	174	122

Table I-20. Length tables of Chinook salmon captured at the Lookout Point Head of Reservoir RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	3/10/22–12/31/22	20	24	98.2	86	118	95
Chinook	3/10/22–12/31/22	21	84	56.5	28	119	57
Chinook	2/1/23–6/30/23	21	5	99.8	94	113	97
Chinook	2/1/23–6/30/23	22	123	46.4	30	93	42
Chinook	7/1/23–12/31/23	22	14	101.8	81	126	105
Chinook	1/1/24–6/30/24	22	15	96.2	75	112	95
Chinook	1/1/24–6/30/24	23	34	59.3	32	89	56.5

Table I-21. Length tables of Chinook salmon captured at the Lookout Point Dam RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	4/28/22–12/31/22	20	22	173.0	151	256	265.5
Chinook	4/28/23–6/30/23	21	56	114.6	58	146	119
Chinook	1/1/23–6/30/23	20	5	246.0	227	275	247
Chinook	1/1/23–6/30/23	21	32	155.9	96	199	116.5
Chinook	1/1/23–6/30/23	22	12	57.3	33	113	53.5
Chinook	7/1/23–12/31/23	21	33	175.3	100	227	182
Chinook	7/1/23–12/31/23	22	59	100.4	31	121	101
Chinook	1/1/24–6/30/24	21	2	208.5	208	209	N/A
Chinook	1/1/24–6/30/24	22	85	124.1	82	180	115

Table I-22. Length tables of Chinook salmon captured at the Dexter Dam RST by brood year from 2022-2024.

Species	Date Range	BY	Number of Fish	Average F.L. (mm)	Min. F.L. (mm)	Max F.L. (mm)	Median F.L. (mm)
Chinook	3/7/22–12/31/22	20	28	170.2	142	226	163
Chinook	3/7/22–12/31/22	21	71	112.7	46	145	117
Chinook	1/1/23–6/30/23	21	15	158.2	103	190	162
Chinook	1/1/23–6/30/23	22	5	85.4	54	109	100
Chinook	7/1/23–12/15/23	20	1	345.0	345	345	N/A
Chinook	7/1/23–12/15/23	21	8	169.1	118	206	167
Chinook	7/1/23–12/15/23	22	28	107.4	84	135	106.5
Chinook	1/1/24–6/30/24	21	1	227	227	227	N/A
Chinook	1/1/24–6/30/24	22	27	130.3	77	177	129

Appendix J – USGS 2024 Turbidity Gage for the Middle Santiam River Below Green Peter Dam

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Appendix J: USGS 2024 Turbidity Gage for the Middle Santiam River Below Green Peter Dam

Figures

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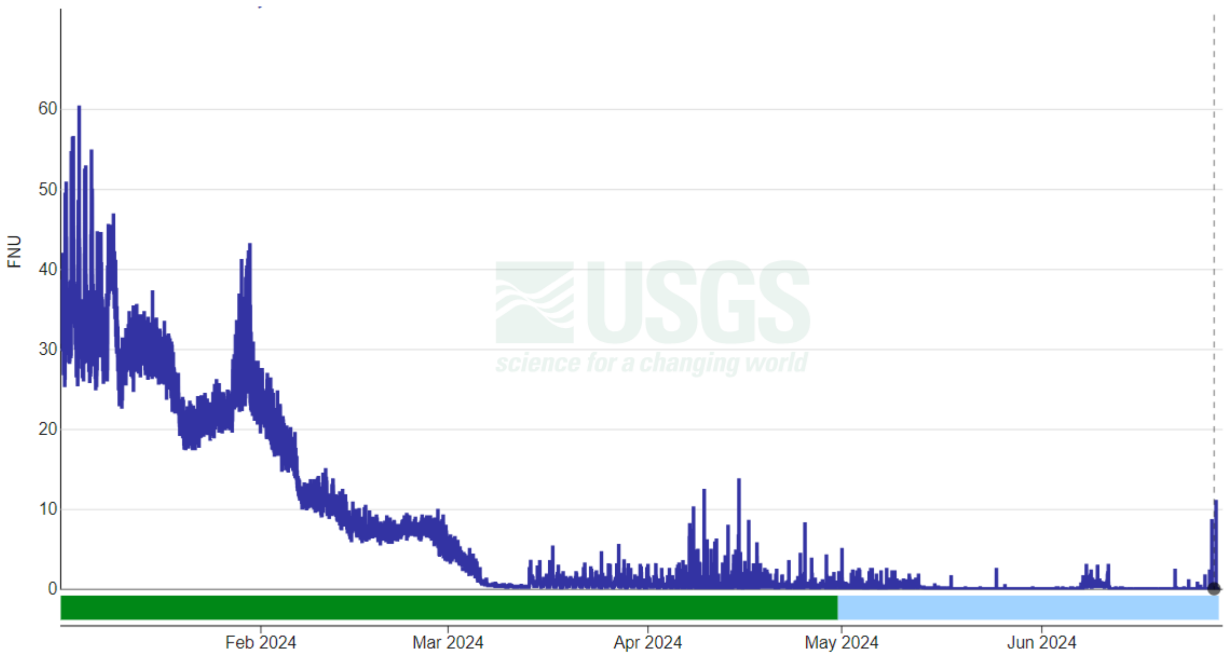

Figure J-1. USGS Turbidity Gage for Calendar Year 2024 for the Middle Santiam River Below Green Peter Dam.

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