FINAL

DOWNSTREAM JUVENILE FISH PASSAGE MONITORING VIA ROTARY SCREW TRAPS

Annual Report

Prepared for

US Army Corps of Engineers

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Acronyms and Abbreviations

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
PIT	Passive Integrated Transponder
PNNL	Pacific Northwest National Laboratory
PTAGIS	PIT Tag Information System
PWR/PH	Powerhouse
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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Glossary

Acoustic Tag	Small sound-emitting devices that allow the detection and/or remote tracking of organisms in aquatic ecosystems.
Adfluvial	Fish that spawn in tributary streams where the young rear from 1 to 4 years before migrating to a lake system, where they grow to maturity.
Adipose Fin	A small, rayless, fleshy dorsal fin present in certain fishes, notably in the salmon family.
Aerated	To introduce air into (a material).
Anadromous	Migrating up rivers from the sea to spawn (of a fish such as the salmon).
Anesthetized	Administer anesthetic, specifically to induce a loss of consciousness.
BiOp (biological opinion)	Any opinion issued by a Government Authority authorized to do so under the Endangered Species Act (ESA).
Bismarck Brown Dye (BBY)	A hydrochloride that is the dihydrochloride of 4,4'-[1,3-phenylenebis(diazene-2,1-diyl)]di(benzene-1,3-diamine). Bismarck Brown Y is a metachromatic dye which stains acid mucins yellow.
Branchial cavity	Area of the body that contains gills and extends into the mouth.
Brood Year	The parental year for a group of returning salmon, i.e. the calendar year when the majority of parents of these fish spawned.
Caudal Clip	Caudal fin is used interchangeably with tail fin. A caudal clip is a tail fin clip.
Cone flux	The rate of volume flow across the submerged portion of a rotary screw trap cone approximated by the number of cone revolutions between trap checks.
Confidence Interval	A range of values so defined that there is a specified probability that the value of a parameter lies within it.
Critical Habitat	Habitat that is needed to support the recovery of a listed species.
Emigrating	Refers to when an animal leaves its home because the habitat is no longer ideal for them, and they need to find a more suitable environment.
Flow	The volume of water moving down a river or through a dam passage route.
Gravid	Pregnant; carrying eggs or young.
Incidental fish	Any fish unintentionally caught in sampling and monitoring gear.
Interim Injunction Measure	Provisional measure sought during legal proceedings before trial. An injunction is an order of the court that requires a party either to do a specific act, or to refrain from doing a specific act.

Interim Injunction Order	A temporary order given by a court of law which tells someone either to do or not do something until an official decision on the case can be made: to seek/grant/make an interim injunction.
Livewell MS-222	A well for keeping fish alive by allowing the surrounding water to circulate. Also known as Syndel's Syncaine (tricaine methanesulfonate), a fish anesthetic used for the temporary immobilization of fish.
Natural Origin (NOR)	The terms natural origin and wild can often be used interchangeably. The term refers to a fish that was spawned and reared in nature, regardless of parental origin.
Natural production	Fish produced to adult lifestage.
Non-target	Species that are incidentally captured while fishing for a target species.
Out planting	To transplant from a location to an outside area. Refers to fish collected from a trap or hatchery and released at a different site.
Passive Integrated Transponder (PIT)	Tracking tags that do not require power. Instead, they have an internal microchip that is activated when it passes close to a special antenna.
Radio Tag	A small radio transmitter attached to an object (fish) to track its location.
Raw Catch	Unadjusted total number of fish caught over a time span.
Riffle	A rocky or shallow part of a stream or river with rough water.
Sac-fry	A newly hatched fry using the yolk sac as a food source.
Salmonids	A fish of the salmon family (*Salmonidae*).
Sedimentation	The process of settling or being deposited as sediment.
Standardized Catch	Catch per unit effort (CPUE) is a fundamental component of fishery stock assessment. In multispecies fisheries, catchability can differ depending on which species is being targeted, and so the yearly trend extracted from the standardized CPUE is likely to be biased.
Target	Fish that are intentionally captured.
Thalweg	A line connecting the lowest points of successive cross-sections along the course of a valley or river.
Tributaries	River or stream flowing into a larger river or lake.
Type II Errors	A type II error is a statistical term used within the context of hypothesis testing that describes the error that occurs when one fails to reject a null hypothesis that is actually false. A type II error produces a false negative, also known as an error of omission.

Visible Implant Elastomer (VIE)	A 2-part silicone-based polymer that is injected as a liquid that hardens to a pliable consistency once warmed. The result is a small color band on the surface of the animal that can be detected by the naked eye.
Watershed	An area or ridge of land that separates waters flowing to different rivers, basins, or seas.

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Rotary Screw Trap Program 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 much 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 that set forth specific actions the Action Agencies could implement to satisfy their legal obligations under the ESA to "…avoid the likelihood of jeopardizing the continued existence of the ESA-listed species or the destruction or adverse modification of their designated critical habitat" (NMFS 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 Reasonable and Prudent Alternative, 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 (RST) were used in accordance to established methods (Keefer et al. 2012, 2013; Romer et al. 2013–2016) to aid and understand the effects of downstream fish passage through the reservoirs and dams in rivers upstream of 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 2023) 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. Results from sampling at these sites under EAS base contract W9127N19D0007 are reported separately (EAS 2024).

This report was written by Environmental Assessment Services, LLC (EAS) for CFS under contract W9127N19D0009. This report contains a compiled summary and analysis of the field study implemented by EAS for RST sampling efforts for all of 2023 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, Fall Creek Dam Tailrace, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point Head of Reservoir, Hills Creek Dam, and Hills Creek Head of Reservoir. For a summary and analysis of all 2023 sampling data from Foster Dam Head of Reservoir-South Santiam River, Cougar Dam Head of Reservoir, and Fall Creek Head of Reservoir, please refer to EAS 2024.

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 preventing 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 12 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, Cougar Dam, Cougar Dam Head of Reservoir, Fall Creek Dam Tailrace, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point Head of Reservoir, Hills Creek Dam, and Hills Creek Head of Reservoir – Middle Fork Willamette River. 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 June 16, 2023, and continued until November 30, 2023, at the end of winter sampling.
- At Big Cliff Dam Tailrace, a single 8-foot RST operated in the tailrace from January 1, 2023, to December 31, 2023.

- A 5-foot RST operated at the Detroit Head of Reservoir – North Santiam River below the Cooper's Ridge Road bridge on May 4, 2023, and continued until November 30, 2023, at the end of winter sampling.
- A 5-foot trap operated at the Green Peter Head of Reservoir – Middle Santiam River from May 4, 2023, and continued until November 30, 2023, at the end of winter sampling. The RST site is located approximately 200 meters downstream from the US Geological Survey (USGS) gauging station.
- At the Green Peter Dam Tailrace – Middle Santiam River, a single 8-foot RST operated from March 14, 2023, and continued through the end of the reporting period.
- At the Cougar Dam Tailrace, three RSTs were operated from January 1, 2023, to December 31, 2023: two 8-foot RSTs in the Powerhouse (PH) channel and one 5-foot RST in the Regulation Outlet (RO) channel.
- At the Fall Creek Dam Tailrace, a single 8-foot RST was used to sample the RO channel from January 1, 2023, to July 15, 2023, and again from October 1, 2023, to December 31, 2023.
- At the Dexter Dam Tailrace, a 5-foot RST was deployed and sampled from January 1, 2023, and continued through December 31, 2023.
- Below the Lookout Dam Tailrace, three 8-foot RSTs were operated from January 1, 2023, through December 31, 2023: two in the PH channel and one in the Spill channel.
- At the Lookout Head of Reservoir – Middle Fork Willamette River site, a 5-foot RST operated from January 1, 2023, through December 31, 2023. The RST site is located at the US Forest Service Seed Farm.
- A 5-foot RST operated at the Hills Creek Head of Reservoir site in the Middle Fork Willamette River above Hills Creek Reservoir from May 9, 2023, through June 30, 2023. The RST site is located at the USGS gauging station.
- At the Hills Creek Dam, two RSTs were operated from January 1, 2023, to June 30, 2023, and from September 15, 2023, through December 31, 2023: one 8-foot RST in the PH and one 5-foot RST in the RO channels.

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. The contracted reporting period refers to dates sampled under contract W9127N19D0009. The total sampling period reflects the data that is summarized and analyzed for this report.

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

Site	Trap Installation	Contracted Reporting Period	Total Sampling in 2023[d]
Breitenbush River	6/16/2023[a]	03/01/2023–11/30/2023	06/16/2023–11/30/2023
Big Cliff Dam	12/01/2022	10/15/2023–12/31/2023*	01/01/2023–12/31/2023
Detroit Head of Reservoir – North Santiam	04/05/2023[c]	03/01/2023–11/30/2023	05/04/2023–11/30/2023
Green Peter Head of Reservoir – Middle Santiam	04/05/2023[c]	03/01/2023–11/30/2023	05/04/2023–11/30/2023
Green Peter Tailrace – Middle Santiam	03/14/2023[b]	12/01/2023–12/31/2023*	02/01/2023–12/31/2023
Cougar Dam PH	12/01/2021	12/01/2023–12/31/2023*	01/01/2023–12/31/2023
Cougar Dam RO	12/01/2021	12/01/2023–12/31/2023*	01/01/2023–12/31/2023
Fall Creek Dam	03/15/2022	07/15/2023–12/31/2023*	01/01/2023–12/31/2023
Dexter Dam Tailrace	03/03/2022	12/16/2023–12/31/2023*	01/01/2023–12/31/2023

Site	Trap Installation	Contracted Reporting Period	Total Sampling in 2023[d]
Lookout Point Dam	03/15/2022	08/01/2023–12/31/2023*	01/01/2023–12/31/2023
Lookout Point Head of Reservoir	03/06/2022	12/16/2023–12/31/2023*	01/01/2023–12/31/2023
Hills Creek Head of Reservoir – Middle Fork Willamette	05/09/2023[a]	03/01/2023–06/30/2023	05/09/2023–06/30/2023
Hills Creek Dam PH	09/15/2022	09/15/2023–12/31/2023*	01/01/2023–12/31/2023
Hills Creek Dam RO	09/15/2022	09/15/2023–12/31/2023*	01/01/2023–12/31/2023

a Initiation of sampling delayed until trap was delivered by manufacturer.
b Initiation of sampling delayed until a new anchor system could be installed.
c Initiation of sampling delayed following contract award in March 2023 and permits approval.
d See Appendix B for more information on sampling outages.
* Previously monitored by EAS for the USACE under contract W9127N23R0019

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 and from 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 natural origin and considered targets. Additionally, at sites in the Santiam River Basin, winter steelhead were considered target fish. Therefore, all juvenile *O. mykiss* captured that did not display any clip, tag, or dye and were presumed to be of natural origin were treated as targets, as it is not possible to accurately distinguish between resident rainbow trout and anadromous steelhead trout. Table 3 lists all sites and 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, or smolt based on morphological characteristics. In general, fry were sub-yearling 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 2. In addition to the injury codes listed, we also enumerated the number of adult gravid female copepods (*Salmincola californeinsis*) by attachment location (branchial cavity or fins) and assigned a value to the level of gas bubble disease observed in fish (1 to 4). 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. A summary of data collected by site is provided in Table 3.

Table 2. 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

Table 3. 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
Big Cliff Dam	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
Detroit Head of Reservoir – North Santiam 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
Green Peter Dam Tailrace – Middle Santiam	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
Green Peter Head of Reservoir – Middle Santiam 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
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 Dam	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes	No
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
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
Lookout Point Head of Reservoir	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Hills Creek Dam	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
Hills Creek Head of Reservoir – Middle Fork Willamette River	Yes, Run of River Fish, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes

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 limited 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 time to get 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) emphasize the importance of sample size in ensuring the validity of regression results. When additional variables are included in the regression model, it's 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 easily escape before they are captured. 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.

Building on previous work that started in late 2021, some trends are starting to become apparent in our efforts to relate TE directly to flow. TEs fall into 3 general categories: 1) positive association of TE with

increasing flow that we were able to use for calculating passage, 2) no apparent association with flow, or not enough trials across flows to determine if there is an association, but we were able to use an average of the TEs to determine passage, and 3) sites where we are unable to determine passage at this time. TE sample sizes are still relatively small with fewer than 20 TE trials at most sites. The following summarizes the categories each trap currently groups with. For additional information regarding TE methodology, refer to the data analysis passage section.

1) Positive association with flow: Big Cliff Tailrace (discrete average TEs at low, medium, and high flow), Lookout Point HOR (linear model), and Hills Creek PH (linear model).
2) Average TE used: Cougar PH, Cougar RO, and Green Peter Dam have no apparent association, while Dexter Dam Tailrace, Breitenbush River, and Detroit HOR do not have enough samples, but appear to have a positive association with flow.
3) Unable to determine passage at Fall Creek Dam, Green Peter HOR, Hills Creek HOR due to too few TE trials, while Hills Creek RO, Lookout Dam PH1, PH2, and Spill have extremely low TE and complex passage routes.

Trapping Efficiency Trials

Hatchery Fish. Due to environmental conditions and hatchery fish availability, we were unable to test each site to the extent we had planned. We performed TE trials with large groups of marked hatchery fish at all sites but often were unable to perform replicate trials across the range of flow levels sampled.

In order to utilize TEs from hatchery fish to calculate ROR passage, we have to assume that hatchery fish and ROR fish have the same probability of being captured in an RST, that all fish released for a trial pass by the trapping site within a one week period, the RST samples continuously during the recapture window after release, and all fish that enter the trap are recovered and identified from the live well. When possible, we performed ROR fish trials to interrogate some of these assumptions. Crews checking traps make note of any observations at the RST that may result in assumption violations. Some examples of issues observed are debris stopping cone rotations and sign of mammalian predators on/near the RST.

All hatchery fish utilized in TE 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 for use in trials were collected from ODFW hatcheries or from Oregon State University's Smith Farms fish facility. Water temperature and dissolved oxygen levels were continuously monitored during fish transportation and corrected as necessary. Upon arrival at the release site, river water was slowly mixed into transport and marking tanks to acclimate fish to the site before work-up and final release. Fish were then anesthetized and marked in small batches and placed into a large tank of river water treated with stress coat to fully recover. Once recovered, fish were released in small groups across the channel being tested to discourage schooling behavior. Fish were released at least one riffle pool complex above the trap, or upstream ~500m, to allow for dispersal across the channel. At below dam sites, fish were released as close to powerhouse, spill, or RO outlet as possible. Fish were released in small groups from alternating banks when possible. 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. ROR fish captured in the RST were marked and released upstream of the trapping sites to assess the natural origin capture efficiency of the trap. These ROR trials only occurred at sites when enough markable size natural origin fish were captured to conduct trials under the assumption 5 or more ROR fish would be recaptured. This assumption of 5 or more recaptures could be met by a single day event trail or multiple day trails pooled together under similar conditions.

We were unable to perform ROR TE trials this spring as we did not capture enough fish that were large enough for us to safely mark for use in trials. For fish used in trials, data was collected on captured fish as normal, fish were then tagged and marked with a caudal clip. Then fish were released approximately 500 meters upstream of the trap. We are unable to utilize VIE marked fish for ROR TE trials that were too small

to safely caudal clip as we cannot uniquely mark fish for this purpose without biasing results of downstream recaptures of VIE marked fish. Additionally, we have observed VIE marked fish that were released downstream of the trap being recaptured in the trap at later dates, thus necessitating the need to add a unique mark. Marked fish released upstream for a TE trial and 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 TE 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 natural origin 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 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 4604 start/stop times with an average duration of 23.97 hours between checks (standard deviation of 2.22 hours). Trap sampling time between checks ranged from 0.5 and 35.63 hours. In almost all instances (>99%) traps were fished overnight, but due to logistics, trap checks occurred at various times the following day. This resulted in sampling duration that included overnight effort ranging from approximately 12 to 35 hours. In a few instances (n=2) 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. 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 trail. Fish were released upstream ~500 m from the trap, or as far upstream as possible 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), Bismarck Brown staining. Unique marking was especially important for sites (e.g., Hills Creek RO) where captured fish could have traveled from two routes to the trap or when second trials occurred within the recapture window of a week. Recaptured fish were recorded, and weekly abundance estimates made based on the hatchery 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, Powerhouse 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.

Since previous rotary screw trap work has shown flow rates to be one of the largest factors in TE (Tattam et al. 2013) EAS started with the assumption that flow would be the best predictor of TE. For this project we 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. At two sites, Lookout Point HOR and Hills Creek PH, we were able to model TE in association with flow and use it for passage calculations. 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 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 based on the standard deviation. For example, at Cougar RO, a highly channelized location, the TE for both hatchery and natural origin fish appears to be unaffected by flow, but more trials are needed at flows above 2,000 cfs to confirm.

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 overtime that can predict TE based on flow rates. This would reduce the overall number of required TEs and decrease error estimates.

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

$$N_{95} = c_w / e_{95}$$

and

$$e_{95} = e_m (\alpha * s * n)$$

where:

- N_{95} = estimated 95% weekly CI for out-migrants, based TE trials at flow levels (low, medium, and high) where possible
- C_w = adjusted weekly catch
- e_m = average measured trap efficiency, based on flow levels (low, medium, and high) where possible
- e_{95} = upper and lower 95% TE CI, based on TE trials at flow levels (low, medium, and high) where possible
- 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.

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

More trials have been conducted in the six months since the biannual 2023 report was published. Unfortunately, in many instances, an inadequate number of additional trials have been conducted to properly model the flow rate in relation to TE. TE trial sample size remains small at high flows in general.

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).

On December 20, 2023, we were able to conduct a 16,000 fish release at Lookout via the PH route and recaptured one fish in the Spill channel trap, three at the PH1 trap, and 25 at the PH2 trap. The PH traps should capture similar numbers of fish. Given that one RST was unsuccessful, it highlights how low the TE is at Lookout Dam Tailrace. This extremely low recapture rate is a concern because trials with fewer than five returns are subsequently removed from the calculations and have the potential to skew the calculated TE results higher than what is actually being illustrated (see following example).

If only successful TE trials (n=1) with at least 5 recaptures are used for Lookout Dam PH1, TE is approximately 0.001. However, if both successful (n=1) and unsuccessful (n=3) 4,000 fish release TE trials (n=4) are pooled, TE is approximately 0.0004, which is approximately 3.5 times difference. The difference in passage total returns is 12,000 (successful TE) vs 45,000 (pooled TE) fish. If the pooled TE of 0.0004 is reflective of the TE at PH1, an estimated 17,000 (14,200 plus a 20% buffer) marked fish would need to be released to have confidence in capturing at least 5 returns. With great effort, we were able to release 16,000 fish at once and still failed to capture at least 5 returns in an RST. If considering cross routes (e.g., Spill release caught in the PH) the TE is much worse. For example, we estimate that to recapture 5 fish in the Spill trap released at the PH, 80,000 fish would need to be released at PH flows >3,000 cfs. It is not realistically possible for the purpose of conducting TE trials, given personal and logistical resources needed. Alternatively, pooling multiple TE trials (both passing and failing) under similar flow conditions might better reflect actual TE. In this report, in some instances at sites with low TEs, we opted to pool passing and failing trials (except when the RST was non-functional) under similar flow conditions as we believe it is more reflective of the actual TE.

There is general difficulty in calculating TE at sites below tailraces (Big Cliff Dam Tailrace, Lookout Dam, Dexter Dam, and Hills Creek Dam RO), due to low TEs, the channels being wide, and complex route operations regularly occurring. At several, if not all of these sites, passage estimates should be interpreted cautiously and considered an index of relative passage rather than absolute passage. These sites are difficult to assess due to the following reasons:

1) Operations often cycle within a single 24-hour time span. Flows can range from almost no flow to high flow, while at other times, steady flows are kept over multiple hours. This can result in similar daily average flows, but the fish can experience drastically different conditions. Out-migrating fish tend to pass more in higher flows, and it is quite possible that if dam operations run at higher flows for a short burst, more fish will pass than if a steady average is held at a lower flow rate.
2) Flow routes often change by route (e.g., PH vs. Spill) within short time spans and both operations can occur simultaneously, making it difficult to calculate daily average flows. If for example, a steady outflow flow is released but it cycles between the PH and Spill over the time span between trap checks it becomes problematic to determine the average flow that the target fish experience. Currently, we are using the daily average, but perhaps the nightly average or average only when water is passing could be used instead.
3) When both operations are occurring simultaneously or within a short time span, it is not possible to determine which route the targets passed through the dam, and this can result in drastically different passage estimates. For example, using our current data, Hills Creek Dam RO has an average TE via the PH route around 0.4% (+/- 0.37) and the RO VIA RO route is 1% (+/-0.7%). Assume 100 targets are caught in the trap. If all the targets caught passed via the PH, then the passage estimate is 22,364 (95% CI ~12,000 to ~140,000), but if all the fish caught passed via the RO the passage estimate is 8891 (95% CI ~5,400 to ~24,000). Without the additional

knowledge of the proportions of fish passing through the spill and PH under different conditions (flows and forebay elevation) it is difficult to determine passage.

4) LOP has an extremely low TE as noted above, especially cross route (PH via Spill and Spill via PH). It is often possible for fish to travel via multiple routes that have different TE values, as noted above. The PH traps are set in a wide deep channel, and operations or fish behavior could result in TE variability we are unable to detect at this time. This combination makes extrapolating total passage difficult, and passages estimates at Lookout Dam PH1, PH2, and Spill should be considered indexes rather than total passage estimates.

5) Dexter Dam has a complex route system. There is a wide (359 feet) concrete spillway equipped with seven spillway gates, and a PH. This creates a wide complex passage for fish making it difficult to determine TE because many possible route combinations can occur. There are eight route options (one PH on/off, six Spill open/closed, and RO open/closed) resulting in 256 unique combinations for passage routes assuming flow is held constant. Given that flow is variable for each route the number of combinations goes up dramatically even if only three categories (low, med, high) of flow are considered. Furthermore, below the dam is a pool followed by riffles and small channels. This can result in fish being directed differently downstream depending on tailrace elevation, and operation. There is one RST in the Dexter Dam tailrace which was relocated downstream in late 2023 due to construction at the Dexter Fish Facility. In the new location the trap is movable but located on the north side of the channel. Based on limited TEs at the new location results indicate fish dropped on the south side with Spill flows ranging from approximately 2,000 to 4,000 cfs mostly avoid the trap as 4 TE trails (~2k drops with 0-2 recaptures per drop). TE trials (n=2) with releases from the North side Spill caught more fish (~2k drops with 10-12 recaptures per drop). TEs from the PH had similar TEs to the North side Spill TEs. At higher flows we believe fewer fish will be recaptured with TEs that occur from the South side, and we are unsure what will happen at lower flows since currents might push across the channel due to shallowing at the riffles. At this time flow data is available for the PH and Spill, but we do not have additional information about release values and specific gates used. Additional data may help, but we hypothesize that fish are primarily passive and going with the flow. Therefore, since the trap is located on the north side of the channel, we will mostly catch fish passing from the north side, unless low flows conditions with Southern Spill gates open transport fish across the channel.

Linear regressions were used to model TE in relation to flow, where possible. However, at this time only Hills Creek PH and Lookout Point HOR have linear fits in relation to flow with P-value cutoffs of 0.05. Sample sizes are at a minimum so the associations may not hold with additional TEs (see Appendix E for linear fits and equations). Furthermore, although linear models work, the TEs in relation to flow are likely logistic because TE must fall between 0 and 1, but many additional trials would be needed to test logistic models. Many of the sites' linear models failed in relation to flow and were non-significant with P-values >0.05. See Appendix E for plots of TE trials in relation to flow and added linear model fits.

Regarding Big Cliff Dam, there was a weak linear fit of TE in relation to flow, but at this time we opted to use a discreet association with flow. We have observed distinct changes in TE at low (<2k cfs), medium (2–4k cfs) and high flows (>4k cfs). The average TE with 95% confidence intervals was calculated for low, medium, and high flows.

At the remaining sites, there is either no apparent pattern in relation to flow and/or not enough TE trials conducted at this time to confidently fit a linear model. For example, Breitenbush looks very promising with a linear model having an Rsq=0.85, but we only conducted 8 TE trials in 2023. It appears TE rates are multivariate and/or other variables besides flow play a role at many sites. In the instances where linear models failed, an average TE was calculated based on all successful trials and 95% CIs calculated from the standard deviation of the successful trials. In some instances, it was not possible to calculate passage due to too few successful TE trials.

Given the complicated nature of TE in relation to flow, we have started exploring alternative variables to flow. One such variable is the revolutions of the trap between checks. The revolutions between checks are

a proxy for the volumetric flux of water into the cone. In plain terms the trap volumetric flux (referred to as cone flux hear after) is the amount of water flowing into the cone. Since the water velocities vary across the channels cone flux varies depending on flow and location of the trap. In many instances we are finding the cone flux one day after TE release to be the best predictor of TE, see Appendix E. All RSTs have been equipped with counters since the project started, but early on there were issues with the reliability of the counters. As such we have worked on counter design and installed two counters on most traps. In most cases the cone flux one day after the TE release is highly correlated with TE see Appendix E. This makes sense because the revolutions are capturing changes in site discharge and where the trap is positioned in relation to the thalweg. Furthermore, the flow and cone flux are correlated and a comparison of the two variables can be used as cross validation to look for outliers, such as the trap malfunctioning. We need to study this more, but it looks promising to help model TE currently. Using cone flux may also help during times when it is not possible to sample directly in thalweg due to high debris or high flow.

In the 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. However, at this time we do not feel confident to incorporate multiple variables given TE sample sizes are low.

EAS would like to note that all TE trial sample sizes are relatively low (n<30) making it difficult to detect assumption violations. With small samples, violation assumptions such as nonnormality or inequality of variances are difficult to detect even when they are present. Therefore, at this time passage estimates and error bars should be interpreted with caution. As more TE trials are conducted, we will hopefully be able to better able to use TE to determine passage and rerun previously collected data with updated passage estimates. Trials are being performed monthly while conditions and fish availability allow and are incorporating knowledge gained from past observations to continue to improve the effectiveness of each trial.

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 brood year, size metrics will be reported by brood year. In some instances, such as Big Cliff Dam fall outmigrants, 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 account 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. The proportional change between injury rates on released fish versus recaptured fish was then applied as a correction factor to observed injuries on target fish to provide better clarity on injuries likely incurred from passage instead of RST capture and handling.

Results

Breitenbush River

A single 5-foot RST was deployed in the Breitenbush River above Detroit Reservoir on June 16, 2023, and continued, to November 30, 2023. The installation of the 5-foot RST was delayed from the contracted start date of February 1, 2023, to June 16, 2023, due to limited availability of screw traps and supply chain issues that prevented the manufacturer from building a new trap on the timeline originally quoted. Sampling outages resulting from high flows, debris and additional issues are listed 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 historic sampling location.

Trapping Efficiency Trials

A total of eight TE trials occurred using hatchery reared Chinook salmon in the Breitenbush River. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 4.

TEs ranged from 0.9% to 20.3%. TE used to calculate passage was the pooled average (6.03% 95% CI +/- 4.32%.) of all (n=8) successful trials with 5 or more recaptures. Although we do not have enough trials to confidently use a model for the TE against flow at this time, a linear model fit to the limited data against flow shows a strong association with TE (Rsq =0.85). TE plots are further detailed in Appendix E. Similarly, cone flux in relation to TE release also shows a strong association with TE (Rsq=0.87). Plots displaying TE in relation to flow and cone flux are provided 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%

Run of River Trapping Efficiency Trials

A total of 143 Chinook salmon and 0 *O. mykiss* were released for ROR TE trials in 2023. A total of 13 fish were recaptured in the trap. A summary of ROR TE fish release and recaptures by is provided in Table 5.

We were able to pool several ROR TE trials (n=11) from September 13 to September 23 and calculate a single ROR TE to be 9.6% in flows that averaged 101 cfs. Hatchery TE trials (n=3) at comparable flows (114 to 133 cfs) have an average TE of 1.6%. Anecdotally, this suggests that the TE of wild fish at this above dam site is 8% higher than hatchery fish, as other researchers have also found higher rates of TE in wild fish in river systems. We hope to be able to release larger groups of ROR fish across a range of flows to allow for passage estimate calculations using ROR data in future analyses.

Table 5. Summary table of run of river releases at the Breitenbush River site for trapping efficiency in 2023.

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%

Target Catch, Passage Estimates and Passage Timing

A total of 377 juvenile Chinook salmon and 361 juvenile *O. mykiss* were captured in 2023 (Figure 1). All juvenile Chinook salmon captured were BY 2022 sub-yearlings (Figure 2) and the first Chinook salmon was captured on June 17, 2023, on the first day of sampling. Based on data from sampling in 2015 by Romer et al., and observations from other nearby sites, it is likely that a majority of BY 2022 Chinook salmon sub-yearlings passed through the trap site prior to the initiation of sampling. The length and weight of sub-yearling Chinook salmon exiting the Breitenbush River was similar to observations from previous work (Romer et al. 2016).

A total of 320 juvenile Chinook salmon were captured in the fall with fish being captured from September 8, 2023, to November 16, 2023. All Chinook salmon captured during this time were BY 2022 sub-yearlings. Chinook salmon catch in the fall coincided with increases in flow, similar to observations from previous sampling efforts. Peak capture of Chinook salmon at this site occurred in September and October (n=299, 79.3% of total Chinook salmon capture). Peak passage during previous sampling efforts occurred in March and April (Romer et al. 2016, Figure 7), further suggesting that a large proportion of BY 2022 Chinook salmon may have exited the system prior to sampling.

Using pooled TEs, we estimate that 15,587 (95% CI: 9,138 to 55,368) juvenile Chinook salmon passed the trapping site in 2023 (Figure 1). However, given the small sample size (n=8) of successful TE trials, the statistical power is very low and there is a high chance of making type II errors. Passage estimates and confidence intervals should be considered preliminary until enough TE trials are conducted.

Peak capture of juvenile *O. mykiss* during the monitoring period occurred in July (n=318, 88.1% of the total *O. mykiss* catch), (Figure 3). The *O. mykiss* captured at this site consists of juveniles from three BYs: BY 2021, BY 2022, and BY 2023 (Figure 4). *O. mykiss* catch in June consisted of two BYs, BY 2022 (n=2) and BY 2023 (n=2). The fall capture of *O. mykiss* consisted of 2 BY 2021, 8 BY 2022, and 347 BY 2023 fish. The observed overlap in size of fish between BYs and the 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 from 2023.

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	1/1/23–6/30/23	22	30	55.5	44	68	55	2.1	1.0	3.3	2.2
Chinook	7/1/23–11/30/23	22	347	89.7	51	114	91	8.1	2.00	16.1	7.9
O. mykiss	1/1/23–6/30/23	23	2	51.5	27	76	N/A	N/A	N/A	N/A	N/A
O. mykiss	1/1/23–6/30/23	22	2	113.5	107	120	N/A	17.6	15.1	20.0	N/A
O. mykiss	7/1/23–11/30/23	21	2	169	139	192	N/A	57.5	22.9	92.0	N/A
O. mykiss	7/1/23–11/30/23	22	8	125.1	85	151	132	22.1	5.5	36.9	24.4
O. mykiss	7/1/23–11/30/23	23	347	31.1	21	165	27	N/A	N/A	N/A	N/A

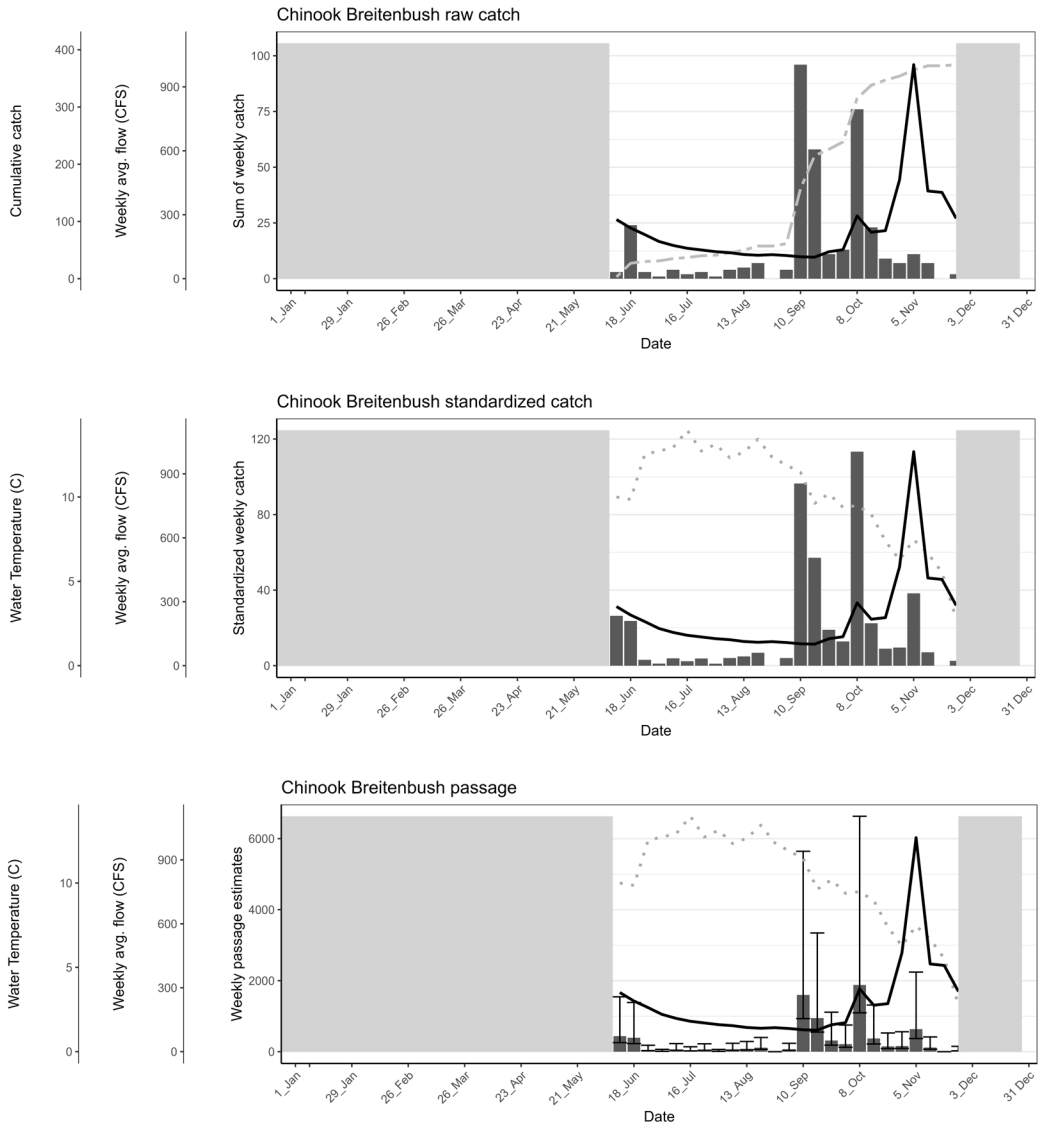

Figure 1. Raw catch (top panel), standardized catch (middle panel), and weekly passage estimates (bottom panel) of natural origin juvenile Chinook salmon at the Breitenbush River site overlayed with flow (black line), cumulative catch (gray dot dash line), stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for 2023.

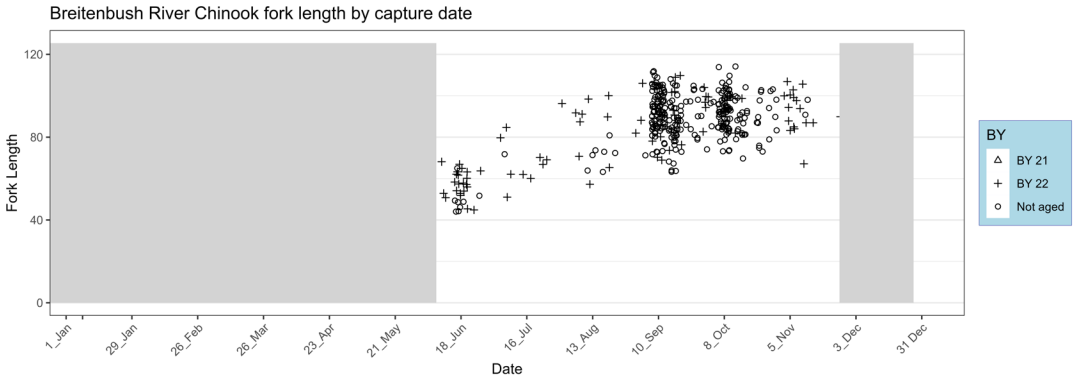

Figure 2. Length-frequency analysis for juvenile Chinook salmon at the Breitenbush River site from 2023.

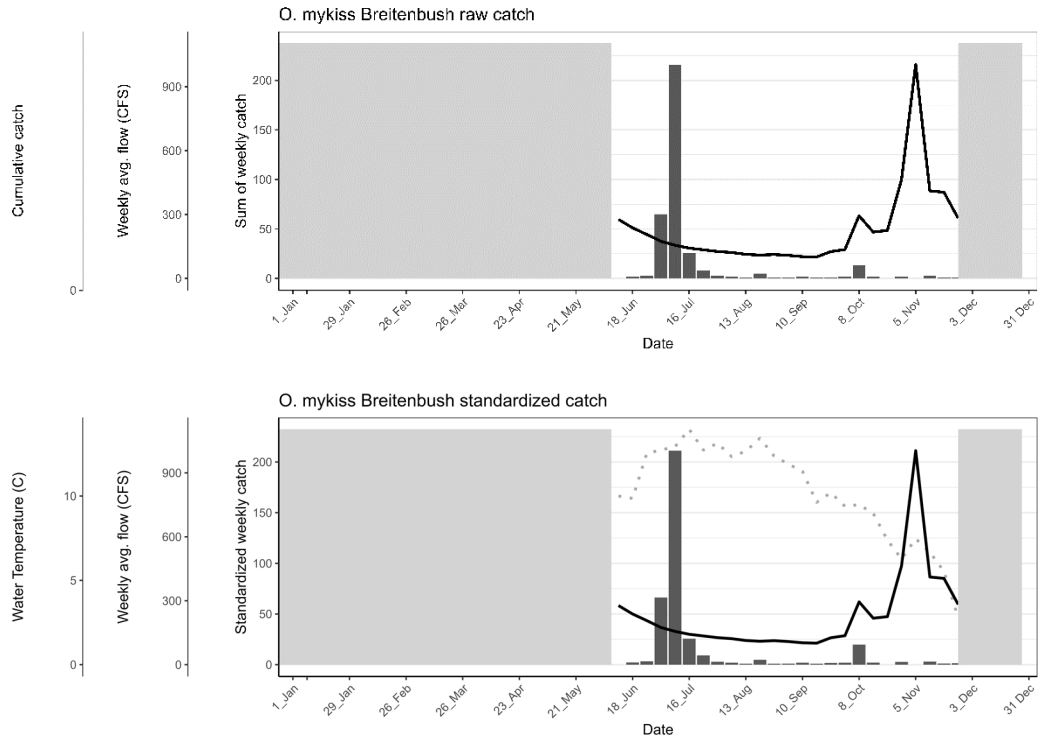

Figure 3. Raw (top panel) and weekly standardized (bottom panel) catch of juvenile *O. mykiss* overlayed with flow (black line), stream temperature (gray dotted line), and non-sampling weeks shaded out (gray) at the Breitenbush River site from 2023.

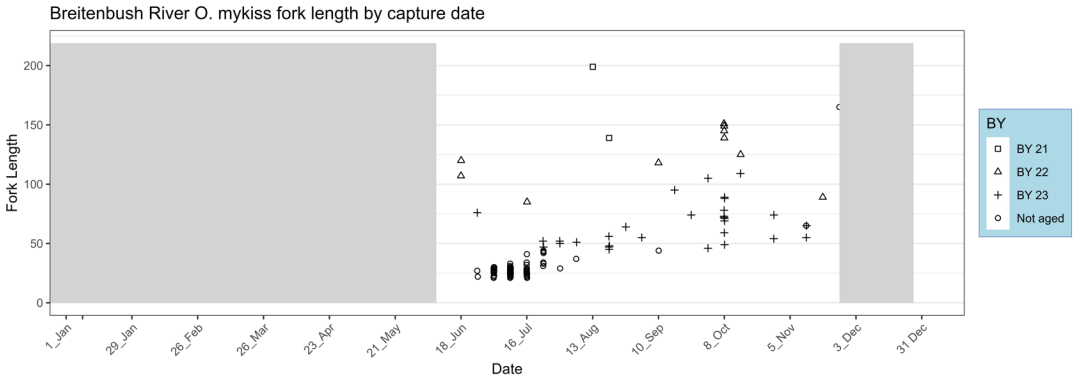

Figure 4. Length-frequency analysis by brood year for juvenile *O. mykiss* at the Breitenbush River site from 2023.

Injury Data

A total of 340 juvenile Chinook salmon (90.2% of total Chinook salmon catch) and 26 juvenile *O. mykiss* (7.2% of total *O. mykiss* catch) displayed at least one of the injury code conditions listed in Table 2. The most predominant injuries encountered on Chinook salmon observed at this site include descaling less than 20%, fin damage, and the presence of copepods. Descaling and fin damage injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces of the trap. Additionally, most of the *O. mykiss* encountered at the Breitenbush River RST were evidenced to have no external injuries. For those *O. mykiss* that did have injuries present, the most predominant injuries include descaling less than 20% and fin damage. Similar to the Chinook salmon encountered, these *O. mykiss* injuries 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. However, infection rate did not increase with the size of fish as has been seen in many below dam sites (Figures 5 and 6). 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 juvenile Chinook salmon and *O. mykiss* at the Breitenbush River RST site from 2023.

Injury Code	Chinook Injuries (NOR) (n=377)	*O. mykiss* Injuries (n=361)
NXI	10.1%	92.8%
MUNK	0.0%	0.3%
DS<2	80.6%	3.9%
DS>2	2.4%	0.8%
BLO	0.3%	0.0%
EYB	0.3%	0.0%
BVT	0.3%	0.3%
FVB	1.1%	0.3%
GBD	0.0%	0.0%
POP	0.3%	0.0%
HIN	0.5%	0.3%
OPD	0.0%	0.8%
TEA	2.7%	0.6%
BRU	2.9%	0.6%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	48.0%	4.4%
PRD	0.8%	0.0%
COP	17.5%	0.8%
BKD	0.0%	0.0%
FUN	2.4%	0.0%

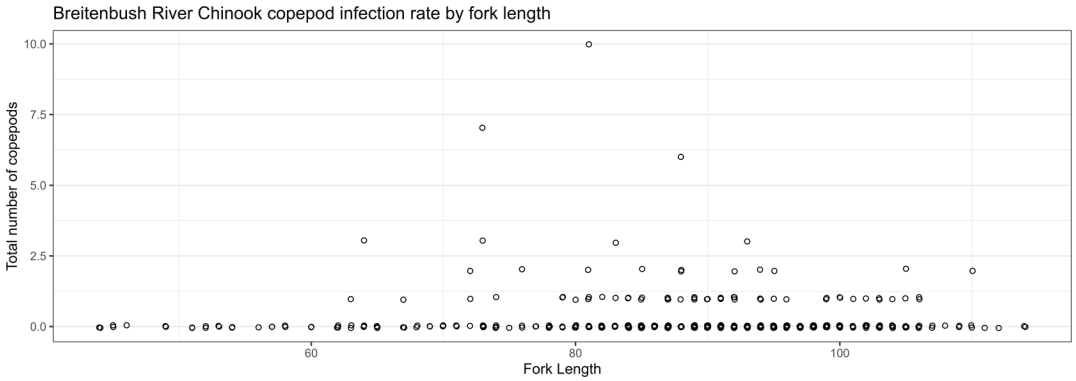

Figure 5. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Breitenbush River from 2023.

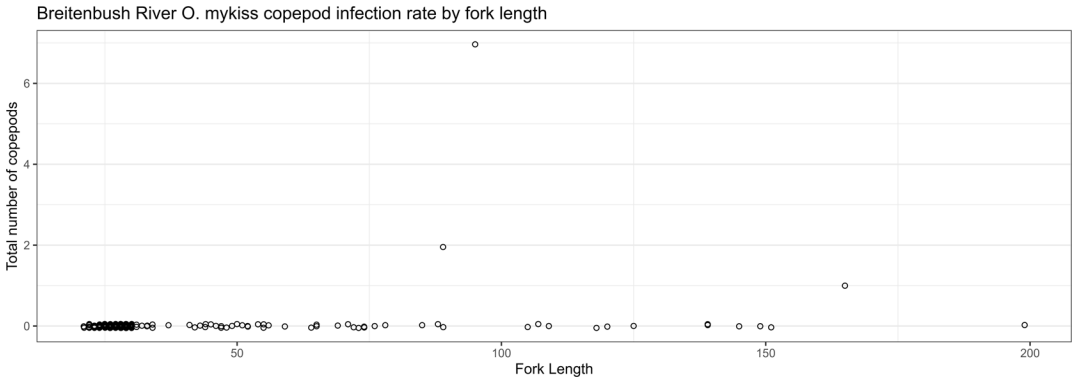

Figure 6. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile *O. mykiss* at Breitenbush River from 2023.

PIT Tagged and VIE Marked Fish

A total of 333 juvenile Chinook salmon and 25 juvenile *O. mykiss* were PIT tagged and released at the Breitenbush River site in 2023. Additionally, a total of 34 Chinook salmon and 20 *O. mykiss* were VIE marked at the Breitenbush site in 2023. Some fish were not tagged, as they were still sac-fry or too small to safely mark. None of the PIT tagged or VIE marked fish have been detected at downstream sites as of December 31, 2023. A summary of VIE marked fish is provided in Table 8. More information regarding PIT tags at the RST and other sites can be found in Appendix C.

Table 8. Summary table of VIE marked Chinook salmon at the Breitenbush River RST site.

Date Tagged	Species	Tag Location	VIE Color	# Tagged	#Recaptured
6/16/2023–6/30/2023	Chinook	Head	Pink	23	0
7/1/2023–7/15/2023	Chinook	Head	Green	2	0
7/16/2023–7/31/2023	Chinook	Head	Green	2	0
7/16/2023–7/31/2023	*O. mykiss*	Head	Green	7	0
8/1/2023–8/15/2023	Chinook	Head	Yellow (2x)	1	0
8/1/2023–8/15/2023	*O. mykiss*	Head	Yellow (2x)	3	0
8/16/2023–8/31/2023	Chinook	Head	Yellow (2x)	2	0
8/16/2023–8/31/2023	*O. mykiss*	Head	Yellow (2x)	5	0
9/1/2023–9/15/2023	*O. mykiss*	Head	Red (2x)	2	0
9/16/2023–9/30/2023	Chinook	Head	Red (2x)	4	0
10/16/2023–10/31/2023	*O. mykiss*	Head	Blue (2x)	2	0
11/1/2023–11/15/2023	*O. mykiss*	Head	Orange (2x)	1	0

Non-Target Capture Data

A total of 411 non-target fish were captured in addition to natural origin juvenile Chinook salmon and *O. mykiss* at the Breitenbush River site in 2023. A summary of non-target species is provided in Table 9.

Table 9. Summary of non-target fish capture at the Breitenbush River RST site.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	383	43
O. mykiss (clipped)	12	5
Cutthroat Trout	3	0
Sculpin	12	2
Dace	1	0
Totals	**411**	**50**

Big Cliff Dam Tailrace

A single 8-foot RST was deployed at Big Cliff Dam on December 1, 2022. Sampling of the RST prior to October 16, 2023, was performed by EAS under contract W9127N19D0007. Sampling from October 16, 2023, through December 31, 2023, was performed by EAS as a sub-contractor for Cramer under contract W9127N19D0009. Data from all sampling performed at this site in 2023 will be included in this report. The trap did not sample from January 1, 2023, to January 16, 2023, due to high flows that created unsafe sampling conditions for both captured fish and crew. There was an additional sampling outage that resulted from high flows that occurred from May 15, 2023, to May 16, 2023. The trap was raised on June 8, 2023, while repairs were made, it was returned to sampling on June 9, 2023. Additional information regarding sampling outages at this site can be found in Appendix B.

Trapping Efficiency Trials

A total of 15 TE trials occurred using hatchery reared Chinook salmon in the Big Cliff Dam Tailrace in 2023. Collectively, a total of 28 trials have been performed by EAS at this site since 2021. A summary of fish release numbers, recaptures, and current flow level for each TE trial is provided in Table 10.

TEs ranged from 0.0% to 20.7%. Trials were grouped by flow (low, medium, and high) for the purpose of creating passage estimates across the range of flows sampled. Plots displaying TE in relation to flow and cone flux for all trials are displayed in Appendix E.

Table 10. 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%

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
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%

*Releases performed by EAS for the USACE under contract W9127N19D0007.
**Release performed by ODFW.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Big Cliff Dam in 2023. 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 2023.

Target Catch, Passage Estimates and Passage Timing

The trap captured 704 juvenile Chinook salmon and 251 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 May and June (n=160, 22.7% of total Chinook salmon) (Figure 7). Peak capture for juvenile *O. mykiss* in the spring occurred in June (n=48, 19.1%) (Figure 9). Chinook salmon catch in the spring consisted of three BY classes: BY 2020, BY 2021, and BY 2022 (Figure 10). The first BY 2022 sub-yearling Chinook salmon was captured on January 31, 2023, significantly earlier in the year than was observed in 2022 when the first fry was captured on April 29. A total of 156 BY 2022 Chinook salmon were captured between January 1, 2023, and June 30, 2023 (48.3% of total Chinook salmon catch for that period) with the peak migration event occurring in February (n=82, 52.6% of Chinook salmon captured for that period). The migration timing of sub-yearling Chinook salmon through Big Cliff Dam is similar to observations from previous years (Romer et al. 2016). A total of 125 BY 2021 Chinook salmon (38.7% of total Chinook salmon catch) were captured from January through June with peak capture occurring from April through June (n=111, 88.8%). In total, 42 BY 2020 Chinook salmon were captured at the site between January 1, 2023, and June 30, 2023. The peak capture for this group occurred in January (n=23, 54.8%).

Chinook salmon capture from July 1, 2023, to the end of the year consisted of 381 individuals (54.1% of total Chinook salmon capture). Scale age analysis from this period shows a significant amount of overlap in size between fish from BY 2021 and BY 2022. This overlap in size of sub-yearling and yearling Chinook salmon is similar to what was observed during RST sampling in 2022 (EAS 2023) and from scale samples collected from Chinook salmon in the forebay of Detroit Reservoir by Monzyk et al. (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. There were 4 BY 2020 Chinook salmon captured from July 1, 2023, to the end of the year at this site. Using TEs by flow category, we estimate that 11,647 (95% CI: 9,257 to 16,196) juvenile Chinook salmon passed the trapping site during RST sampling in 2023 (Figure 7).

Peak capture of Chinook salmon at Big Cliff Dam coincided with spill operations at Detroit and Big Cliff dams that occurred in January and late April/May. We observed modest catch for a period of time after each spill event which suggests that fish were still present in the forebay and passed through the PH at a slower rate once spill had ceased (Figure 8). Downstream movement of 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 Tailrace (Beeman et al. 2015, Table 1-12). Assuming these migration rates for fish to reach the forebay of Big Cliff Dam Tailrace from the Detroit Dam

Tailrace, it is reasonable to accept that the two periods of highest catch at Big Cliff Dam Tailrace in the spring are associated with Detroit Dam RO and surface spill operations. The fall passage event occurred a couple of weeks after RO spill operations reached their highest outflow during the fall. Also of note was that the forebay of Detroit Reservoir fell below 1,500 feet around this period and coincided with the increased capture of Chinook salmon in the trap below Big Cliff Dam Tailrace, suggesting that these fish likely passed through Detroit Dam during this event. However, these spill operations and periods of increased catch are also associated with high flow events that could also contribute to the observed increase in catch. Results from studies by CFS (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 2020 through 2023 are available in Appendix I.

From July 18, 2023, to July 28, 2023, the RST was not sampled due to a planned debris spill at Big Cliff Dam Tailrace to flush debris accumulated subsequent to the 2020 wildfires. The trap was raised and secured in a safe location to prevent it from incurring damage during the debris flush. It is likely that juvenile Chinook salmon and *O. mykiss* passed through the dam and sampling site during this time. Previous sampling efforts have observed significant increases in Chinook salmon catch during this period in 2021 and 2022 (CFS 2023; EAS 2023).

O. mykiss capture in the RST below Big Cliff Dam in the spring consisted of three BYs, BY 2021, BY 2022, and BY 2023 (Figure 11). The first BY 2023 fish was captured on February 14, 2023. This early capture is likely the result of reservoir *O. mykiss* spawning and not that of winter steelhead. A majority of the 46 BY 2023 *O. mykiss* captured in the spring occurred between April and June (n=43, 93.5% of BY 2023 captured in the spring). 10 fish from BY 2022 were captured between February and June along with 2 BY 2021 *O. mykiss.*

Fall capture of *O. mykiss* consisted of 174 fish comprising BYs 2021, 2022, and 2023 (Figure 11). A single fish from BY 2021 was captured on July 5, 2023, and 2 BY 2022 *O. mykiss* were caught between July 1, 2023, and the end of the year. BY 2023 made up the majority of the *O. mykiss* catch in the fall with 171 individuals. Peak capture of BY 2023 *O. mykiss* occurred in July (n=156, 62.2% of total *O. mykiss* catch). Information on fork lengths and weights of each BY captured for Chinook salmon and *O. mykiss* at Big Cliff Dam is provided below in Table 11.

Table 11. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* of natural origin at the Big Cliff Dam RST site by brood year from 2023.

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	1/1/2023–6/30/2023	20	42	202.8	157	340	195	85.3	38.1	328.5	70.5
Chinook	1/1/2023–6/30/2023	21	125	155.8	72	199	160	43.6	3.8	84.4	44.0
Chinook	1/1/2023–6/30/2023	22	156	51.8	29	130	37	N/A	N/A	N/A	N/A
Chinook	7/1/2023–12/31/2023	20	4	234.8	199	300	220	138.6	89.6	224.8	240.1
Chinook	7/1/2023–12/31/2023	21 and 22	377	137.0	91	191	137	29.4	7.4	76.9	27.7
O. mykiss	1/1/2023–6/30/2023	21	3	297	274	335	282	185.2	134.1	254.4	167.0
O. mykiss	1/1/2023–6/30/2023	22	27	200.4	155	269	194	78.9	21.5	187.4	61.5
O. mykiss	1/1/2023–6/30/2023	23	47	29.7	25	71	28	N/A	N/A	N/A	N/A
O. mykiss	7/1/2023–12/31/2023	21	1	295	295	295	N/A	226.5	226.5	226.5	N/A

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)
O. mykiss	7/1/2023–12/31/2023	22	2	151	145	157	N/A	36.2	36.0	36.4	N/A
O. mykiss	7/1/2023–12/31/2023	23	171	31.8	24	120	29	N/A	N/A	N/A	N/A

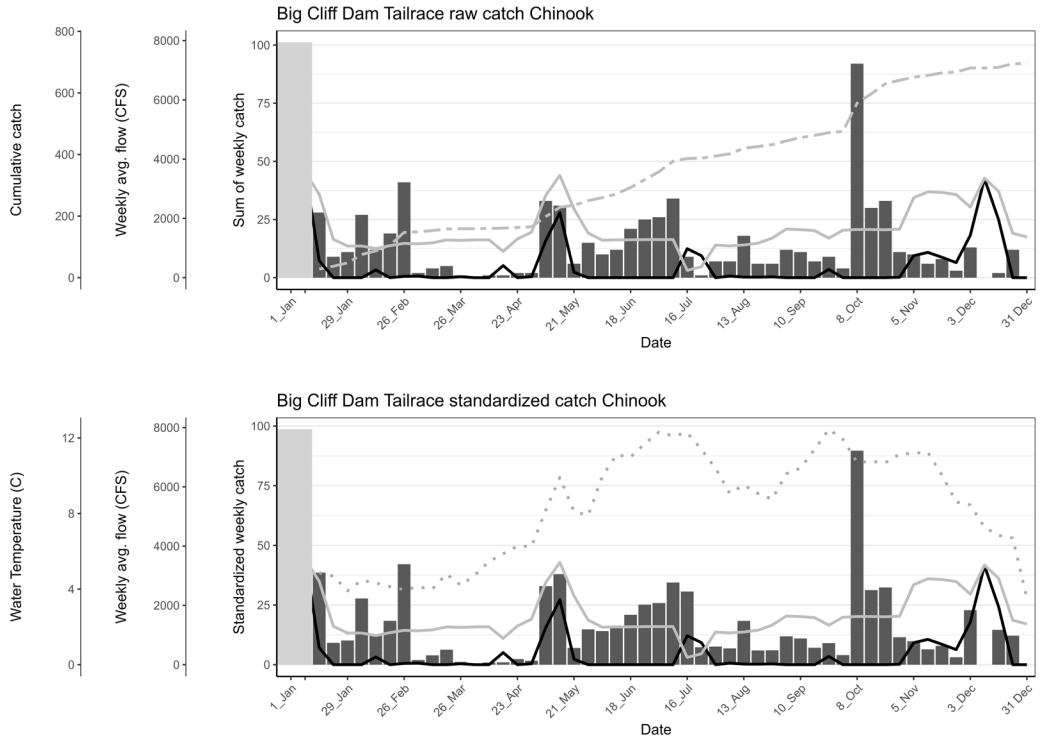

Figure 7. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at Big Cliff Dam with spill (black line), Powerhouse flow (gray line), cumulative catch (grey dot dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) from 2023.

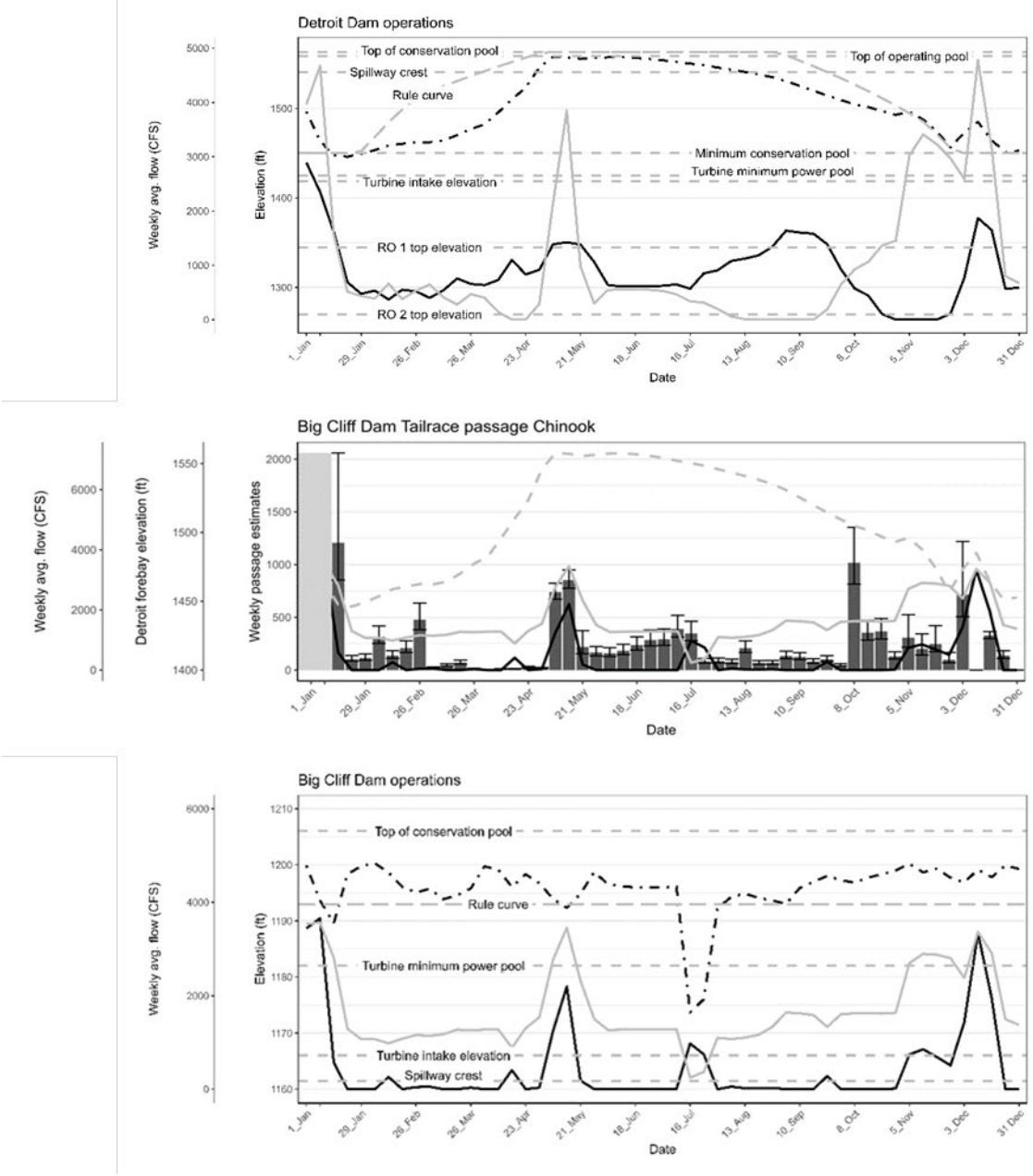

Figure 8. Detroit Dam (top panel) and Big Cliff Dam (bottom panel) operations with rule curve (gray long dash line), forebay elevation (black dot dash line), spill/RO outflow (black line) and Powerhouse outflow (gray line). Passage estimates with 95% confidence for juvenile Chinook salmon at Big Cliff Dam (middle panel) with spill at Big Cliff Dam (black line), Powerhouse outflow from Big Cliff Dam (gray line), Detroit forebay elevation (gray dash line), and non-sampling weeks shaded out (gray) from 2023.

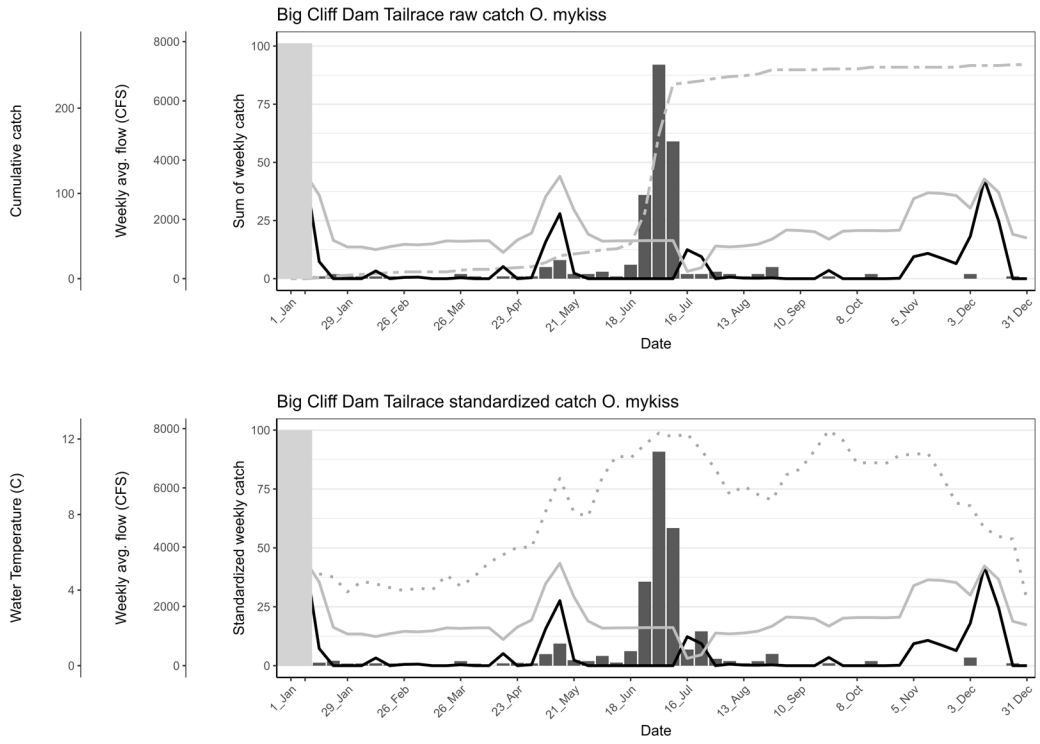

Figure 9. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile *O. mykiss* at Big Cliff Dam with spill (black line), Powerhouse flow (gray line), cumulative catch (grey dot dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) from 2023.

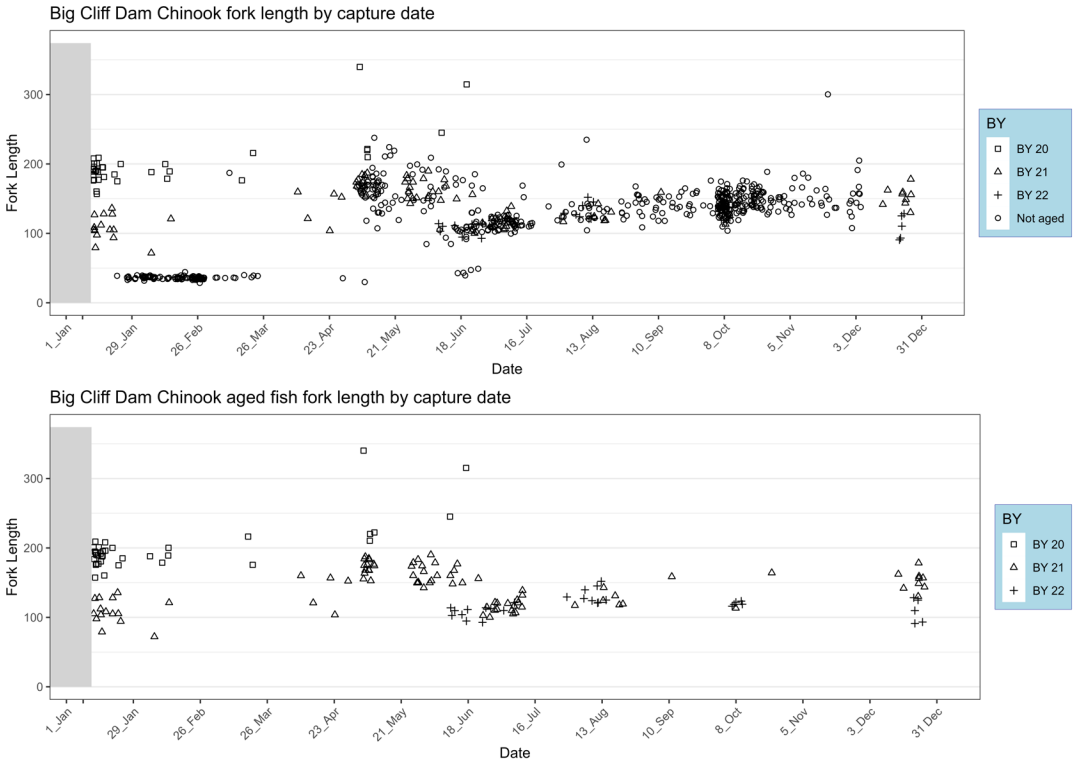

Figure 10. Length-frequency of juvenile Chinook salmon at the Big Cliff Dam Tailrace site from 2023. Top panel shows all fish and bottom panel shows only the aged fish.

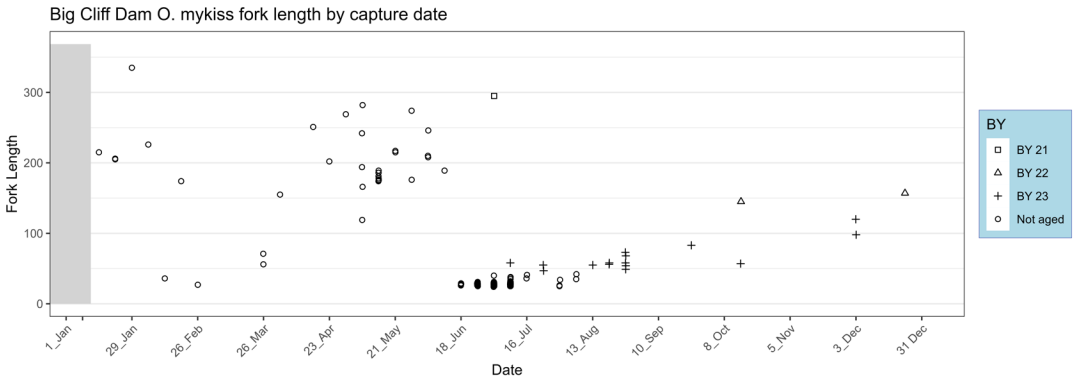

Figure 11. Length-frequency of juvenile *O. mykiss* at the Big Cliff Dam Tailrace site from 2023.

Injury Data

A total of 593 juvenile Chinook salmon (84.2% of total Chinook salmon catch) and 50 juvenile *O. mykiss* (19.9% of total *O. mykiss* catch) displayed at least one of the injury code conditions, other than copepods, listed in Table 2. 53 Chinook salmon (7.5%) and 11 *O. mykiss* (4.0%) were dead at the time the trap was checked. To provide insight on injuries associated with capture in the RST, injury data was collected from 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 with captured natural origin fish include descaling less than 20%, descaling greater than 20%, operculum damage and fin damage (Table12).

Additionally, 39 Chinook salmon (12.1% of total Chinook salmon catch) and 12 *O. mykiss* (15.6% of 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 12 illustrates that as tailrace flows increase, so does bodily injury, specifically, descaling less than 20%. Additionally, gas bubble disease in target catch was found to increase slightly when spill increases (Figure 12). A total of 165 juvenile Chinook salmon and 23 juvenile *O. mykiss* were infected with copepods at time of capture (Table 12). Copepod presence on captured Chinook salmon shows a positive correlation with the size of fish, similar to observations made by previous studies (CFS 2023; Monzyk et al. 2015) (Figure 13). 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 14).

Findings from bulk marked and recaptured Chinook salmon illustrated a significantly higher amount of descaling both greater than and less than 20% as compared to their TE released counterparts. Additionally, these fish were evidenced to have a greater percentage of blood eye (hemorrhage), operculum damage, head injury, body tears and the presence of fungus (Table 13). It is worth noting that while TE release injuries at the Big Cliff Dam Tailrace site are assessed using more than 700 Chinook salmon, the bulk marking recapture injuries were seen in only seven individuals. Further assessment and increased sample sizes will be utilized to yield more informed discussions.

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 12. Summary of injuries for Chinook salmon released for trapping efficiency fish, natural origin Chinook salmon, and PIT tagged bulk mark release Chinook salmon at Big Cliff Dam from 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=750)	TE Recapture Injuries (proportion of total) (n=600)	Proportional Percent Change	Observed Chinook Injuries (n=704)	Bulk Marking Recapture Injuries (proportion of total) (n=7)
NXI	33.2%	0.7%	-32.5%	18.3%	0.0%
MUNK	0.0%	0.0%	0.0%	0.2%	0.0%
DS<2	41.7%	89.8%	48.1%	24.2%	57.1%
DS>2	5.1%	7.3%	2.3%	9.5%	42.9%
BLO	0.0%	0.0%	0.0%	0.3%	0.0%
EYB	0.0%	1.0%	1.0%	4.7%	14.3%
BVT	0.0%	0.0%	0.0%	1.3%	0.0%
FVB	0.0%	0.0%	0.0%	2.8%	0.0%
GBD	0.0%	1.8%	1.8%	6.5%	0.0%
POP	0.0%	0.0%	0.0%	1.5%	0.0%
HIN	0.0%	1.0%	1.0%	3.3%	14.3%
OPD	0.4%	8.5%	8.1%	7.0%	14.3%
TEA	0.0%	0.3%	0.3%	1.8%	14.3%
BRU	0.3%	1.3%	1.1%	3.8%	0.0%
HBP	0.0%	0.0%	0.0%	0.5%	0.0%
HO	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.2%	0.0%
HBO	0.0%	0.0%	0.0%	0.2%	0.0%
FID	49.7%	94.7%	44.9%	27.2%	0.0%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=750)	TE Recapture Injuries (proportion of total) (n=600)	Proportional Percent Change	Observed Chinook Injuries (n=704)	Bulk Marking Recapture Injuries (proportion of total) (n=7)
COP	0.0%	0.0%	0.0%	27.5%	85.7%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.1%	0.8%	0.7%	1.2%	14.3%

Table 13. Count and percentages of *O. mykiss* displaying injury by type at Big Cliff Dam Tailrace RST site from 2023.

Injury Code	*O. mykiss* Injuries (n=251)
NXI	80.1%
MUNK	0.0%
DS<2	9.6%
DS>2	4.8%
BLO	0.0%
EYB	2.0%
BVT	1.6%
FVB	4.0%
GBD	5.2%
POP	0.4%
HIN	2.8%
OPD	4.0%
TEA	1.6%
BRU	3.2%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.4%
FID	15.1%
PRD	0.4%
COP	10.4%
BKD	0.0%
FUN	0.8%

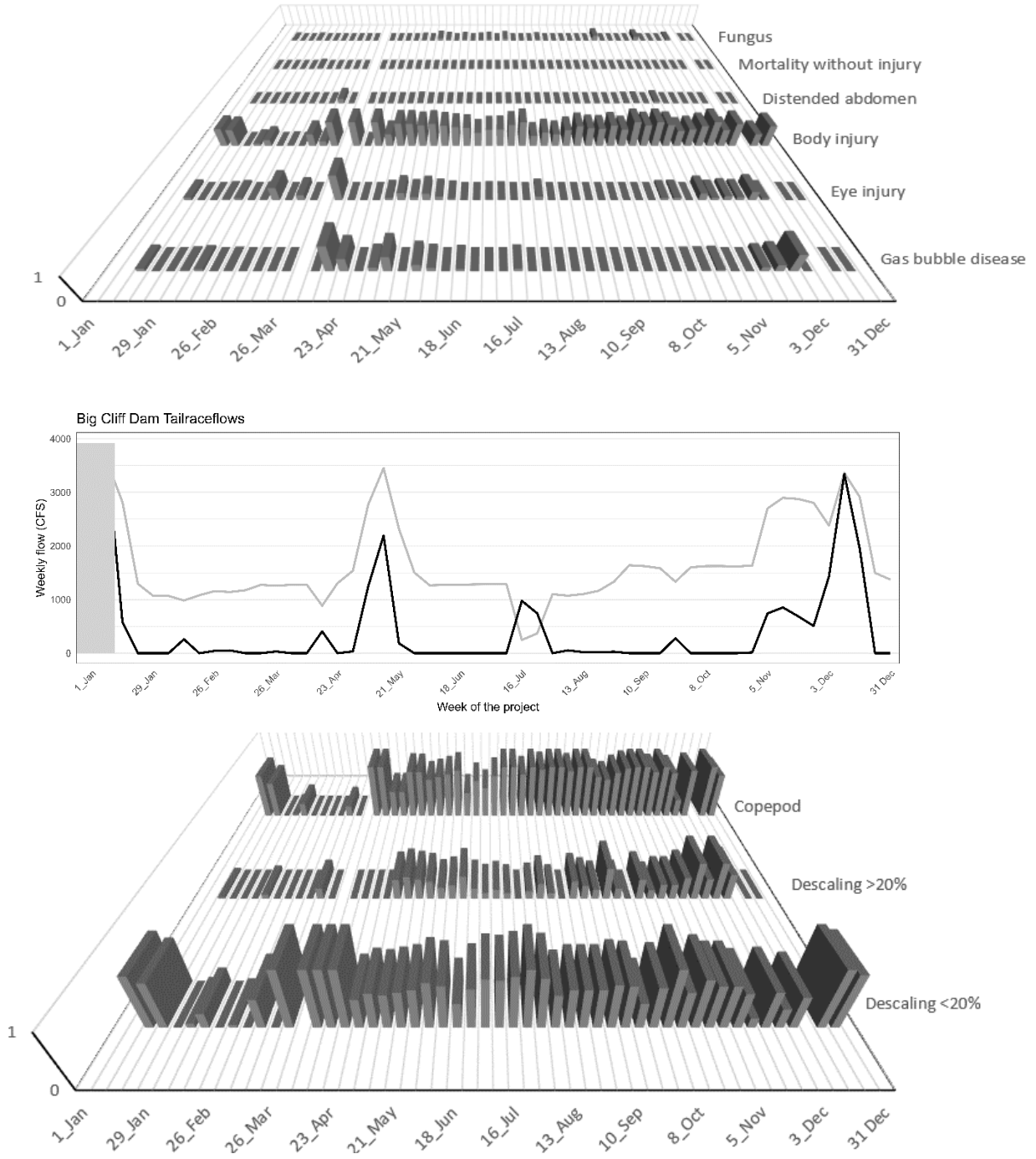

Figure 12. Injury rate of captured Chinook salmon below Big Cliff Dam displaying proportion of fish with injuries by type (top panel) and descaling injuries and copepod presence (bottom panel). The middle panel shows spill (black line) and Powerhouse flow (gray line) at Big Cliff Dam from 2023.

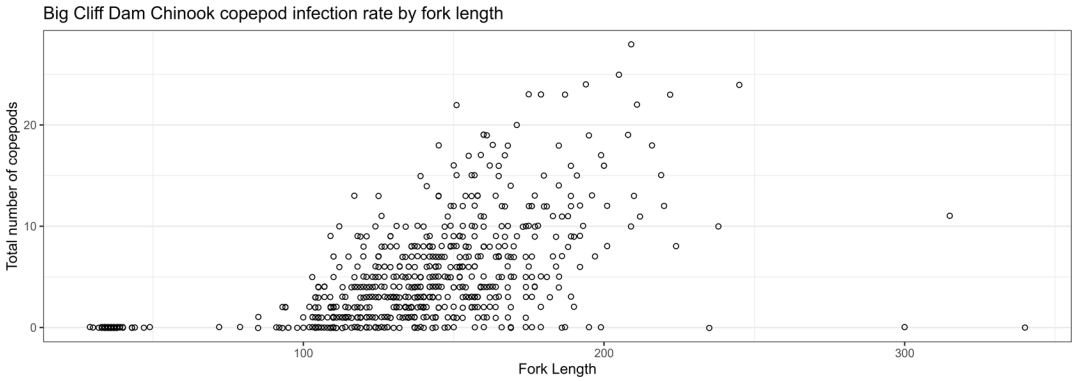

Figure 13. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon below Big Cliff Dam from 2023.

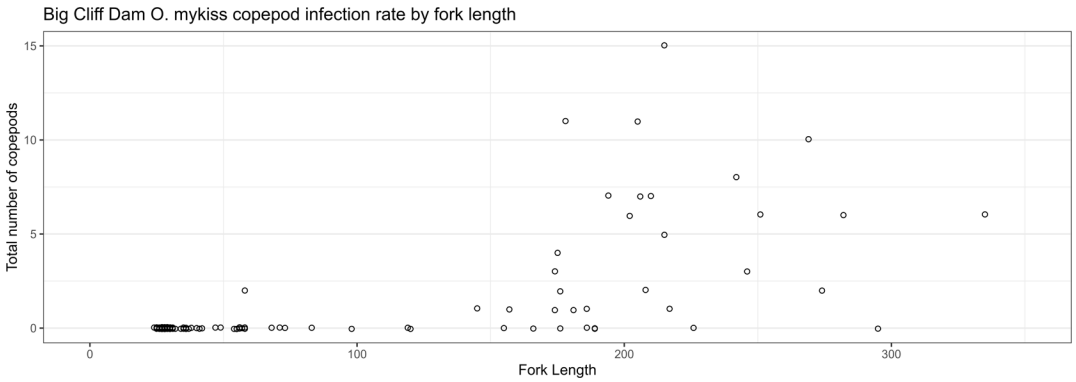

Figure 14. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile *O. mykiss* below Big Cliff Dam from 2023.

24-Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook salmon and *O. mykiss* captured in the Big Cliff Dam Tailrace to assess delayed mortality potentially from dam passage, collection, or holding. A total of 758 fish, 600 Chinook salmon and 158 *O. mykiss*, were held in 2023 (Table 14). A total of 83 fish died during hold (10.9%), 79 of the 600 Chinook salmon (13.2%) and 4 of the 158 *O. mykiss* (2.5%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100%.

Table 14. Summary of 24-hour hold trials for fish captured in the RST at the Big Cliff Dam Tailrace site for 2023.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
1/16/2023–1/31/2023	Chinook	39	4	89.7%
1/16/2023–1/31/2023	*O. mykiss*	2	0	100.0%
10/1/2023–10/15/2023	Chinook	67	19	71.6%
10/16/2023–10/31/2023	Chinook	59	15	74.6%
10/16/2023–10/31/2023	*O. mykiss*	2	0	100.0%
11/1/2023–11/15/2023	Chinook	20	4	80.0%
11/1/2023–11/15/2023	*O. mykiss*	0	0	--
11/16/2023–11/30/2023	Chinook	9	3	66.7%
11/16/2023–11/30/2023	*O. mykiss*	0	0	--
12/1/2023–12/15/2023	Chinook	9	2	77.8%
12/1/2023–12/15/2023	*O. mykiss*	1	0	100.0%
12/16/2023-12/31/2023	Chinook	14	1	92.9%

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
12/16/2023–12/31/2023	*O. mykiss*	1	1	0.0%
2/1/2023–2/15/2023	Chinook	43	1	97.7%
2/1/2023–2/15/2023	*O. mykiss*	3	0	100.0%
2/16/2023–2/28/2023	Chinook	43	0	100.0%
2/16/2023–2/28/2023	*O. mykiss*	1	0	100.0%
3/1/2023–3/15/2023	Chinook	22	0	100.0%
3/1/2023–3/15/2023	*O. mykiss*	1	1	0.0%
3/16/2023–3/31/2023	Chinook	7	0	100.0%
3/16/2023–3/31/2023	*O. mykiss*	1	1	0.0%
4/1/2023–4/15/2023	Chinook	1	0	100.0%
4/1/2023–4/15/2023	*O. mykiss*	2	0	100.0%
4/16/2023–4/30/2023	Chinook	3	0	100.0%
4/16/2023–4/30/2023	*O. mykiss*	1	0	100.0%
5/1/2023–5/15/2023	Chinook	38	7	81.6%
5/1/2023–5/15/2023	*O. mykiss*	7	0	100.0%
5/16/2023–5/31/2023	Chinook	19	3	84.2%
5/16/2023–5/31/2023	*O. mykiss*	3	1	66.7%
6/1/2023–6/15/2023	Chinook	27	3	88.9%
6/1/2023–6/15/2023	*O. mykiss*	2	0	100.0%
6/16/2023–6/30/2023	Chinook	49	1	98.0%
6/16/2023–6/30/2023	*O. mykiss*	37	0	100.0%
7/1/2023–7/15/2023	Chinook	42	3	92.9%
7/1/2023–7/15/2023	*O. mykiss*	78	0	100.0%
7/16/2023–7/31/2023	Chinook	11	0	100.0%
7/16/2023–7/31/2023	*O. mykiss*	3	0	100.0%
8/1/2023–8/15/2023	Chinook	20	3	85.0%
8/1/2023–8/15/2023	*O. mykiss*	4	0	100.0%
8/16/2023–8/31/2023	Chinook	20	3	85.0%
8/16/2023–8/31/2023	*O. mykiss*	8	0	100.0%
9/1/2023–9/15/2023	Chinook	22	4	81.8%
9/1/2023–9/15/2023	*O. mykiss*	0	0	--
9/16/2023–9/30/2023	Chinook	16	3	81.3%
9/16/2023–9/30/2023	*O. mykiss*	1	0	100.0%

PIT Tagged fish and Downstream Detections

A total of 54 fish were PIT tagged at the Big Cliff Dam site in 2023, 51 juvenile Chinook salmon and 3 juvenile *O. mykiss*. The first 60 target fish captured at this location every week are prioritized for the 24-hour hold study and not tagged. No PIT tagged fish were detected downstream and no VIE marked fish were detected at the site from upstream release sites. A summary of all tagged fish can be found in Appendix C.

Willamette Valley Projects Encounters

In March of 2023, ODFW released 100,000 Bismarck dyed hatchery Chinook fry into Detroit Reservoir at the Mongold boat launch (L. Whitman, Personal Communication, July 14, 2023). None of these fish were observed in the Big Cliff RST during 2023. However, it is likely that some of these fish were captured in the RST, but crews were no longer able to distinguish them as they were not adipose clipped and it is possible that the Bismarck Brown could not be detected. Additionally, ODFW released 2,968 Bismarck dyed

hatchery Chinook fry into the Big Cliff Dam Tailrace. A total of 61 fish from this release group were captured in the Big Cliff Dam RST within 1 week of the initial release.

Additionally, Cramer released large groups of PIT tagged fish in the North Santiam River basin in 2023. A total of 7 adipose clipped and PIT tagged Chinook salmon from Cramer Fish Science's bulk mark releases were detected at the Big Cliff Dam RST in the fall of 2023. For more information regarding release groups, dates, and other redetections, refer the *Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

A total of 447 non-target fish were captured in addition to natural origin juvenile Chinook salmon and *O. mykiss* at the Big Cliff Dam RST site in 2023 (Table 15). The most common non-targets captured were kokanee and bluegill.

Table 15. Summary of non-target species captured at the Big Cliff Dam RST site for 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	103	47
Brown Bullhead	6	2
Chinook (clipped)	43	6
Crappie	1	0
Dace	1	0
Sculpin	2	1
Chinook (adult)	1	1
Kokanee	212	40
Kokanee (clipped)	18	7
O. mykiss (clipped)	6	2
Pumpkinseed	45	11
Unknown	1	1
Mountain Whitefish	8	1
Totals	**447**	**119**

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

Detroit Head of Reservoir – North Santiam River

A single 5-foot RST was deployed in the North Santiam River above Detroit Reservoir on April 5, 2023. Initiation of sampling at this site was delayed from February 1, 2023, to May 4, 2023, when sampling permits were approved. Sampling occurred from May 4, 2023, to November 30, 2023. The trap did not sample from May 30, 2023, to May 31, 2023, to prevent damage to Chinook salmon fry in the livewell, after ODFW released hatchery *O. mykiss* at the RST site. A summary of trap sampling outages can be found in Appendix B.

Trapping Efficiency Trials

A total of nine TE trials (all successful with five or more returns) occurred using hatchery reared Chinook salmon at the Detroit Head of Reservoir – North Santiam site. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 16.

TEs ranged from 1.7% to 11.2%. The TE pooled average of all nine trials was 6.1% with 95% CI of 2.51%. A linear fit to the data suggests a positive association with flow (Rsq=0.37), but currently is not statistically significant (P=0.08) at the P=0.05 level. Interestingly, cone flux one day after the TE trial also show a stronger positive association with TE (Rsq=0.67) and significant P-value (p=0.007). A linear fit of cone flux one day after the trial compared to the flow shows a positive association (Rsq=0.5) and has a significant P-value (p=0.03). Although correlated, it appears the cone flux is capturing more information related to the TE rather than flow alone, and we plan to explore this in more detail in the future. Plots displaying TE in relation to flow, cone flux, and flow against cone flux for all trials are displayed in Appendix E.

Table 16. 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	540	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%

Run of River Trapping Efficiency Trials

A total of 359 Chinook salmon were released for ROR TE trials in 2023. A total of 18 fish were recaptured in the RST. Table 17 shows a summary of ROR TE trial releases and recaptures by month for this site.

Table 17. Summary table of run of river releases at the Detroit Head of Reservoir site for trapping efficiency for 2023.

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%

Target Catch, Passage Estimates and Passage Timing

The trap captured 10,141 juvenile Chinook salmon and 590 juvenile *O. mykiss* in 2023 (Figures 15 and 17). Peak capture of juvenile Chinook salmon entering Detroit Head of Reservoir in the spring occurred during May (n=6,849, 64.0% of total Chinook salmon catch). Chinook salmon catch from the initiation of sampling through June 30, 2023, was composed almost entirely of BY 2022 juveniles (n=9,125) (Figure 16). A single BY 2021 Chinook salmon was captured on May 24, 2023, while BY 2022 Chinook salmon were captured throughout the sampling period. The first BY 2022 sub-yearling captured at the trap occurred on May 5, on the first day of sampling. Previous monitoring efforts observed median migration dates in May with the earliest median date of migration being April 20 (Romer et al. 2016). This coupled with the capture of fry on the first day of sampling suggests that many fish migrated into Detroit Reservoir prior to the initiation of sampling. Chinook catch from 2023 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 2022. Similar observations were made during previous sampling were 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 B1). Adult Chinook out planting numbers for 2020 through 2023 are provided in Appendix I, Table I-1.

A total of 1,014 juvenile Chinook salmon were captured between July 1, 2023, and November 30, 2023. Peak capture of juvenile Chinook salmon in the fall occurred in November (n=375, 3.7% of total Chinook salmon catch). All Chinook salmon captured during this time were BY 2022 sub-yearlings. Chinook salmon catch in the fall coincided with increases in flow, similar to observations from previous sampling efforts and other sites within this report. Using TEs by flow category, we estimate that 216,134 (95% CI: 153,414 to 528,666) juvenile Chinook salmon passed the trapping site in 2023 (Figure 15).

Peak capture of juvenile *O. mykiss* in the spring monitoring period occurred in May (n=451, 91.7% of total *O. mykiss* catch), while peak capture in the fall monitoring period occurred in August (n=18, 3.1% of total *O. mykiss* catch) (Figure 17). *O. mykiss* catch from the initiation of sampling to June 30, 2023, consisted of four BYs: BY 2019, 2021, 2022, and 2023 (Figure 18). BY 2023 was the dominant age class captured at the site with 484 individuals (98.2% of spring capture). A total of 1 BY 2019, 1 BY 2021, and 7 BY 2022 *O. mykiss* were also captured during this time.

Capture of *O. mykiss* from July 1, 2023, to November 30, 2023, comprised 98 fish from three BYs: 2 BY 2021, 1 BY 2022, and 94 BY 2023 fish. Fall capture of *O. mykiss* did not coincide with increases in flow or stream temperature. A summary of fork length and weight data for Chinook salmon and *O. mykiss* captured at this site in 2023 is provided in Table 18.

Table 18. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* of natural origin at the Detroit Head of Reservoir RST site by brood year from 2023.

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	1/1/23–6/30/23	21	1	61	61	61	N/A	2.6	2.6	2.6	N/A
Chinook	1/1/23–6/30/23	22	9,125	35.6	28	70	35	N/A	N/A	N/A	N/A
Chinook	7/1/23–11/30/23	22	1,015	76.0	33	117	79	5.5	1.0	18.2	5.5
O. mykiss	1/1/23–6/30/23	19	1	408	408	408	N/A	N/A	N/A	N/A	N/A
O. mykiss	1/1/23–6/30/23	21	1	188	188	188	N/A	66.5	66.5	66.5	N/A
O. mykiss	1/1/23–6/30/23	22	7	79.4	49	99	82	7.0	2.3	10.6	6.4
O. mykiss	1/1/23–6/30/23	23	484	35.5	25	46	35	N/A	N/A	N/A	N/A
O. mykiss	7/1/23–11/30/23	21	2	199.5	169	230	N/A	74.5	53.4	95.6	N/A
O. mykiss	7/1/23–11/30/23	22	1	112	112	112	N/A	15.4	15.4	15.4	N/A
O. mykiss	7/1/23–11/30/23	23	94	35.8	20	90	26	N/A	N/A	N/A	N/A

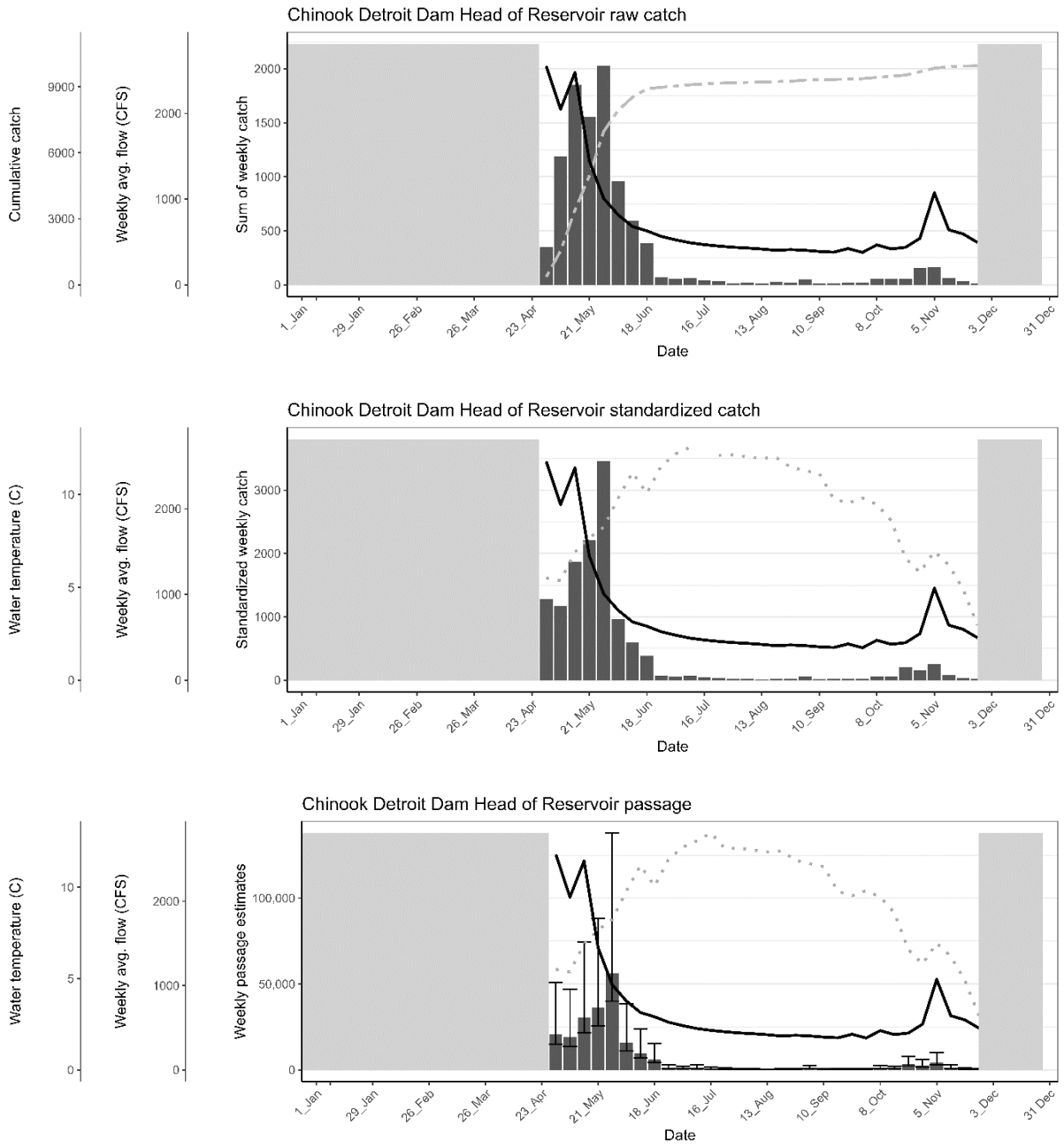

Figure 15. Raw catch (top panel), standardized catch (middle panel), and weekly passage estimates (bottom panel) of natural origin juvenile Chinook salmon at the Detroit Head of Reservoir – North Santiam River site with stream flow (black line), cumulative catch (gray dot dash line), water temperature (gray dots), and non-sampling weeks shaded out (gray) for 2023.

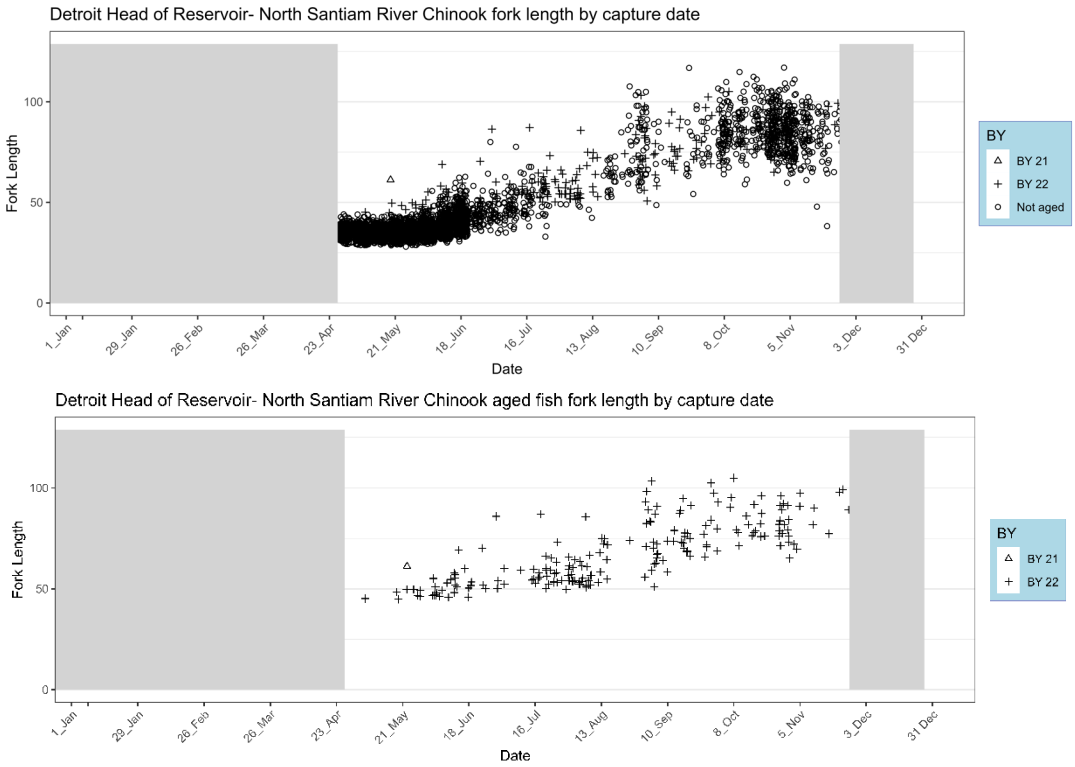

Figure 16. Length-frequency of juvenile Chinook salmon by brood year at the Detroit Head of Reservoir – North Santiam River site for 2023. Top panel shows all fish and bottom panel shows only the aged fish.

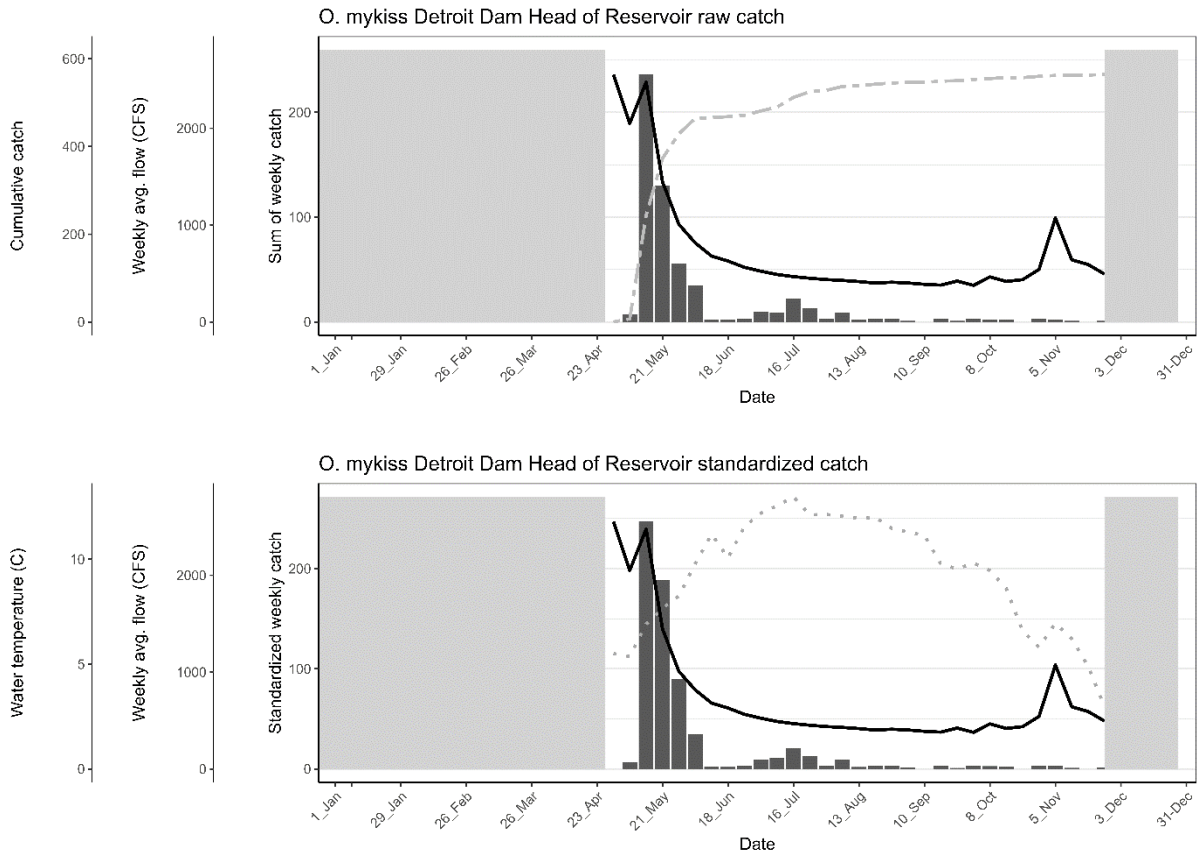

Figure 17. Shows raw (top panel) and weekly standardized (bottom panel) catch of juvenile *O. mykiss* overlayed with flow (black line), stream temperature (gray dotted line), and non-sampling weeks shaded out (gray) at the Detroit Head of Reservoir – North Santiam River site for 2023.

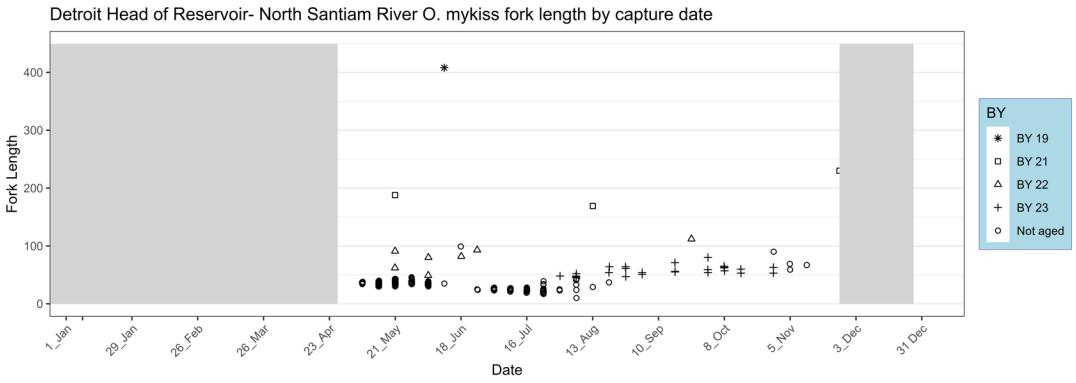

Figure 18. Length-frequency of juvenile *O. mykiss* by brood year at the Detroit Head of Reservoir – North Santiam River site for 2023.

Injury Data

A total of 943 juvenile Chinook salmon (9.3% of total Chinook salmon catch) and 32 *O. mykiss* (5.4% of total *O. mykiss* catch) displayed at least one of the injury code conditions listed in Table 2. The most frequently observed injury in both Chinook salmon and *O. mykiss* at the Detroit Head of Reservoir RST site was descaling less than 20% (Table 19). 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 target catch (90.1% of

Chinook salmon catch and 93.6% of *O. mykiss* catch) at this site was evidenced to have no external injuries found (Table 19). There were 58 Chinook salmon mortalities (0.1% of Chinook salmon catch) likely resulting from high debris in the trap. Copepods were only observed on Chinook salmon with fork lengths greater than 50 mm and did not show a strong association with increasing size of fish, as has more recently been observed below dams (Figures 19 and 20). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 19. Summary of injuries observed on juvenile Chinook salmon and *O. mykiss* at the Detroit Head of Reservoir – North Santiam River RST site for 2023.

Injury Code	Chinook Injuries (NOR) (n=10,141)	*O. mykiss* Injuries (n=590)
NXI	90.1%	93.6%
MUNK	0.0%	0.2%
DS<2	7.0%	2.2%
DS>2	0.5%	0.8%
BLO	0.1%	0.2%
EYB	0.1%	0.8%
BVT	0.3%	0.2%
FVB	0.5%	0.3%
GBD	0.0%	0.2%
POP	0.1%	0.3%
HIN	0.3%	1.0%
OPD	0.5%	0.7%
TEA	0.5%	0.5%
BRU	0.7%	1.0%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	0.3%	2.9%
PRD	0.2%	0.3%
COP	0.5%	0.2%
BKD	0.0%	0.0%
FUN	0.1%	0.2%

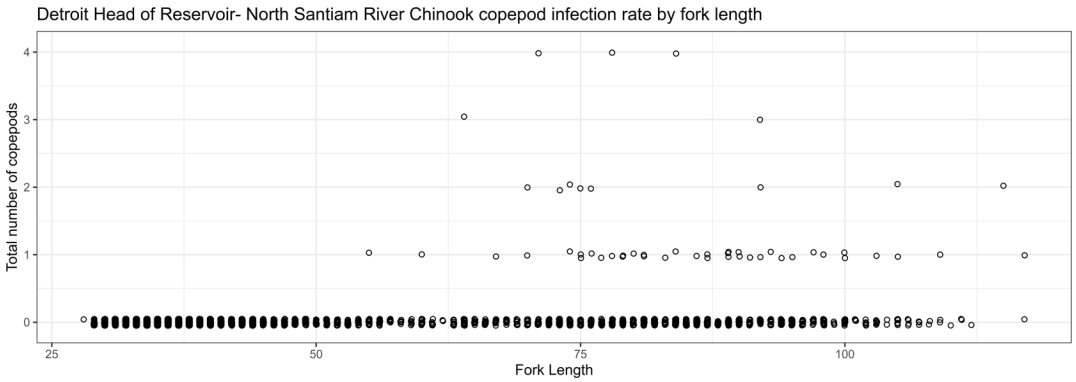

Figure 19. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Detroit Head of Reservoir from 2023.

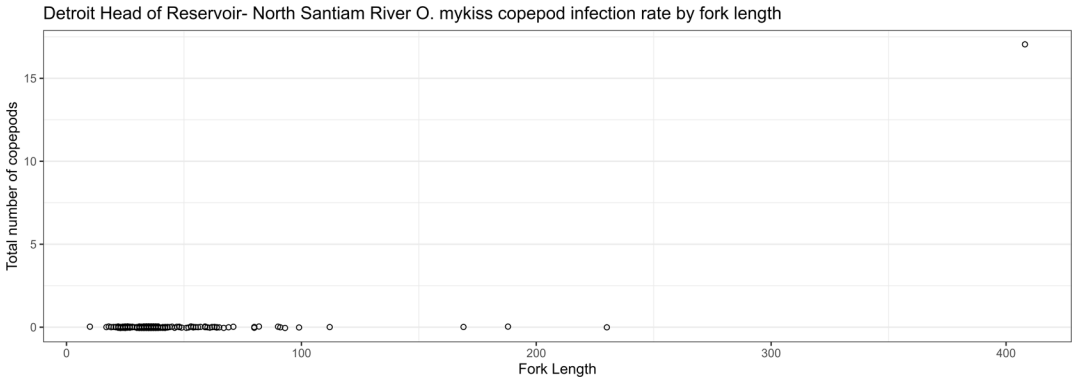

Figure 20. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile *O. mykiss* at Detroit Head of Reservoir from 2023.

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 736 NOR fish were PIT tagged at this site in 2023, 720 Chinook salmon and 16 *O. mykiss*. A total of 5,439 NOR Chinook salmon and 345 NOR *O. mykiss* were VIE marked during 2023. Some fish were not marked, as they were still sac-fry or too small to safely mark. As of December 31, 2023, none of the PIT tagged or VIE marked fish have been detected at downstream sites. Table 20 provides a summary of VIE marked fish for the reporting period.

Table 20. Summary table of VIE marked fish at the Detroit Head of Reservoir – North Santiam RST site for 2023.

Date Tagged	Species	Tag Location	VIE Color	# Tagged	# Recaptured
5/01/2023–5/15/2023	Chinook	Right Dorsal	Orange	889	0
5/01/2023–5/15/2023	*O. mykiss*	Right Dorsal	Orange	60	0
5/16/2023–5/31/2023	Chinook	Right Dorsal	Orange	2,700	0
5/16/2023–5/31/2023	*O. mykiss*	Right Dorsal	Orange	237	0
6/1/2023–6/15/2023	Chinook	Right Dorsal	Pink	1048	0
6/1/2023–6/15/2023	*O. mykiss*	Right Dorsal	Pink	21	0
6/16/2023–6/30/2023	Chinook	Right Dorsal	Pink	539	0
7/1/2023–7/15/2023	Chinook	Right Dorsal	Green	110	0
7/16/2023–7/31/2023	Chinook	Right Dorsal	Green	74	0
7/16/2023–7/31/2023	*O. mykiss*	Right Dorsal	Green	1	0
8/1/2023–8/15/2023	Chinook	Right Dorsal	Yellow (2x)	25	0
8/1/2023–8/15/2023	*O. mykiss*	Right Dorsal	Yellow (2x)	7	0
8/16/2023–8/31/2023	Chinook	Right Dorsal	Yellow (2x)	21	0
8/16/2023–8/31/2023	*O. mykiss*	Right Dorsal	Yellow (2x)	3	0
9/1/2023–9/15/2023	Chinook	Right Dorsal	Red (2x)	20	0
9/1/2023–9/15/2023	*O. mykiss*	Right Dorsal	Red (2x)	4	0
9/16/2023–9/30/2023	Chinook	Right Dorsal	Red (2x)	4	0
9/16/2023–9/30/2023	*O. mykiss*	Right Dorsal	Red (2x)	2	0
10/1/2023–10/15/2023	Chinook	Right Dorsal	Blue (2x)	1	0
10/1/2023–10/15/2023	*O. mykiss*	Right Dorsal	Blue (2x)	5	0
10/16/2023–10/31/2023	*O. mykiss*	Right Dorsal	Blue (2x)	2	0
10/16/2023–10/31/2023	Chinook	Right Dorsal	Blue (2x)	2	0
11/1/2023–11/15/2023	*O. mykiss*	Right Dorsal	Orange (2x)	3	0
11/1/2023–11/15/2023	Chinook	Right Dorsal	Orange (2x)	3	0
11/16/2023–11/30/2023	Chinook	Right Dorsal	Orange (2x)	3	0

Willamette Valley Projects Encounters

A total of 4 adipose clipped and PIT tagged Chinook salmon were captured at this site in 2023. 1 tag number was identified as an orphan tag. The remaining 3 tags are part of the bulk mark release groups tagged by Cramer and are suspected of having escaped from Marion Forks Fish Hatchery. 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

We captured 497 non-target fish in addition to natural origin juvenile Chinook salmon. A summary of species and numbers of fish caught is provided in Table 21. The most commonly captured non-target species were adipose clipped Chinook salmon and kokanee.

Table 21. 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)	376	1
Cutthroat Trout	4	1
Dace	3	0
Kokanee (wild)	81	1
Mountain Whitefish	5	1
O. mykiss (clipped)	9	2
Sculpin	16	3
Northern Pikeminnow	1	0
Unknown Salmonid	2	1
Totals	**497**	**10**

*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 April 5, 2023. The initiation of sampling was delayed until May 4, 2023, when sampling permits were approved. Sampling occurred from May 4, 2023, to November 30, 2023. The trap began sampling much later than the target date of February 1, 2023, likely missing a significant portion of juvenile Chinook salmon that out-migrated in the spring. Additionally, the USACE out-planted 600 adult Chinook salmon above the trapping site on private land. The landowner denied access for spawning ground surveys in the Middle Santiam River; thus, spawning success in the fall of 2022 for the fish released here is unknown (USACE 2022). Additional information regarding sampling outages is listed in Appendix B.

Trapping Efficiency Trials

A total of nine TE trials occurred using hatchery reared Chinook salmon at the Green Peter Head of Reservoir – Middle Santiam site in 2023. All trials failed to capture five or more returns. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 22.

TEs ranged from 0.0% to 0.1%. Due to a delay in the initiation of sampling and confirmation of access to the release site, we were unable to perform enough trials to calculate a weekly passage estimate for this site. We were unable to test this site until June, at which point gage height (a proxy for flow) had dropped to a level that resulted in the trap rotating slowly or completely stopping, allowing fish to easily avoid the trap. The location of the RST is limited by the fact that the trap and its associated highline must be wholly contained 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, or 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.

Additionally, the RST is located within the thalweg, the best overall sampling position for the RST across all seasons, and does not spin sufficiently at low flows in the summer, an occurrence commonly evidenced when operating sampling machinery of this nature. As such, TE at this site is anticipated to increase with flow as faster water velocity through this site allows the trap to sample more effectively. Comparing flow rate against gage height, the trap stops spinning at and below a gage height of 2 ft. Seven trials occurred when the gage height was at <2 ft and the trap did not spin between checks. One trial occurred at a gage height of 2.69 ft, but the trap was not functional due to a log stuck in the cone. The last remaining trial captured one fish at a gage height of 2.54 ft. None of the trials performed in 2023 yielded the minimum number of recaptures necessary to consider them successful trials. All trials performed in 2023 were conducted during low flow conditions. These low flow trials suggest that below a certain flow level, the trap cannot efficiently sample and capture out-migrating fish. Based on weekly gage height averages, the trap is essentially non-functional from June to early November in 2023 (Figure 21). Additional trials across more gage heights >2 ft are planned in 2024 to allow for passage estimates in future reports. In the past year, gage height at this site ranged from 0.86 ft to 8.64 ft.

Table 22. 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	1	0.1%
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	1.0	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%

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	10/11/2023	2.69	750	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	10/31/2023	1.46	750	0	0.0%
Green Peter Head of Reservoir – Middle Santiam (dead fish)	10/31/2023	1.46	1,000	0	0.0%
Green Peter Head of Reservoir – Middle Santiam	11/15/2023	2.54	749	1	0.1%

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Green Peter Head of Reservoir in 2023. There were insufficient capture numbers from fish large enough to mark to perform trials.

Target Catch, Passage Estimates, and Passage Timing

The trap captured 25 juvenile Chinook salmon and 1 juvenile *O. mykiss*. All captures of juvenile Chinook salmon and *O. mykiss* predominantly occurred prior to May 16, 2023. Peak capture of juvenile Chinook salmon in the spring occurred in May (n=21, 84.0% of total catch), while peak capture in the fall occurred in November (n=4, 16% of total catch) (Figure 21). Chinook salmon catch was composed entirely of BY 2022 fish (Figure 23). The first BY 2022 sub-yearling captured at the trap occurred on May 5, one day after the start of sampling. This, combined with observations of early sub-yearling out migration in the nearby South Santiam system, suggest that many Chinook salmon sub-yearlings likely passed the trapping site prior to the initiation of sampling (EAS 2023). Figure 21 shows raw and standardized catch overlayed with flow at the Green Peter Head of Reservoir- Middle Santiam site.

Using TE trials, EAS was not able to make passage estimates. As previously stated, low gage heights (especially below 2 ft) resulted in TE trials that yielded insignificant results. Additional trials at gage heights >2 ft are planned in future reports.

Peak capture of juvenile *O. mykiss* at Green Peter Head of Reservoir occurred in May (n=1, 100% of total catch). *O. mykiss* were not encountered at this RST site during the fall months throughout 2023 (Figure 22). The one *O. mykiss* captured was a sub-yearling (BY 2023) with a fork length of 36 mm (Figure 24). A summary of fork lengths and weights of captured Chinook salmon and *O. mykiss* by BY is provided in Table 23.

Table 23. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* of natural origin at the Green Peter Head of Reservoir RST site by brood year from 2023.

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	1/1/23–6/30/23	22	21	36.4	33	45	36	N/A	N/A	N/A	N/A
Chinook	7/1/23–11/30/23	22	4	105.5	98	114	105	13.9	11.3	18	13.2
O. mykiss	1/1/23–6/30/23	23	1	36	36	36	N/A	N/A	N/A	N/A	N/A

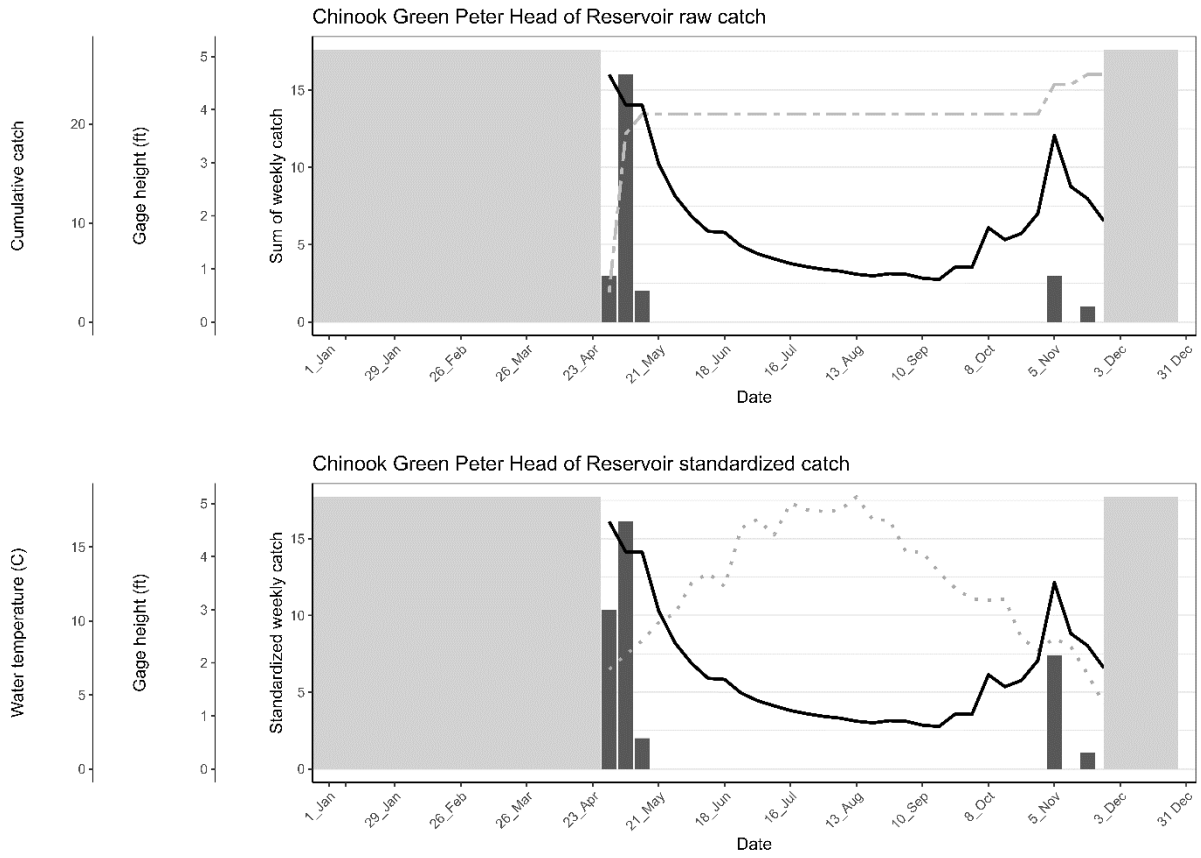

Figure 21. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at the Green Peter Head of Reservoir with stream gage height (black line), cumulative catch (gray dot dash line), stream temperature (gray dash line), and non-sampling weeks shaded out (gray) for 2023.

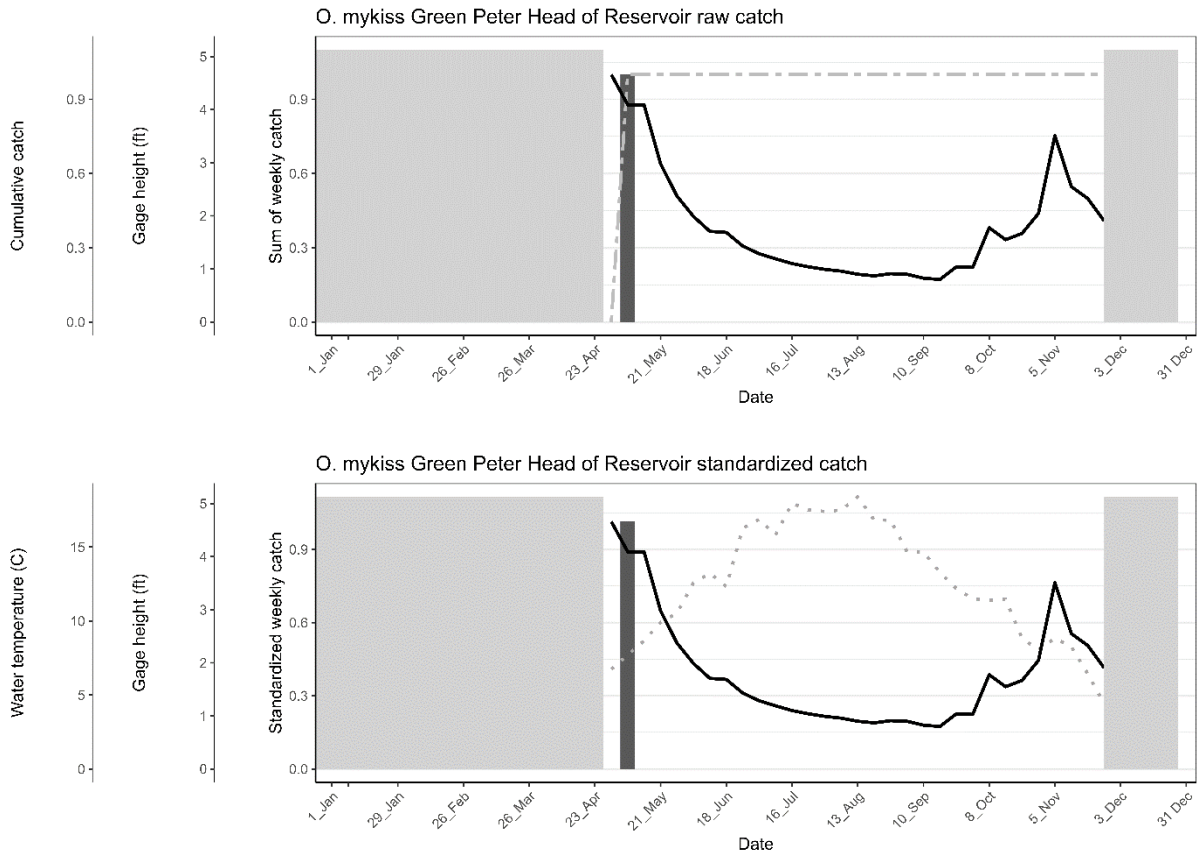

Figure 22. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile *O. mykiss* at the Green Peter Head of Reservoir with stream gage height (black line), cumulative catch (gray dot dash line), stream temperature (gray dash line), and non-sampling weeks shaded out (gray) for 2023.

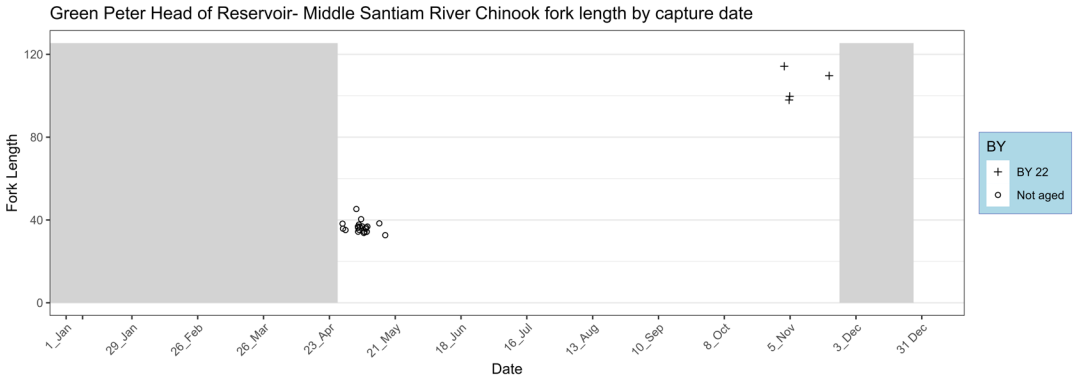

Figure 23. Length-frequency of juvenile Chinook salmon at the Green Peter Head of Reservoir site for 2023.

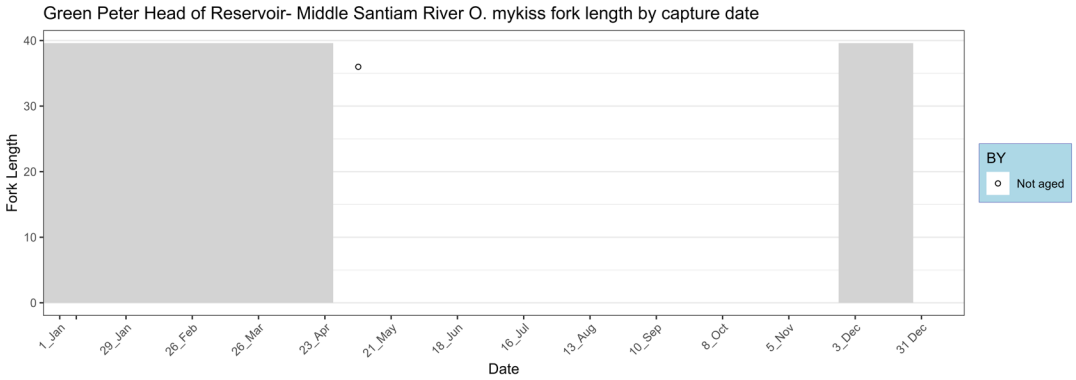

Figure 24. Length-frequency of juvenile *O. mykiss* at the Green Peter Head of Reservoir site for 2023.

Injury Data

A total of 6 juvenile Chinook salmon (24.0% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 2. Descaling less than 20%, descaling greater than 20%, bruising, and fin damage were the most common injuries seen in Chinook salmon at the Green Peter Head of Reservoir RST (Table 24). These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. Only one *O. mykiss* was trapped for the season, it was unharmed. No fish were observed with copepods at this site (Figures 25 and 26). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 24. Summary of injuries observed on juvenile Chinook salmon and *O. mykiss* at the Green Peter Head of Reservoir – Middle Santiam River RST site for 2023.

Injury Code	Chinook Injuries (NOR) (n=6)	*O. mykiss* Injuries (n=1)
NXI	76.0%	100.0%
MUNK	0.0%	0.0%
DS<2	12.0%	0.0%
DS>2	4.0%	0.0%
BLO	0.0%	0.0%
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	0.0%	0.0%
TEA	4.0%	0.0%
BRU	8.0%	0.0%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	16.0%	0.0%
PRD	4.0%	0.0%
COP	0.0%	0.0%
BKD	0.0%	0.0%
FUN	0.0%	0.0%

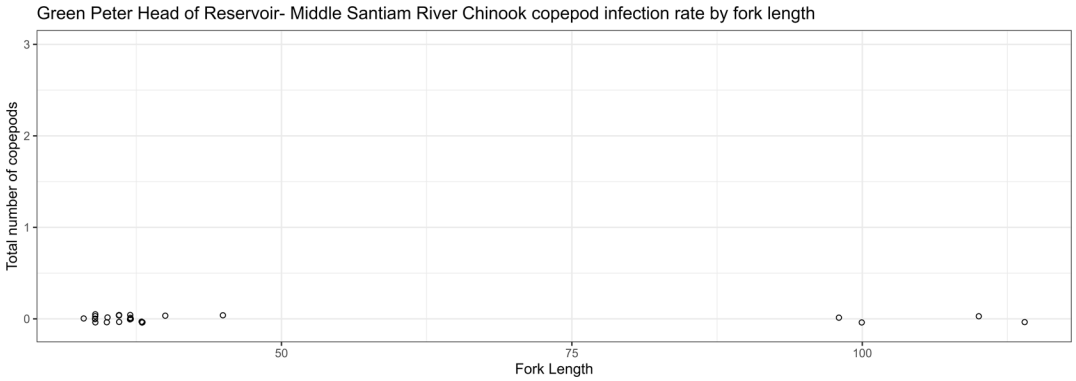

Figure 25. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Green Peter Head of Reservoir from 2023.

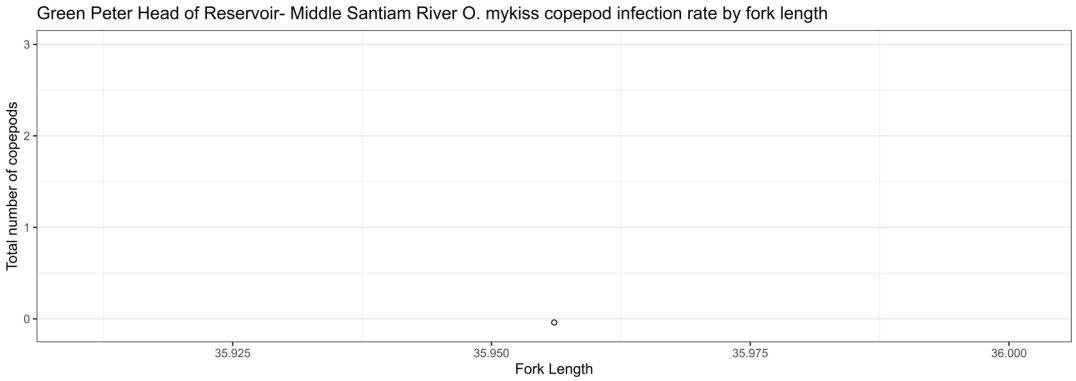

Figure 26. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile *O. mykiss* at Green Peter Head of Reservoir from 2023.

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 4 juvenile Chinook salmon were PIT tagged and 15 were VIE marked at the Green Peter Head of Reservoir – Middle Santiam site in 2023. The 1 juvenile *O. mykiss* captured was VIE marked. The rest of the fish captured 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 25 shows a summary of VIE marked fish with the tagging period and mark details.

Table 25. 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 to Date
5/01/2023–5/15/2023	Chinook	Right dorsal	Orange	14	0
5/01/2023–5/15/2023	*O. mykiss*	Right dorsal	Orange	1	0
5/16/2023–5/31/2023	Chinook	Right dorsal	Orange	1	0

Non-Target Capture Data

A total 36 non-target fish were captured in addition to natural origin juvenile Chinook salmon and *O. mykiss*. A summary of species and numbers of fish caught are provided in Table 26. The most commonly captured non-target species were dace and kokanee.

Table 26. 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)	2	0
Largescale Sucker	1	1
Dace	25	1
Kokanee (wild)	5	1
Sculpin	3	0
Totals	**36**	**3**

Green Peter Dam Tailrace – Middle Santiam River

A single 8-foot RST was deployed in the Green Peter Dam Tailrace on March 14, 2023. The initiation of sampling was delayed while a new highline anchor was being designed. The highline was reinstalled on a temporary anchor and the trap began sampling on March 14, 2023. Sampling from March 14 to November 30, 2023, was performed under contract W9127N19D0007. However, all data collected in 2023 for this site will be included in this report. The trap was raised to the non-sampling position from March 23, 2023, to March 31, 2023, while EAS sub-contracted construction crews were working in the tailrace to install the new highline and anchor. Flows in the Green Peter Dam Tailrace were maintained at 50 cfs in March through the new highline anchor installation. Spill was initiated once the reservoir reached the spillway crest, after the new highline was installed and the RST was actively sampling.

Further details regarding trap sampling outages can be found in Appendix B. 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 2023a).

Trapping Efficiency Trials

A total of two TE trials occurred using hatchery reared Chinook salmon in the Green Peter Dam Tailrace for this contract. A cumulative total of 17 trials have occurred at this site since sampling initiated in 2022. Sampling prior to December 1, 2023, was conducted by EAS for the USACE under contract W9127N19D0007. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 27.

TEs for live fish releases ranged from 0.0% to 2.8%. TE used to calculate passage was composed of the pooled average of 13 trials: 1.4% with 95% CI of 0.47%. The one trial performed with dead fish did not yield any recaptures. Due to the late start resulting from new anchor construction, low flows in April, and constraints on hatchery fish availability due to illness, fewer trials were performed than previously anticipated. Some issues impacting trials at this site have resulted from unscheduled changes to flow and suspected predation of fish in the live well by mammalian predators. Future trials will be conducted at this site to provide more data on the trap's efficiency across the range of flows sampled throughout the year. Plots displaying TE against flow for all trials are provided in Appendix E.

Table 27. 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	1310	518	9	1.7%
Green Peter Dam Tailrace – Spill (dead fish)*	5/11/2023	1910	1,001	0	0.0%
Green Peter Dam Tailrace – Spill*	5/11/2023	1910	999	9	0.9%
Green Peter Dam Tailrace – PWR*	5/25/2023	1980	1,000	10	1.0%
Green Peter Dam Tailrace – Powerhouse (dead fish)	6/30/2023	2190	1,000	9	0.9%
Green Peter Dam Tailrace – Powerhouse*	6/30/2023	2,190	1,000	10	1.0%
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	1970	1,000	8	0.8%
Green Peter Dam Tailrace – PWR*	10/4/2023	2930	1,005	0	0.0%
Green Peter Dam Tailrace*	11/1/2023	1800	1,000	22	2.2%
Green Peter Dam Tailrace*	11/14/2023	1300	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	3700	1,000	25	2.5%
Green Peter Dam Tailrace – Spill	12/19/2023	50	1,000	3	0.3%

*Release performed by EAS for the USACE under contract W9127N19D0007.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Green Peter Dam in 2023. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study. Thus, sufficient numbers of ROR fish were not available to perform ROR TE trials.

Target Catch, Passage Estimates and Passage Timing

The trap captured 107 naturally produced juvenile Chinook salmon and 12 juvenile *O. mykiss* at this site in 2023. *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 the latter half of May (n=86, 80.4% of total Chinook salmon catch) (Figure 27). Peak capture of juvenile *O. mykiss* also occurred in May (n=8, 66.6% of total *O. mykiss* catch) (Figure 28). Chinook salmon catch was composed entirely of BY 2022 sub-yearlings (Figure 29). The *O. mykiss* captured consisted of two-year old (n=5, 41.7%), one-year old (n=6, 50.0%), and a sub-yearling (n=1, 8.3%) fish (Figure 30). Descriptive statistics on fork length and size of fish captured at Green Peter Dam by BY is provided below in Table 28.

Peak capture of both Chinook salmon and *O. mykiss* occurred in the spring and coincided with surface spill operations. There were also fish captured prior to the initiation of surface spill suggesting that some juvenile Chinook salmon had arrived in the forebay earlier in the year while the reservoir was still in spring refill operations. Some Chinook salmon were observed in the RST catch as the fall drawdown neared 900 ft of elevation and again once the drawdown had reached its lowest elevation in November (Figures 27 and 28). During this time, the water in the tailrace of Green Peter Dam became increasingly turbid and kokanee dominated the catch (see Appendix J, Figure J-1). Crews also noted an uptick in activity from river otters and suspected that they may have been able to circumvent our attempts to exclude them from the RST live well. Considering these factors, it is possible that some Chinook salmon may have entered the RST and not been detected during this time leading to a low estimate of Chinook salmon passage during the fall drawdown period. However, TE trials conducted during this period suggests that detection and retention of Chinook salmon in the trap was normal throughout the drawdown. EAS estimate that during sampling in 2023 9,533 (95% CI: 7,083 to 14,571) juvenile Chinook salmon passed through Green Peter Dam Tailrace (Figure 27).

Table 28. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* of natural origin at the Green Peter Dam Tailrace RST site by brood year in 2023.

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	1/1/2023–6/30/2023	22	100	66.8	33	98	66	3.7	1.0	10.8	3.5
Chinook	7/1/2023–12/31/2023	22	7	112.1	89	155	103	15.4	6.8	35.3	12.0
O. mykiss	1/1/2023–6/30/2023	21	5	271.4	240	318	268	183.8	114.0	340.0	143.9
O. mykiss	1/1/2023–6/30/2023	22	5	185.8	174	195	185	62.4	54.4	71.6	59.0
O. mykiss	1/1/2023–6/30/2023	23	1	29	29	29	N/A	N/A	N/A	N/A	N/A
O. mykiss	7/1/2023–12/31/2023	22	1	125	125	125	N/A	90.0	90.0	90.0	N/A

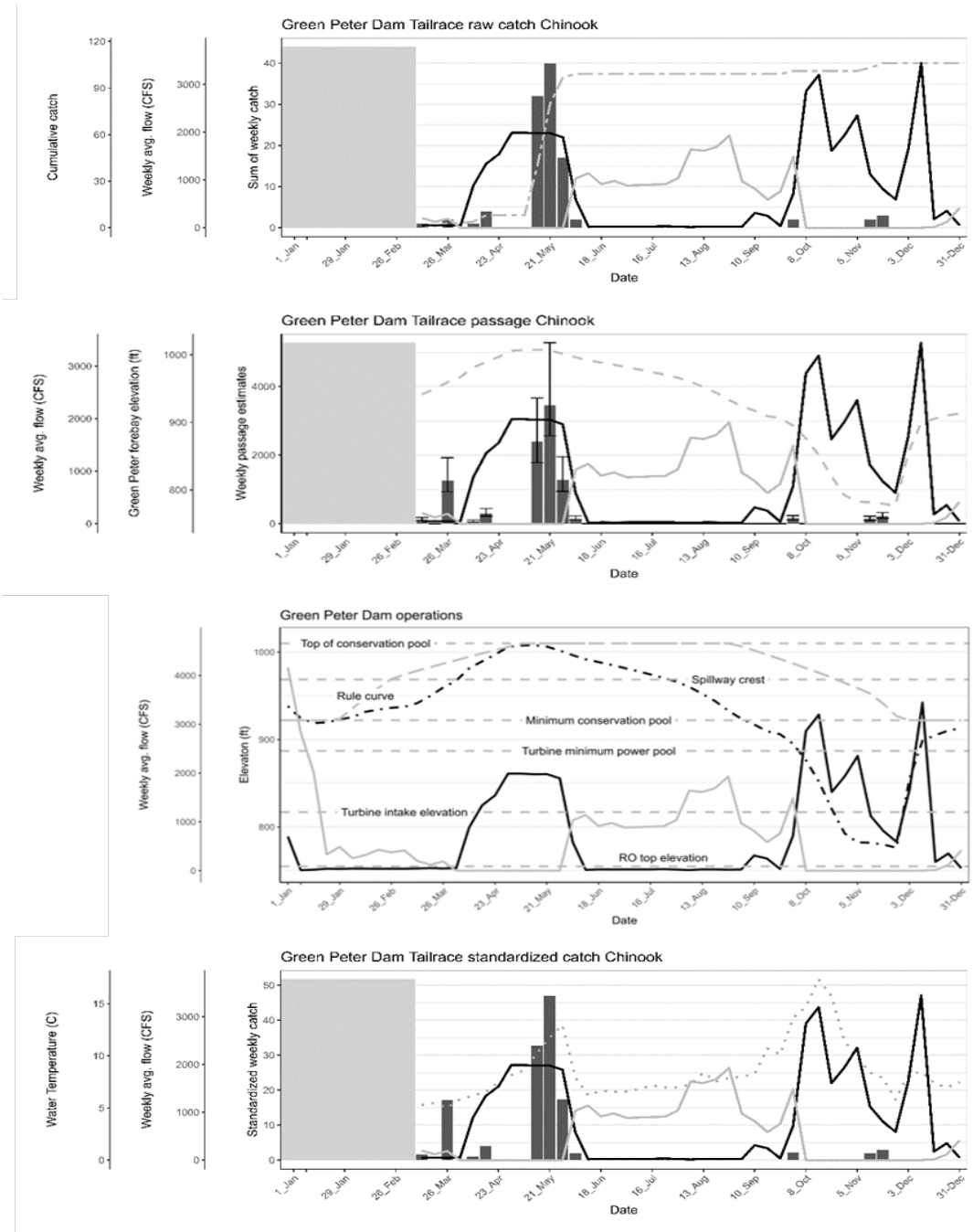

Figure 27. Raw catch (top panel), weekly standardized catch (second panel), and weekly passage estimates (bottom panel) of natural origin juvenile Chinook salmon at Green Peter Dam Tailrace with spill (black line), Powerhouse flow (gray line), cumulative catch (grey two dash line) stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for 2023. 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) from 2023.

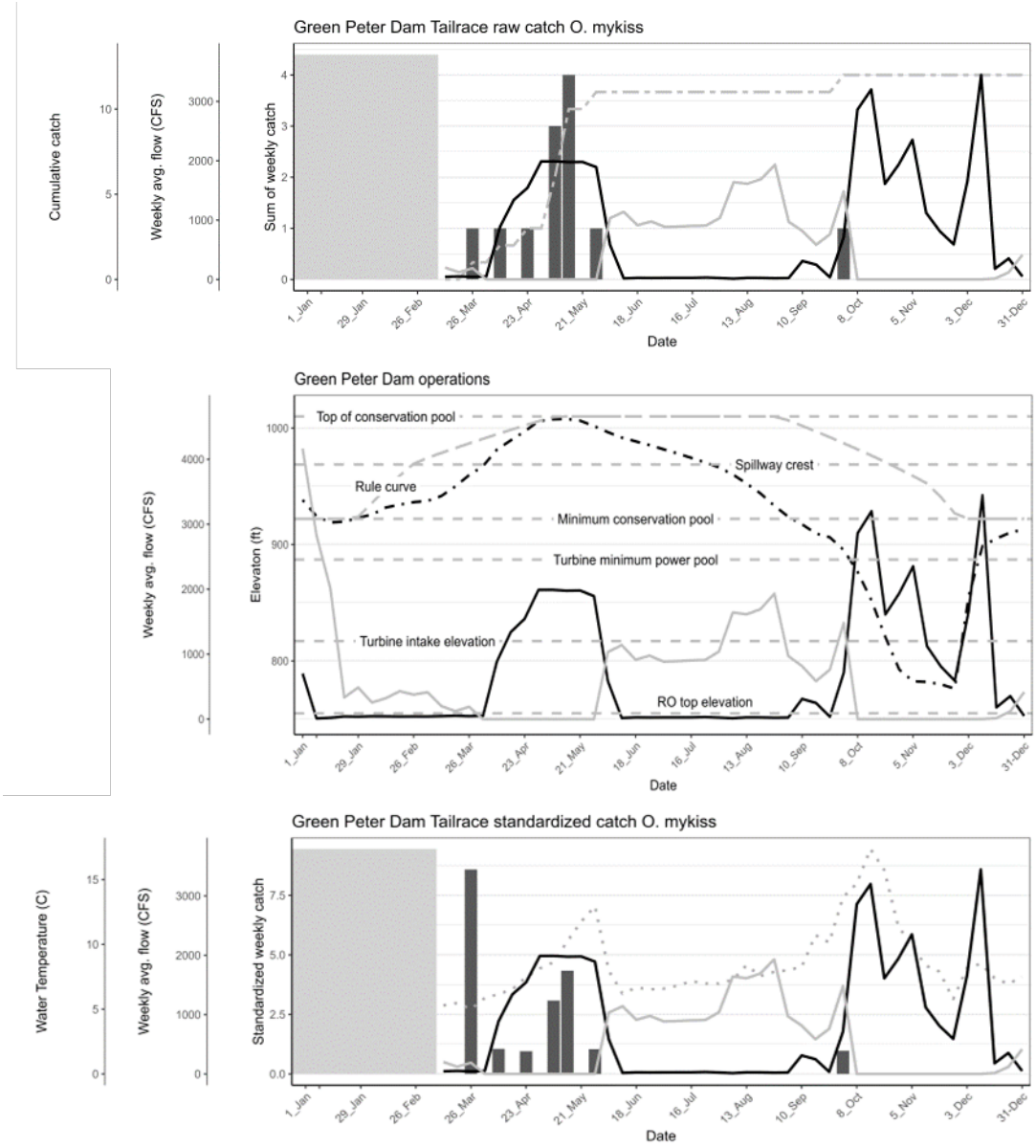

Figure 28. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile *O. mykiss* at Green Peter Dam Tailrace with spill (black line) and Powerhouse flow (gray line), cumulative catch (grey two dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for 2023. 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) from 2023.

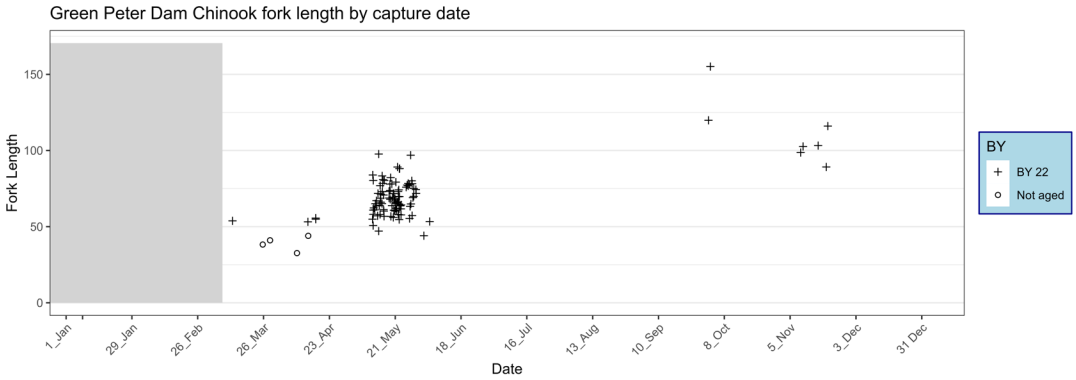

Figure 29. Age length-frequency for captured natural origin Chinook salmon at the Green Peter Dam Tailrace site for 2023.

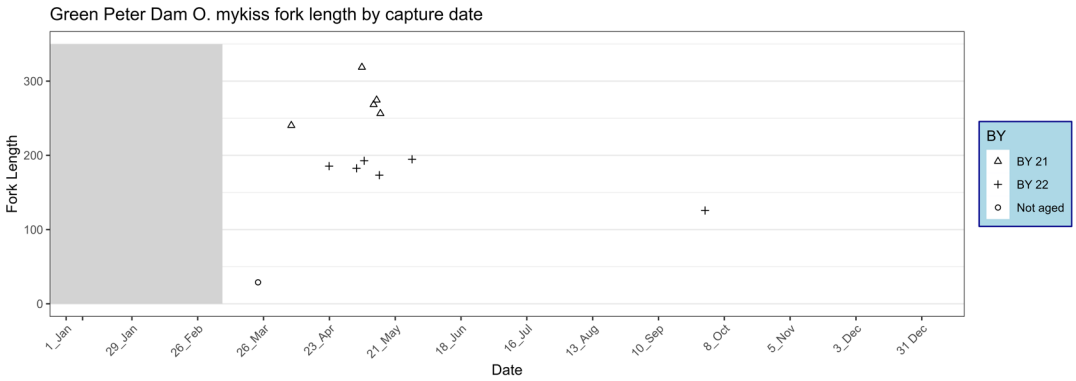

Figure 30. Age length-frequency for captured natural origin *O. mykiss* at the Green Peter Dam Tailrace site for 2023.

Injury Data

A total of 99 juvenile Chinook salmon (92.5%) and 11 juvenile *O. mykiss* (91.7%) displayed at least one of the injury code conditions listed in Table 2. To provide insight on injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for TE trials at time of release and upon recapture. Injury rates by type both pre and post capture were then compared to provide information on a rate of injury occurrence attributable to trap capture. 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 (Table 29). 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.

Chinook salmon that were bulk marked recaptures, from Cramer releases, evidenced higher rates of descaling, broken fin blood vessels, bloody eye (hemorrhage), bleeding from vent, gas bubble disease, head injuries and overall bruising as compared to their TE counterparts (Table 29).

The most common injuries observed on juvenile Chinook salmon and *O. mykiss* at this site include descaling, fin damage and gas bubble disease (Tables 29 and 30). Figures 32 and 33 illustrate that there is no discernable relationship between overall size of Chinook salmon and the presence of copepods.

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.

Observations in relation to injury and flow, predominantly from the spill, are based off 107 wild Chinook salmon captured at the RST site. This is a relatively small sample size, and therefore, it is warranted that additional data is collected to help further elucidate potential patterns. Additionally, 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.

Twenty-one of the 107 natural Chinook salmon (19.6%) and 5 of the 12 *O. mykiss* (41.6%) were dead when crews checked the trap. A summary of injury type by species is included in Table 29. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 29. Summary of injuries for natural origin Chinook salmon and PIT tagged bulk mark release Chinook salmon at Green Peter Dam from 2023.

Injury Code	Chinook Injuries (NOR) (n=107)	Chinook Injuries (PIT tagged bulk mark release recaptures) (n=32)
NXI	8.4%	0.0%
MUNK	2.8%	0.0%
DS<2	52.3%	67.7%
DS>2	26.2%	32.3%
BLO	1.9%	6.5%
EYB	14.0%	6.5%
BVT	7.5%	3.2%
FVB	10.3%	29.0%
GBD	30.8%	32.3%
POP	1.9%	0.0%
HIN	14.0%	9.7%
OPD	13.1%	9.7%
TEA	4.7%	3.2%
BRU	8.4%	6.5%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	65.4%	90.3%
PRD	0.0%	0.0%
COP	6.5%	0.0%
BKD	0.0%	0.0%
FUN	1.9%	0.0%

Table 30. Count and percentages of *O. mykiss* displaying injury by type at Green Peter Dam Tailrace RST site from 2023.

Injury Code	*O. mykiss* Injuries (n=12)
NXI	8.3%
MUNK	0.0%
DS<2	41.7%
DS>2	50.0%
BLO	0.0%
EYB	16.7%
BVT	8.3%
FVB	8.3%
GBD	50.0%
POP	33.3%
HIN	16.7%
OPD	33.3%
TEA	0.0%
BRU	16.7%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	83.3%
PRD	0.0%
COP	25.0%
BKD	0.0%
FUN	0.0%

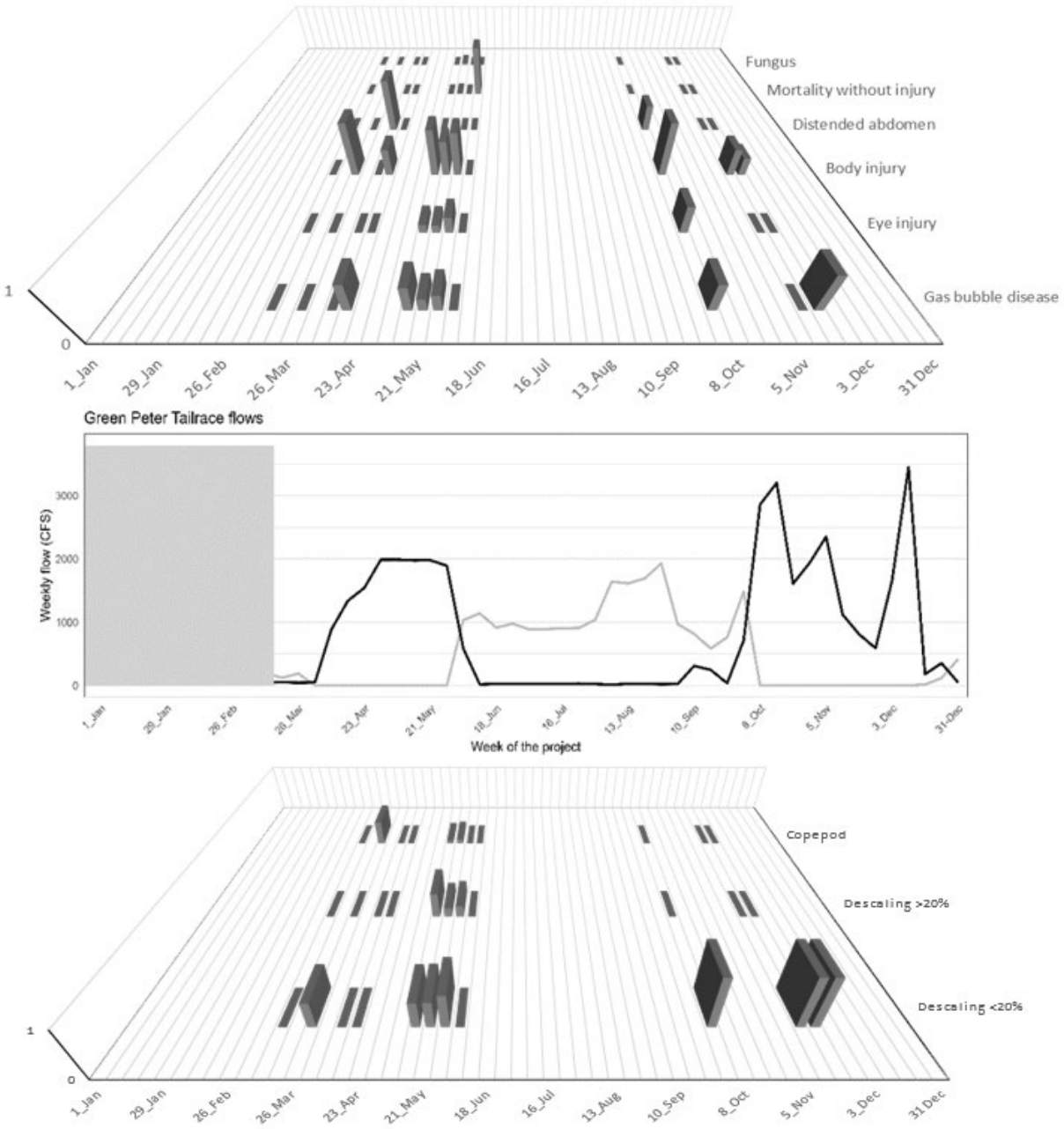

Figure 31. Injury rate of captured Chinook salmon below Green Peter Dam displaying proportion of fish with injuries by type (top panel) and descaling injuries and copepod presence (bottom panel). The middle panel shows spill (black line) and Powerhouse flow (gray line) at Green Peter Dam from 2023.

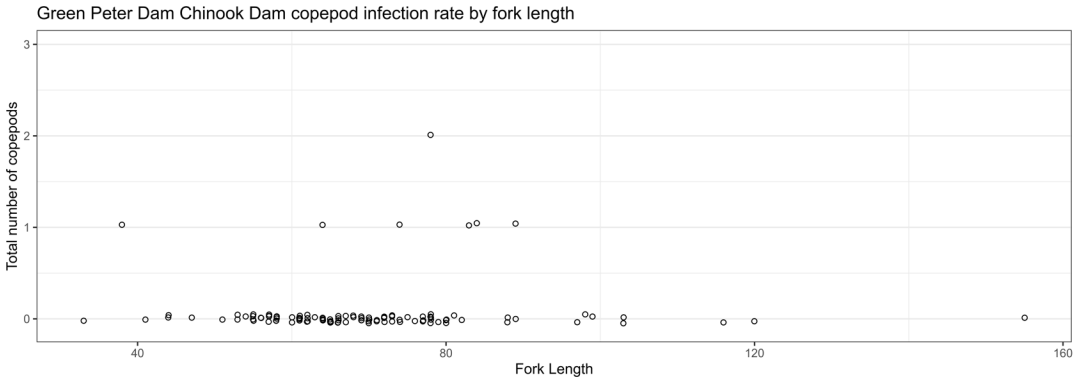

Figure 32. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon below Green Peter Dam from 2023.

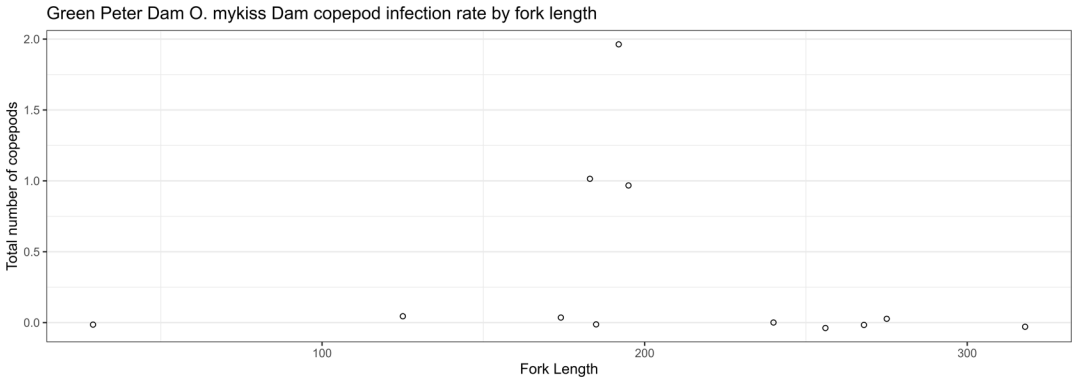

Figure 33. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile *O. mykiss* below Green Peter Dam from 2023.

24-Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook salmon and *O. mykiss* captured in the Green Peter Dam Tailrace to assess delayed mortality resulting from dam passage. A total of 92 fish, 86 Chinook salmon and 6 *O. mykiss*, were held in 2023 (Table 31). A total of 48 fish died during hold (52.2%), 46 of the 86 Chinook salmon (53.5%) and 2 of the 6 *O. mykiss* (33.3%). Mortality rates across the two-week period in which fish were held ranged from 0 to 100%.

Table 31. Summary of 24-hour hold trials for fish captured in the RST at the Green Peter Dam Tailrace site for 2023.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
3/16/2023–3/31/2023	Chinook	1	0	100.0%
4/1/2023–4/15/2023	Chinook	2	1	50.0%
4/1/2023–4/15/2023	*O. mykiss*	2	2	0.0%
4/16/2023–4/30/2023	Chinook	4	0	100.0%
4/16/2023–4/30/2023	*O. mykiss*	1	0	100.0%
5/1/2023–5/15/2023	*O. mykiss*	1	0	100.0%
5/16/2023–5/31/2023	Chinook	71	43	39.4%
5/16/2023–5/31/2023	*O. mykiss*	2	0	100.0%
6/1/2023–6/15/2023	Chinook	2	0	100.0%
10/1/2023–10/15/2023	Chinook	2	1	50.0%
11/1/2023–11/15/2023	Chinook	1	1	0.0%
11/16/2023–11/30/2023	Chinook	3	0	100.0%

PIT Tagged fish and Downstream Detections

No fish were PIT tagged at the Green Peter Dam Tailrace site by EAS in 2023 as catch never exceeded the 60 fish per week set aside for the 24-hour hold study. A summary including tag numbers, observation date, and site can be found in Appendix C.

Willamette Valley Projects Encounters

11 radio and PIT tagged Chinook salmon were captured in the Green Peter Dam Tailrace trap in 2023. These fish are a part of a PNNL/USACE dam passage study. Additionally, 33 adipose clipped and PIT tagged Chinook salmon were captured in 2023 that were associated with large bulk mark releases performed by Cramer. 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 27,650 non-target fish were captured in addition to natural origin juvenile *O. mykiss* in the Green Peter Dam Tailrace RST in 2023 (Table 32). The most common species captured were bluegill and wild kokanee.

Table 32. Summary of non-target fish capture at the Green Peter Dam Tailrace RST from 2023.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	107	32
Bluegill	1,475	253
Crappie	903	250
Dace	5	1
Kokanee (wild)	24,920	16,350
Kokanee (clipped)	15	6
Largemouth Bass	1	0
O. mykiss (clipped)	31	7
O. mykiss (adult)	6	1
Cutthroat Trout	1	0
Sculpin	5	1
Smallmouth Bass	34	11
Brown Bullhead Catfish	40	1
Largescale Sucker	3	1
Mountain Whitefish	3	1
Northern Pikeminnow	5	0
Spotted Bass	3	2
Uknown Bass	89	84
Walleye	1	0
Unknown	2	0
Unknown Salmonid	1	1
Totals	**27,650**	**17,002**

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

Cougar Dam Tailrace

EAS began monitoring three RSTs (two 8-foot RSTs in the PH Channel and one 5-foot RST in the Regulating Outlet Channel) below Cougar Dam on December 1, 2021. Sampling from January 1, 2023, to November 30, 2023, was performed under contract W9127N19D0007. Sampling from December 1, 2023, through December 31, 2023, was performed by EAS as a sub-contractor for Cramer under contract W9127N19D0009. However, data from all sampling in 2023 will be included in this report.

There were two short periods of time when the PH traps did not sample due to low flows out of the PH that prevented the RSTs from being lowered into the sampling position. The RO at Cougar Dam went offline in June for scheduled construction on the RO chute. The RO RST was removed for maintenance on June 8, 2023, while the RO was offline. It was returned to service on August 29, 2023, prior to the RO being returned to service. Additional information regarding sampling outages at this site can be found in Appendix B.

Trapping Efficiency Trials

A total of one TE trial occurred using hatchery reared Chinook salmon below Cougar Dam for this contract. Cumulatively, 31 trials have occurred since sampling started in December of 2021. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 33.

TEs ranged from 0% to 8.5% in the RO channel and from 1.0% to 19.1% in the PH channel. TE used to calculate passage for the RO was the pooled average of 14 trials: 6.1% with 95% CI of 1.6%. TE used to calculate passage for the PH was the pooled average of 10 trials: 13.04% with 95% CI of 4.7%. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 33. At this time, there appears to be no relationship with flow rate for both the PH and RO channels as linear model fits were non-significant (P>0.05), but samples are lacking at higher flows. Plots displaying TE in relation to flow (PH and RO) and cone flux (RO only) for all trials are provided in Appendix E. In the future the RO TE in relation to cone flux (Rsq=0.83) has the potential to be used as an alternative model.

Cougar RO cone flux is a promising alternative variable to flow for modeling TE, but we also present other alternatives explored. Specifically, we investigate hatchery TE of successful trials (five or more recaptures) BY, life stage (sub-yearlings vs yearling), and length as possible factors affecting TE.

For the BY test, hatchery TE trials were grouped by brood year to investigate differences between hatchery year classes. BY 2020, 2021, and 2022 were found to not be significantly different (p-value=0.83) with a Kruskal Wallis test (Figure E-17). This is an expected result as hatchery operations are unlikely to change year to year in a way that would result in behavior or biological differences that resulted in changes in catchability. A non-parametric test was chosen because the data set is small, and we could not assume a normal distribution. However, parametric analysis (ANOVA) also yielded statistically non-significant results.

To investigate life stage differences in TE, hatchery TE trials were grouped by life stage releases into sub-yearling and yearling groups. Yearling and sub-yearling TEs were found to not be significantly different (p-value=1.0) from each other with a Wilcoxon rank sum test (Figure E-17). A non-parametric test was chosen because the data set is small, and we could not assume a normal distribution. However, parametric analysis (t-test) also yielded statistically non-significant results (p-value >0.05).

Testing for length data was more complicated, because lengths of the juvenile hatchery fish were often quite variable in a single TE release. The Cougar RO TE trials had an average size range of 75 mm per release. This is quite high considering the fish were all under 200 mm. The wide range of TE fish sizes made it difficult to bin single trials into size groups. However, the large size range allowed us to test if different sizes were more vulnerable to capture (e.g., smaller fish swim slower and captured more). To determine differences in catchability, we looked for length differences between fish released and recaptured fish for each TE (Figure E-18). For each trial, a subset of the released fish were measured, and all recaptured fish were measured. Of the trials tested 82% were found to be non-significant (p-value > 0.05) using the Mann-Whitney U test. Trials 4, and 17 were found to be significant (p-value < 0.05). However, there was not a clear trend as trial 4 had larger recaptures sizes, and trial 17 had smaller recaptures sizes. Since 82% of the length tests showed no statistical difference in size and the 2 significant trials had no

trend, we see a lack of evidence for size selection in the Cougar RO RST at this time. As with the other variables tested, we assumed non-normal data distributions, but parametric analysis yielded similar results.

Table 33. 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%
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%

*Release performed by EAS for the USACE under contract W9127N19D0007.

Run of River Trapping Efficiency Trials

A total of 2,287 Chinook salmon were released for ROR TE trials in 2023 (Table 22). A total of 124 fish were recaptured in the RO channel trap.

A total of 30 dead Chinook TE releases occurred in 2023. These were fish that were found dead in the RST at time of trap check and were used to conduct these trials. Fish were both upper and lower caudal clipped so as not to be confused with other dead fish found in the trap. In the spring, 13 dead fish TE trials occurred between April 12 and April 28, where a total of 86 dead fish were released and 6 dead fish were recaptured. Due to the low recapture rates, all the April dead fish TEs were pooled together resulting in an average TE of 7.0 %. The average daily RO flow during the trials was 1,076 cfs. In the fall, 17 dead TE trails occurred from October 16 to November 8, where a total of 306 dead fish were released and 7 dead fish were recaptured. Due to the low recapture rates, all the fall dead TEs were pooled together resulting in an average TE of 2.3 %. The average daily RO flow during the fall trials was 1,380 cfs.

A total of 30 natural origin ROR Chinook TE releases occurred in 2023. Fish were uniquely marked (typically pit tagged and lower caudal clipped) to allow for identification. In the spring, 16 ROR TE trials occurred between April 11 and April 30, where a total of 507 natural origin fish were released and 10 were recaptured. Due to the low recapture rates, 15 of the April TEs were pooled together resulting in an average TE of 2.0%. One trial was removed due to a low flow condition that differed significantly from the rest of the pooled trials. The average daily RO flow of the pooled spring ROR TE trials was 1,118 cfs.

In the fall 18 ROR TE trails occurred from October 16 to November 15, where a total of 1682 fish were released, and 101 fish were recaptured. The number of ROR fish released, recaptured, and daily RO flows were variable making it difficult to objectively determine when to use ROR TE as based on a single day, pooled over multiple days, or to remove a trial from pooling-based flow differences. We opted to select TEs based on RO flow and date proximity to other trials. This resulted in a single day TE, 3 pooled TEs, and 7 single TEs being removed. The four fall ROR TEs ranged from 5.1% to 9.8%. We considered other grouping options including simply aggregating all the fall ROR trials with an average TE of 6.0%. However, the method we chose potentially provides more insight by providing 4 TE trials with flows within 150 cfs of each other instead of a single trial across a variety of flows. We also included 5 single day ROR trials (five or more recaptures in each trail) from 2022.

The Cougar Dam RO plot (Appendix E) overlayed with the hatchery, ROR, and dead TE trials indicates that there are no differences between any of the groups in relation to RO flows. It appears that Cougar RO TEs is on average near 6% with random variability. As this site is a highly channelized section below the spill, we theorize that physical conditions (e.g., high dissolved oxygen) are such that fish will want to immediately exit the area, as opposed to Head of Reservoir locations where natural origin fish TE are likely to hide and move at night. We cannot conclusively state there are no differences between the ROR and hatchery TEs in relation to RO daily average flows because most of the hatchery TEs occurred when flow was less than 1,000 cfs and all the successful ROR TEs happened in flows over 1,000 cfs.

Given there appears to be no difference between ROR and hatchery TE trials at this site, we opted to only include hatchery TEs in the passage calculations. We chose this method because there is a degree of control and consistency with the hatchery TEs that is not present in the ROR TEs. The ROR TE trials are opportunistic with highly variable numbers of fish released, recaptured, and subjectively grouped trials.

Table 34. Summary table of run of river releases at the Cougar Dam site for trapping efficiency for 2023.

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	1508	65	4.3%
Regulating Outlet	November 2023	480	43	9.0%

Target Catch, Passage Estimates and Passage Timing

A total of 5,700 juvenile Chinook salmon were captured at the Cougar Dam Tailrace during the reporting period. Of these, 427 Chinook salmon were captured in the PH traps (7.5% of total catch) (Figure 34) and

5,273 in the RO trap (92.5% of total catch) (Figure 35). Peak capture in the PH traps occurred in June (n=45, 10.5% of total PH catch). Peak capture in the RO channel in the fall occurred in November (n= 2729, 51.8% of total RO catch) Total catch for the spring of 2023 was lower than the observed catch for the spring of 2022 and 2021 but within the range observed from sampling by ODFW from 2011 to 2016 (see Appendix I and Romer et al. 2012–2016).

Chinook salmon catch from January 1, 2023, to June 30, 2023, comprised two BYs, BY 2021 yearlings (n=802, 92.8% of spring catch) and BY 2022 sub-yearlings (n= 62, 7.2% of spring catch) (Table 35 and Figure 36). Of note, catch of yearling Chinook salmon below Cougar Dam during this period was significantly higher in 2023 than had been observed in the past by previous monitoring efforts (Romer et al. 2016; CFS 2023). This could be related to increased RO outflows during the spring period of 2023 that typically did not occur in previous years or the number of adult Chinook out plants that occurred. Sampling from 2015 (Romer et al. 2016) showed a majority of spring capture occurred in the powerhouse traps similar to observations from sampling in 2022 and 2021 (EAS 2023; Cramer 2023) further suggesting that the increased RO flows and high proportion of fish captured in the RO trap are contributing to this increase in catch. Capture of BY 2021 Chinook salmon occurred throughout the spring period and peaked in April when 673 fish were captured (83.9% of BY 2021 spring capture). The first BY 2022 sub-yearling was captured on March 16, 2023, and catch of sub-yearlings continued through the end of June. Peak spring capture of BY 2022 Chinook salmon occurred in June (n=39, 62.9%).

Chinook salmon catch from July 1, 2023, to the end of the year consisted of 4,836 (84.8% of total Chinook salmon catch) individuals from three BYs, BY 2020, BY 2021, and BY 2022. Scale age analysis shows a significant overlap in size between BY 2021 and BY 2022 in the fall. 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 in the fall will be reported for both BYs combined. A total of 354 Chinook salmon were captured in the PH traps (7.3% of fall catch) and 4,482 were captured in the RO trap (92.7% of fall catch). A total of 141 BY 2020 were captured during this period along with 4,695 BY 2021 and BY 2022 Chinook salmon. Peak capture of Chinook salmon occurred in October and November (n=4,314, 75.7% of total Chinook salmon catch) (Table 35). A summary of fork length and weight data by BY is provided in Table 35.

Peak capture of Chinook salmon below Cougar Dam in 2023 coincided with spring and fall RO operations. Capture data shows significant increases in catch rate upon initiation of RO spill in October. This rate of catch increases in November as the forebay elevation drops to elevation 1532 and below. There was also an increase in Chinook salmon capture in the PH traps that occurred in December that coincided with a rain event that resulted in a significant increase in inflow and forebay elevation. Outflow from both the RO and PH increased during this period which may have resulted in the increase rate of catch observed. We estimate that 86,419 (95% CI: 68,406 to 117,310) Chinook salmon passed through the RO and 4,415 (95% CI: 3,349 to 6,478) passed through the PH from January 1, 2023, through December 31, 2023 (Figures 34 and 35). Total passage for this period at Cougar Dam is estimated to be 90,834 (95% CI: 71,755 to 123,788) juvenile Chinook salmon.

Table 35. Summary of fork length and weight observed on juvenile Chinook salmon of natural origin at the Cougar Dam RST sites by brood year from 2023.

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	1/1/23–6/30/23	21	802	144.1	76	196	149	33.7	4.2	80.0	35.2
Chinook	1/1/23–6/30/23	22	62	57.3	33	102	54.5	3.8	1.0	15.0	2.9
Chinook	7/1/2023–11/30/2023	20	141	211.0	182	286	209	96.2	54.4	162.3	93.5
Chinook	7/1/2023–11/30/2023	21 and 22	4695	114.3	47	176	115	17.4	1.2	93.3	16.5

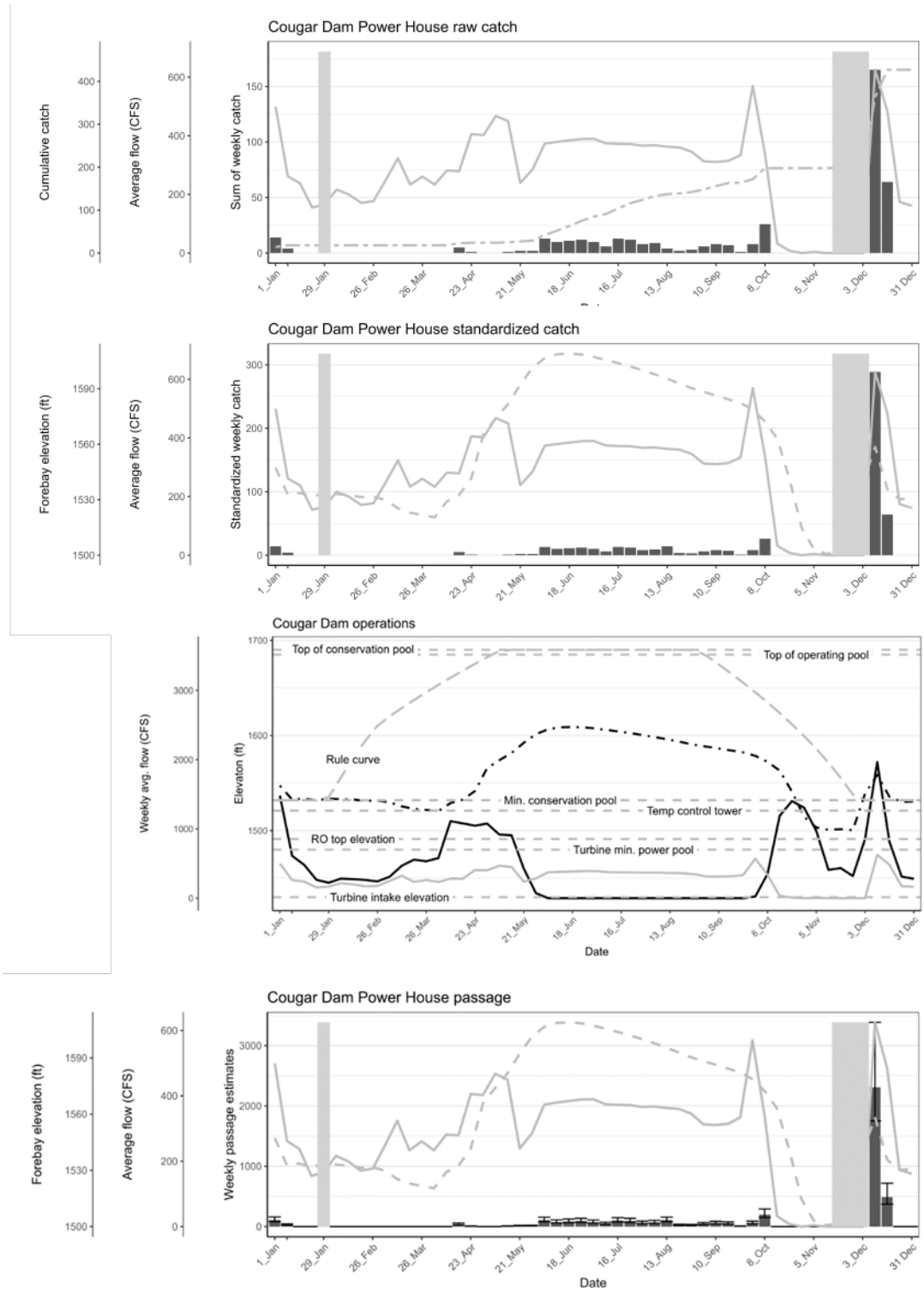

Figure 34. Raw catch (top panel), standardized catch (second panel), Cougar Dam Operations (third panel), and weekly passage estimates (bottom panel) overlayed with Powerhouse outflow (gray line), cumulative catch (gray dashed dot line), forebay elevation (gray dashed line), and non-sampling weeks shaded out (gray) for the Powerhouse traps at Cougar Dam from 2023.

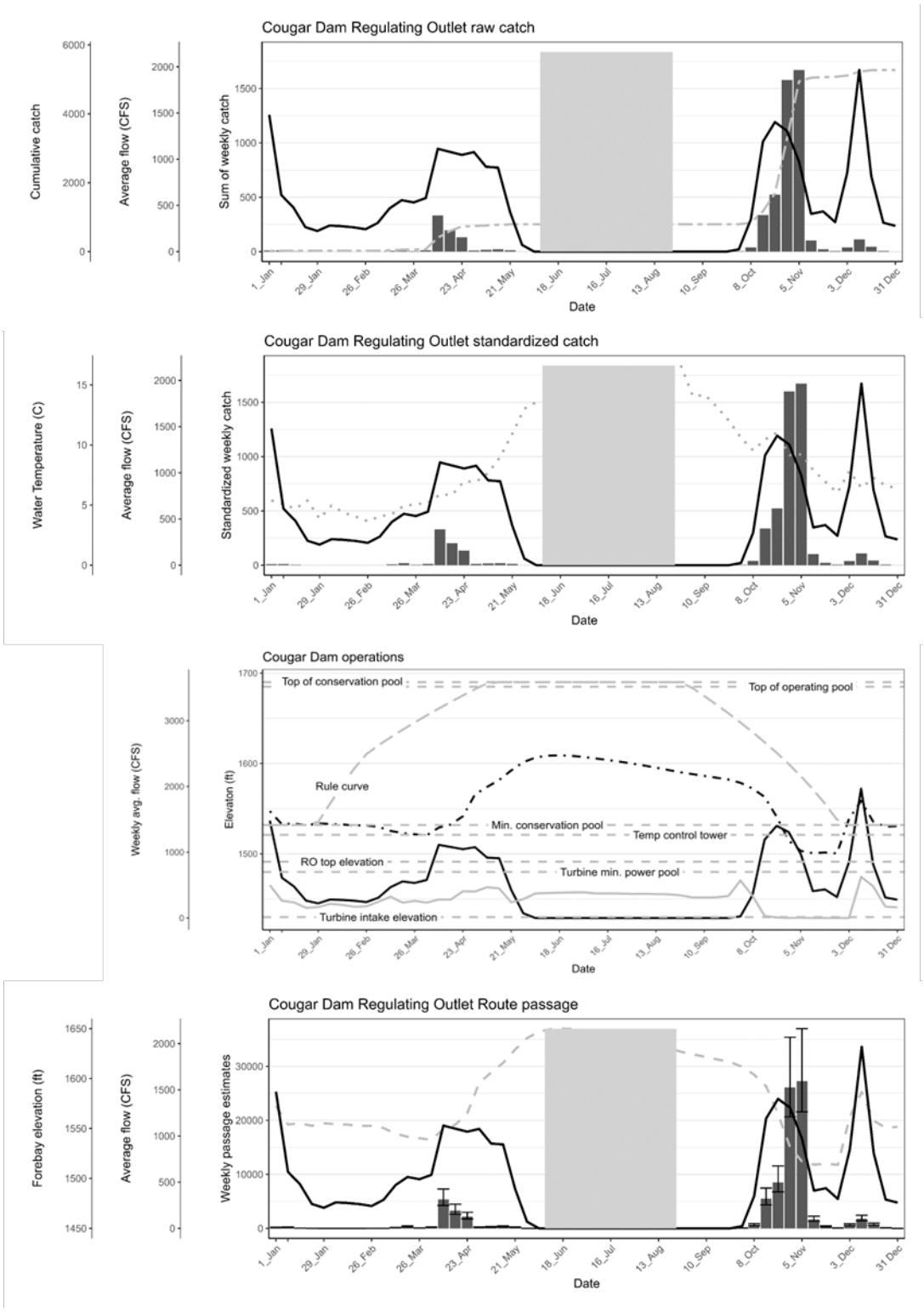

Figure 35. Raw catch (top panel), standardized catch (second panel), Cougar Dam Operations (third panel), and weekly passage estimates (bottom panel) overlayed with regulating outlet outflow (black line), cumulative catch (gray dashed dot line), water temperature (gray dot line), and non-sampling weeks shaded out (gray) for the RO trap at Cougar Dam from 2023.

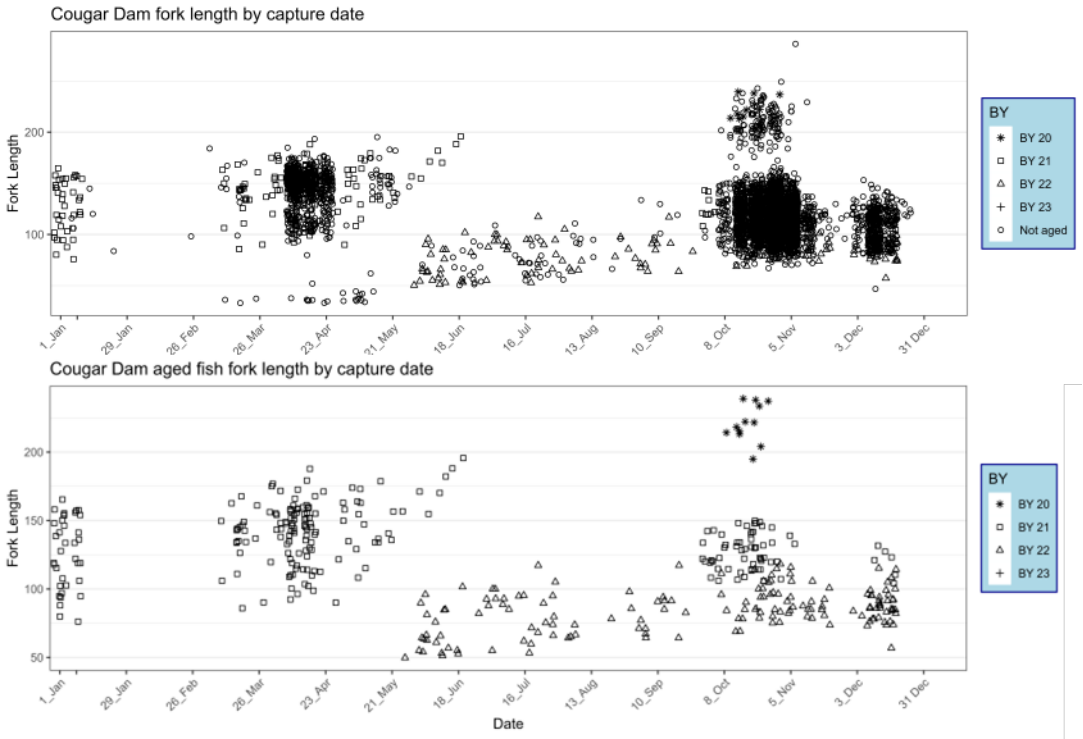

Figure 36. Length-frequency age analysis for juvenile Chinook salmon captured below Cougar Dam from 2023. The top panel shows all fish and bottom panel shows only the aged fish.

Injury Data

A total of 5,645 juvenile Chinook salmon (99.0% of total Chinook salmon catch), 5,239 captured in the RO trap (99.4% of total RO catch) and 406 captured in the PH traps (95.1% of total PH catch), displayed at least one of the injury code conditions listed in Table 2. 562 Chinook salmon (9.8% of total Chinook salmon catch) were dead at the time the RST was checked.

To provide insight on injuries associated with capture in a RST, injury data was collected from 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.

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 (Tables 36 and 37). However, Chinook salmon that were recaptured from TE trials were found to have higher percentages of descaling and fin damage when compared to the bulk mark recaptured Chinook salmon.

For fish captured in the PH traps, the most common injuries are descaling less than 20% and fin damage while the most common injuries for fish in the RO are descaling less than 20%, descaling greater than 20%, fin damage, operculum damage, and gas bubble disease. 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.

Tables 36 and 37 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 37. Furthermore, positive associations between spill at Cougar Dam Tailrace and bodily injury, descaling and copepod presence in Chinook salmon are indicated in Figure 37. 680 juvenile Chinook salmon (78.7% of total Chinook catch) were infected with copepods at time of capture (Figure 38). Copepod presence on captured Chinook salmon was

evidenced to increase with the size of fish similar to observations made by previous studies (CFS 2023; 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.

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, Tables D-3 and 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 36. Summary of injuries for Chinook salmon released for trapping efficiency fish, natural origin Chinook salmon, and PIT tagged bulk mark release Chinook salmon at the Cougar Dam Powerhouse RSTs from 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=450)	TE Recapture Injuries (proportion of total) (n=430)	Proportional Percent Change	Observed Chinook Injuries (n=427)	Bulk Marking Recapture Injuries (proportion of total) (n=71)
NXI	42.0%	6.3%	-35.7%	4.9%	0.0%
MUNK	0.0%	0.7%	0.7%	0.2%	0.0%
DS<2	50.0%	73.0%	23.0%	74.7%	69.0%
DS>2	5.6%	3.0%	-2.5%	9.8%	31.0%
BLO	0.4%	0.0%	-0.4%	1.6%	7.0%
EYB	0.4%	1.6%	1.2%	0.0%	4.2%
BVT	0.0%	0.0%	0.0%	4.4%	4.2%
FVB	0.0%	0.0%	0.0%	7.3%	8.5%
GBD	0.0%	0.5%	0.5%	1.4%	2.8%
POP	0.0%	0.0%	0.0%	1.2%	2.8%
HIN	0.7%	0.7%	0.0%	3.0%	4.2%
OPD	0.2%	4.7%	4.4%	4.4%	14.1%
TEA	0.2%	0.9%	0.7%	5.6%	7.0%
BRU	1.1%	0.5%	-0.6%	6.1%	7.0%
HBP	0.0%	0.2%	0.2%	4.4%	0.0%
HO	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.5%	4.2%
HBO	0.0%	0.0%	0.0%	0.2%	0.0%
FID	50.7%	83.3%	32.6%	52.2%	0.0%
PRD	0.0%	0.0%	0.0%	0.5%	0.0%
COP	0.0%	0.0%	0.0%	60.4%	19.7%
BKD	0.0%	2.3%	2.3%	0.0%	0.0%
FUN	0.0%	0.5%	0.5%	2.1%	4.2%

Table 37. Summary of injuries for Chinook salmon released for trapping efficiency fish, natural origin Chinook salmon, and PIT tagged bulk mark release Chinook salmon at the Cougar Dam RO RST from 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=750)	TE Recapture Injuries (proportion of total) (n=130)	Proportional Percent Change	Observed Chinook Injuries (n=5273)	Bulk Marking Recapture Injuries (proportion of total) n=1620
NXI	22.4%	1.5%	-20.9%	0.6%	0.4%
MUNK	0.0%	0.0%	0.0%	0.0%	0.0%
DS<2	69.8%	92.3%	22.5%	72.9%	82.1%
DS>2	5.1%	2.3%	-2.8%	19.1%	13.9%
BLO	0.4%	0.0%	-0.4%	0.6%	0.3%
EYB	0.7%	0.0%	-0.7%	11.0%	6.5%
BVT	0.0%	0.0%	0.0%	2.8%	1.1%
FVB	0.4%	0.0%	-0.4%	14.3%	8.2%
GBD	0.0%	0.0%	0.0%	30.3%	21.0%
POP	0.0%	0.8%	0.8%	1.2%	0.7%
HIN	0.2%	2.3%	2.1%	4.5%	2.7%
OPD	0.0%	0.8%	0.8%	15.8%	12.5%
TEA	0.7%	1.5%	0.9%	5.7%	1.9%
BRU	0.7%	1.5%	0.9%	5.7%	3.7%
HBP	0.0%	0.0%	0.0%	3.4%	0.4%
HO	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%	0.0%
FID	69.8%	94.6%	24.8%	83.8%	93.6%
PRD	0.0%	0.0%	0.0%	0.3%	0.3%
COP	0.0%	0.0%	0.0%	90.9%	18.5%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.2%	1.5%	1.3%	10.2%	4.4%

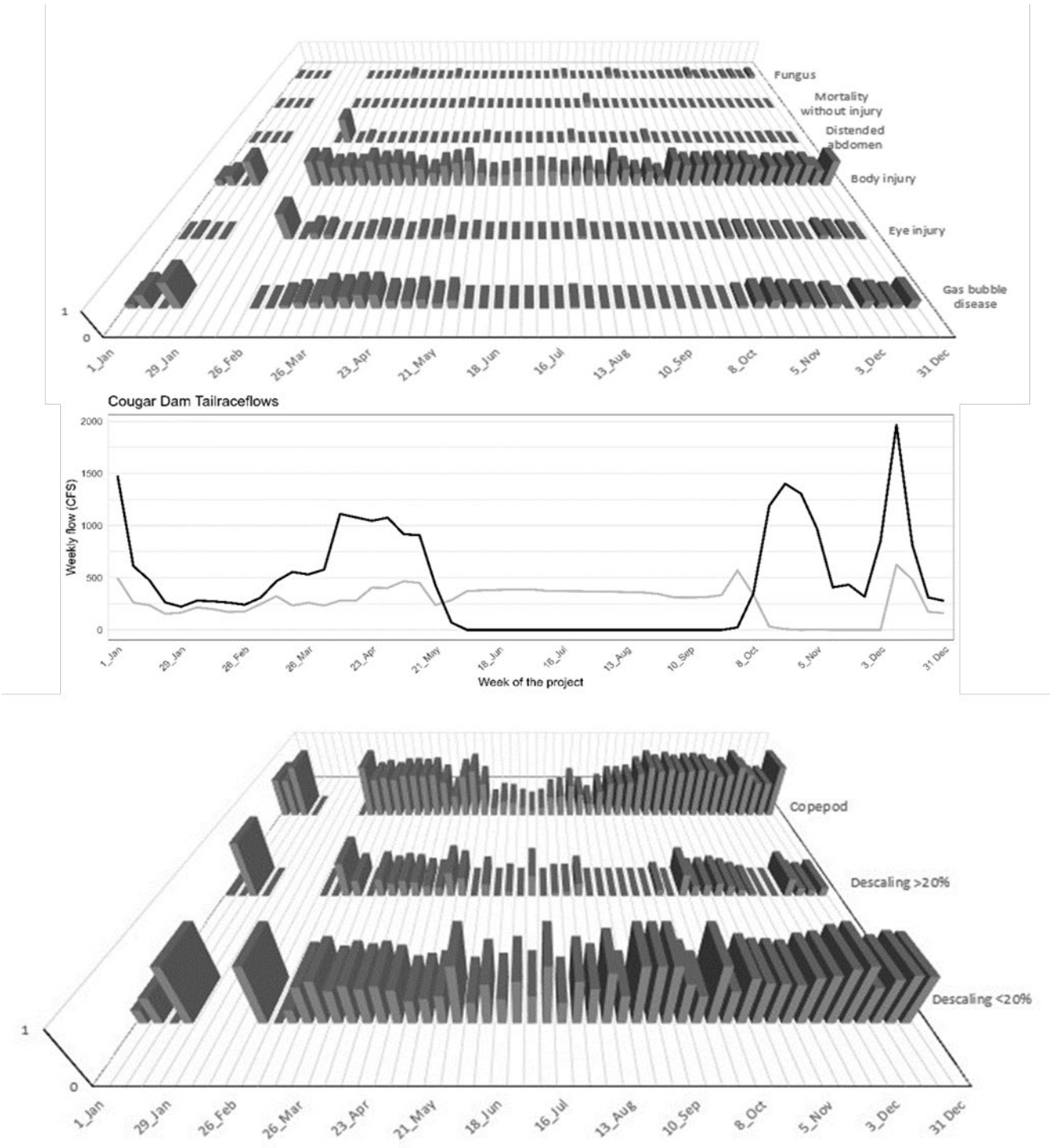

Figure 37. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data from Cougar Dam showing cfs of spill (black line) and Powerhouse flow (gray line) outflows (middle panel), and proportion of captured juvenile Chinook salmon displaying descaling and copepod injuries (bottom panel) from 2023.

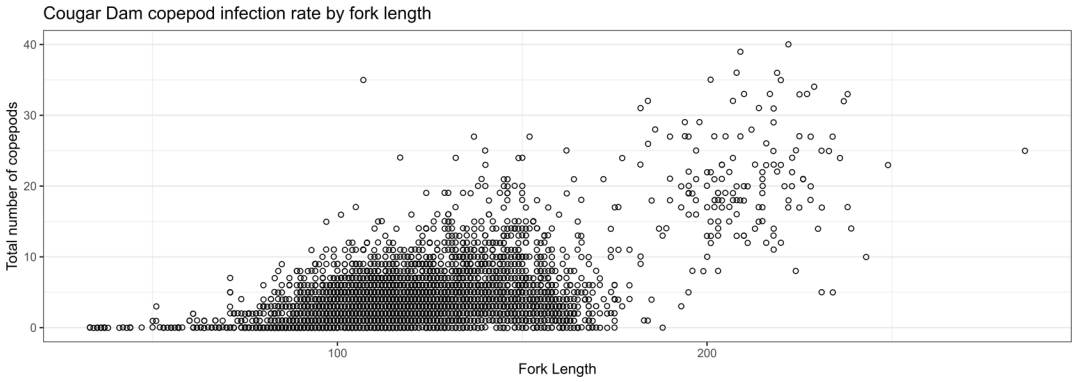

Figure 38. Copepod presence vs fork length on juvenile Chinook salmon captured at Cougar Dam from 2023.

24-Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook salmon captured at Cougar Dam to assess delayed mortality resulting from dam passage. A total of 993 fish, 773 from the RO and 220 from the PH, were held (Table 38). A total of 92 fish died during hold (9.3%), 73 of the RO Chinook salmon (9.4%) and 19 of the PH Chinook salmon (8.6%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 66.7%.

Table 38. Summary of 24-hour trials for Chinook salmon captured in the RSTs at the Powerhouse and regulating outlet locations from 2023.

Hold Period	Route	Number of Fish Held	Mortalities	% Survived
1/1/2023–1/15/2023	PWR	18	1	94.4%
1/1/2023–1/15/2023	RO	21	0	100.0%
1/16/2023–1/31/2023	RO	3	0	100.0%
3/1/2023–3/15/2023	RO	6	0	100.0%
3/16/2023–3/31/2023	RO	24	1	95.8%
4/1/2023–4/15/2023	RO	73	2	97.3%
4/16/2023–4/30/2023	RO	134	6	95.5%
5/1/2023–5/15/2023	RO	22	0	100%
5/16/2023–5/31/2023	PWR	6	1	83.3%
5/16/2023–5/31/2023	RO	19	5	73.7%
6/1/2023–6/15/2023	PWR	19	1	94.7%
6/16/2023–6/30/2023	PWR	21	1	95.2%
7/1/2023–7/15/2023	PWR	18	0	100.0%
7/16/2023–7/31/2023	PWR	19	3	84.2%
8/1/2023–8/15/2023	PWR	16	0	100.0%
8/16/2023–8/31/2023	PWR	3	2	33.3%
19/1/2023–9/15/2023	PWR	11	1	90.9%
9/16/2023–9/30/2023	PWR	10	1	90.0%
10/1/2023–10/15/2023	PWR	29	4	86.2%
10/1/2023–10/15/2023	RO	69	19	72.5%
10/16/2023–10/31/2023	PWR	0	0	--
10/16/2023–10/31/2023	RO	149	29	80.5%
11/1/2023–11/15/2023	PWR	0	0	--
11/1/2023–11/15/2023	RO	120	6	95.0%
11/16/2023–11/30/2023	PWR	0	0	--

Hold Period	Route	Number of Fish Held	Mortalities	% Survived
11/16/2023–11/30/2023	RO	24	0	100.0%
12/1/2023–12/15/2023	PWR	9	0	100.0%
12/1/2023–12/15/2023	RO	86	5	94.2%
12/16/2023–12/31/2023	PWR	41	4	90.2%
12/16/2023–12/31/2023	RO	23	0	100.0%

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 4,128 natural origin juvenile Chinook salmon were PIT tagged and released at the Cougar Dam sites in 2023. 6 PIT tags were redetected downstream in the Columbia River Estuary. 2 Chinook salmon containing PIT tags from Cougar Head of Reservoir were captured in the regulating outlet. 5 VIE marked fish were encountered in the RO Trap in November 2023. These fish were VIE marked by EAS at the Cougar Dam Head of Reservoir site in May 2023. Table 39 shows a summary of the fish redetected at downstream sites. Information regarding PIT tags at the RST site can be found in Appendix C.

Table 39. Summary of redetections of fish PIT tagged at the Cougar Dam sites.

PIT Tag #	Mark Date	Mark Site	Redetection Date	Recap Site	Travel Time
3DD.003BEE178A	1/12/2023	CGRTAL – CGR – Release into the Tailrace within 0.5 km downstream of dam	4/30/2023	PD6 – Columbia River Estuary rkm 68	
3DD.003BEE198D	1/12/2023	CGRTAL – CGR – Release into the Tailrace within 0.5 km downstream of dam	4/18/2023	PD5 – Columbia River Estuary rkm 62	
3DD.003BEE23D8	1/12/2023	CGRTAL – CGR – Release into the Tailrace within 0.5 km downstream of dam	4/14/2023	TWX – Estuary Towed Array (Exp.)	
3DD.003BEE2748	1/12/2023	CGRTAL – CGR – Release into the Tailrace within 0.5 km downstream of dam	5/4/2023	PD5 – Columbia River Estuary rkm 62	
3DD.003BEE2791	1/12/2023	CGRTAL – CGR – Release into the Tailrace within 0.5 km downstream of dam	5/1/2023	TWX – Estuary Towed Array (Exp.)	
3DD.003BEE2B8A	1/12/2023	CGRTAL – CGR – Release into the Tailrace within 0.5 km downstream of dam	4/15/2023	PD6 – Columbia River Estuary rkm 68	

*TWX Operational Dates were from 4/12/2023 – 6/14/2023.
*PD5 Operational Dates were from 3/20/2023 – 10/10/2023.
*PD6 Operational Dates were from 3/21/2023 – 10/3/2023.

Willamette Valley Projects Encounters

A total of 1,851 adipose clipped and PIT tagged fish were captured at the Cougar Dam traps in 2023. 1,629 of 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). 193 PIT tagged fish were from releases performed by EAS in conjunction with ODFW District staff at the Cougar Dam Head of Reservoir site. 4 PIT tagged fish were NOR fish tagged by EAS and released at The Cougar Head of Reservoir site. They had an average travel time of 50 days (min: 7 days, max: 103 days). The remaining 25 tags were shown as orphans in PTAGIS and likely are fish that are associated with Cramer bulk mark releases and either failed to upload or were recorded incorrectly in the field. Additionally, one spawning adult Chinook salmon with a Floy tag was encountered in the PH traps.

Non-Target Capture Data

A total of 2,800 non-target fish were captured at the Cougar Dam traps in 2023. A summary of species and catch is provided below in Table 40. The most commonly captured non-target species were dace, clipped Chinook salmon and sculpin. The Bull Trout encountered at this site were reported to ODFW staff. More information regarding captured Bull Trout is provided in Appendix C.

Table 40. Summary of non-target fish capture for the Cougar Dam RSTs from 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bull Trout	2	0
Chinook (clipped)	633	35
Chinook (adult)	3	1
Cutthroat Trout	19	0
Bluegill	1	0
Lamprey	3	0
Dace	1,785	3
Largescale Sucker	8	0
Mountain Whitefish	26	5
O. mykiss	1	1
Sculpin	274	5
Smallmouth Bass	7	1
Spotted Bass	34	0
Unknown Bass	4	0
Totals	**2,800**	**51**

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

Fall Creek Dam Tailrace

EAS began monitoring the single 8-foot RST in the RO channel of Fall Creek Dam on March 15, 2022. Sampling from March 15, 2022, to October 1, 2023, was performed by EAS under contract W9127N19D0007. Sampling from October 1, 2023, through December 31, 2023, was performed by EAS as a sub-contractor for Cramer under contract W9127N19D0009. All data from sampling in 2023 will be included within this report. Prior to EAS operating the RST at Fall Creek Dam, RST sampling was performed by the Corps. Results from Corps sampling are reported in the respective Corps bi-annual reports. The trap did not sample from January 1 to January 11, 2023, and from January 25 to March 2, 2023, when riverbed movement from reservoir drawdown filled the RO channel with sediment to the point that the cone could not be lowered to the sampling position. Furthermore, the Fall Creek Dam Tailrace RST did not fish in February, June, July, August, September, and December of 2023. Additional details regarding sampling dates and trap outages can be found in Appendix B.

Trapping Efficiency Trials

A total of eight TE trials occurred using hatchery reared Chinook salmon in the RO channel for this contract. Collectively, eight trials have occurred here from the time that EAS began monitoring in 2022. Sampling prior to October 1, 2023, was performed by EAS for the USACE under contract W9127N19D0007. The summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 41. TEs were 0% for six of the trials, 2.1% and 1.4% for the two successful trials. At this time, we do not feel comfortable calculating passage based on two successful trials out of eight attempted trials

Due to limitations involving the availability of hatchery Chinook salmon from Middle Fork Willamette brood stocks and low catch rate of natural origin fish at this site, we were unable to perform enough TE trials in the early spring, when flows were sufficient to spin the cone of the trap. 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.

Table 41. 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%

*Releases performed by EAS for the USACE under contract W9127N19D0007.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Fall Creek Dam Tailrace in 2023. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study and are not tagged. Sufficient numbers of fish needed for ROR trials were not encountered at this site in 2023.

Target Catch, Passage Estimates and Passage Timing

The trap in the Regulating Outlet Channel below Fall Creek Dam captured 150 juvenile Chinook salmon during sampling in 2023. Capture of juvenile Chinook salmon occurred in March, April, October, and November. (Figure 39). Peak spring capture occurred in March (n=44, 29.3% of total Chinook salmon capture). This timing is later than 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). Recent observations of juvenile Chinook salmon in the Fall Creek Adult Fish Facility (D. Garletts, personal communication, July 13, 2023) suggest that juvenile Chinook salmon continue passing through Fall Creek Dam later in the spring and summer than RST capture indicates. 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 near 728 ft. Only BY 2022 sub-yearlings were captured at this site during the spring monitoring period (Figure 40). Sampling in 2022 above Fall Creek Dam in the spring and below Fall Creek Dam in the spring and fall captured no BY 2021 fish (EAS 2023).

Capture of Chinook salmon at Fall Creek Dam from July 1, 2023, to December 31, 2023, comprised 89 fish from two BYs: 85 BY 2021 and 4 BY 2022 fish. Peak capture of fish in the fall occurred in October (n=79, 52.7% of total Chinook salmon capture) and comprised primarily BY 2021 Chinook salmon (n=85, 56.6% of total 2023 Chinook salmon catch). This is the first observation of BY 2021 fish in the Fall Creek Dam Tailrace since EAS began monitoring the site on March 15, 2022. A summary of fork lengths and weights for Chinook salmon captured at Fall Creek Dam by BY is provided in Table 42.

Capture of Chinook salmon at this site coincided with spring and fall spill operations. Fall capture also correlated with the reservoir drawdown operation showing that Chinook salmon exited the reservoir as the pool elevation dropped and hit its lowest level. Peak capture in October implies that juvenile Chinook salmon had been actively holding in or near the forebay prior to the initiation of the drawdown and exited soon after spill ramped up and the reservoir neared streambed or run of river flows. However, conditions during this time resulted in significant fluctuations to the reservoir level and extended the time necessary to reach a consistent run of river level. For raw weekly catch of Chinook at this site for sampling from 2022 and 2023, see Appendix I.

Table 42. Summary of fork length and weight observed on juvenile Chinook salmon of natural origin at the Fall Creek Dam RST site by brood year in 2023.

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	1/1/2023–6/30/2023	22	61	36.8	33	60	37	N/A	N/A	N/A	N/A
Chinook	7/1/2023–12/31/2023	21	85	181.0	142	203	185	73.4	33.8	109.3	75.3
Chinook	7/1/2023–12/31/2023	22	4	100	94	106	100	10.9	8.8	14.5	10.2

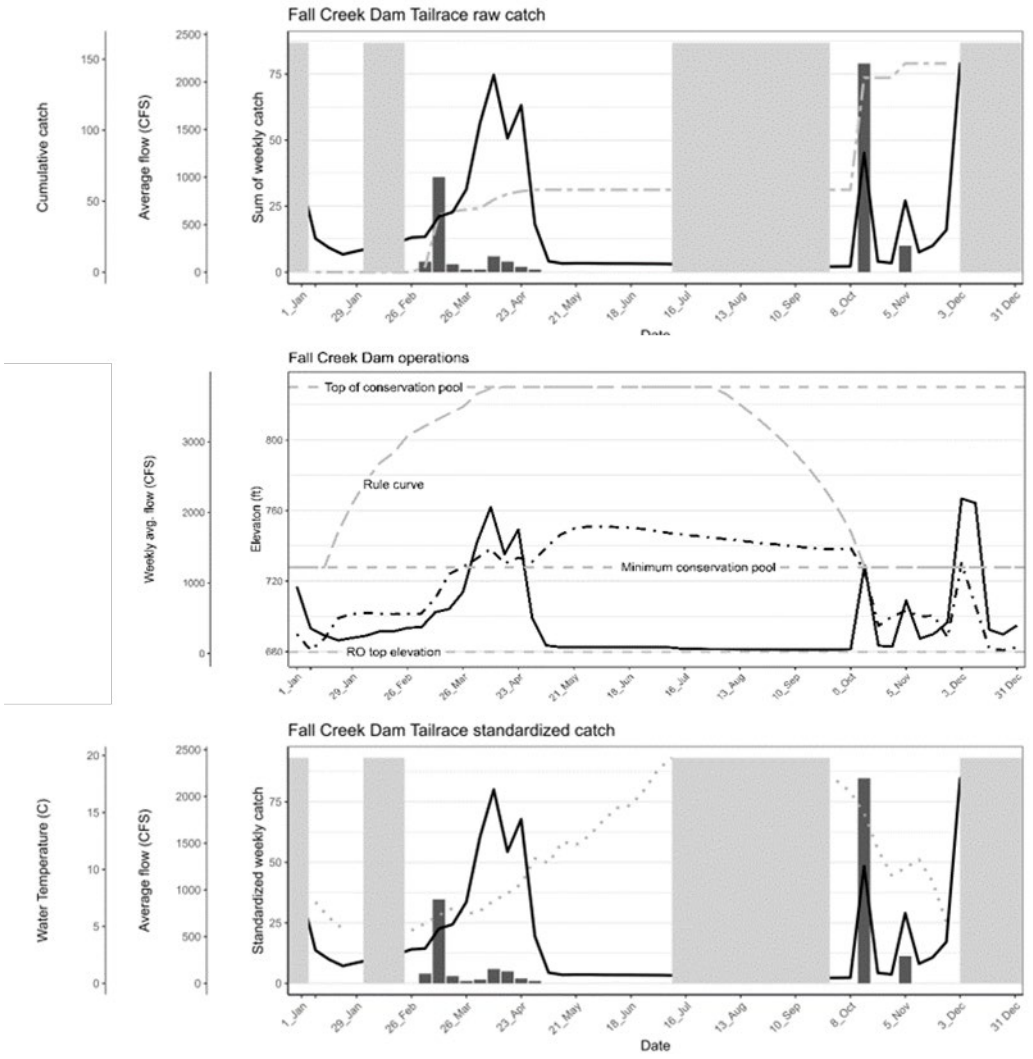

Figure 39. Raw catch (top panel), Fall Creek Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at the Fall Creek Dam Tailrace site with RO outflow (black line), forebay elevation (black dot dash line), intake elevations (gray dash line), cumulative catch (gray dot dash line), stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for 2023.

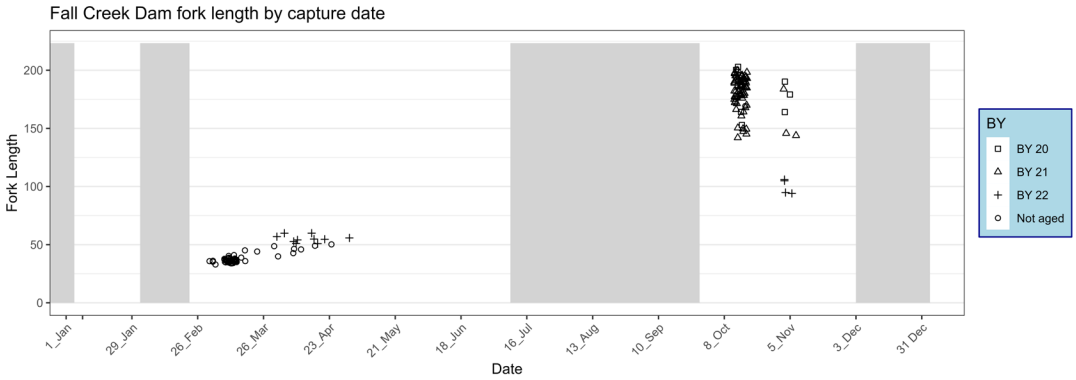

Figure 40. Length-frequency of juvenile Chinook salmon at the Fall Creek Dam Tailrace site for 2023.

Injury Data

In total, 100 juvenile Chinook salmon (66.6% 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 less than 20%, descaling greater than 20%, fin damage, and the presence of copepods (Table 43).

Comparatively, juvenile Chinook salmon that were of natural origin (NOR) and were encountered at the Fall Creek Dam Tailrace site exhibited lower percentages of descaling, damaged fin blood vessels, operculum damage, fin damage, and the presence of copepods when assessed against the PIT tagged bulk marked released Chinook salmon (Table 43).

Furthermore, juvenile Chinook salmon encountered at the Fall Creek Dam Tailrace illustrated a strong, positive correlation between size and copepod presence, as seen in Figure 41. Similar to other sites detailed within this report, results illustrated that Chinook salmon less than 60 mm were more likely to have no external injuries than those measuring above 60 mm (Appendix D, Table D-5). 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 were descaling and fin damage (Appendix D, Table D-5).

A total of 34 Chinook salmon were dead at the time of trap check (22.7% of total Chinook salmon capture). A summary of injuries by type is shown in Table 43. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 43. Percentage of target Chinook salmon and bulk marked Chinook salmon displaying injury by type at the Fall Creek Tailrace site for 2023.

Injury Code	Chinook Injuries (NOR) (n=150)	Chinook Injuries (PIT tagged bulk mark release recaptures) (n=435)
NXI	13.3%	0.0%
MUNK	0.0%	0.0%
DS<2	11.4%	72.6%
DS>2	13.3%	26.9%
BLO	0.5%	2.5%
EYB	1.3%	1.4%
BVT	3.4%	1.4%
FVB	4.5%	10.1%
GBD	2.4%	1.4%
POP	0.0%	0.5%
HIN	2.7%	1.4%
OPD	3.2%	12.6%
TEA	1.6%	0.5%
BRU	2.7%	1.6%
HBP	0.5%	0.0%
HO	0.0%	0.0%
BO	0.3%	0.0%
HBO	0.0%	0.0%
FID	22.8%	99.5%
PRD	0.0%	0.0%
COP	16.7%	6.9%
BKD	0.0%	0.0%
FUN	0.3%	0.7%

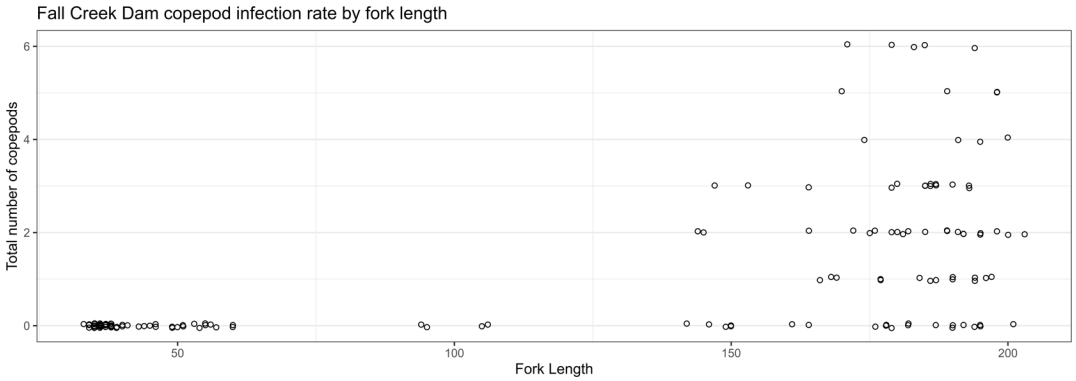

Figure 41. Copepod presence vs fork length on juvenile Chinook salmon captured at Fall Creek Dam from 2023.

24-Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook salmon captured in the Fall Creek Dam Tailrace to assess delayed mortality potentially from dam passage, collection, or holding. A total of 115 Chinook salmon were held in 2023 (Table 44). A total of 12 Chinook salmon died during hold (10.4%). Mortality rates between the two-week reporting periods ranged from 0.0% to 23.4%.

Table 44. Summary of 24-hour trials for fish captured in the RST at the Fall Creek Dam Tailrace site from 2023.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
3/1/2023–3/15/2023	Chinook	33	0	100.0%
3/16/2023–3/31/2023	Chinook	9	0	100.0%
4/1/2023–4/15/2023	Chinook	10	1	90.0%
4/16/2023–4/30/2023	Chinook	6	0	100.0%
10/16/2023–-10/31/2023	Chinook	47	11	76.6%
11/1/2023–11/15/2023	Chinook	10	0	100.0%

PIT Tagged/VIE Marked fish and Downstream Detections

No fish were PIT tagged at the Fall Creek Dam Tailrace site in 2023 as all captured fish were placed into the 24-hour hold study. No VIE marked Chinook salmon were detected at this site in 2023. Further information on tagged fish at this site is available in Appendix C.

Willamette Valley Projects Encounters

A total of 434 adipose clipped and PIT tagged Chinook salmon were captured in the Fall Creek Dam RST in 2023 that were associated with large bulk mark releases performed by Cramer. 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 2,181 non-target fish in addition to natural origin juvenile Chinook salmon. A summary of species and numbers of fish caught is provided in Table 45. The most commonly captured non-target species were largescale sucker and *O. mykiss*.

Table 45. Summary of non-target fish catch at the Fall Creek Dam Tailrace RST in 2023.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	16	4
Walleye	1	0
Brown Bullhead	56	18
Cutthroat Trout	53	2
Lamprey	16	0
Dace	210	12
Largescale Sucker	1,501	160
Northern Pikeminnow	19	1
O. mykiss	258	20
O. mykiss (clipped)	23	5
Pacific Lamprey	3	0
Peamouth	4	2
Redside Shiner	12	0
Sculpin	9	0
Totals	**2,181**	**224**

Dexter Dam Tailrace

EAS began monitoring the single 5-foot RST in the Dexter Dam Tailrace on March 3, 2022. Sampling prior to December 16, 2023, was performed by EAS under contract W9127N19D0007. Sampling from December 16, 2023, through December 31, 2023, was performed by EAS as a sub-contractor for Cramer under contract W9127N19D0009. Additionally, due to construction being undertaken, the Dexter Dam Tailrace RST was relocated further downstream from Dexter Dam on November 6, 2023. All data collected in 2023 is presented in the results below. Information on monitoring periods and sampling outages that resulted from high flows and high debris are listed in Appendix B and RST locations are shown in Appendix A.

Trapping Efficiency Trials

A total of 21 TE trials occurred using hatchery reared Chinook salmon at the Dexter Dam Tailrace for this contract, 10 in the spillway outflow and 11 in PH outflow. A total of 30 trials have been performed by EAS at this location since monitoring began in 2022. Releases prior to December 16, 2023, were performed by EAS for the USACE under contract W9127N19D0007. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 46.

The location of the trap in the Dexter Dam Tailrace prior to November 6, 2023, was fixed in the same location across all flows as a highline was not approved to be installed at this location. Thus, the trap could not be adjusted to improve sampling as flows changed, resulting in a wide array of capture efficiencies at this site. Additionally, 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. This change in location and multiple operations for flows requires additional trials to gain a better understanding of the area and passage estimates at the new location. As such samples are lacking to explore these options individually at this time, and we opted to pool samples before and after the trap was moved. However, RST TE results will continue to be explored as more trials are completed in the future. TEs in the spillway release ranged from 0.2% to 6.6% and those in PH ranged from 0.0% to 1.2%.

TE used to calculate passage at the upstream location was the pooled average of 12 trials: 1.3% with 95% CI of 1.1%. TE used to calculate passage at the downstream location was the pooled average of 4 successful trials: 0.56% with 95% CI of 0.14%, results should be interpreted with caution due to a lack of sample size, complexity of operations and the trap being relocated.

We were unable to perform TE trials to the extent we wanted in the spring, as BY 2021 Middle Fork Willamette hatchery fish were limited in availability and BY 2022 hatchery Chinook salmon were too small to safely mark until early May. During four of the releases, spill and PH operations occurred between trap checks further confounding TE calculation efforts via route. Before the trap was moved, five out of seven spill trials and seven out of fourteen PH trials yielded the minimum number of five recaptures in a week needed to calculate efficiencies, with 2 of the PH trials having a mix of route flow from the spill and PH. Efficiencies at this site have varied widely and we opted to make pooled estimates of Chinook salmon passage before and after the trap was moved at this time. Plots displaying TE in relation to flow and cone flux with consideration of route for all trials are provided in Appendix E.

Table 46. 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-Powerhouse#	12/21/2023	4,850	4,005	3	0.1%
Dexter Dam Powerhouse#	12/28/2023	1,990	8,032	46	0.6%

*Release performed by EAS for the USACE under contract W9127N19D0007.
#Release performed after RST was relocated downstream.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Dexter Dam Tailrace in 2023. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study and are not tagged. Sufficient numbers of fish were not encountered to perform trials in 2023.

Target Catch, Passage Estimates and Passage Timing

The trap captured 57 juvenile Chinook salmon in 2023 (Figure 42). Chinook salmon catch below Dexter Dam was composed of BY 2021 yearlings (n=23, 40.4% of total catch), 1 BY 2020 Chinook salmon (1.8% of total catch) and BY 2022 sub-yearlings (n=33, 57.9%) (Figure 44). Data summarizing fork lengths and weights of Chinook salmon captured at Dexter Dam can be found in Table 47. The first BY 2022 fish captured at the trap occurred on May 24, 2023, a few weeks earlier than sub-yearlings were observed in 2022. Capture of juvenile Chinook salmon leaving Dexter Reservoir showed two periods of increased catch in May and December. Peak capture at Dexter Dam in the spring shows an association with the concurrent surface spill events at Lookout and Dexter dams (Figure 43). Similarly, fall capture of Chinook salmon also coincides with the drawdown of Lookout Reservoir and increases in spill operations at Dexter and Lookout dams. We estimate that during sampling in 2023, 7,782 (95% CI: 5,648 to 23,612) juvenile Chinook salmon migrated past the trapping site but due to the trap moving, lack of successful TE trials, and complexity of

the system, results should be interpreted with caution (Figure 43). Refer to Appendix I for figures displaying raw weekly catch of Chinook at this site for sampling in 2022 and 2023.

Table 47. Summary of fork length and weight observed on juvenile Chinook salmon of natural origin at the Dexter Dam Tailrace RST site by brood year in 2023.

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	1/1/2023–6/30/2023	21	15	158.2	103	190	162	46.3	12.9	65.5	49.0
Chinook	1/1/2023–6/30/2023	22	5	85.4	54	109	100	8.1	1.5	13.0	11.0
Chinook	7/1/2023-12/15/2023	20	1	345	345	345	N/A	410.7	410.7	410.7	N/A
Chinook	7/1/2023–12/15/2023	21	8	169.1	118	206	167	67.4	23.0	121.7	55.6
Chinook	7/1/2023–12/15/2023	22	28	107.4	84	135	106.5	12.3	5.7	26.0	11.5

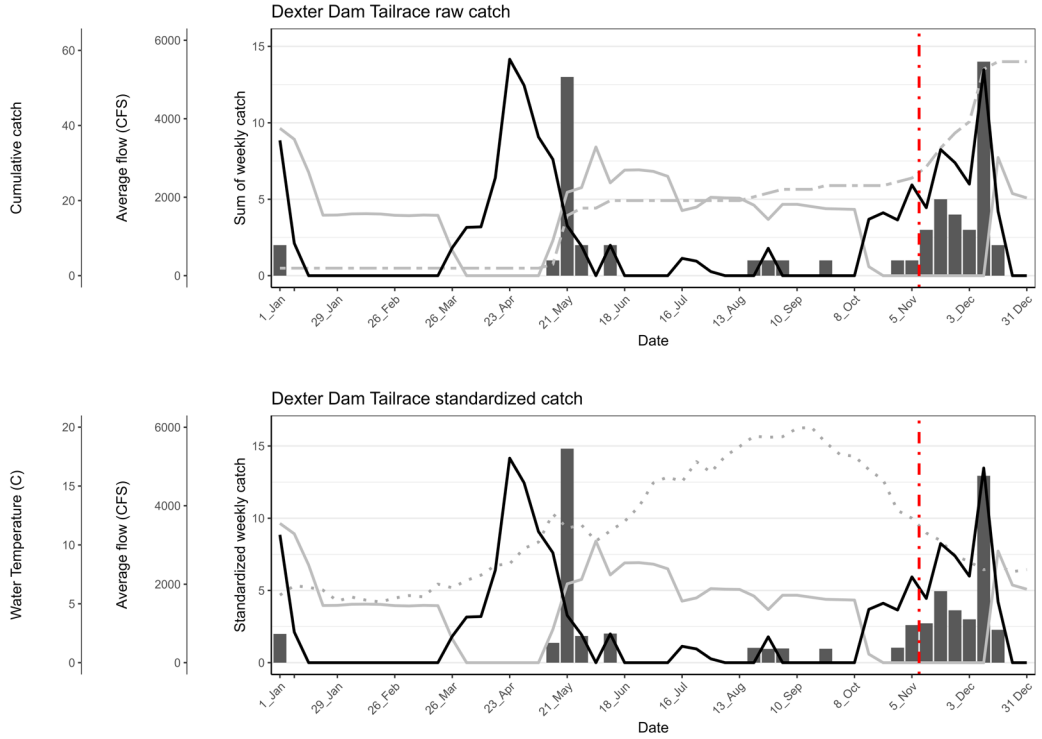

Figure 42. Raw catch Dexter Dam (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at the Dexter Dam Tailrace site with spill (black line), Powerhouse outflow (gray line), cumulative catch (gray dot dash line), and water temperature (gray dots) from 2023. The red dot dash line denotes when the trap was moved downstream to the new sampling location due to construction.

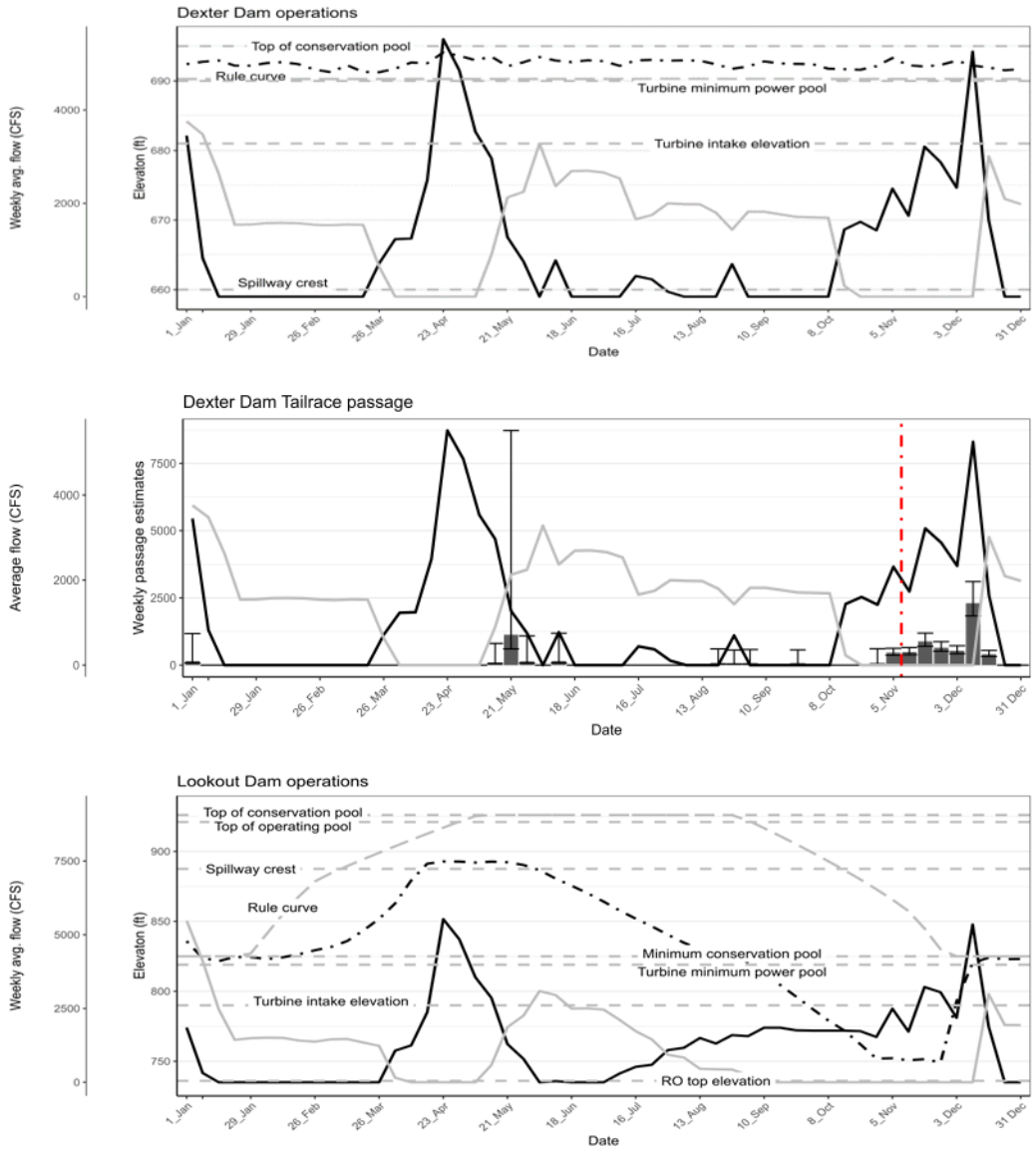

Figure 43. Dexter Dam (top panel) and Lookout Dam (bottom panel) operations with rule curve (gray long dash line), forebay elevation (black dot dash line), spill/RO outflow (black line) and Powerhouse outflow (gray line). Weekly passage estimates with 95% confidence for juvenile Chinook salmon at Dexter Dam (middle panel) with spill (black line), Powerhouse outflow (gray line), cumulative catch (gray dot dash line), and water temperature (gray dots) from 2023. The red dot dash line denotes when the trap was moved downstream to the new sampling location due to construction efforts at Dexter Fish Facility.

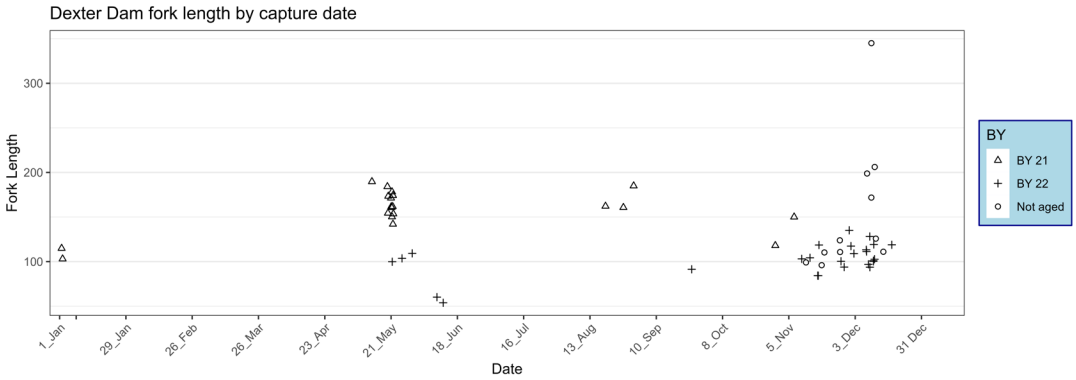

Figure 44. Length-frequency of juvenile Chinook salmon by brood year at the Dexter Dam Tailrace site from 2023.

Injury Data

A total of 55 juvenile Chinook salmon (96.5% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 2. No mortalities were observed during the spring monitoring period. There were five (9.1% of total Chinook salmon catch) mortalities recorded during the fall and winter monitoring period.

To provide insight on injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for TE trials at time of release and upon recapture. Injury rates by type, both pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. The most common injuries observed at this site include descaling less than and greater than 20% and fin damage (Table 48). 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 a relatively small sample size and additional data will be collected in 2024 to provide additional clarity regarding injuries at this location.

Like other results illustrated throughout this report, Chinook salmon utilized in TE trials exhibited a lesser percentage of descaling and fin damage when compared to those used in bulk mark recapture studies (Table 48). Figure 45 shows 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 46). 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).

Table 48. Summary of injuries for Chinook salmon released for trapping efficiency fish, natural origin Chinook salmon, and PIT tagged bulk mark release Chinook salmon at the Dexter Dam RST from 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=900)	TE Recapture Injuries (proportion of total) (n=185)	Proportional Percent Change	Observed Chinook Injuries (n=57)	Bulk Marking Recapture Injuries (proportion of total) (n=21)
NXI	13.1%	7.0%	-6.1%	3.5%	0.0%
MUNK	0.0%	0.0%	0.0%	0.0%	0.0%
DS<2	69.7%	71.9%	2.2%	54.4%	71.4%
DS>2	12.3%	18.4%	6.0%	38.6%	23.8%
BLO	0.0%	0.0%	0.0%	0.0%	0.0%
EYB	1.3%	1.6%	0.3%	12.3%	9.5%
BVT	0.0%	0.0%	0.0%	1.8%	4.8%
FVB	1.4%	1.1%	-0.4%	7.0%	19.0%
GBD	0.0%	3.2%	3.2%	22.8%	28.6%
POP	0.2%	0.5%	0.3%	5.3%	4.8%
HIN	0.0%	0.0%	0.0%	8.8%	4.8%
OPD	0.7%	4.9%	4.2%	15.8%	23.8%
TEA	0.0%	2.7%	2.7%	10.5%	4.8%
BRU	0.8%	0.0%	-0.8%	5.3%	14.3%
HBP	0.0%	0.0%	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%	0.0%
FID	79.7%	85.9%	6.3%	77.2%	95.2%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	21.1%	28.6%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.2%	3.2%	3.0%	0.0%	4.8%

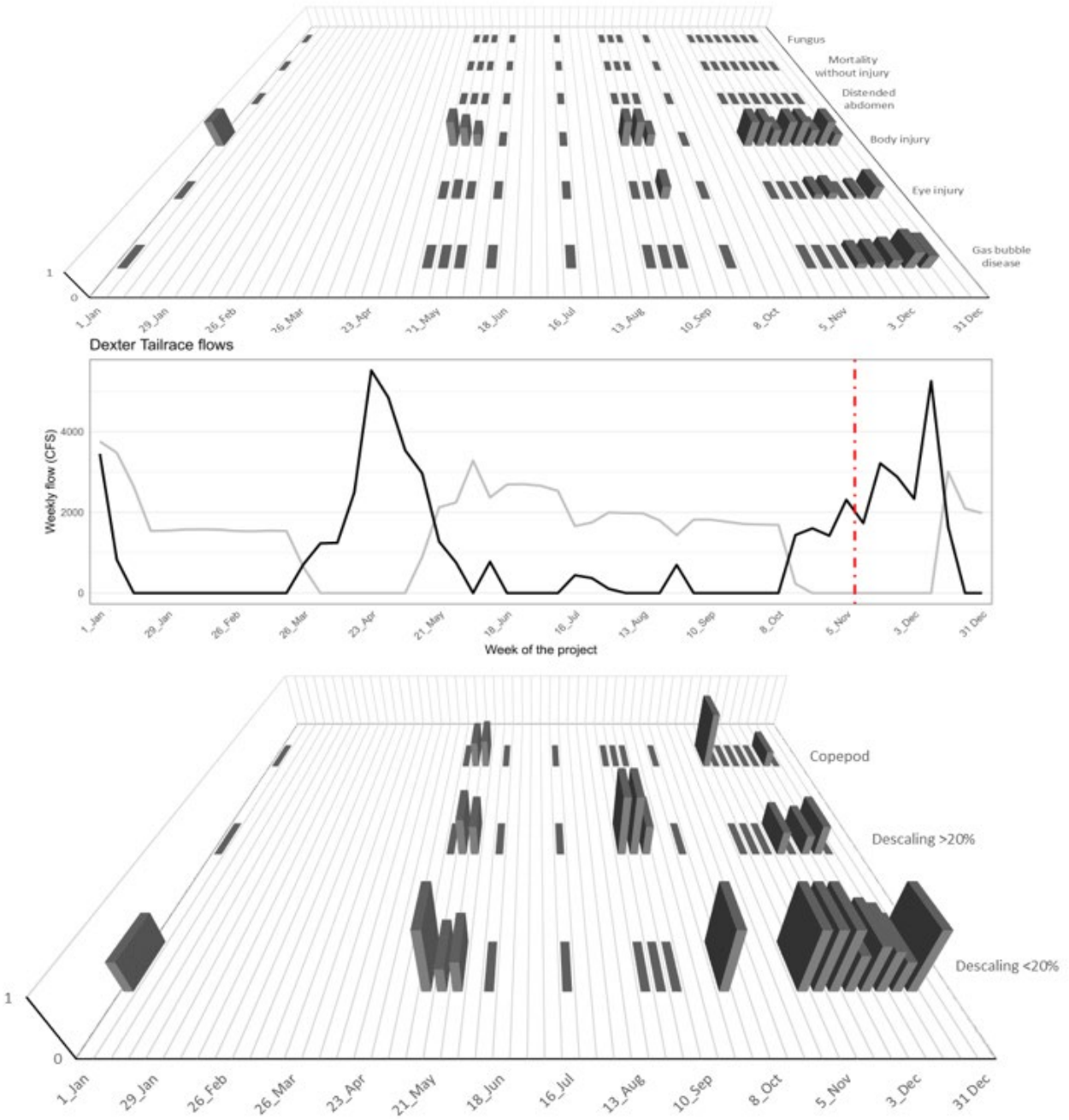

Figure 45. Proportion of captured juvenile Chinook salmon displaying descaling less or greater than 20% descaling (top panel), operations data from Dexter Dam Tailrace showing cfs of spill (black line) and Powerhouse flow (gray line) outflows (middle panel), and proportion of captured juvenile Chinook salmon displaying injuries by type (bottom panel) from 2023.

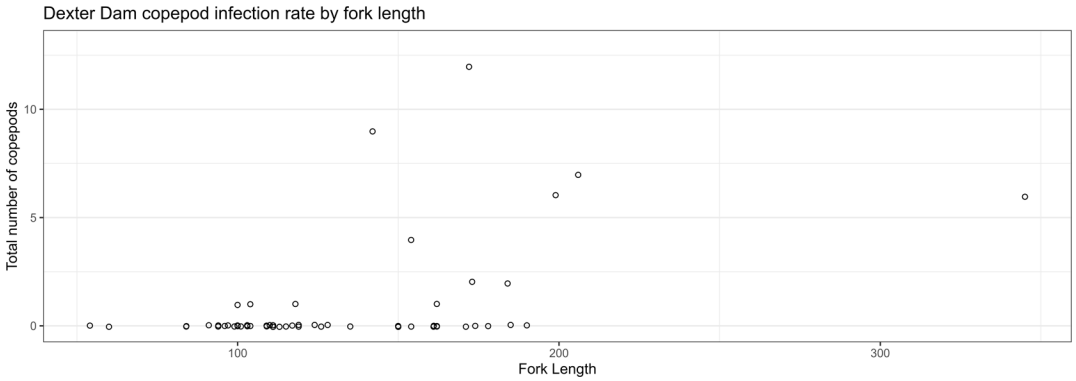

Figure 46. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Dexter Dam Tailrace from 2023.

24-Hour Hold Trials

24-hour hold trials were performed on NOR juvenile Chinook salmon captured in the Dexter Dam Tailrace to assess delayed mortality from dam passage. 49 Chinook salmon were held in 2023 (Table 49). A total of 3 Chinook salmon died during hold (6.1%). Mortality rates between the two-week reporting periods ranged from 0.0% to 100%.

Table 49. Summary of 24-hour hold trials for Chinook salmon captured in the RST at the Dexter Dam Tailrace site in 2023.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
1/1/2023–1/15/2023	Chinook	2	0	100.0%
5/16/2023–5/31/2023	Chinook	15	0	100.0%
6/1/2023–6/15/2023	Chinook	1	0	100.0%
6/16/2023–6/30/2023	Chinook	2	0	100.%
8/16/2023–8/31/2023	Chinook	1	1	0.0%
9/16/2023–9/30/2023	Chinook	1	0	100.0%
11/1/2023–11/15/2023	Chinook	4	0	100.0%
11/16/2023–11/30/2023	Chinook	8	1	87.5%
12/1/2023–12/15/2023	Chinook	15	1	93.3%
12/16/2023–12/30/2023	Chinook	2	0	100.0%

PIT Tagged/VIE Marked fish and Downstream Detections

No Chinook salmon were PIT tagged at the Dexter Dam Tailrace site in 2023, as all 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.

Willamette Valley Projects Encounters

A total of 22 adipose clipped and PIT tagged Chinook salmon were captured at the Dexter Dam Tailrace site in 2023. 20 of these fish were a part of Cramer Fish Science's bulk marked fish releases. 1 of these fish also had a suture mark indicating that it was an acoustic tagged fish from a passage study conducted by USGS. One tag was listed as an orphan tag on PTAGIS and likely was associated with Cramer Fish Science's bulk marked release groups and was either not entered in PTAGIS or incorrectly recorded in the field by EAS crews. 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 7,191 non-target fish were captured in 2023 in addition to NOR juvenile Chinook salmon. A summary of species and numbers of fish caught are provided in Table 50. The most commonly captured non-target species were crappie, sculpin, and clipped Chinook salmon (escapees from the Dexter Fish Facility).

Table 50. Summary of non-target fish captured in the RST at the Dexter Dam Tailrace site January 1 to December 31, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	143	21
Chinook (clipped)	808	6
Crappie	3,787	436
Cutthroat Throat	8	5
Dace	35	4
Largescale Sucker	9	2
O. mykiss	19	2
O. mykiss (clipped)	12	0
Redside Shiner	40	1
Sculpin	1,784	128
Smallmouth Bass	38	22
Brown Bullhead Catfish	1	0
Largemouth Bass	2	0
Mountain Whitefish	13	0
Northern Pikeminnow	30	0
Unknown	2	0
Unknown Bass	146	38
Walleye	314	48
Totals	**7,191**	**713**

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

Lookout Dam Tailrace

EAS began monitoring three 8-foot RSTs in the Middle Fork Willamette River in the Lookout Dam Tailrace on March 15, 2022. Sampling prior to August 1, 2023, was performed by EAS under contract W9127N19D0007. Sampling from August 1, 2023, through December 31, 2023, was performed by EAS as a sub-contractor for Cramer under contract W9127N19D0009. All data from sampling in 2023 in the Lookout Dam Tailrace will be included in this report. 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. These traps can capture fish that pass either the PH, spillways, or RO and thus a route of passage cannot be reliably assigned to fish captured in the traps. Instead, catch is reported by trap and not by route of passage. On September 5, 2023, the sampling orientation of the PH traps changed so that they fished side by side to allow crews safer access to both traps. A summary of sampling outages at this site can be found in Appendix B.

Trapping Efficiency Trials

A total of seven TE trials occurred using hatchery reared Chinook salmon at the Lookout Dam Tailrace site for this contract. Collectively, a total of 13 trials have been performed by EAS at this site since monitoring began in 2022. Releases prior to August 1, 2023, were performed by EAS for the USACE under contract W9127N19D0007. A summary of fish release numbers, recaptures, and flow level for the trials are provided in Table 51.

Trapping efficiencies are poor and complex at this site. One trap is located in a channel for the spill but can also catch fish via the PH route in extremely low numbers under specific conditions. Two traps are located on the PH side channel. Prior to September 5, 2023, the two traps had been oriented in the Powerhouse channel with one trap upstream closer to the north shore and the second trap just downstream and offset to the south of the upstream trap. The decision was made to change the trap orientation to sample them side by side so as to address personnel safety concerns resulting from checking the traps in the previous setup. It was anticipated that this change would not negatively impact the effectiveness of the traps when sampling and was believed it would improve catch as the new orientation ensures that the traps sample next to each other instead of potentially following similar current lines if the previous offset changed with various flow conditions.

Spill TE via spill routes had two out of seven successful trials with an average TE of 0.97% 95% CI of +/- 1.6% and Spill TE via PH route had one out of six successful trials TE 0.17%, but that trial also had a significant amount of spill occur. PH daily average was 1,817 and Spill daily average was 1,342 cfs. For the remainder of the trials, the RST either was not functioning (n=4) due to low flow, or stopped by debris and failed to get five returns including the utilization of a 16,000 fish TE trial undertaken via the PH route that yielded a single return.

PH1 TE via PH route had had one out of seven successful trials, with a pooled (includes all TEs when the trap was functional n=6) with an average TE of 0.028% 95% CI of +/- 0.038% and P 1 TE via Spill route had two out of eight successful trials average TE 0.0073%. For the rest of the trials the trap either was not functioning (n=1) or failed to get five returns including a 16,000 fish TE trial undertaken via the PH route that yielded three returns, resulting in a TE of 0.019%. The pooled average TE P 1 via Powerhouse route (37,047 fish released and 9 recaptures) when the trap was functional (n=6) is 0.0243%.

PH2 (relocated trap) TE via PH route had three out of seven successful trials, with a pooled (includes all TEs when the trap was functional n=7) with an average TE of 0.13% 95% CI of +/- 0.13% and PH2 TE via Spill route had two out of eight successful trials average TE 0.025%. For the rest of the trials the trap was not functioning (n=6 spill route) or failed to get five returns (n=5 Powerhouse route). The 16,000 fish TE trial, which occurred after the trap was moved via the PH route, yielded 25 returns and a TE of 0.15%. The pooled average TE P 1 via Powerhouse route (37,047 fish released and 25 recaptures) when the trap was functional (n=8) is 0.15%.

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. With

the new configuration of PH1 and PH2 side by side they will have similar TEs or a ratio between the traps and we will be able to gain some statistical power.

Recaptures were pooled in the below table. Due to the low efficiency of the traps and the wide range of flows sampled, more trials are needed to calculate passage estimates for this site. Plots displaying trap efficiency in relation to flow with consideration of route for all trials are provided in Appendix E.

Table 51. 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%

*Release performed by EAS for the USACE under contract W9127N19D0007.
#Release performed after Powerhouse RSTs sampling orientation changed.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Lookout Point Dam in 2023. The first 60 wild fish caught per week are prioritized for the 24-hour hold mortality study and are not tagged. Sufficient numbers of fish were not available to perform trials in 2023.

Target Catch and Passage Timing

A total of 139 juvenile Chinook salmon were captured in the Lookout Dam Tailrace during the 2023 sampling period, 68 in the PH traps (48.9% of total catch, 25 in PH1, 43 in PH2) (Figures 47 and 48) and 71 in the Spill trap (51.1% of total catch) (Figure 49). Chinook salmon capture from January 1, 2023, to June 30, 2023, comprised individuals from BY 2020 (n=5, 10.2% of spring Chinook salmon catch), BY 2021 (n=32, 65.3% of spring Chinook salmon catch), and BY 2022 (n=12, 24.5% of spring Chinook salmon catch) (Figure 50). The first BY 2022 sub-yearling was captured on March 28, 2023.

Capture of Chinook salmon from July 1, 2023, to the end of the year was composed of 92 fish from two BYs: 33 BY 2021 and 59 BY 2022 fish. Peak capture of Chinook salmon in the fall occurred in December when 75 fish were captured (53.2% of total Chinook salmon capture). A summary of fork length and weight data for Chinook salmon captured in the Lookout Dam Tailrace RSTs by BY is provided in Table 52.

Our trapping rate in the Lookout Dam Tailrace was approximately 0.4 fish per day. This is similar to rates from sampling in 2022 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 2021 through 2023, total adult Chinook out planting was 396, 1142, and 71 adult Chinook, respectively.

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, as Dexter Reservoir and Dexter Dam are immediately below Lookout Dam, we were able to provide passage estimates for the trap in the tailrace of Dexter 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). The overall catch below Lookout Point Dam in 2023 coincided with surface spill events in the late spring and early summer, in concurrence with previous study's conclusions. Additionally, a majority of the Chinook salmon captured in the RSTs occurred in December as the reservoir refilled during a large rain event. Catch rates decreased after this event, suggesting that the increase in flow into the reservoir may have triggered some fish to migrate downstream. For raw weekly catch of Chinook at the Lookout Dam RST sites for sampling from 2021 to 2023, refer to Appendix I.

Table 52. Summary of fork length and weight observed on juvenile Chinook salmon of natural origin at the Lookout Point Dam Tailrace RST sites by brood year in 2023.

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	1/1/2023–6/30/2023	20	5	246	227	275	247	158.7	37.9	269.0	161.4
Chinook	1/1/2023–6/30/2023	21	32	155.9	96	199	116.5	47.3	9.4	81.9	47.5
Chinook	1/1/2023–6/30/2023	22	12	57.3	33	113	53.5	N/A	N/A	N/A	N/A
Chinook	7/1/2023–12/31/2023	21	33	175.3	100	227	182	67.4	12.1	134.9	69.8
Chinook	7/1/2023–12/31/2023	22	59	100.4	31	121	101	11.7	1.0	21.7	10.8

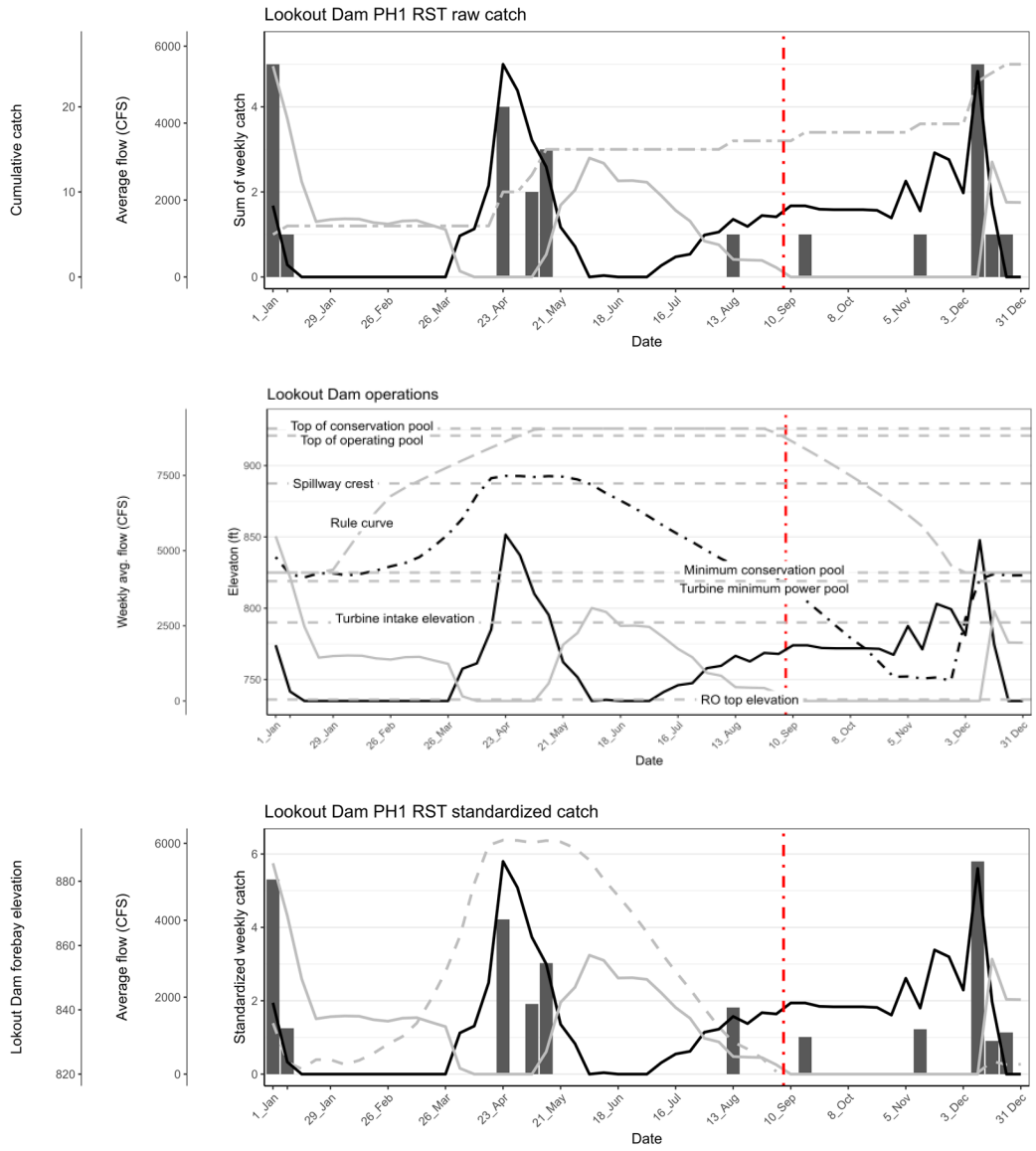

Figure 47. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at Lookout Point Dam Tailrace PH1 trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), and cumulative catch (gray dot dash line) for 2023. The red dot dash line denotes when the Powerhouse traps were moved side by side for crew safety and trapping efficiency.

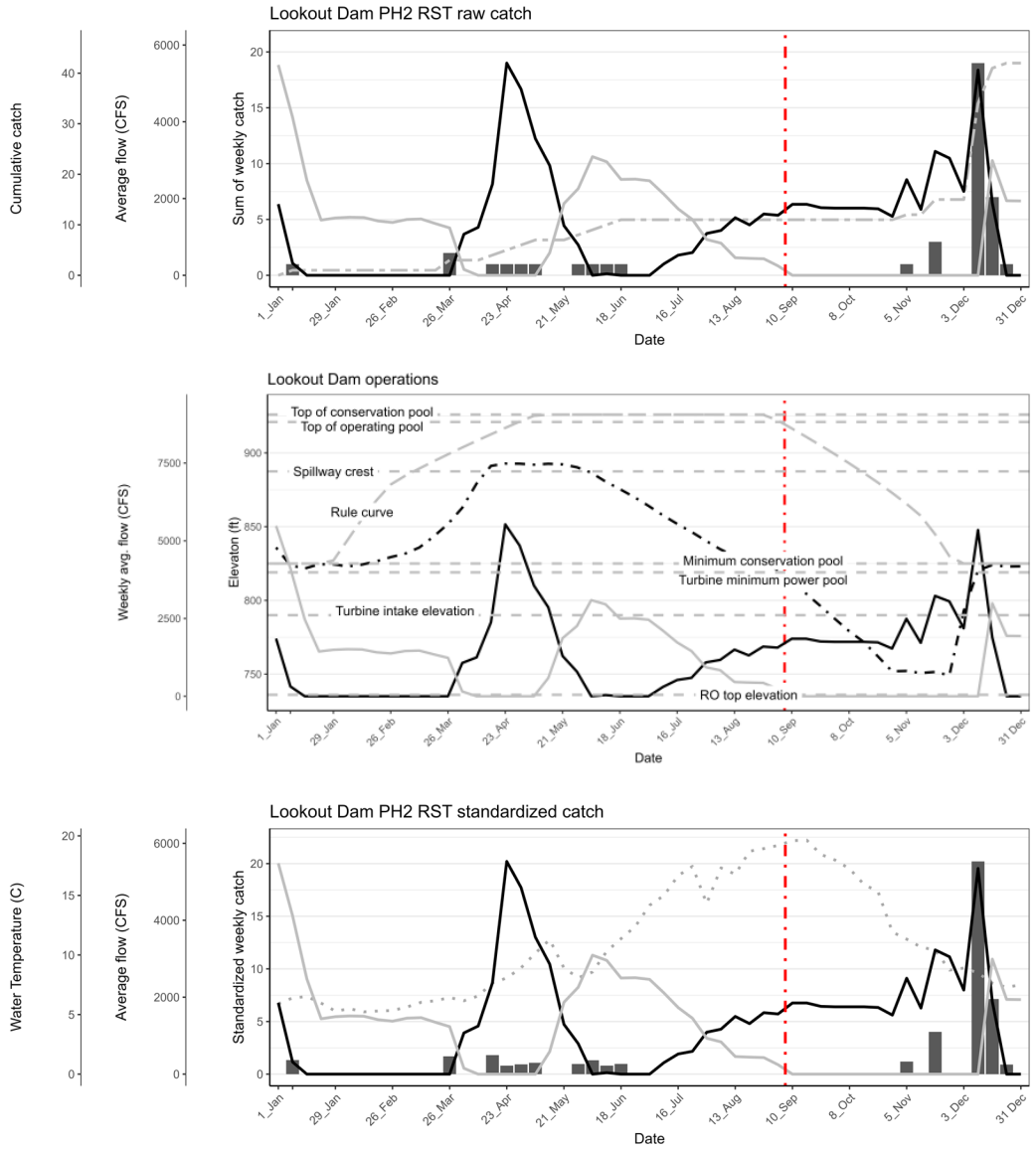

Figure 48. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at Lookout Dam Tailrace PH2 trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) for 2023. The red dot dash line denotes when the Powerhouse traps were moved side by side for crew safety and trapping efficiency.

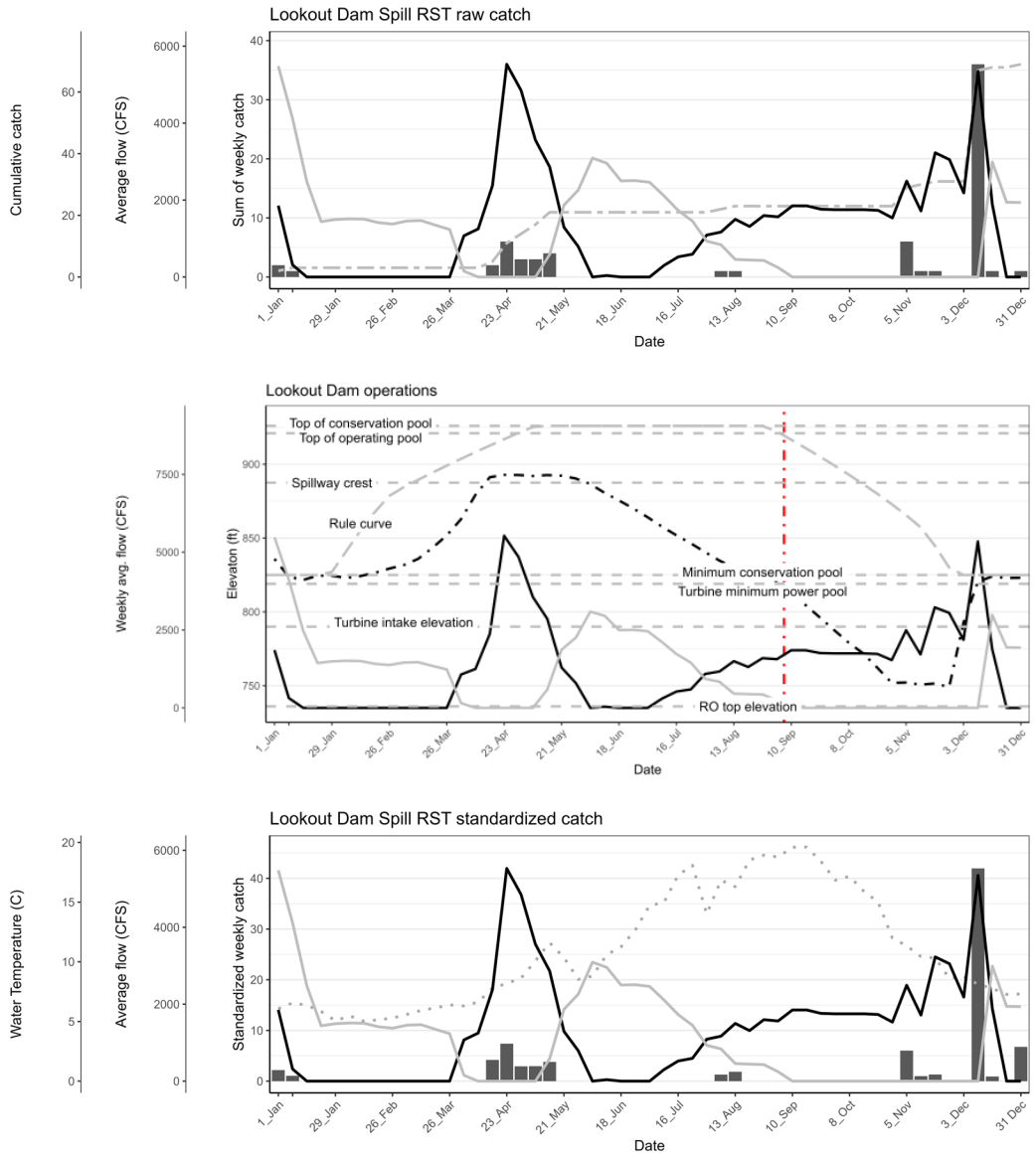

Figure 49. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at Lookout Dam Tailrace Spill trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) for 2023. The red dot dash line denotes when the Powerhouse traps were moved side by side for crew safety and trapping efficiency.

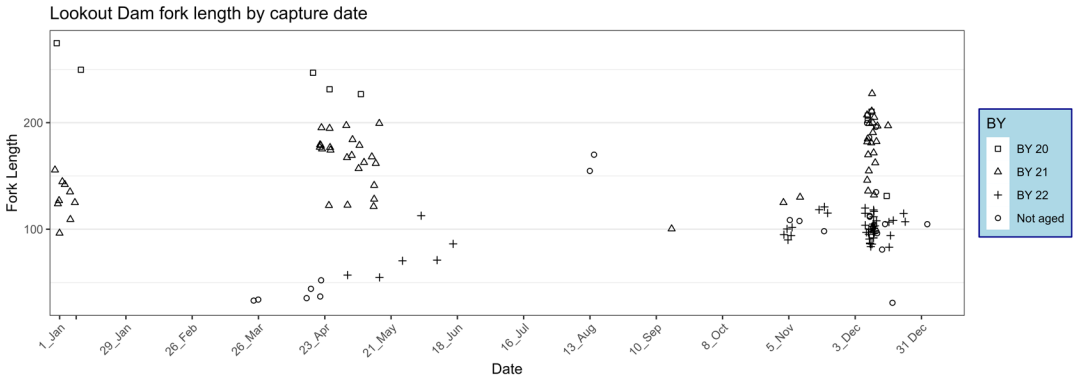

Figure 50. Length-frequency analysis for age of juvenile Chinook salmon captured below Lookout Point Dam from 2023.

Injury Data

A total of 135 juvenile Chinook salmon (97.1% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 2. 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 53). At the Lookout Point Dam Tailrace RST site, natural origin juvenile Chinook salmon and PIT tagged bulk mark released recaptures exhibited similar injuries (Table 53). Similarly, the most common injuries within these sampled fish were descaling, fin damage, gas bubble disease, and the presence of copepods (Table 53).

Figure 51 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 on captured Chinook salmon showed a positive correlation with the size of fish similar to observations made by previous studies (CFS 2023; Monzyk et al. 2015). However, this correlation is not as strong as those seen in other basins (Figure 52). Additional information regarding injuries by size and average injuries per fish is available 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 53. The percentage of target Chinook salmon and bulk marked Chinook salmon displaying injury by type at Lookout Point Dam Tailrace in 2023.

Injury Code	Chinook Injuries (NOR) (n=139)	Chinook Injuries (PIT tagged bulk mark release recaptures) (n=71)
NXI	2.9%	1.4%
MUNK	0.0%	0.0%
DS<2	47.5%	47.9%
DS>2	43.9%	47.9%
BLO	1.4%	1.4%
EYB	8.6%	8.5%
BVT	5.8%	2.8%
FVB	19.4%	19.7%
GBD	43.2%	50.7%
POP	1.4%	2.8%
HIN	11.5%	12.7%
OPD	14.4%	14.1%
TEA	7.2%	4.2%
BRU	7.2%	4.2%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	1.4%	2.8%
FID	85.6%	87.3%
PRD	0.0%	0.0%
COP	31.7%	33.8%
BKD	0.0%	0.0%
FUN	0.7%	0.0%

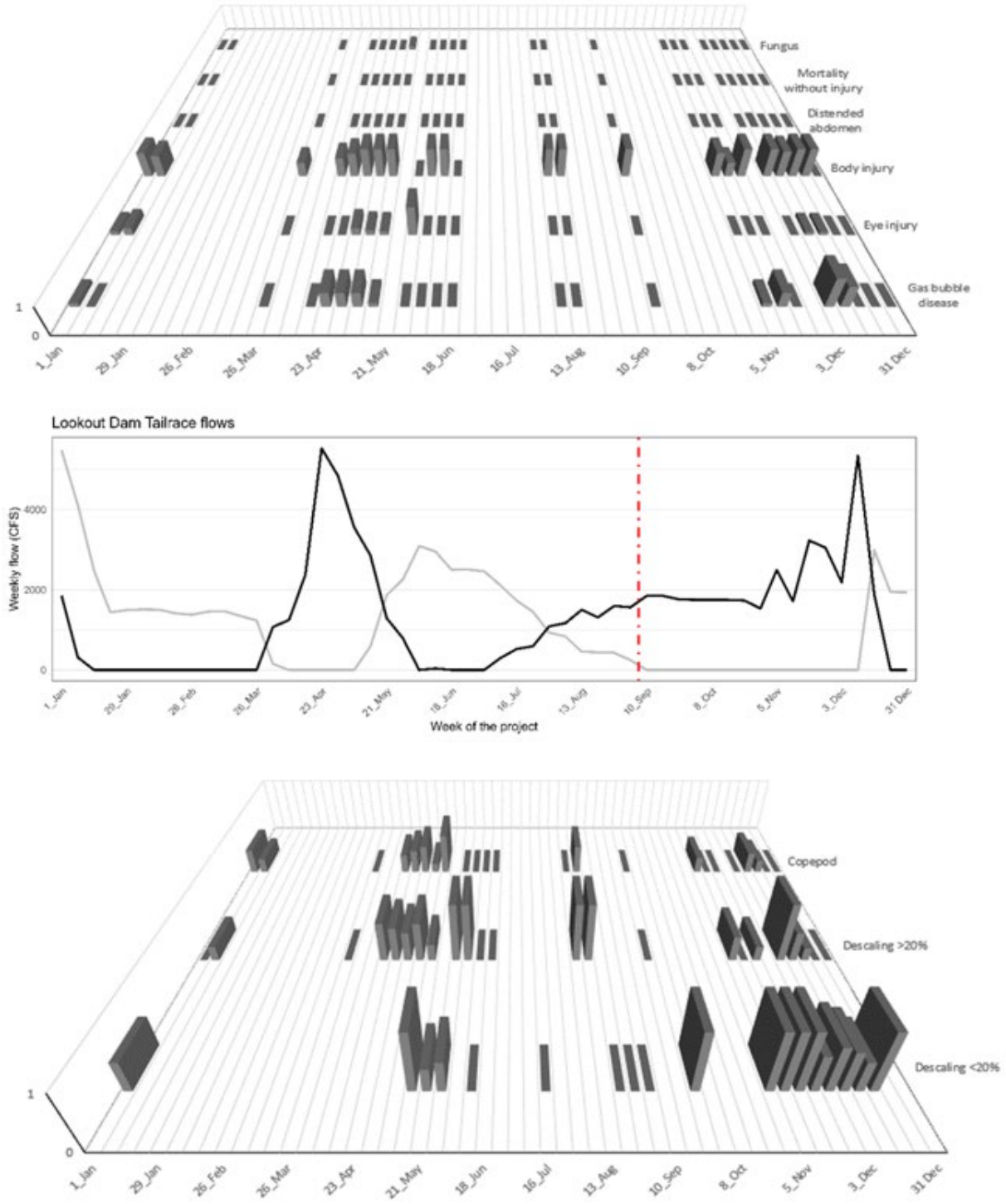

Figure 51. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data from the Lookout Dam Tailrace showing cfs of spill (black line) and Powerhouse flow (gray line) outflows (middle panel), and proportion of captured juvenile Chinook salmon displaying descaling injuries and copepod presence (bottom panel) from 2023.

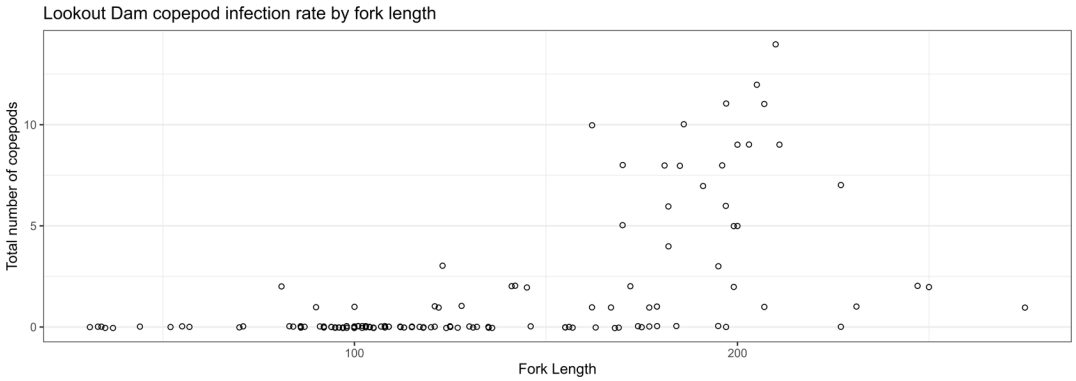

Figure 52. Copepod prevalence vs fork length on juvenile Chinook salmon captured below Lookout Point Dam from 2023.

24-Hour Hold Trials

24-hour hold trials were performed at the Lookout Dam Tailrace site to assess delayed mortality resulting from dam passage. A total of 95 fish, 51 from the Spill and 44 from the PH traps, were held (Table 54). A total of 40 fish died during hold (42.1%). 24 of the 51 Spill Chinook salmon died (47.1%) and 16 of the 44 PH Chinook salmon died (36.4%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100%.

Table 54. Summary of 24-hour trials for Chinook salmon captured in the RSTs at the Lookout Dam Tailrace sites from 2023.

Hold Period	Route	Number of Fish Held	Mortalities	% Survived
1/16/2023–1/31/2023	PWR	6	0	100%
1/16/2023–1/31/2023	Spill	3	0	100%
3/16/2023–3/31/2023	PWR	2	0	100%
4/16/2023–4/30/2023	PWR	5	0	100%
4/16/2023–4/30/2023	Spill	8	3	62.5%
5/1/2023–5/15/2023	PWR	3	2	33.3%
5/1/2023–5/15/2023	Spill	7	2	71.4%
5/16/2023–5/31/2023	PWR	3	1	66.7
5/16/2023–5/31/2023	Spill	1	0	100%
6/1/2023–6/15/2023	PWR	2	1	50.0%
6/16/2023–6/30/2023	PWR	1	1	0%
9/16/2023–9/30/2023	PWR	1	0	100.0%
11/1/2023–11/15/2023	PWR	1	1	0.0%
11/1/2023–11/15/2023	RO	6	4	33.3%
11/16/2023–11/30/2023	PWR	4	2	50.0%
12/1/2023–12/15/2023	PWR	6	6	0.0%
12/1/2023–12/15/2023	RO	23	14	39.1%
12/16/2023–12/31/2023	PWR	10	2	80.0%
12/16/2023–12/31/2023	RO	3	1	66.7%

PIT Tagged/VIE Marked Fish and Downstream Detections

No juvenile Chinook salmon were PIT tagged at the RST sites below Lookout Point Dam in 2023 as all captured fish were placed into the 24-hour hold study. No fish were VIE marked at this location in 2023 as fish were prioritized for the 24-hour hold study and no VIE marked fish from upstream sites were detected.

Willamette Valley Projects Encounters

A total of 38 adipose clipped and PIT tagged Chinook salmon were encountered below Lookout Point Dam in 2023. These fish were associated with bulk mark fish releases performed by Cramer. 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 199,739 non-target fish were captured in the RSTs below Lookout Point Dam in 2023 (Table 55). The most common non-target species encountered were crappie and unknown bass. The vast majority of crappie and bass capture consisted of small young of year fish similar to observations from sampling in 2022 (EAS 2023).

Table 55. Summary of non-target fish capture below Lookout Point Dam from 2023.

Species	Season Total	Season Total Mortality (subset of total)
Largemouth Bass	23	23
Bass Unknown	27,314	24,329
Bluegill	108	21
Brown Bullhead	6	3
Chinook (clipped)	397	91
Crappie	170,727	118,238
Largescale Sucker	35	9
Northern Pikeminnow	69	5
O. mykiss	22	3
O. mykiss (clipped)	4	0
Pumpkinseed	1	0
Redside Shiner	2	0
Sculpin	185	13
Smallmouth Bass	619	476
Spotted Bass	2	0
Unknown	7	7
Walleye	218	53
Totals	**199,739**	**143,271**

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

Lookout Point Head of Reservoir – Middle Fork Willamette River

EAS began monitoring a single 5-foot RST in the Middle Fork Willamette River above Lookout Point Reservoir on March 6, 2023. Sampling prior to December 16, 2023, was performed by EAS under contract W9127N19D0007. Sampling from December 16, 2023, through December 31, 2023, was conducted by EAS as a sub-contractor for Cramer under contract W9127N19D0009. All data collected from this site in 2023 will be included in this report. The trap did not sample from March 16, 2023, to May 17, 2023, due to safety concerns at the site. Additional information regarding sampling outages is listed in Appendix B.

Trapping Efficiency Trials

A total of one TE trial occurred using hatchery reared Chinook salmon at the Lookout Point Head of Reservoir site for this contract. Collectively, a total of 19 trials have occurred at the site since monitoring began in 2022. Releases prior to December 16, 2023, were performed by EAS for the USACE under contract W9127N19D0007. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 56.

TEs ranged from 0.0% to 2.0%. Two trials near the end of 2022 yielded zero recaptures. Crew observations from this time suggest that the trap may have been visited by mammalian predators at night between trap checks. These encounters could have potentially cleared the live well of fish. Additional exclusion devices were added, but during low flow conditions, signs of predators have still been observed. TE pooled (restricted to successful trials due to possible predation) average of 9 trials 3.2% with 95% CI of 2.42%. However, a linear model (n=9) which showed increasing TE with increasing flow was fit to the TE trials (Rsq=0.61 and P value<0.05) (see Appendix E). However, the sample size is small, and results could change with more data due to difficulty detecting model assumption violations with small sample sizes. This estimate does not include any fish that may have migrated while the trap was not sampled during this reporting period. Given the small sample size of successful TE trials at this site, passage estimates, and confidence intervals should be considered preliminary until additional TE trials are conducted. Plots displaying TE in relation to flow and cone flux for all trials are provided in Appendix E.

Table 56. 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%

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
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%

*Release performed by EAS for the USACE under contract W9127N19D0007.

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Lookout Point Head of Reservoir in 2023. There were insufficient capture numbers from fish large enough to mark.

Target Catch, Passage Estimates, and Passage Timing

The trap captured 142 juvenile Chinook salmon during sampling in 2023. Peak capture of juvenile Chinook salmon entering Lookout Point Reservoir occurred in May (n= 46, 32.4%). It is likely that peak spring passage of juvenile Chinook salmon into Lookout Point Reservoir occurred in April while the site was offline due to safety concerns. This timing would be consistent with past observations from sampling in 2022 (see Appendix I). Peak capture of juvenile Chinook salmon entering Lookout Point Reservoir in the fall occurred in December (n=5, 3.5% of total catch). Figure 53 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 2021 yearlings (n= 5, 3.5% of total catch) and BY 2022 sub-yearlings (n= 137, 96.5%). BY 2022 Chinook salmon were the dominant age class captured at this site throughout the sampling period (Figure 54). The first BY 2022 sub-yearling captured at the trap occurred on January 12, 2023. Fork length and weight data by BY for Chinook salmon captured at this site is provided in Table 57.

Using TEs by flow category, we estimate that 5,967 (95% CI: 3,992 to 11,805) juvenile Chinook salmon passed the sampling site during monitoring in 2023 (Figure 53). This estimate does not include any fish that may have migrated while the trap was not sampled during this reporting period. Given a limited number of successful TE trials at this site along with possible predation occurring, passage estimates and confidence intervals should be interpreted with caution. Plots displaying TE in relation to flow and cone flux for all trials are provided in Appendix E.

Table 57. Summary of fork length and weight observed on juvenile Chinook salmon of natural origin at the Lookout Point Head of Reservoir RST site by brood year from 2023.

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	2/1/23–6/30/23	21	5	99.8	94	113	97	10.5	7.7	14.5	8.5
Chinook	2/1/23–6/30/23	22	123	46.4	30	93	42	N/A	N/A	N/A	N/A
Chinook	7/1/23–12/31/23	22	14	101.8	81	126	105	13.6	6.2	38.7	12.5

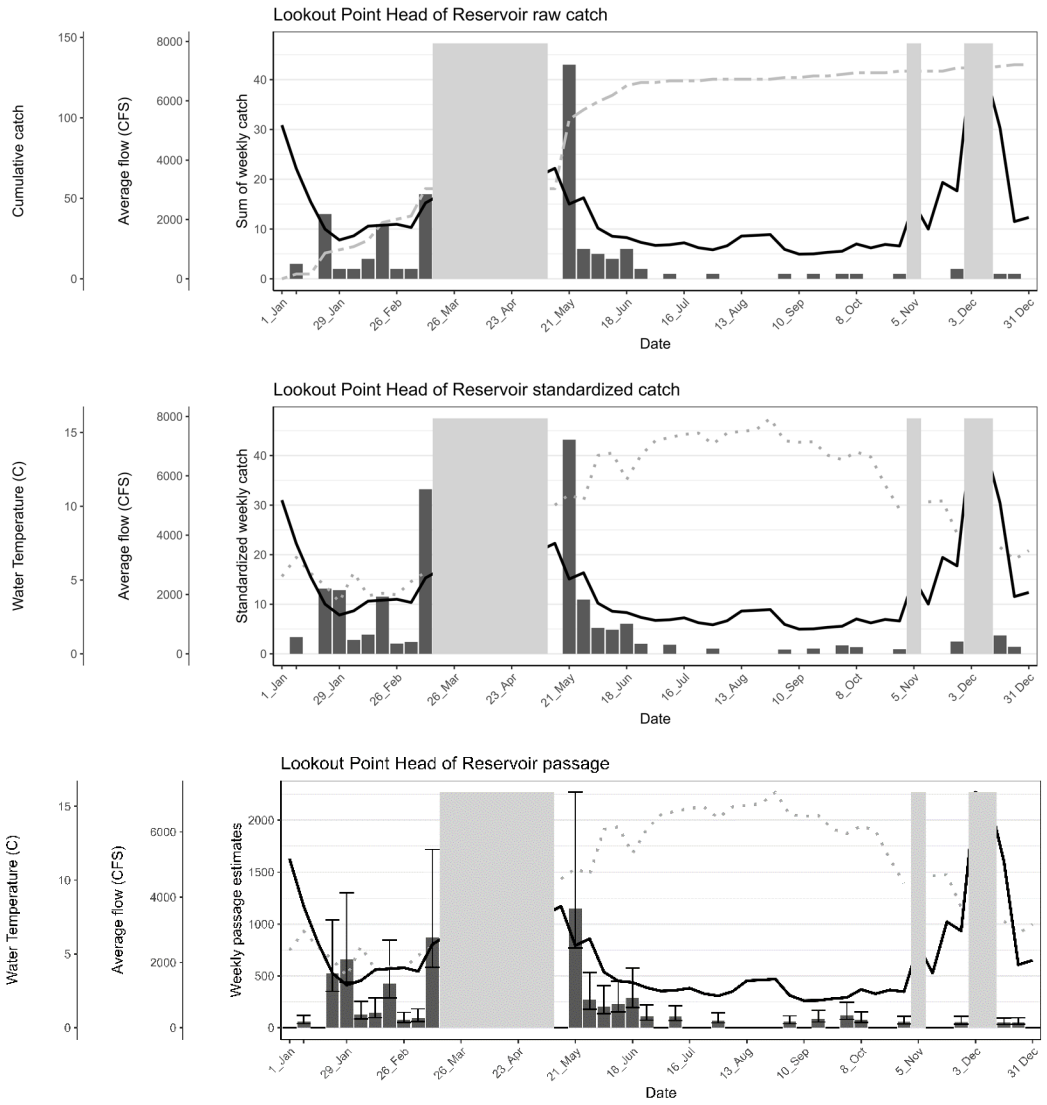

Figure 53. Raw catch (top panel), standardized catch (middle panel), and weekly passage estimates (bottom panel) of natural origin juvenile Chinook salmon at the Lookout Point Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), stream temperature (gray dotted line), and non-sampling weeks shaded out (gray) for 2023.

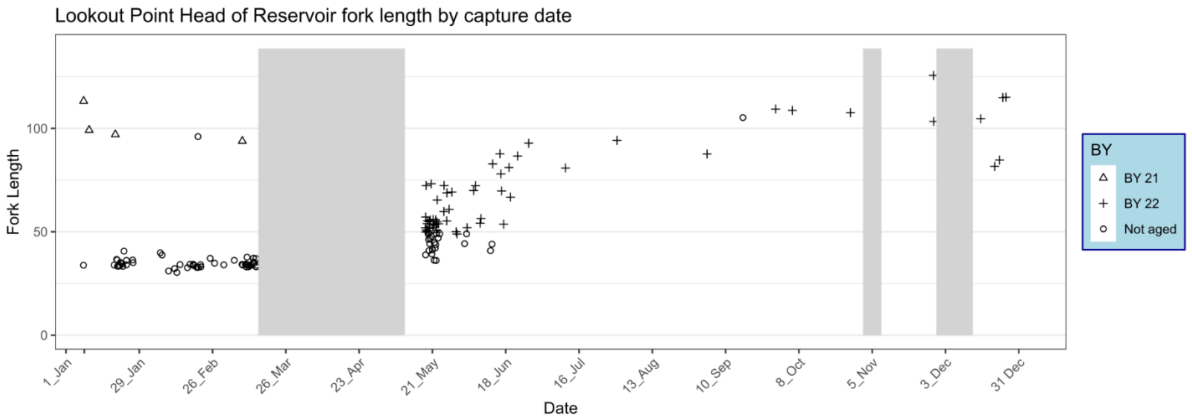

Figure 54. Length-frequency of juvenile Chinook salmon at the Lookout Point Head of Reservoir site from 2023.

Injury Data

A total of 50 juvenile Chinook salmon (35.0% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 2. The most common injuries observed at this site include descaling less than 20%, descaling greater than 20%, operculum damage, and fin damage (Table 58).

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 2023; Monzyk et al. 2015). However, at the Lookout Point Head of Reservoir RST site, only one copepod attached to a relatively small fish captured was evidenced in 2023 (Figure 55). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

There were six mortalities (4.2% of total Chinook salmon catch) observed upon trap check during the reporting period. These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Like 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 58. Summary of observed injuries on natural origin juvenile Chinook salmon captured in the Lookout Point Head of Reservoir RST

Injury Code	Chinook Injuries (NOR) (n=142)
NXI	65.5%
MUNK	0.7%
DS<2	21.1%
DS>2	3.5%
BLO	0.7%
EYB	2.1%
BVT	0.0%
FVB	1.4%
GBD	0.0%
POP	0.7%
HIN	0.7%
OPD	3.5%
TEA	2.1%
BRU	2.8%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	17.6%
PRD	0.0%
COP	0.7%
BKD	0.0%
FUN	0.0%

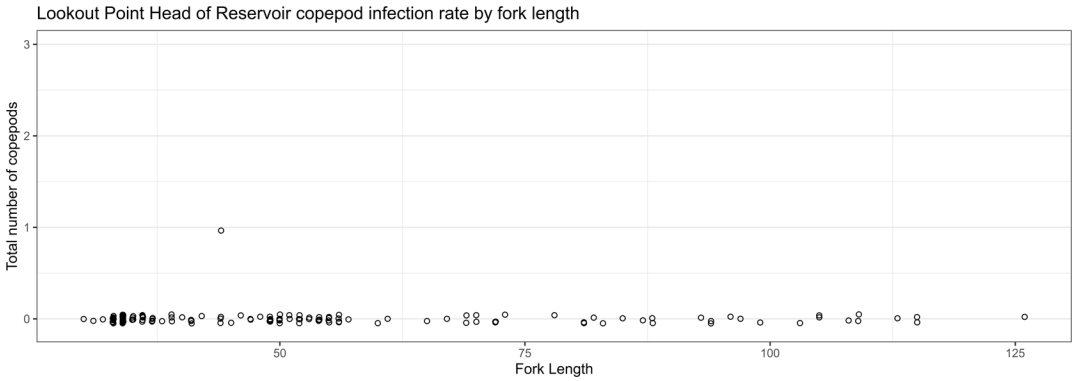

Figure 55. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Lookout Point Head of Reservoir from 2023.

PIT Tagged/VIE Marked fish and Downstream Detections

A total of 28 juvenile Chinook salmon were PIT tagged and 68 were VIE marked at the Lookout Point Head of Reservoir site in 2023. Fish that were not tagged were either still sac-fry or below minimum length requirements for tagging. As of December 31, 2023, no PIT tagged or VIE marked fish have been redetected at downstream sites. Table 59 shows a summary of VIE marked fish with the tagging period and mark details.

Table 59. Summary of VIE tagged Chinook salmon at the Lookout Point Head of Reservoir site.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured to Date
6/25/2022–7/15/2022	Left Dorsal	Yellow	3	0
7/16/2022–7/31/2022	Left Dorsal	Red	1	0
1/1/2023–1/31/2023	Left Dorsal	Blue	7	0
2/1/2023–2/15/2023	Right Dorsal	Yellow	2	0
2/16/2023–2/28/2023	Right Dorsal	Yellow	1	0
3/1/2023–3/15/2023	Right Dorsal	Red	3	0
5/16/2023–5/31/2023	Right Dorsal	Orange	33	0
6/1/2023–6/15/2023	Right Dorsal	Pink	9	0
6/16/2023–6/30/2023	Right Dorsal	Pink	9	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 in 2023. 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 1,151 non-target fish were captured at the Lookout Point Head of Reservoir site in addition to natural origin juvenile Chinook salmon. A summary of species and numbers of fish caught is provided in Table 60. The most commonly captured non-target species were dace and *O. mykiss*.

Table 60. 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)	72	4
Bluegill	2	0
Crappie	12	12
Cutthroat Trout	18	0
Dace	567	20
Largescale Sucker	88	3
Mountain Whitefish	61	16
Northern Pikeminnow	87	28
O. mykiss	205	4
Redside Shiner	4	0
Sculpin	34	1
Spotted Bass	1	0
Totals	**1,151**	**88**

Hills Creek Head of Reservoir – Middle Fork Willamette River

EAS began monitoring a single 5-foot RST in the Middle Fork Willamette River above Hills Creek Dam on May 9, 2023. Sampling occurred from May 9, 2023, to June 30, 2023. The initiation of sampling at this site was delayed due to limited trap availability resulting from supply chain issues preventing the manufacturer from delivering new traps within the quoted timelines. A summary of sampling outages at this site can be found 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).

Trapping Efficiency Trials

A total of two TE trials occurred using hatchery reared Chinook salmon at the Hills Creek Head of Reservoir – Middle Fork Willamette River sites in 2023. TEs ranged from 0.8% to 8.5%. TE pooled average of two trials 4.63% with 95% CI of 5.32%, and since the confidence intervals are outside of the average, we do not feel comfortable calculating passage estimates at this time.

Due to the delay in the initiation of sampling at this site and shortened sampling period, we were unable to accomplish enough trials to perform passage estimates. Undertaking additional TE trials over the range of flows sampled will be needed to provide passage estimates in the future. In the last year, gage height at this site ranged from 8.47 ft to 13.54 ft. A summary of TE trials is provided in Table 61.

Table 61. 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%

Run of River Trapping Efficiency Trials

No TE trials using ROR fish were performed at Hills Creek Head of Reservoir in 2023. There were insufficient capture numbers from fish large enough to mark to perform trials.

Target Catch, Passage Estimates and Passage Timing

A total of 93 NOR juvenile Chinook salmon were captured in the RST above Hills Creek Dam in 2023. Peak capture of juvenile Chinook salmon entering Hills Creek Reservoir in the spring occurred during June (n=48, 51.6% of total Chinook salmon catch) (Figure 56). Scale age analysis showed that all the Chinook salmon captured were BY 2022 sub-yearlings (Figure 57). The first Chinook salmon sub-yearling was captured on May 10, 2023, on the first day of sampling (Figures 56 and 57). Sampling in 2015 found that the median migration date for sub-yearling Chinook salmon was March 29, 2023, and it is speculated that fry moved into the reservoir prior to their sampling start in March (Romer et al. 2016, Appendix B, Table B-2). It is likely that many fish migrated into Hills Creek Reservoir prior to the initiation of sampling on May 9, 2023. A summary of fork length and weight data by brood year for Chinook salmon captured at this site in 2023 is provided in Table 62.

Utilizing TE trials, EAS was not able to confidently make passage estimates at this site. As previously stated, low flows resulted in TE trials that yielded insignificant results. Additional trials across various gage height (proxy for flow) ranges are planned to allow for more accurate passage estimates in future reports.

Table 62. Summary of fork length and weight observed on juvenile Chinook salmon of natural origin at the Lookout Point Head of Reservoir RST site by brood year from 2023.

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	2/1/23–6/30/23	22	93	43.7	30	76	44	N/A	N/A	N/A	N/A

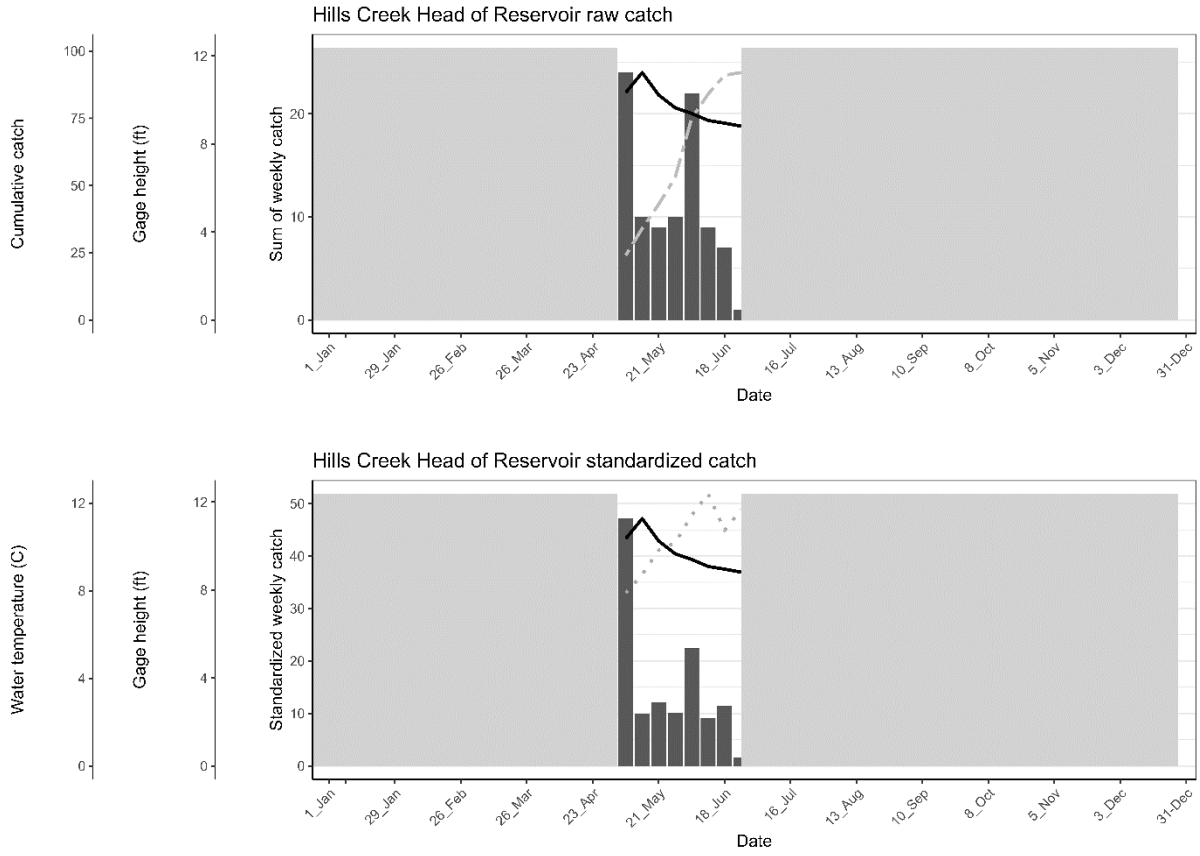

Figure 56. Raw (top panel) and weekly standardized (bottom panel) catch with stream gage height (black line), stream temperature (gray dot line), cumulative catch (gray dash dot line), and non-sampling weeks shaded out (gray) for the Hills Creek Head of Reservoir- Middle Fork Willamette River RST for sampling for 2023.

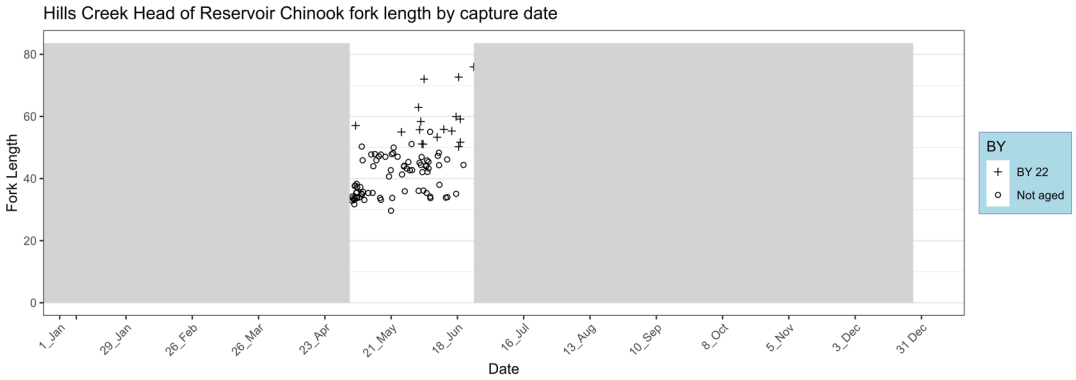

Figure 57. Length-frequency of juvenile Chinook salmon by brood year at the Hills Creek Head of Reservoir – Middle Fork Willamette River for 2023.

Injury Data

A total of eight (8.6% of total Chinook salmon catch) juvenile Chinook salmon displayed at least one of the injury code conditions listed in Table 2. Injuries at this site are likely due to being captured in the RST. A summary of observed injuries can be found in Table 63. The most common injuries exhibited at the Hills Creek Head of Reservoir RST site are descaling 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.

No copepods were observed attached to fish captured at this site in 2023 (Figure 58). Additional information regarding injuries by size and average injuries per fish is available in Appendix D. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 63. Summary of injuries observed on juvenile Chinook salmon at the Hills Creek Head of Reservoir – Middle Fork Willamette River RST site for 2023.

Injury Code	Chinook Injuries (NOR) (n=93)
NXI	91.4%
MUNK	0.0%
DS<2	6.5%
DS>2	0.0%
BLO	0.0%
EYB	0.0%
BVT	0.0%
FVB	0.0%
GBD	0.0%
POP	0.0%
HIN	0.0%
OPD	0.0%
TEA	0.0%
BRU	0.0%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	2.2%
PRD	1.1%
COP	0.0%
BKD	0.0%
FUN	0.0%

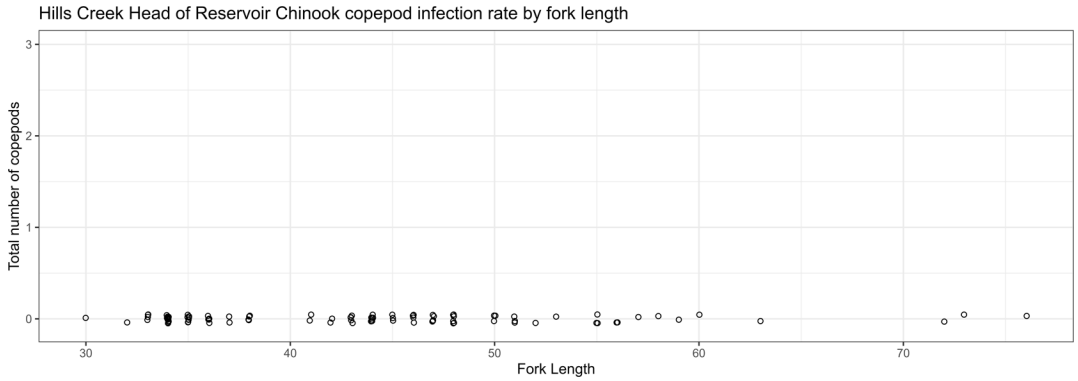

Figure 58. Copepod prevalence vs fork length on juvenile Chinook salmon captured at Hills Creek Head of Reservoir in 2023.

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 3 NOR Chinook were PIT tagged and 60 fish were VIE marked. Some Chinook salmon were not tagged, as they were still sac-fry or too small to safely mark. As of December 31, 2023, no PIT tagged or VIE marked fish were redetected downstream. Table 64 provides a summary of VIE marked fish at the Hills Creek Head of Reservoir – Middle Fork Willamette River site.

Table 64. Summary table of VIE marked Chinook salmon at the Hills Creek Head of Reservoir – Middle Fork Willamette River RST site for 2023.

Date Tagged	Species	Tag Location	VIE Color	# Tagged	# Recaptured to Date
5/1/2023–5/30/2023	Chinook	Left Dorsal	Orange	19	0
6/1/2023–6/30/2023	Chinook	Left Dorsal	Pink	41	0

Non-Target Species

In addition to natural origin juvenile Chinook salmon, a total of 325 non-target fish were captured. A summary of species and number of fish caught is provided in Table 65. The most commonly captured non-target species were dace and largescale sucker. The Bull Trout captured at this site was reported to ODFW staff. Information regarding Bull Trout captures, fork lengths, and PIT tags is provided in Appendix C.

Table 65. Summary of non-target fish capture at the Hills Creek Head of Reservoir – Middle Fork Willamette River RST site for 2023.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	8	1
Brook Lamprey	17	2
Bull Trout	1	0
Cutthroat Trout	2	0
Dace	87	1
Largescale Sucker	58	1
Mountain Whitefish	1	0
O. mykiss	32	0
Redside Shiner	12	0
Sculpin	20	1
Dace	87	1
Totals	**325**	**7**

Hills Creek Dam Tailrace

Monitoring in the Middle Fork Willamette River in the Hills Creek Dam Tailrace began on October 16, 2021. EAS began monitoring two RSTs (5-foot and 8-foot) in the Middle Fork Willamette River in the Hills Creek Dam Tailrace on September 15, 2023. Sampling prior to July 1, 2023, was conducted by EAS under contract W9127N19D0007. Sampling from July 1, 2023, through December 31, 2023, was performed by EAS as a sub-contractor for Cramer under contract W9127N19D0009. All data collected in 2023 will be included in this report. A summary of sampling outages at this site can be found in Appendix B.

Two traps sampled in the Tailrace of Hills Creek Dam in 2023. One is a 5-foot trap positioned below the confluence of the RO and PH outlet channels and is referred to as the RO trap. This trap captures fish from both outlets and thus juvenile Chinook salmon encountered in this RST cannot be assigned to a route of passage. The other is an 8-foot trap positioned in the outlet of the PH and is referred to as the PH trap.

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.

Trapping Efficiency Trials

A total of eleven TE trials occurred using hatchery reared Chinook salmon in the Hills Creek Dam sites for this contract. Collectively, a total of 35 trials have performed by EAS at this site since monitoring began in 2021. Releases prior to September 15, 2023, were performed by EAS for the USACE under contract W9127N19D0007. Fish released in the PH channel can be captured in the RO trap. Thus, each PH release is treated as a separate trial for both the PH and RO trap. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 66.

TEs ranged from 1.0% to 12.3% in the PH trap and from 0.0% to 3.2% in the RO trap.

Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled (Figure 47) for the PH trap. A linear model for the PH trap had shown a decreasing TE with increasing flow in previous reports, but that has reversed to a positive association with additional trials (Rsq=0.68 and P-value=0.005) (see Appendix E). However, the sample size is small, and the y intercept had to be set to 0. Results could change with more data as it is difficult to detect model assumption violations with small sample sizes. We estimate that 4,045 (95% CI: 2,537 to 9,974) juvenile Chinook salmon passed through the PH during sampling in 2023.

We were unable to calculate a passage estimate for the RO trap at this time as TEs varied greatly at this trap. More trials with larger release groups will be needed to provide sufficient data to calculate more detailed passage estimates. Plots displaying TE in relation to flow and cone flux for all trials with consideration of route for the RO are provided in Appendix E.

Table 66. 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 Regulating Outlet	11/29/2023	2130	504	2	0.4%
Hills Creek Dam Regulating Outlet	12/26/2023	750	505	10	2.0%

*Release was performed by EAS for the USACE under contract W9127N19D0007.

Run of River Trapping Efficiency Trials

A total of 96 dead Chinook salmon were marked and released for ROR TE trials in 2023 (Table 67). A total of 6 fish were recaptured in the PH trap. Live ROR fish were prioritized for the 24-hour hold mortality study. Therefore, dead fish captured in the Hills Creek Dam traps were distinctly marked and released below the PH to test dead fish TE. A summary of dead fish trials is provided below.

Table 67. Summary table of run of river releases at the Hills Creek Dam site for trapping efficiency for 2023.

Release Location	Date of Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Hills Creek Dam Powerhouse	September 2023	19	0	0.0%
Hills Creek Dam Powerhouse	October 2023	77	6	7.8%

Target Catch, Passage Estimates and Passage Timing

A total of 644 juvenile Chinook salmon were captured in the Hills Creek Dam RSTs during sampling in 2023, 397 in the PH trap (61.6% of total catch) and 247 in the RO trap (38.4% of total catch) (Figures 59 and 60). Peak capture of juvenile Chinook salmon occurred between March 8, 2023, and April 28, 2023, when 340 fish were captured (52.8% of total Chinook salmon catch). 135 Chinook salmon were captured in the RO trap (37.1% of catch for the spring period) and 229 were captured in the PH trap (62.9% of catch for the spring period). Scale age analysis showed that Chinook salmon captured from January 1, 2023, to June 30, 2023, consisted of four BYs: BY 2019, 2020, 2021, and 2022 (Figure 61). One BY 2019 fish was captured on June 27, 2023, that had a fork length of 314 mm and weighed 290.2 g. A total of 12 BY 2020 Chinook salmon (3.3% of total Chinook salmon catch) were caught in the spring period. One BY 2019 fish was captured on June 27, 2023. BY 2022 sub-yearlings comprised a majority of the catch below Hills Creek Dam in spring monitoring period (n= 346, 95.1% of total Chinook salmon catch). There were also four Chinook salmon captured that could not be assigned a BY due to the nature of the injuries they incurred during this period.

In the fall monitoring period from September 15, 2023, to December 31, 2023, a total of 280 juvenile Chinook salmon were captured in the RSTs below Hills Creek Dam: 168 in the PH trap (60.0% of fall catch) and 112 in the RO trap (40.0% of fall catch). Chinook salmon captured during this period consisted of one BY 2020, 261 BY 2021, and 18 BY 2022 fish.

Due to the aforementioned factors on TE trials, we are only able to make an estimate for Chinook salmon passage through the PH at this time. We estimate that 7,881 (95% CI: 5,519 to 13,782) juvenile Chinook salmon passed through the PH during sampling in 2023 (Figure 60). Fork length and weight data for Chinook salmon captured in the Hills Creek Dam Tailrace RSTs by BY is provided in Table 68.

Previously, a majority of observed Chinook salmon passage at Hills Creek Dam occurred during our sampling from October 2021 to the end of January 2022. Prior monitoring found that peak passage at Hills Creek Dam occurred November through January (Keefer et al. 2012). Previous studies also captured no small sub-yearling Chinook salmon below Hills Creek Dam. Our spring monitoring period catch in 2023 was composed primarily of sub-yearlings that may or may not have originated from above Hills Creek Reservoir. Future data using VIE or PIT tagged fry may help clarify the origin of these fish. 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 RST in both the spring and fall monitoring periods coincided with RO spill operations.

However, a majority 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 reservoir inflow or pool elevation may be influencing Chinook salmon movement out of Hills Creek Reservoir. For raw weekly Chinook catch at the Hills Creek Dam RSTs for sampling from 2021 through 2023, refer to Appendix I.

Table 68. Summary of fork length and weight observed on juvenile Chinook salmon of natural origin at the Hills Creek Dam Tailrace RST site by brood year in 2023.

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	1/1/2023–6/30/2023	19	1	314	314	314	N/A	290.2	290.2	290.2	N/A
Chinook	1/1/2023–6/30/2023	20	12	255.1	234	285	251.5	171.6	124.8	218.5	177.8
Chinook	1/1/2023–6/30/2023	21	1	122	122	122	N/A	19.6	19.6	19.6	N/A
Chinook	1/1/2023–6/30/2023	22	346	36	31	61	35	N/A	N/A	N/A	N/A
Chinook	1/1/2023–6/30/2023	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chinook	7/1/2023–12/31/2023	20	1	298	298	298	N/A	317.0	317.0	317.0	N/A
Chinook	7/1/2023–12/31/2023	21	261	188.4	129	233	193	80.6	20.4	149.3	82.1
Chinook	7/1/2023–12/31/2023	22	18	96.1	69	121	96	9.4	4.7	18.6	8.5

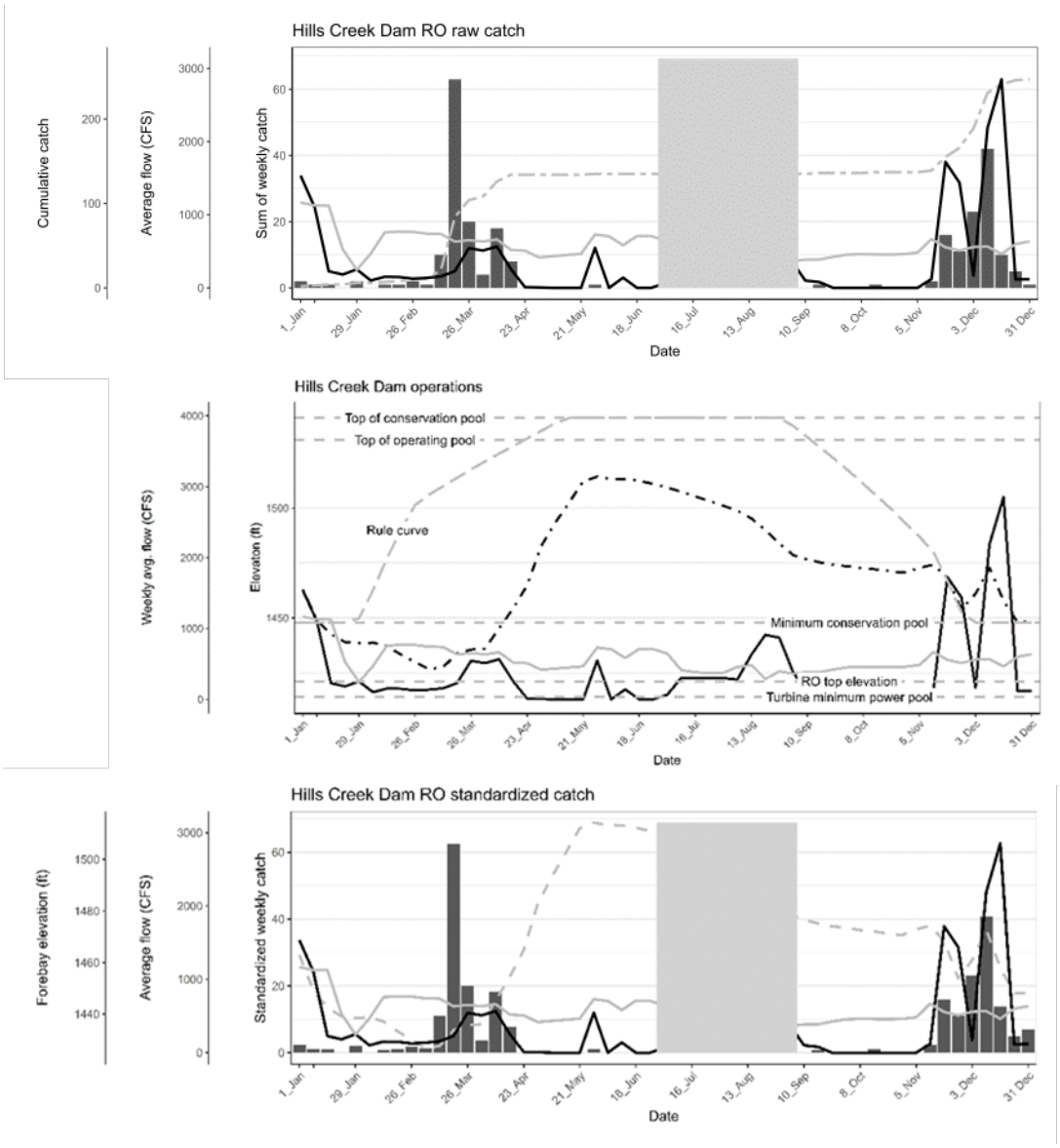

Figure 59. Raw catch (top panel) and weekly standardized catch (bottom panel) overlayed with RO outflow (black line), Powerhouse outflow (gray line), cumulative catch (gray dash dot line), and forebay elevation (gray dash line) for the RO trap below Hills Creek Dam for sampling from 2023. The middle 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).

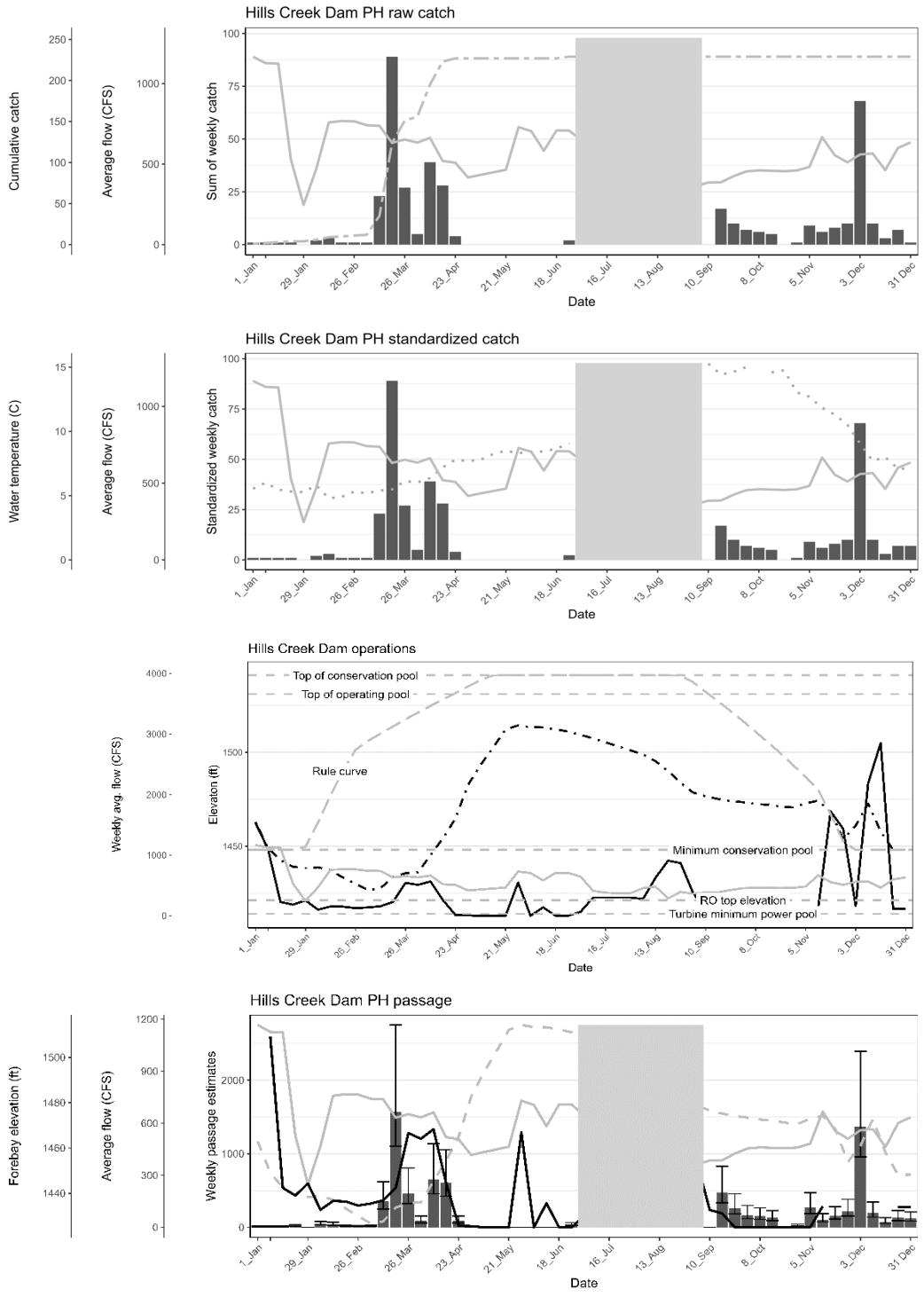

Figure 60. Raw catch (top panel), weekly standardized catch (second panel), Hills Creek Dam operations and features of interest (third panel), and weekly passage estimates (bottom panel) overlayed with Powerhouse outflow (gray line), RO outflow (black line), cumulative catch (gray dash dot line), forebay elevation (black dot dash line) and stream temperature (gray dots) for the PH trap below Hills Creek Dam for sampling from 2023.

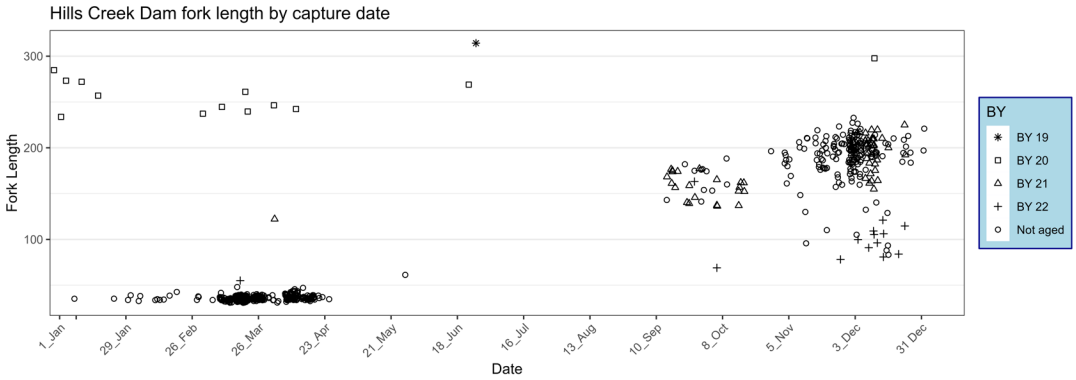

Figure 61. Length-frequency of juvenile Chinook salmon by brood year at the Hills Creek Dam site from 2023.

Injury Data

A total of 334 juvenile Chinook salmon (51.9% of total Chinook salmon catch) displayed at least one of the injury code conditions listed in Table 2. To provide insight on injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for TE trials at time of release and upon recapture. Injury rates by type both pre and post capture were then compared to determine a rate of injury occurrence associated with trap capture.

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 (Tables 69 and 70). 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 62. Copepod presence on captured Chinook salmon at this site illustrated a positive correlation with the size of fish, similar to observations made by previous studies (CFS 2023; Monzyk et al. 2015) (Figure 63).

Proportional injuries between TE releases, observed Chinook salmon and bulk marking recapture were highly variable at the Hills Creek Dam PH and RO traps. Pre-trial TE release injuries were consistent with those encountered at other sites and were predominantly descaling and fin damage (Tables 69 and 70). 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 (Tables 69 and 70).

There were two mortalities (0.5% of total Chinook salmon capture) at the time of trap check for this site: one in PH trap (0.4% of PWR capture) and one in the RO trap (0.7% of RO capture). There was no clear association with RO spill and increased injury rate at this site (Figure 62). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 69. Summary of injuries for Chinook salmon released for trapping efficiency fish, natural origin Chinook salmon, PIT tagged bulk mark release Chinook salmon at Hills Creek Dam Powerhouse RST in 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=400)	TE Recapture Injuries (proportion of total) (n=274)	Proportional Percent Change	Observed Chinook Injuries (n=397)	Bulk Marking Recapture Injuries (proportion of total)
NXI	41.3%	46.4%	5.1%	49.1%	0.0%
MUNK	0.0%	0.0%	0.0%	0.3%	0.0%
DS<2	49.5%	41.2%	-8.3%	21.7%	37.2%
DS>2	1.8%	4.4%	2.6%	22.9%	62.8%
BLO	0.0%	0.0%	0.0%	1.3%	1.2%
EYB	0.0%	0.0%	0.0%	6.3%	14.0%
BVT	0.0%	0.4%	0.4%	12.8%	11.6%
FVB	0.0%	0.7%	0.7%	14.4%	27.9%
GBD	0.0%	0.0%	0.0%	4.3%	1.2%
POP	0.0%	0.0%	0.0%	3.0%	0.0%
HIN	0.0%	0.4%	0.4%	7.6%	12.8%
OPD	0.5%	2.2%	1.7%	12.3%	16.3%
TEA	0.3%	0.0%	-0.3%	4.3%	3.5%
BRU	0.5%	0.0%	-0.5%	9.8%	15.1%
HBP	0.0%	0.0%	0.0%	2.3%	1.2%
HO	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	1.5%	3.5%
HBO	0.0%	0.0%	0.0%	0.5%	0.0%
FID	46.8%	49.6%	2.9%	42.3%	97.7%
PRD	0.0%	0.0%	0.0%	0.3%	0.0%
COP	0.0%	0.0%	0.0%	41.6%	55.8%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.3%	1.1%	0.8%	1.8%	5.8%

Table 70. Summary of injuries for Chinook salmon released for trapping efficiency fish, natural origin Chinook salmon, and PIT tagged bulk mark release Chinook salmon at Hills Creek Dam Regulatory Outlet RST in 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=400)	TE Recapture Injuries (proportion of total) (n=39)	Proportional Percent Change	Observed Chinook Injuries (n=247)	Bulk Marking Recapture Injuries (proportion of total)
NXI	18.3%	30.8%	12.4%	46.6%	0.0%
MUNK	0.0%	0.0%	0.0%	0.4%	0.0%
DS<2	81.3%	30.8%	-50.6%	22.7%	51.0%
DS>2	0.0%	30.8%	30.8%	26.3%	46.2%
BLO	0.0%	0.0%	0.0%	1.2%	4.8%
EYB	0.3%	0.0%	-0.3%	7.3%	15.4%
BVT	0.3%	0.0%	-0.3%	8.5%	9.6%
FVB	3.0%	0.0%	-3.0%	13.4%	16.3%
GBD	0.0%	0.0%	0.0%	6.9%	9.6%
POP	0.0%	0.0%	0.0%	0.8%	2.9%
HIN	0.0%	2.6%	2.6%	11.7%	14.4%
OPD	0.7%	0.0%	-0.7%	14.6%	16.3%
TEA	0.3%	0.0%	-0.3%	2.0%	4.8%
BRU	0.7%	0.0%	-0.7%	10.1%	10.6%
HBP	0.0%	0.0%	0.0%	0.8%	1.9%
HO	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	1.2%	0.0%
HBO	0.0%	0.0%	0.0%	0.4%	1.9%
FID	70.7%	64.1%	-6.6%	45.3%	96.2%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	42.5%	46.2%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	2.0%	30.8%	-2.0%	0.4%	7.7%

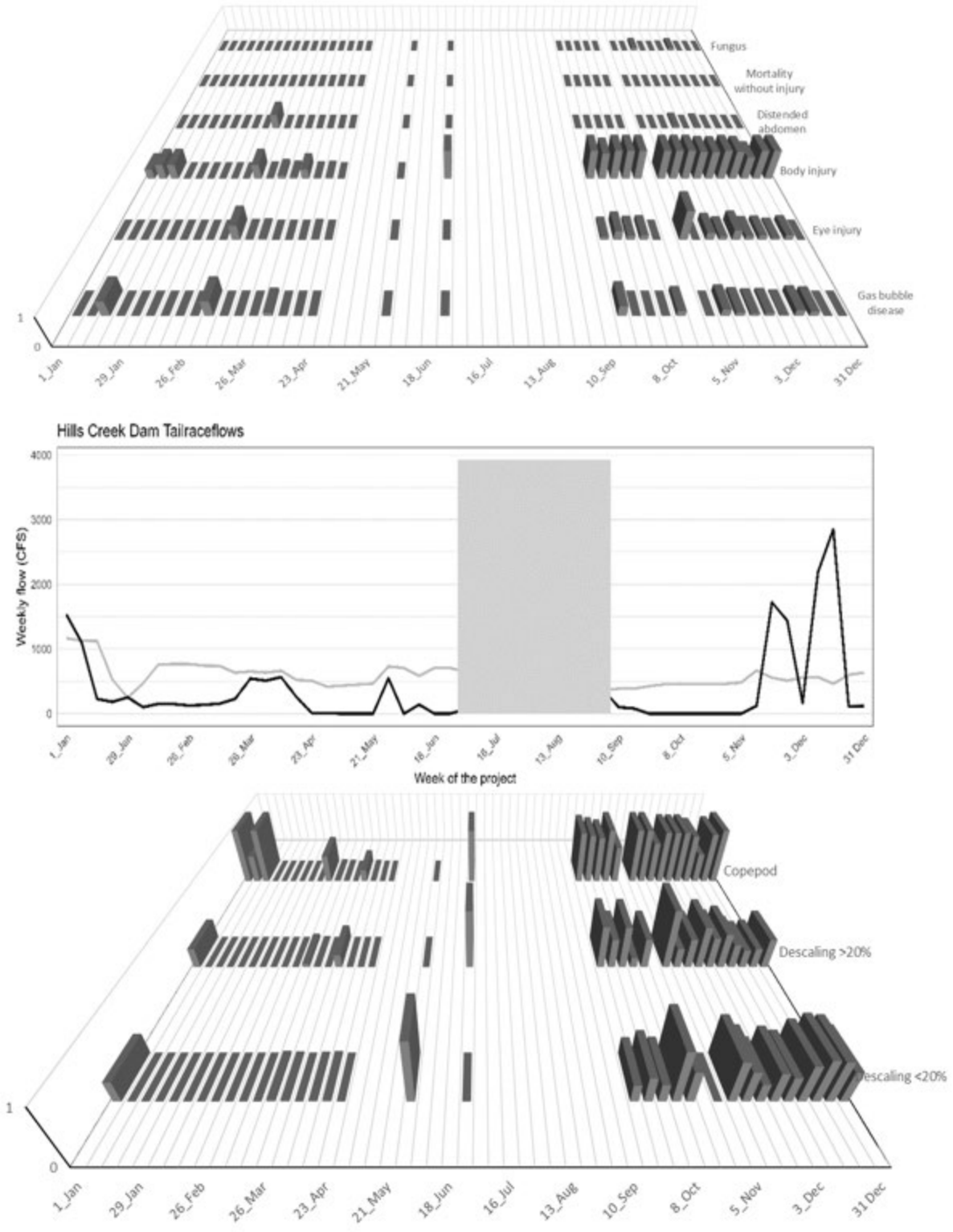

Figure 62. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data from the Hills Creek Dam showing cfs of spill (black line) and Powerhouse flow (gray line) outflows (middle panel), and proportion of captured juvenile Chinook salmon displaying descaling injuries and copepods (bottom panel) from 2023.

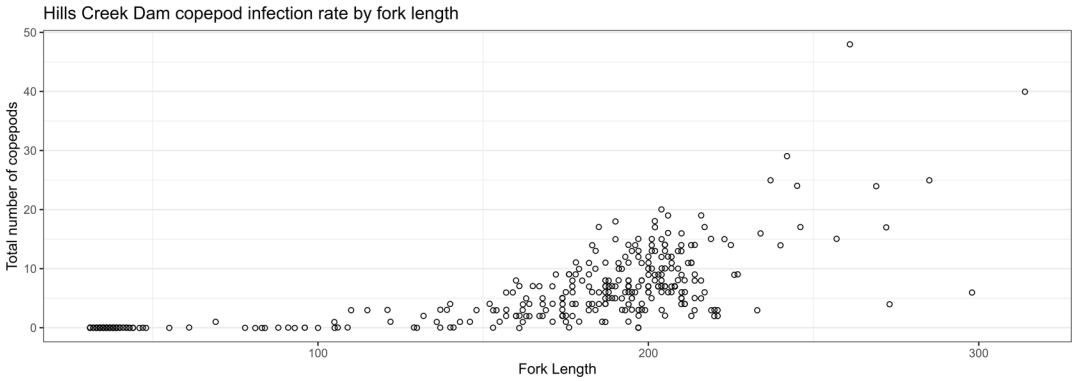

Figure 63. Copepod presence vs fork length on juvenile Chinook salmon captured below Hills Creek Dam from 2023.

24-Hour Hold Trials

24-hour hold trials were performed at the Hills Creek Dam site to assess delayed mortality resulting from dam passage. A total of 392 fish, 156 from the RO and 236 from the PH traps, were held (Table 71). A total of 52 fish died during hold (13.3%). 25 of the 156 RO Chinook salmon died (16.0%) and 27 of the 236 PH Chinook salmon died (11.4%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100.0%.

Table 71. Summary of 24-hour hold trials for Chinook salmon captured in the RST at the Hills Creek Dam site from 2023.

Hold Period	Trap	Number of Fish Held	Mortalities	% Survived
1/1/2023–1/15/2023	PH	2	1	50.0%
1/1/2023–1/15/2023	RO	2	0	100.0%
1/16/2023–1/31/2023	PH	1	0	100.0%
1/16/2023–1/31/2023	RO	3	0	100.0%
2/1/2023–2/15/2023	PH	3	0	100.0%
2/16/2023–2/28/2023	PH	4	0	100.0%
2/16/2023–2/28/2023	RO	4	0	100.0%
3/1/2023–3/15/2023	PH	6	0	100.0%
3/1/2023–3/15/2023	RO	3	0	100.0%
3/16/2023–3/31/2023	PH	75	0	100.0%
3/16/2023–3/31/2023	RO	54	0	100.0%
4/1/2023–4/15/2023	PH	45	0	100.0%
4/1/2023–4/15/2023	RO	18	0	100.0%
4/16/2023–4/30/2023	PH	31	0	100.0%
4/16/2023–4/30/2023	RO	8	1	87.5%
6/1/2023–6/15/2023	RO	1	0	100.0%
9/16/2023–9/30/2023	PWR	5	1	80.0%
9/16/2023–9/30/2023	RO	0	0	--
10/1/2023–10/15/2023	PWR	6	1	83.3%
10/1/2023–10/15/2023	RO	0	0	--
10/16/2023–10/31/2023	PWR	1	0	100.0%
10/16/2023–10/31/2023	RO	1	0	100.0%
11/1/2023–11/15/2023	PWR	11	1	90.9%
11/1/2023–11/15/2023	RO	1	1	0.0%
11/16/2023–11/30/2023	PWR	8	3	62.5%
11/16/2023–11/30/2023	RO	7	1	85.7%
12/1/2023–12/15/2023	PWR	31	19	38.7%
12/1/2023–12/15/2023	RO	41	18	56.1%
12/16/2023–12/31/2023	PWR	7	1	85.7%

Hold Period	Trap	Number of Fish Held	Mortalities	% Survived
12/16/2023–12/31/2023	RO	13	4	69.2%

PIT Tagged/VIE Marked Fish and Downstream Detections

At the Hills Creek Dam RST sites, one NOR Chinook salmon was PIT tagged and 39 were VIE marked. All other fish were either sac-fry or below minimum size for tagging. 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. The tagged fish were not redetected downstream as of Dember 31, 2023 (Table 72).

Table 72. Summary of VIE tagged Chinook salmon at the Hills Creek Dam site from 2023.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured to Date
3/16/2023–3/31/2023	Head	Red	39	0

Willamette Valley Projects Encounters

A total of 228 adipose clipped and PIT tagged Chinook salmon were captured in the RSTs below Hills Creek Dam in 2023. 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 4,844 non-target fish were captured. The most commonly captured non-target species were sculpin and crappie. A summary of species and numbers of fish caught is provided in Table 73.

Table 73. Summary of non-target catch for the RSTs in the Hills Creek Dam from 2023.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	1,704	763
Brook Lamprey	2	0
Cutthroat Trout	3	0
Bass Unknown	26	20
Bluegill	333	168
Pumpkinseed	2	2
Brown Bullhead	8	1
Crappie	1,625	1,214
Walleye	1	1
Dace	90	11
Largemouth Bass	7	3
Largescale Sucker	359	112
Northern Pikeminnow	1	0
O. mykiss	108	25
O. mykiss (clipped)	16	8
Redside Shiner	8	1
Sculpin	403	2
Smallmouth Bass	29	26
Spotted Bass	116	57
Unknown	3	3
Totals	**4,844**	**2,417**

*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
Big Cliff Dam Tailrace

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-3
Detroit Head of Reservoir –
North Santiam River

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
Cougar Dam Tailrace

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-7
Fall Creek Dam Tailrace

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-8

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

FIGURE A-9
Lookout Dam Tailrace

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-10
Lookout Point Head of Reservoir –
Middle Fork Willamette River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-11
Hills Creek Head of Reservoir –
Middle Fork Willamette River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-12

Hills Creek Dam Tailrace

RST Locations

500 Feet

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)	44.76786, -122.09588	One 5ft
Big Cliff Dam Tailrace	44.756329, -122.305269	One 5ft (2014–2016)	44.756329, -122.305269	One 8ft
Detroit Head of Reservoir- North Santiam	44.692766, -122.050425	One 5ft (2010–2016)	44.692766, -122.050425	One 5ft
Green Peter Head of Reservoir- Middle Santiam River	N/A	N/A	44.51486, -122.37353	One 5ft
Green Peter Dam Tailrace	N/A	N/A	44.44844, -122.55004	One 8ft
Cougar Dam Tailrace	44.755886, -122.235798	PWR two 8ft, RO two 5ft (2011), PWR two 8ft, RO one 5ft (2012–2016)	44.755886, -122.235798	PWR two 8ft, RO one 5ft
Fall Creek Dam Tailrace	43.945477, -122.760329	One 8ft (2006–2009) (2015–2016)	43.945477, -122.760329	One 8ft
Dexter Dam Tailrace	N/A	N/A	43.92527, -122.81147	One 5ft
Lookout Dam Tailrace	43.91442, -122.75658	Three 8ft	43.91442, -122.75658	Three 8ft
Lookout Point Head of Reservoir- Middle Fork Willamette River	43.76669, -122.53139	One 8ft (2007–2008) (2011–2016) Two 8ft (2009–2010)	43.76669, -122.53139	One 5ft
Hills Creek Dam Tailrace	43.71113, -122.42464	One 8ft (2007–2008) (2010–2016)	43.71113, -122.42464	One 8ft
Hills Creek Dam Tailrace RO	43.71208, -122.42340	One 5ft	43.71304, -122.42497	One 5ft
Hills Creek Head of Reservoir- Middle Fork Willamette River	43.60359, -122.45622	One 5ft (2015)	43.60359, -122.45622	One 5ft

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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
Breitenbush River	2/1/2023–6/16/2023	The manufacturer experienced delays and could not manufacture traps during this reporting period. No other traps were available until 6/16/2023. Trap was installed and began sampling on 6/16/2023.
Breitenbush River	11/2/2023–11/3/2023	The RST cone was raised to its non-fishing position due to high levels of debris, potentially resulting in damage to both the trap and associated fish within the trap.
Breitenbush River	11/4/2023–11/5/2023	The RST cone was raised to its non-fishing position due to high levels of debris, potentially resulting in damage to both the trap and associated fish within the trap.
Breitenbush River	11/6/2023–11/9/2023	The RST cone was raised to its non-fishing position due to high levels of debris, potentially resulting in damage to both the trap and associated fish within the trap.
Breitenbush River	11/18/2023–11/19/2023	Elevated rainstorms occurring in the area were expected to increase flows to dangerous levels for sampling, trap safety and overall fish health, resulting in raising the RST cone.
Breitenbush River	11/30/2023	The RST was raised and removed from its sampling location at Breitenbush River due to the completion of its 2023 contract.
Big Cliff Dam Tailrace	1/1/2023–1/16/2023	River flows surpassed 5,000 cfs and the RST was subsequently secured to the riverbank. As flows were expected to increase significantly to above 9,000 cfs, the RST was fully removed.
Big Cliff Dam Tailrace	5/15/2023–5/16/2023	The RST cone was raised to its non-fishing position due to high flows over 6,000 cfs. Flows at this level are dangerous for sampling, trap safety and overall fish health.
Big Cliff Dam Tailrace	6/8/2023–6/9/2023	The RST cone was raised to its non-fishing position and the trap was secured to the riverbank due to the highline and loop line breaking under increased and excessive pressure.
Big Cliff Dam Tailrace	7/17/2023–7/28/2023	The RST cone was raised to its non-fishing position due to a debris spill above the Big Cliff Dam Tailrace. A debris passage event was scheduled to clear debris from 2020 wildfires that had accumulated in Big Cliff Reservoir. The reservoir elevation was dropped to near run of river levels to pass as much debris as possible thus, necessitating securing the RST in a safe location to prevent damage from occurring.
Big Cliff Dam Tailrace	12/6/2023–12/10/2023	The RST cone was raised to its non-fishing position and the trap was secured to the riverbank as flows were rising to 5,800 cfs and then 10,00 cfs. The RST was therefore removed from the highline and secured to the riverbank to prevent potential irreparable damage.
Big Cliff Dam Tailrace	12/11/2023–12/22/2023	The RST cone was raised to its non-fishing position due to high flows over 6,000 cfs. Flows at this level are dangerous for sampling, trap safety and overall fish health.
Detroit Head of Reservoir-North Santiam River	2/1/2023–5/4/2023	The Contract with USACE was not approved until March. The initiation of sampling was further delayed until permits were approved by ODFW and NOAA. EAS were unable to procure the RST until contract negotiations were finalized, resulting in the RST and associated permits being sourced later than expected
Detroit Head of Reservoir-North Santiam River	5/30/2023–5/31/2023	The RST was raised to its non-sampling position to prevent damage to Chinook fry resulting from overcrowding of trap after a hatchery *O. mykiss* release in front of the trap.
Detroit Head of Reservoir-North Santiam River	11/5/2023–11/8/2023	The RST cone was raised to its non-fishing position due to elevated flows and high levels of debris, potentially resulting in damage to both the trap and associated fish within the trap.
Detroit Head of Reservoir-North Santiam River	11/30/2023	The RST was raised and removed from its sampling location at Detroit Head of Reservoir due to the completion of its 2023 contract.
Green Peter Head of Reservoir- Middle Santiam River	2/1/2023–5/4/2023	The Contract with USACE was not approved until March. The initiation of sampling was further delayed until permits were approved by ODFW and NOAA. EAS were unable to procure the RST until contract negotiations were finalized, resulting in the RST and associated permits being sourced later than expected

Site	Date(s) of Trap Outage	Reason for Outage
Green Peter Head of Reservoir- Middle Santiam River	7/6/2023–7/8/2023	The RST cone was raised to its non-fishing position due to culvert work and subsequent road closures being undertaken by Guistina Logging.
Green Peter Head of Reservoir- Middle Santiam River	7/24/2023–7/25/2023	The RST cone was raised to its non-fishing position due to road construction occurring at the Sunnyside campground, subsequently disrupting access to the RST for monitoring purposes.
Green Peter Head of Reservoir- Middle Santiam River	8/22/2023–8/24/2023	The RST cone was raised to its non-fishing position as a USACE crane was blocking the dam road from access and the RST wan unable to be accessed.
Green Peter Head of Reservoir- Middle Santiam River	11/1/2023–11/2/2023	The RST cone was raised to its non-fishing position due to an atmospheric river occurring within the localized area and subsequent elevated flows.
Green Peter Head of Reservoir- Middle Santiam River	11/4/2023–11/8/2023	The RST cone was raised to its non-fishing position due to high levels of debris, potentially resulting in damage to both the trap and associated fish within the trap.
Green Peter Head of Reservoir- Middle Santiam River	11/30/2023	The RST was raised and secured from its original sampling location at Green Peter Head of Reservoir due to the completion of its 2023 contract.
Green Peter Dam Tailrace – Middle Santiam River		Installation of the RST was delayed as engineering plans were required for a new anchor system.
Green Peter Dam Tailrace – Middle Santiam River	3/23/2023–3/31/2023	The RST cone was raised to its non-fishing position due to the construction of new anchor points being undertaken below dam.
Green Peter Dam Tailrace – Middle Santiam River	7/24/2023–7/25/2023	The RST cone was raised to its non-fishing position due to road construction occurring at the Sunnyside campground, subsequently disrupting access to the RST for monitoring purposes.
Green Peter Dam Tailrace – Middle Santiam River	11/3/2023–11/8/2023	The RST cone was raised to its non-fishing position due to elevated flows and high levels of debris, potentially resulting in damage to both the trap and associated fish within the trap.
Cougar Dam Tailrace (PH1)	1/16/2023–1/20/2023	The RST cone was raised to its non-fishing position because powerhouse (PH) flows were lowered without notice. The PH1 RST was being damaged by nearby rocks due to the decreased water depth.
Cougar Dam Tailrace (PH1 and PH2)	1/24/2023–2/9/2023	The RST cones were raised to their non-fishing positions because PH flows were lowered, and the RST bottomed out. RST elevated legs were added on 12/9/2023 to ensure its ability to fish safely.
Cougar Dam Tailrace (PH1 and PH2)	8/14/2023–8/22/2023	The RST cones were raised to their non-fishing positions due to wildfires at Lookout. Subsequently, level 3 evacuations along HWY 126 were put into effect and the RSTs were unable to be accessed in a safe manner.
Cougar Dam Tailrace (PH1 and PH2)	11/16/2023–12/12/2023	The RST cones were raised to their non-fishing positions due to the PH channel being dewatered. Therefore, the RSTs were unable to fish safely.
Cougar Dam Tailrace (RO)	6/8/2023–8/29/2023	The RST cone was raised to its non-fishing position and subsequently removed for its location to allow safe access of work being undertaken on the spillway (RO).
Fall Creek Dam Tailrace	1/1/2023–1/10/2023	The RST cone was raised to its non-fishing position due to low flows and the port side pontoon being positioned onto the bank due to the decreased flows. Additionally, sediment was heavily built up and accumulating quickly at this time.
Fall Creek Dam Tailrace	1/25/2023-3/2/2023	The RST cone was raised to its non-fishing position due to low flows, resulting in the RST grounding out and being raised due to operational concerns.
Fall Creek Dam Tailrace	7/15/2023–10/1/2023	The RST cone was raised to its non-sampling position for end of contracted sampling period.
Fall Creek Dam Tailrace	10/16/2023–10/17/2023	The RST cone was raised to its non-fishing position because of a debris flush taking place at Fall Creek Dam. The RST was subsequently raised the morning of October 16th to allow for safe passage of built-up debris.
Fall Creek Dam Tailrace	12/1/2023	The RST cone was raised to its non-fishing position due to significant reoccurring sediment flushes. The RST was full of logs and debris on December 3rd. The RST attempted fishing on December 16th, but silt and sediments filled the RST so quickly that

Site	Date(s) of Trap Outage	Reason for Outage
		EAS deemed it unsafe for fish health and potentially detrimental to RST operations.
Dexter Dam Tailrace	8/15/2023–8/17/2023	The RST cone was raised to its non-fishing position due to the Air Quality Index (AQI) rising to over 400 from the Bedrock and Lookout fires. The localized AQI did not decrease to below 200 until after 8/17/2023.
Lookout Dam Tailrace (PH1, PH2 and Spill (RO))	8/10/2023–8/11/2023	The RST's located at Lookout Point Dam Tailrace were raised to their non-fishing positions due temperature thresholds being exceeded, resulting in potential issues involving fish health.
Lookout Dam Tailrace (PH1, PH2 and Spill (RO))	8/15/2023–8/18/2023	The RST cone was raised to its non-fishing position due to the Air Quality Index (AQI) rising to over 400 from the Bedrock and Lookout fires. The localized AQI did not decrease to below 100 until after 8/18/2023.
Lookout Point Head of Reservoir – Middle Fork Willamette River	1/1/2023–1/6/2023	The RST cone was raised to its non-fishing position due to elevated water levels and increased debris.
Lookout Point Head of Reservoir – Middle Fork Willamette River	1/30/2023–2/6/2023	The RST cone was raised to its non-fishing position due to decreased flows, resulting in the RST cone itself coming into contact with the riverbed.
Lookout Point Head of Reservoir – Middle Fork Willamette River	3/16/2023–5/17/2023	The RST cone was raised to its non-fishing position due to ongoing security issues within the immediate area. EAS was escorted by OSP to raise the cone and EAS personnel were unable to access the RST until proper safety measures were put into place.
Lookout Point Head of Reservoir – Middle Fork Willamette River	4/18/2023–4/20/2023	The RST cone was raised to its non-fishing position due to elevated levels of large, woody debris moving downstream.
Lookout Point Head of Reservoir – Middle Fork Willamette River	8/15/2023–8/18/2023	The RST cone was raised to its non-fishing position due to the Air Quality Index (AQI) rising to over 400 from the Bedrock and Lookout fires. The localized AQI did not decrease to below 100 until after 8/18/2023.
Lookout Point Head of Reservoir – Middle Fork Willamette River	10/4/2023–10/9/2023	The RST cone was raised to its non-fishing position due to decreased water levels, elevated levels of debris and increasing temperatures that could be potentially detrimental to fish health.
Lookout Point Head of Reservoir – Middle Fork Willamette River	10/21/2023–10/25/2023	The RST cone was raised to its non-fishing position due to decreased water levels and an increased amount of debris.
Lookout Point Head of Reservoir – Middle Fork Willamette River	11/5/2023–11/13/2023	The RST cone was raised to its non-fishing position due to increased debris.
Lookout Point Head of Reservoir – Middle Fork Willamette River	12/3/2023–12/18/2023	The RST cone was raised to its non-fishing position due to elevated water levels and increased debris.
Lookout Point Head of Reservoir – Middle Fork Willamette River	12/21/2023–12/23/2023	The RST cone was raised to its non-fishing position due to elevated levels of debris moving downstream. EAS personnel attempted to fish the trap over the duration of this outage but risked irreparable damage to the trap until fishing had ceased.
Hills Creek Head of Reservoir- Middle Fork Willamette River	2/1/2023–5/9/2023	The initiation of sampling was delayed until permits were approved by ODFW and NOAA. The trap manufacturer experienced delays and could not build a new trap for this site in time to start sampling. A trap from another location was prioritized to this site. EAS were unable to procure the RST until contract negotiations were finalized, resulting in the RST and associated permits being sourced.
Hills Creek Dam Tailrace	6/30/2023–9/15/2023	The RST cone was raised to its non-sampling position for end of contracted sampling period.
Hills Creek Dam Tailrace – Middle Fork Willamette River	12/17/2023–12/19/2023	The RST cone was raised to its non-fishing position due to elevated flows, surpassing the safe threshold for sampling as detailed by EAS staff.

*The outages table detailed above is a comprehensive list of all sites sampled throughout the 2023 monitoring year under both RST monitoring contracts and encompasses the entire year. While the report does not include all of the dates that are listed within the table above, all outages for 2023 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.

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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

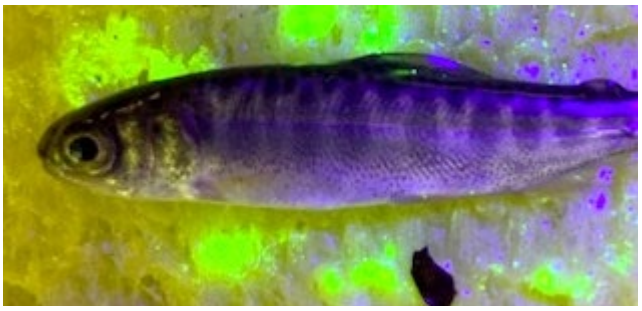

Figure C-1. Example of a VIE marked Chinook salmon. A green, fluorescent elastomer mark can be seen along the dorsal fin.

PIT Tags

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

Site	UDF	MRR Site/Release Site
Big Cliff Dam	BCL	BCLTAL
Breitenbush River	BRT	BREITR
Detroit Head of Reservoir- North Santiam River	DTA	NSANTR
Green Peter Dam	GPR	GPD
Green Peter Head of Reservoir- Middle Santiam River	GPA	MSANTR
Foster HOR	SAN	SSANTR
Cougar Dam	CGR	CGRTAL
Cougar HOR	SMK	MCKESF
Fall Creek Dam	FCR	FALTAL
Fall Creek HOR	FCA	FALL2C
Dexter Dam	DEX	DEXTAL
Hills Creek Dam	HCR	HCRREG
Lookout Dam Tail.	LOP	LOPTAL
Lookout Point HOR	LOA	WILRMF
Hills Creek Head of Reservoir- Middle Fork Willamette River	HCA	WILRMF
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 sites in 2023.

Tagging Site	Species	Total PIT Tagged	Total VIE Marked	Orphan Tags[a]	Missed Protocol VIE[b]
Breitenbush River	Chinook	333	35	2	1
	O. mykiss	25	21	0	1
Big Cliff Dam Tailrace	Chinook	51	0	1	0
	O. mykiss	3	0	0	0
Detroit Head of Reservoir- North Santiam River	Chinook	720	5,439	2	0
	O. mykiss	16	345	0	0
Green Peter Head of Reservoir- Middle Santiam River	Chinook	4	15	0	0
	O. mykiss	0	1	0	0
Green Peter Dam Tailrace – Middle Santiam River	Chinook	0	0	0	0
	O. mykiss	0	0	0	0
Cougar Dam Tailrace	Chinook	4,132	0	17	0
Fall Creek Dam Tailrace	Chinook	0	0	0	0
Dexter Dam Tailrace	Chinook	0	0	0	0
Lookout Dam Tailrace	Chinook	0	0	0	0
Lookout Point Head of Reservoir – Middle Fork Willamette River	Chinook	29	68	1	0
Hills Creek Head of Reservoir- Middle Fork Willamette River	Chinook	3	71	0	11
Hills Creek Dam Tailrace	Chinook	1	39	1	0

a Orphan Tags denotes PIT tag numbers that had errors reported in PTAGIS (0.5% error rate)
b Missed protocol VIE marks denotes fish that were accidentally tagged in the wrong location while training new crew members (0.2% error rate)

Table C-3. List of downstream redetections for fish PIT tagged at RST sites in 2023.

PIT Tag #	Mark Date	Mark Site	Recap Date	# of Days Between Release and Recapture	Recap Site
3DD.003BD226FB	3/19/2023	Foster Head of Reservoir- South Santiam	5/18/2023	60	TWX – Estuary Towed Array (Exp.)
3DD.003BEE178A	1/12/2023	Cougar Dam	4/30/2023	108	PD6 – Columbia River Estuary rkm 68
3DD.003BEE198D	1/12/2023	Cougar Dam	4/18/2023	96	PD5 – Columbia River Estuary rkm 62
3DD.003BEE23D8	1/12/2023	Cougar Dam	4/14/2023	92	TWX – Estuary Towed Array (Exp.)
3DD.003BEE2748	1/12/2023	Cougar Dam	5/4/2023	112	PD5 – Columbia River Estuary rkm 62
3DD.003BEE2791	1/12/2023	Cougar Dam	4/30/2023	108	TWX – Estuary Towed Array (Exp.)
3DD.003BEE2B8A	1/12/2023	Cougar Dam	4/15/2023	93	PD6 – Columbia River Estuary rkm 68

Table C-4. List of Bull Trout captured at RST sites and collected data in 2023.

Site	Date	Length (est. mm)	Tag(s)	Condition
Cougar Dam Tailrace	5/29/2023	240	None	Unharmed
Cougar Dam Tailrace	6/5/2023	165	None	Unharmed
Hills Creek Head of Reservoir- Middle Fork Willamette	5/31/2023	245	None	Unharmed

Table C-5. Summary of fish containing PIT tags encountered by EAS at RST sites in 2023.

Site	Trap	Total Number of PIT tagged fish	Species
Big Cliff Dam Tailrace	8 ft	7	Chinook
Detroit Head of Reservoir – North Santiam River	5 ft	4	Chinook
Green Peter Dam Tailrace – Middle Santiam River	8 ft	34	Chinook
Cougar Dam Tailrace	PH	71	Chinook
Cougar Dam Tailrace	RO	1,622	Chinook
Fall Creek Dam Tailrace	8 ft	435	Chinook
Dexter Dam Tailrace	5 ft	21	Chinook
Lookout Dam Tailrace	PH	21	Chinook
Lookout Dam Tailrace	RO	17	Chinook
Lookout Point Head of Reservoir – Middle Fork Willamette River	5 ft	1	Chinook
Hills Creek Dam Tailrace	PH	87	Chinook
Hills Creek Dam Tailrace	RO	104	Chinook

Table C-6. List of radio tagged and acoustically tagged Chinook captured at RST sites in 2023.

Site	Trap	PIT Tag Number	Date	Species
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD568B5	11/9/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD568EF	11/9/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54C28	11/9/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54BDF	11/10/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54BDA	11/10/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD5690B	11/14/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54DD3	11/18/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54D44	11/20/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54E3B	11/20/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54DBD	11/22/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54E20	11/29/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD57BCC	12/8/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD54BAF	12/9/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD57BA0	12/11/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD57B7D	12/11/2023	Chinook
Green Peter Tailrace – Middle Santiam River*	8 ft	3DD.003BD57B88	12/11/2023	Chinook
Dexter Dam Tailrace**	5 ft	3DD.003BD61662	11/5/2023	Chinook

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

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Appendix D –
Injury by Lifestage for Tailrace Sites

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Appendix D: Injury by Lifestage for Tailrace Sites

Tables

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

Total Chinook (n=699)	<60mm (n=121)	>60mm and <110mm (n=55)	>110mm (n=523)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	90.9%	3.6%	0.0%
MUNK	0.8%	0.0%	0.0%
DS<2	4.1%	78.2%	70.2%
DS>2	0.0%	12.7%	27.3%
BLO	0.0%	0.0%	1.1%
EYB	0.8%	5.5%	8.4%
BVT	0.8%	0.0%	4.2%
FVB	0.0%	1.8%	7.8%
GBD	1.7%	0.0%	9.0%
POP	1.7%	1.8%	1.3%
HIN	0.8%	3.6%	5.9%
OPD	0.0%	1.8%	17.4%
TEA	2.5%	0.0%	6.1%
BRU	1.7%	10.9%	10.3%
HBP	0.8%	0.0%	1.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.2%
FID	1.7%	61.8%	78.4%
PRD	0.0%	1.8%	0.4%
COP	0.0%	54.5%	90.2%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	1.8%	2.7%
Total (%) of captured fish with injuries	**9.1%**	**96.4%**	**100.0%**
Average number of injuries per fish (non NXI)	**0.2**	**2.4**	**3.4**

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

Total Chinook (n=107)	<60 (n=25)	>60 and <110 mm (n=79)	>110 mm (n=3)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	20.0%	5.1%	0.0%
MUNK	8.0%	1.3%	0.0%
DS<2	40.0%	54.4%	100.0%
`DS>2	16.0%	30.4%	0.0%
BLO	4.0%	0.0%	33.3%
EYB	20.0%	11.4%	33.3%
BVT	4.0%	8.9%	0.0%
FVB	0.0%	13.9%	0.0%
GBD	16.0%	34.2%	66.7%
POP	4.0%	1.3%	0.0%
HIN	12.0%	15.2%	0.0%
OPD	24.0%	10.1%	0.0%
TEA	8.0%	3.8%	0.0%
BRU	8.0%	8.9%	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	52.0%	68.4%	100.0%
PRD	0.0%	0.0%	0.0%
COP	4.0%	7.6%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	2.5%	0.0%
Total (%) of captured fish with injuries	**80.0%**	**94.9%**	**100.0%**
Average number of injuries per fish (non NXI)	**2.2**	**2.7**	**3.3**

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

Total Chinook (n=423)	<60mm (n=23)	>60mm and <110mm (n=255)	>110mm (n=145)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	43.5%	3.5%	0.4%
MUNK	0.0%	0.0%	0.0%
DS<2	30.4%	77.3%	45.1%
DS>2	8.7%	9.4%	5.5%
BLO	4.3%	1.2%	0.8%
EYB	13.0%	3.5%	2.0%
BVT	4.3%	4.3%	2.7%
FVB	4.3%	6.3%	5.1%
GBD	0.0%	1.2%	1.2%
POP	0.0%	2.0%	0.0%
HIN	4.3%	2.7%	2.0%
OPD	13.0%	2.4%	3.9%
TEA	4.3%	7.1%	2.0%
BRU	13.0%	4.7%	4.3%
HBP	0.0%	5.1%	2.4%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.4%	0.0%
FID	26.1%	51.0%	33.3%
PRD	0.0%	0.8%	0.0%
COP	13.0%	44.7%	54.5%
BKD	0.0%	0.0%	0.0%
FUN	4.3%	2.0%	1.2%
Total (%) of captured fish with injuries	**56.5%**	**96.5%**	**99.6%**
Average number of injuries per fish (non NXI)	**1.4**	**2.3**	**2.9**

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

Total Chinook (n=5272)	<60mm (n=20)	>60mm and <110mm (n=1483)	>110mm (n=3769)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	75.0%	0.9%	0.1%
MUNK	0.0%	0.0%	0.0%
DS<2	10.0%	75.4%	72.3%
DS>2	0.0%	14.7%	20.9%
BLO	0.0%	0.7%	0.6%
EYB	0.0%	12.5%	10.4%
BVT	0.0%	2.6%	2.9%
FVB	10.0%	8.2%	16.7%
GBD	5.0%	20.7%	34.1%
POP	0.0%	2.1%	0.8%
HIN	0.0%	5.0%	4.3%
OPD	0.0%	13.4%	16.8%
TEA	0.0%	8.1%	4.8%
BRU	5.0%	5.2%	5.9%
HBP	0.0%	4.0%	3.2%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	15.0%	80.8%	85.3%
PRD	0.0%	0.3%	0.2%
COP	0.0%	82.8%	94.5%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	9.1%	10.7%
Total (%) of captured fish with injuries	**25.0%**	**99.1%**	**99.9%**
Average number of injuries per fish (non NXI)	**0.5**	**3.5**	**3.8**

Table D-5. Cougar Dam Regulatory Outlet route injuries for Chinook for October through December 2021, 2022, and 2023.

Injury Code	Oct. through Dec. 2021	Oct. through Dec. 2022	Oct. through Dec. 2023
NXI	1.2%	3.1%	0.4%
MUNK	0.1%	0.0%	0.0%
DS<2	55.9%	59.0%	76.5%
DS>2	18.9%	26.9%	16.6%
BLO	0.0%	1.5%	0.5%
EYB	4.1%	11.3%	9.5%
BVT	0.2%	2.5%	2.2%
FVB	1.3%	7.0%	12.8%
GBD	1.1%	19.0%	25.1%
POP	0.5%	0.6%	0.9%
HIN	0.1%	4.2%	4.2%
OPD	13.0%	11.1%	14.9%
TEA	5.0%	2.0%	4.5%
BRU	9.5%	5.8%	4.8%
HBP	2.2%	1.4%	3.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.1%	0.0%
HBO	0.0%	0.1%	0.0%
FID	13.0%	66.0%	86.8%
PRD	0.1%	0.0%	0.0%
COP	93.0%	72.0%	71.1%
BKD	0.0%	0.1%	0.0%
FUN	0.1%	0.6%	9.6%
Total # of Fish Captured	2470	2379	6055

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

Total Chinook (n=126)	<60mm (n=61)	>60mm and <110mm (n=4)	>110mm (n=61)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	82.0%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	6.6%	100.0%	41.0%
DS>2	0.0%	0.0%	59.0%
BLO	1.6%	0.0%	1.2%
EYB	3.3%	0.0%	3.6%
BVT	1.6%	0.0%	14.5%
FVB	0.0%	0.0%	20.5%
GBD	3.3%	0.0%	8.4%
POP	0.0%	0.0%	0.0%
HIN	3.3%	0.0%	9.6%
OPD	1.6%	0.0%	13.3%
TEA	1.6%	0.0%	6.0%
BRU	1.6%	0.0%	10.8%
HBP	1.6%	0.0%	1.2%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	6.6%	75.0%	94.0%
PRD	0.0%	0.0%	0.0%
COP	0.0%	0.0%	74.7%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	25.0%	0.0%
Total (%) of captured fish with injuries	**18.0%**	**100.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**0.3**	**2.0**	**4.9**

Table D-7. Dexter Dam Tailrace injuries for Chinook by size.

Total Chinook (n=57)	<60mm (n=2)	>60mm and <110mm (n=19)	>110mm (n=36)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	100.0%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	73.7%	47.2%
DS>2	0.0%	15.8%	52.8%
BLO	0.0%	0.0%	0.0%
EYB	0.0%	5.3%	16.7%
BVT	0.0%	0.0%	2.8%
FVB	0.0%	0.0%	11.1%
GBD	0.0%	15.8%	27.8%
POP	0.0%	0.0%	8.3%
HIN	0.0%	5.3%	11.1%
OPD	0.0%	10.5%	19.4%
TEA	0.0%	10.5%	11.1%
BRU	0.0%	0.0%	8.3%
HBP	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	0.0%	63.2%	88.9%
PRD	0.0%	0.0%	0.0%
COP	0.0%	10.5%	27.8%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%
Total (%) of captured fish with injuries	**0.0%**	**100.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**0.0**	**0.4**	**0.9**

Table D-8. Lookout Dam Tailrace (RO and PWR) injuries for Chinook by size.

Total Chinook (n=140)	<60mm (n=9)	>60mm and <110mm (n=49)	>110mm (n=79`)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	44.4%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	11.1%	75.5%	35.4%
DS>2	11.1%	22.4%	59.5%
BLO	0.0%	0.0%	2.5%
EYB	22.2%	8.2%	7.6%
BVT	0.0%	4.1%	7.6%
FVB	11.1%	6.1%	29.1%
GBD	0.0%	36.7%	51.9%
POP	0.0%	2.0%	1.3%
HIN	22.2%	6.1%	12.7%
OPD	11.1%	6.1%	19.0%
TEA	22.2%	2.0%	7.6%
BRU	0.0%	0.0%	12.7%
HBP	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	2.0%	0.0%
FID	22.2%	79.6%	96.2%
PRD	0.0%	0.0%	0.0%
COP	0.0%	6.1%	51.9%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	1.3%
Total (%) of captured fish with injuries	**55.6%**	**100.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**1.3**	**2.6**	**4.0**

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

Total Chinook (n=397)	<60mm (n=220)	>60mm and <110mm (n=5)	>110mm (n=165)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	88.6%	0.0%	0.0%
MUNK	0.5%	0.0%	0.0%
DS<2	2.3%	100.0%	45.5%
DS>2	0.0%	0.0%	52.7%
BLO	0.0%	0.0%	3.0%
EYB	1.8%	20.0%	12.1%
BVT	2.3%	0.0%	27.3%
FVB	0.0%	20.0%	33.3%
GBD	0.0%	20.0%	9.7%
POP	1.4%	20.0%	4.8%
HIN	0.9%	0.0%	17.0%
OPD	1.4%	0.0%	27.9%
TEA	2.3%	0.0%	7.3%
BRU	2.7%	0.0%	19.4%
HBP	0.0%	0.0%	5.5%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.6%
HBO	0.0%	0.0%	1.2%
FID	1.4%	100.0%	93.9%
PRD	0.0%	0.0%	0.0%
COP	0.0%	40.0%	95.8%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	4.2%
Total (%) of captured fish with injuries	**11.4%**	**100.0%**	**100.0%**
Average number of injuries per fish (non NXI)	**0.2**	**3.2**	**4.6**

Table D-10. Hills Creek Dam Regulatory Outlet route injuries for Chinook by size.

Total Chinook (n=227)	<60mm (n=125)	>60mm and <110mm (n=11)	>110mm (n=106)
Injury Code	**Injuries for (%) <60mm**	**Injuries (%) >60mm and <110mm**	**Injuries (%) >110mm**
NXI	92.0%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	0.8%	90.9%	42.5%
DS>2	0.8%	9.1%	55.7%
BLO	0.0%	0.0%	2.8%
EYB	0.8%	9.1%	14.2%
BVT	0.0%	0.0%	17.9%
FVB	0.8%	0.0%	29.2%
GBD	0.0%	9.1%	14.2%
POP	1.6%	0.0%	0.0%
HIN	2.4%	0.0%	23.6%
OPD	1.6%	9.1%	31.1%
TEA	0.0%	0.0%	4.7%
BRU	2.4%	0.0%	20.8%
HBP	0.0%	0.0%	1.9%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.9%
FID	1.6%	54.5%	95.3%
PRD	0.0%	0.0%	0.9%
COP	0.0%	0.0%	96.2%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.9%
Total (%) of captured fish with injuries	92.0%	**100.0%**	**100.0%**
Average number of injuries per fish (non NXI)	0.0%	**1.8**	**4.5**

Appendix E –
Trap Efficiency Plots

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Appendix E: Trap Efficiency Plots

Figures and Tables

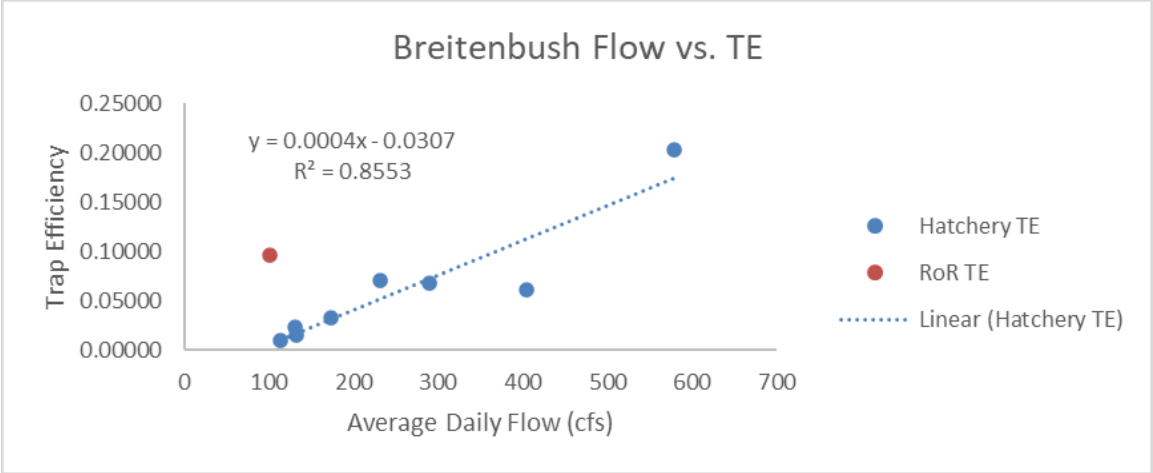

Figure E-1. Breitenbush River trapping efficiency versus flow levels.

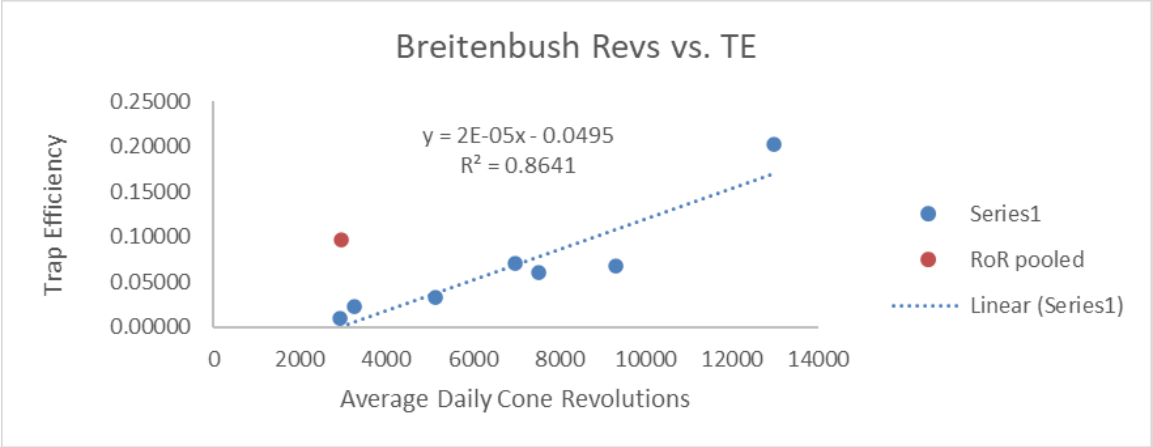

Figure E-2. Breitenbush River trapping efficiency versus cone flux the day after fish were released.

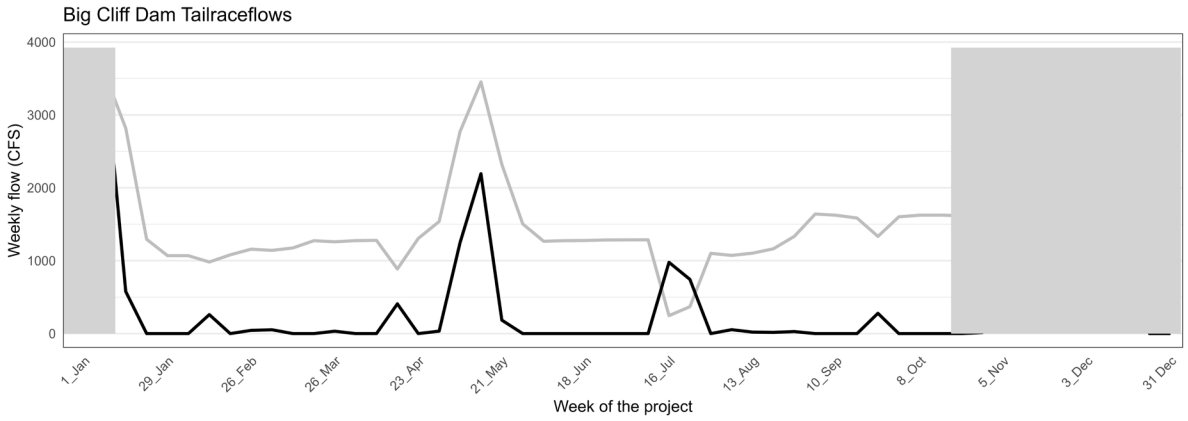

Figure E-3. Big Cliff Dam Tailrace powerhouse outflow (gray line) and spill outflow (black line) for 2023.

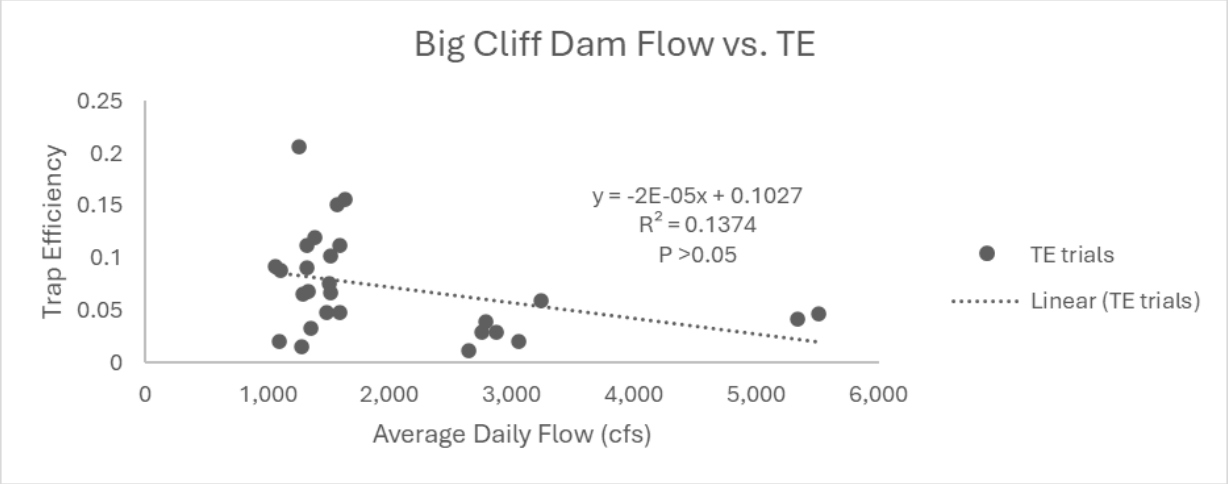

Figure E-4. Big Cliff Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus flow levels.

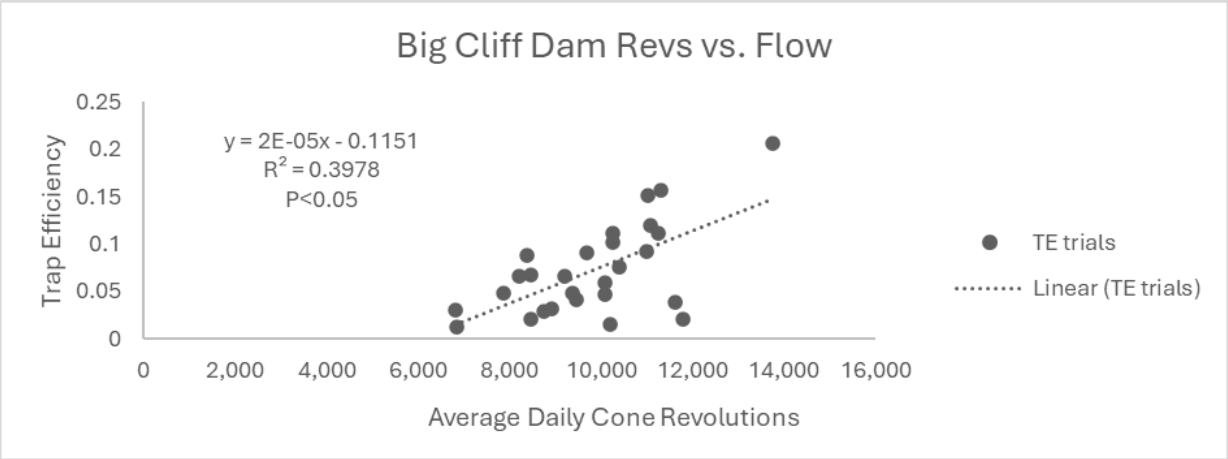

Figure E-5. Big Cliff Dam Tailrace trap efficiency trial plots. Linear regression fit is significant. Plot displays trapping efficiencies versus cone flux the day after fish were released.

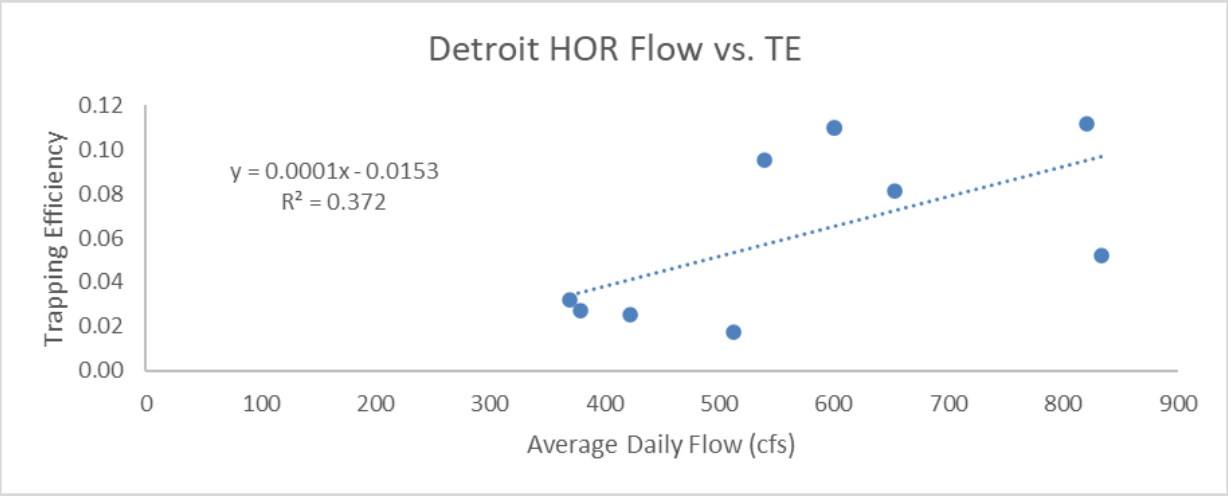

Figure E-6. Detroit Head of Reservoir trap efficiency trial plots versus flow levels.

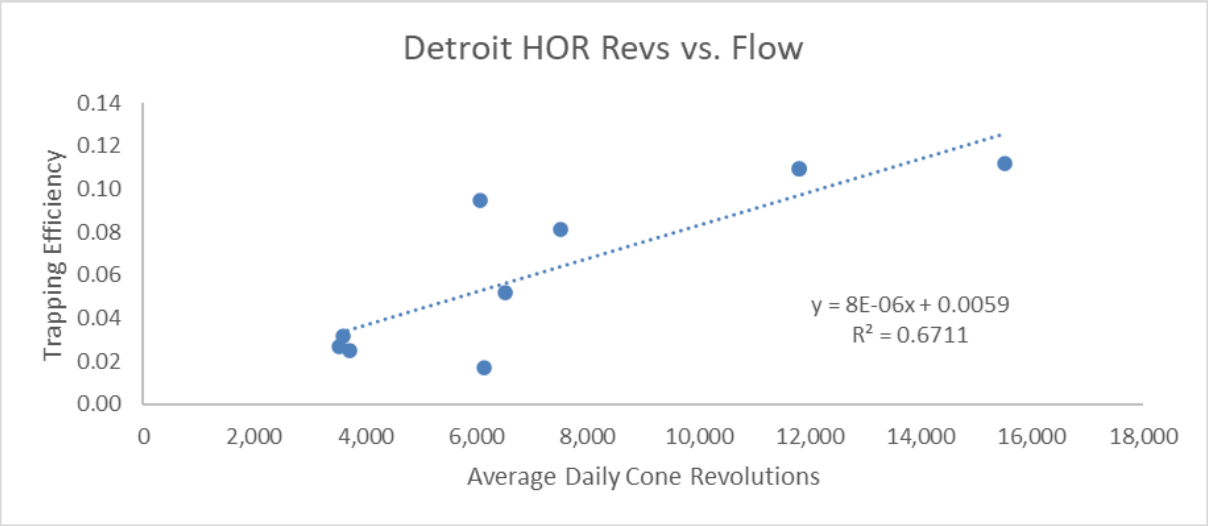

Figure E-7. Detroit Head of Reservoir trap efficiency trial plots versus cone flux the day after fish were released.

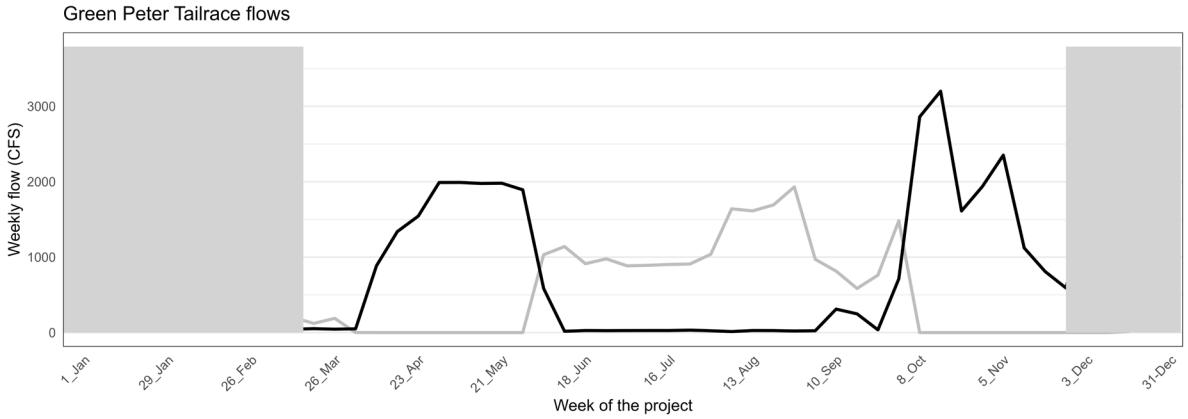

Figure E-8. Green Peter Dam Tailrace powerhouse outflow (gray line) and spill outflow (black line) for 2023.

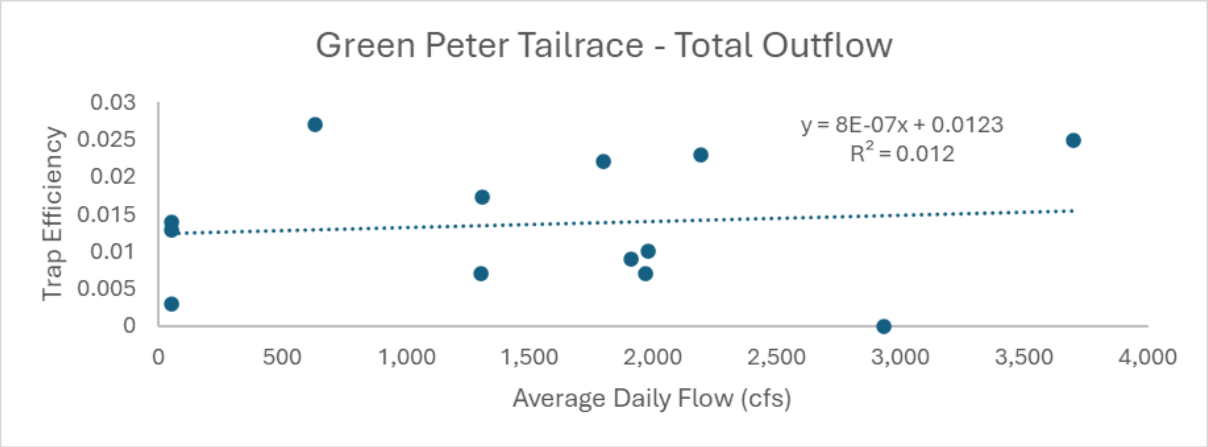

Figure E-9. Green Peter Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus total outflow.

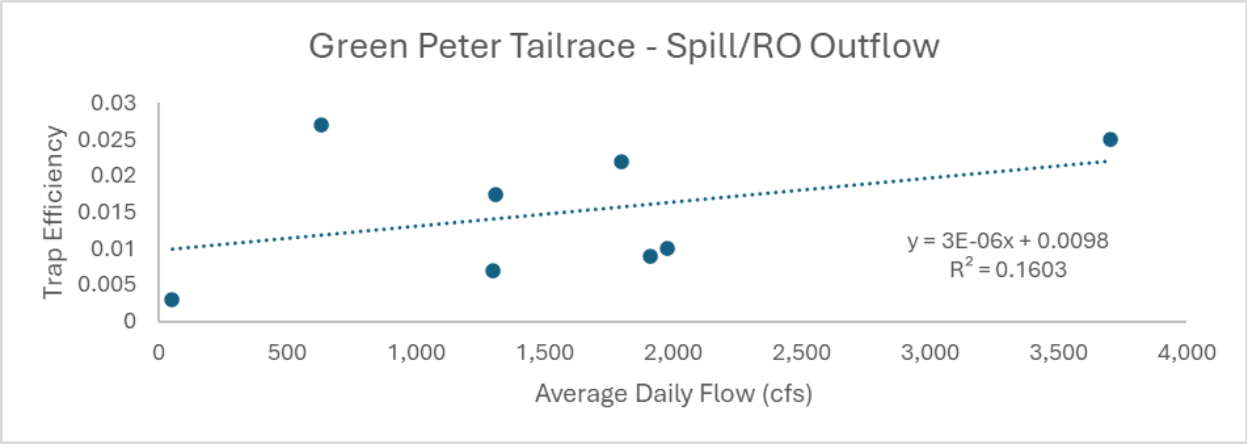

Figure E-10. Green Peter Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus Spill/RO flows.

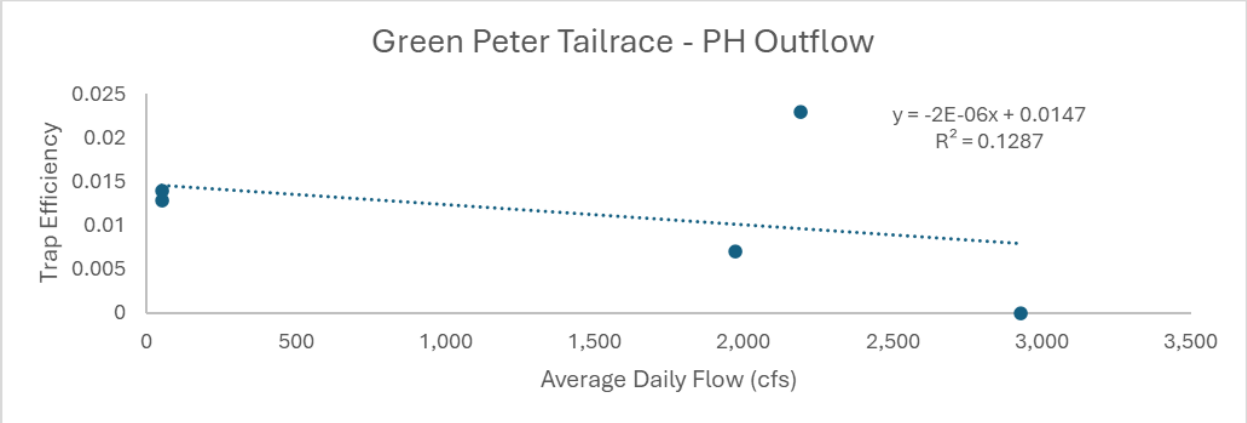

Figure E-11. Green Peter Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus powerhouse flows.

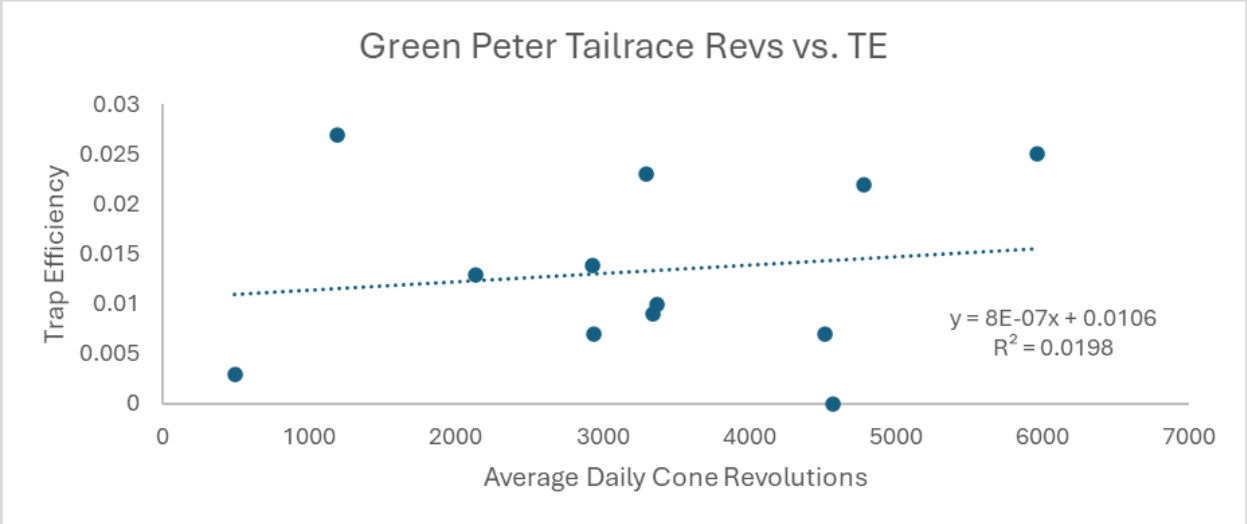

Figure E-12. Green Peter Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus cone flux the day after trial fish were released.

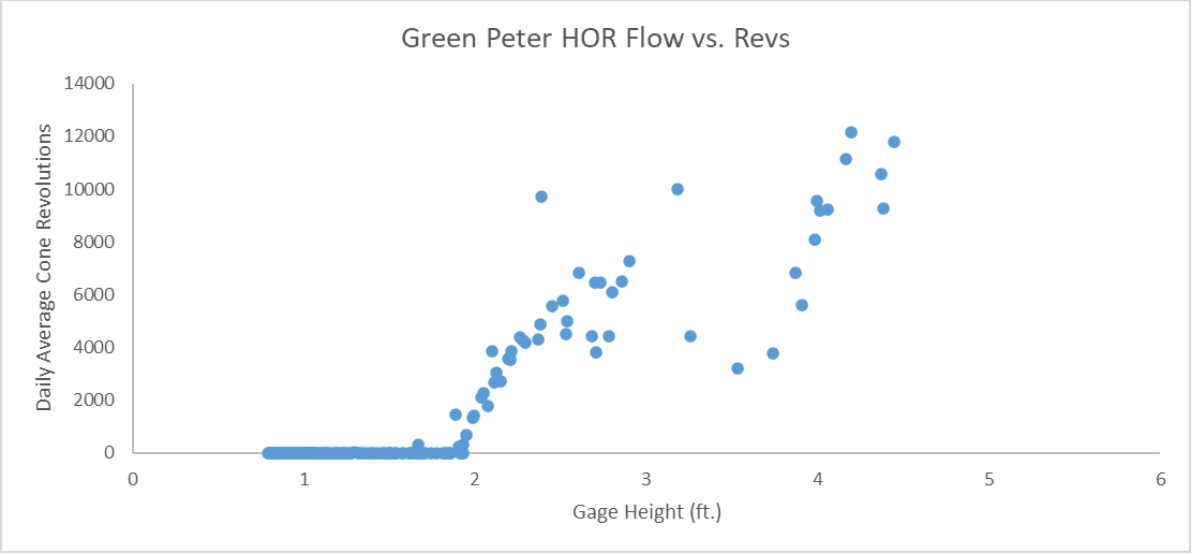

Figure E-13. Green Peter Dam Head of Reservoir- Middle Santiam gage height vs cone flux plot.

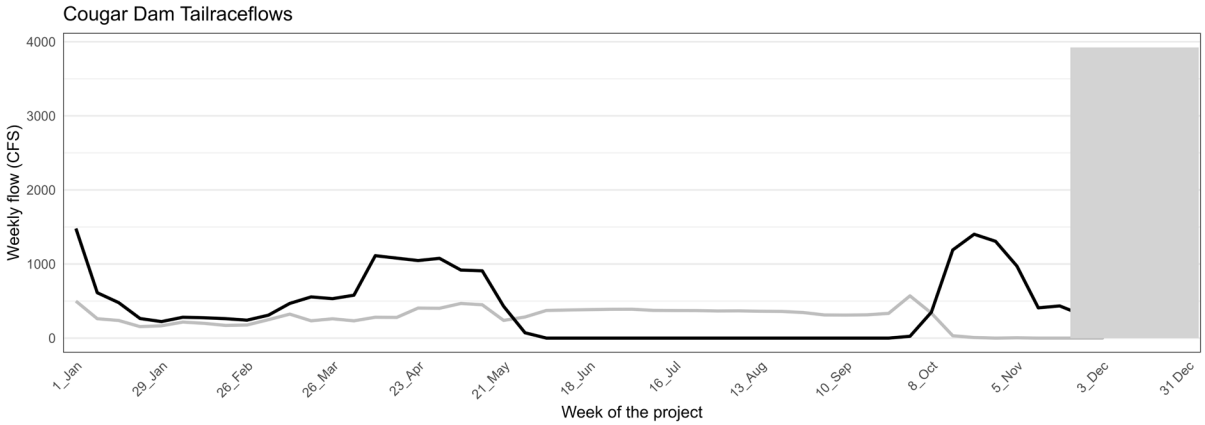

Figure E-14. Cougar Dam Tailrace powerhouse outflow (gray line) and spill outflow (black line) for 2023.

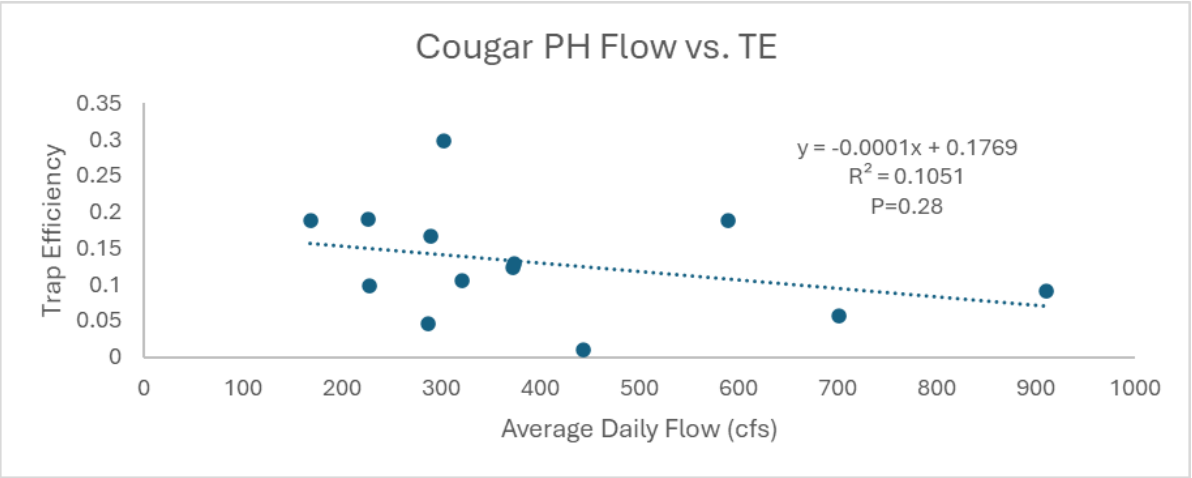

Figure E-15. Cougar Dam trap efficiency trial plot versus flows. Linear regression fit is non-significant.

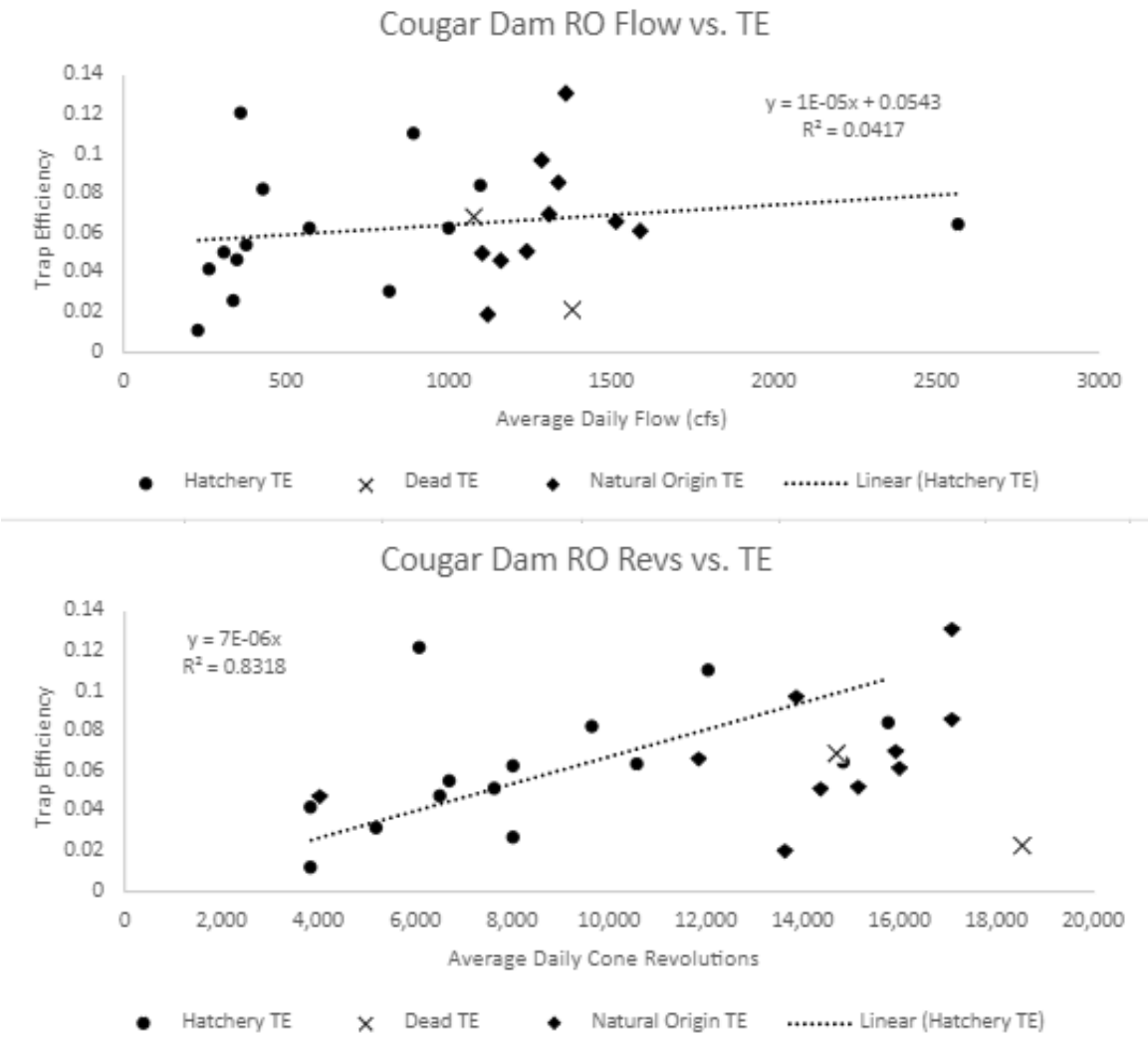

Figure E-16. Cougar Dam Tailrace RO trap efficiency trials versus flows (top panel) and compared to cone flux (bottom panel). Linear regression fit is only to hatchery TE trials in both panels which is non-significant for flow and significant for cone flux.

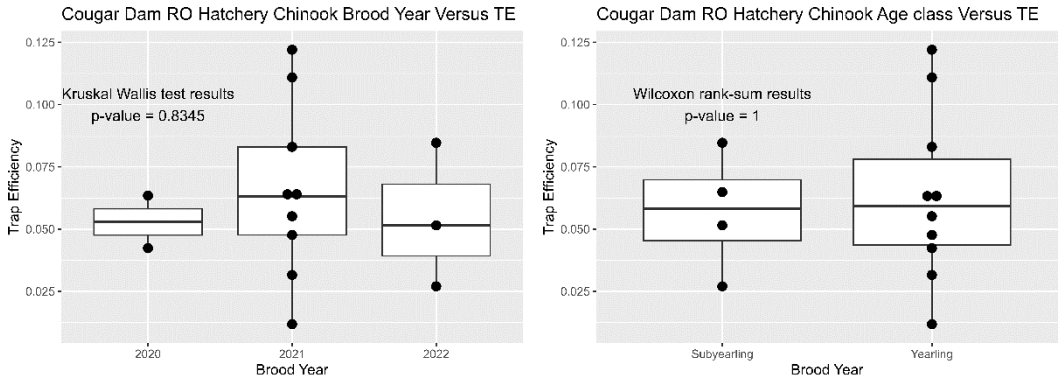

Figure E-17. Cougar Dam Tailrace RO trap efficiency trials compared with brood year (left panel) and age class (right panel).

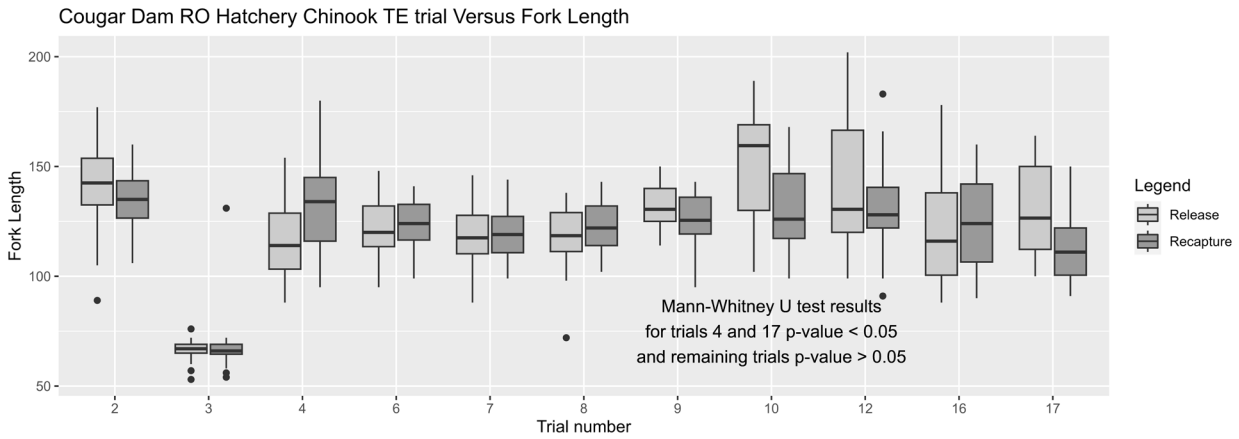

Figure E-18. Cougar Dam Tailrace RO trap efficiency trials compared with fork length.

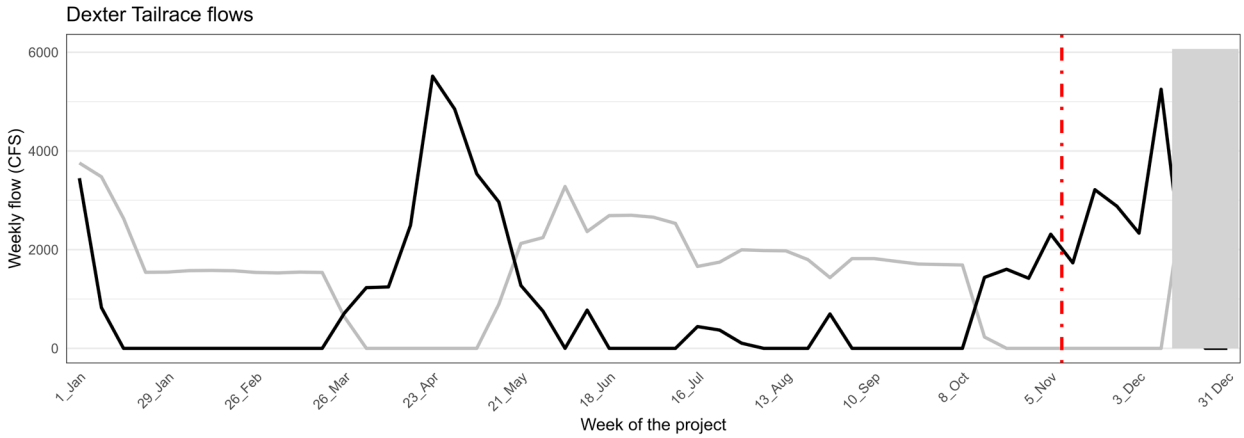

Figure E-19. Dexter Dam Tailrace powerhouse flow (gray line) and spill flow (black line) for 2023. The red dashed line denotes when the RST was moved downstream due to construction.

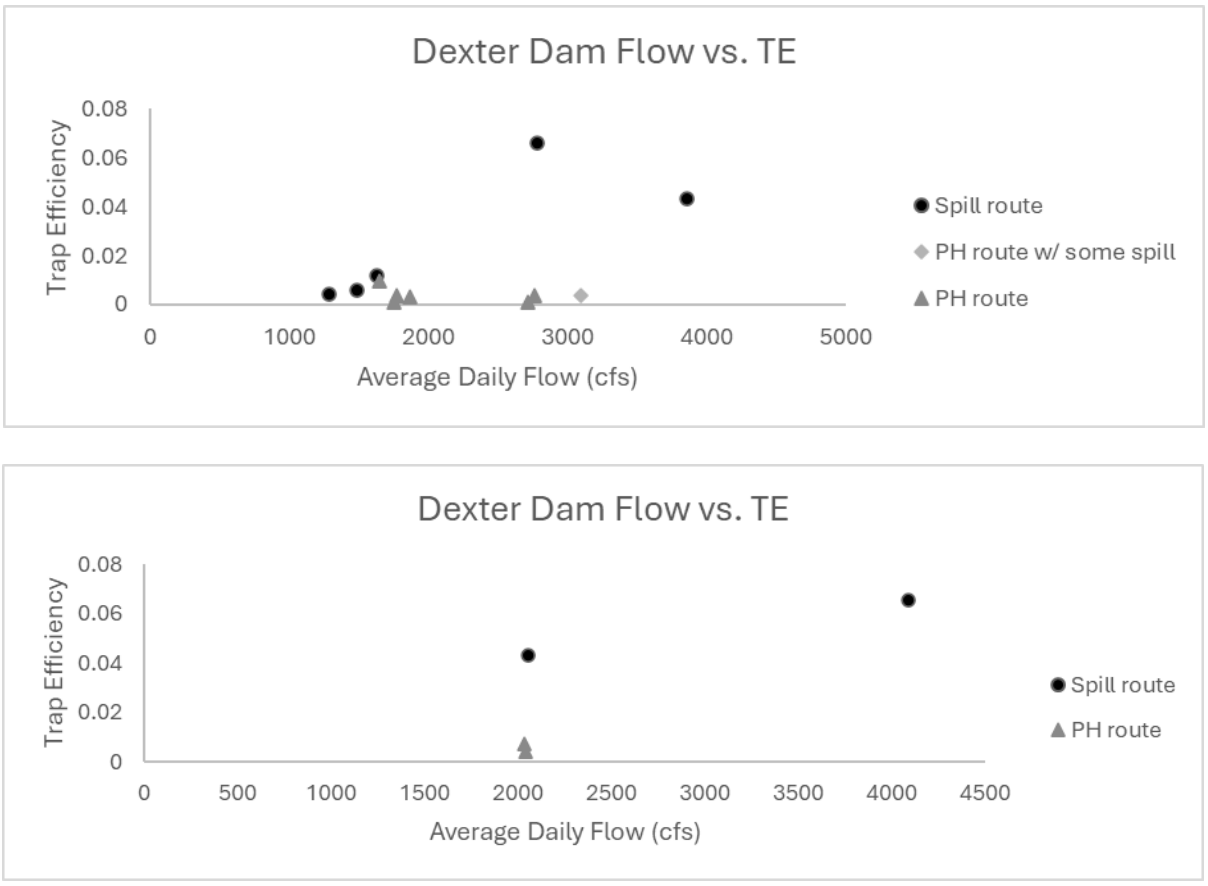

Figure E-20. Dexter Dam Tailrace trap efficiency trial plots versus flow levels for the RST position near the powerhouse (top panel) and downstream near the boat launch (bottom panel).

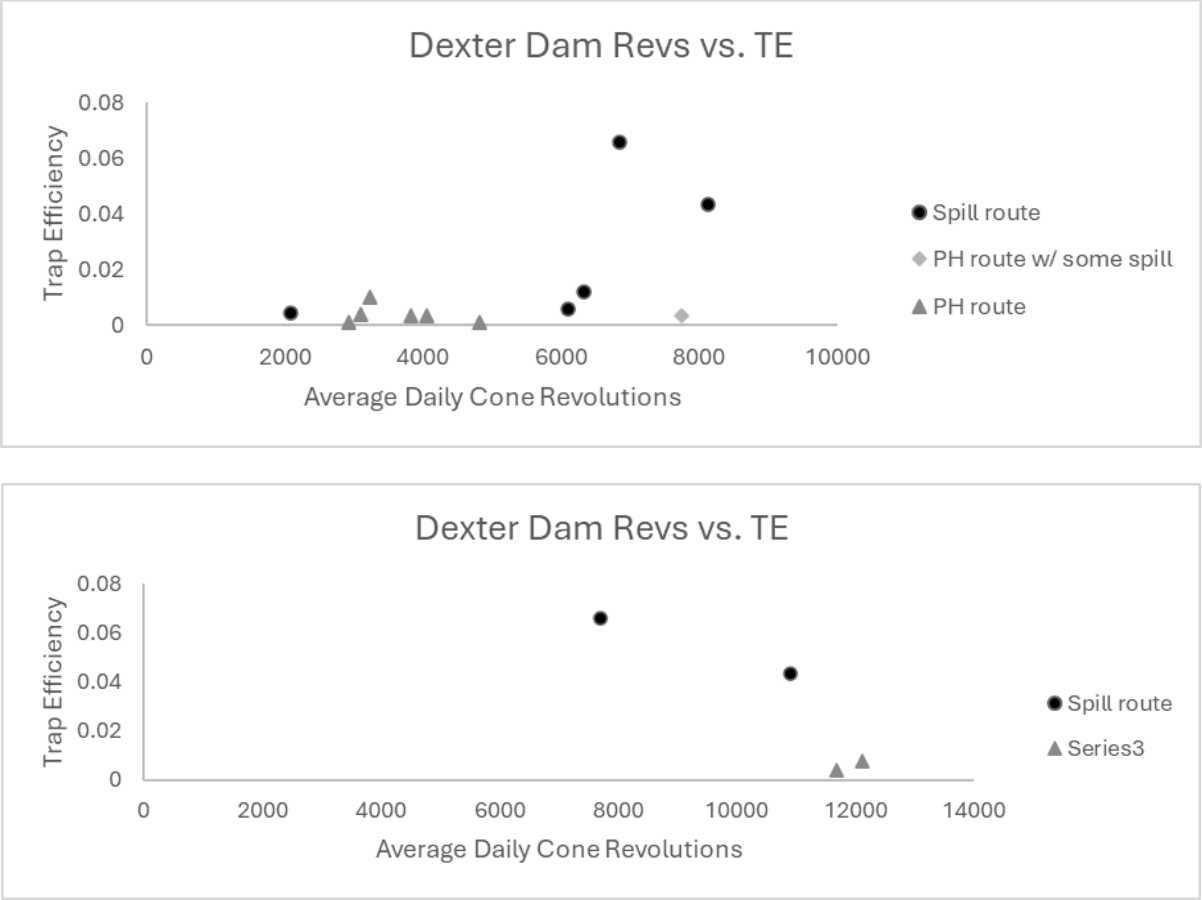

Figure E-21. Dexter Dam Tailrace trap efficiency trial plots versus cone flux for the RST position near the powerhouse (top panel) and downstream near the boat launch (bottom panel).

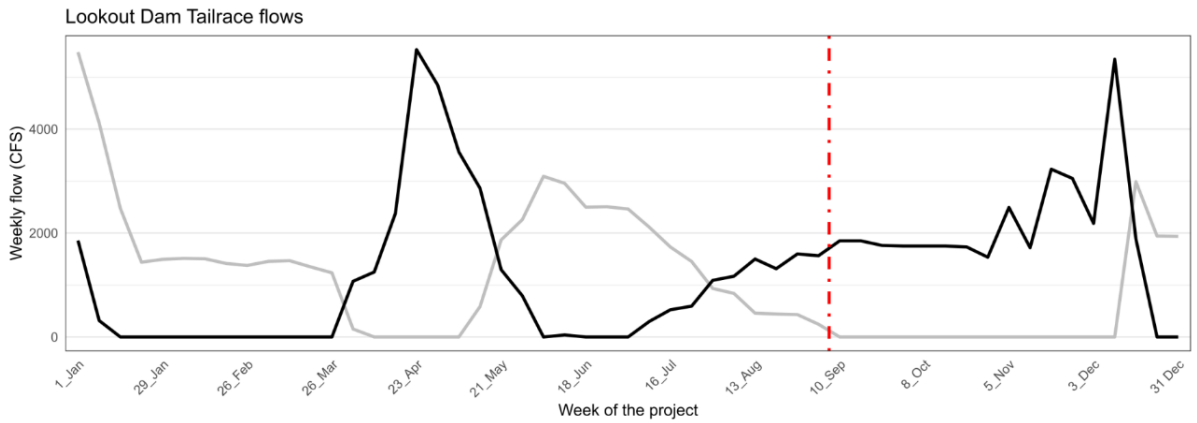

Figure E-22. Lookout Dam Tailrace powerhouse flow (gray line) and spill flow (black line) for 2023. The red dot dashed line denotes when the powerhouse RSTs were moved to a side-by-side orientation for safety.

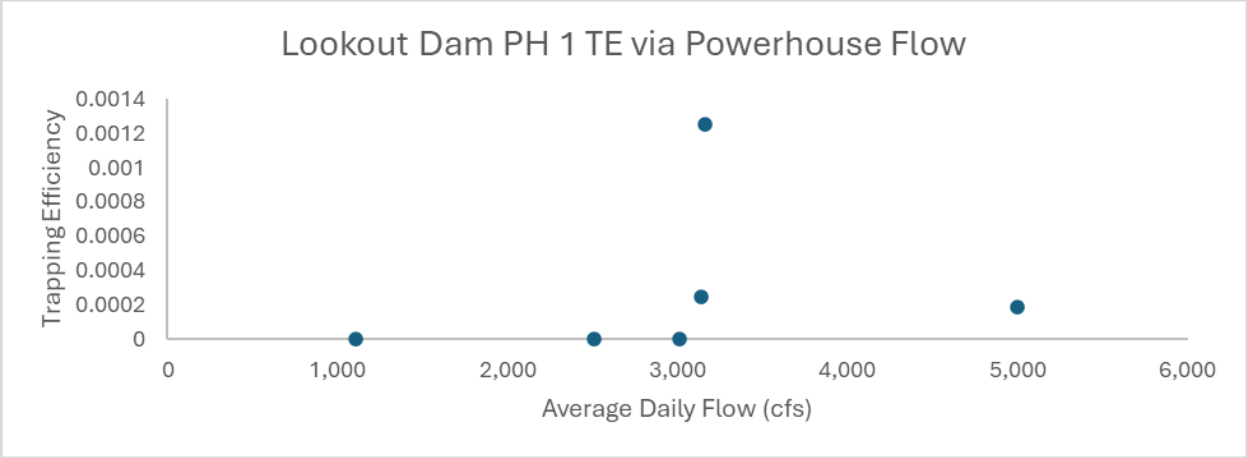

Figure E-23. Lookout Dam Tailrace PH1 trapping efficiency versus powerhouse flows.

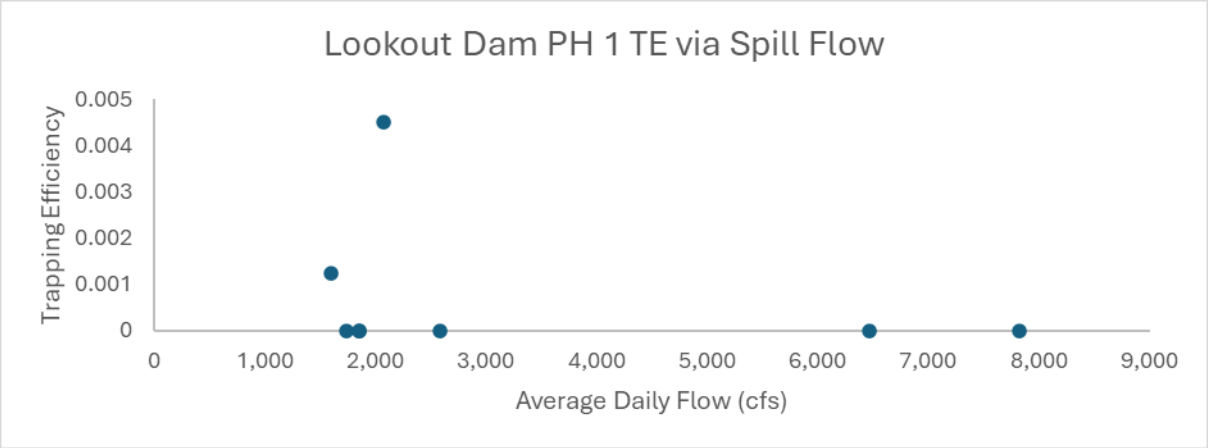

Figure E-24. Lookout Dam Tailrace PH1 trapping efficiency versus Spill/RO flows.

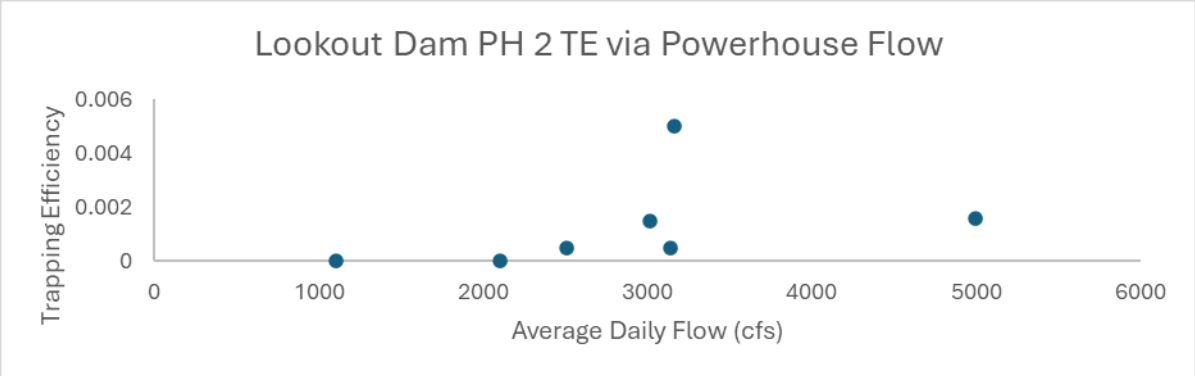

Figure E-25. Lookout Dam Tailrace PH2 trapping efficiency versus powerhouse flows.

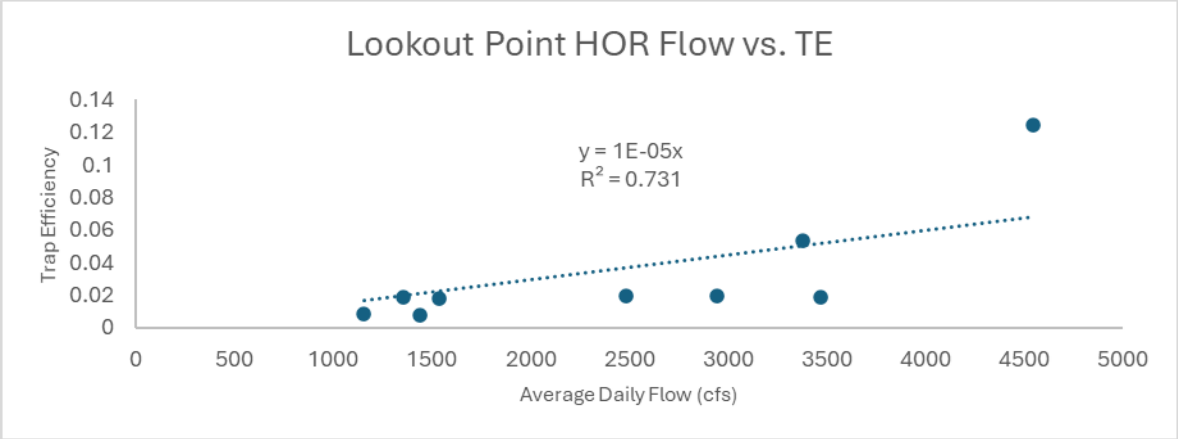

Figure E-26. Lookout Point Head of Reservoir trapping efficiency versus flows.

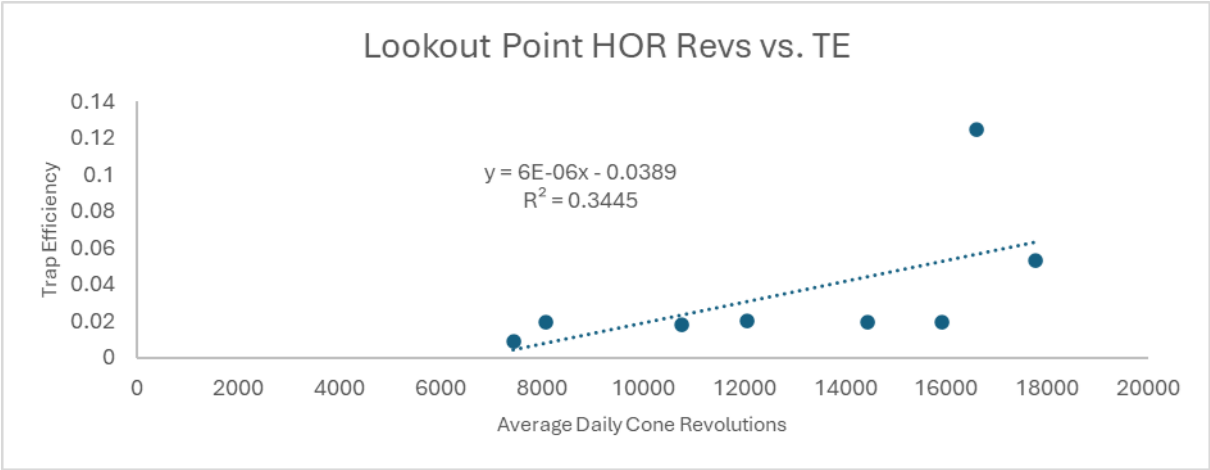

Figure E-27. Lookout Point Head of Reservoir trapping efficiency versus cone flux the day after fish were released.

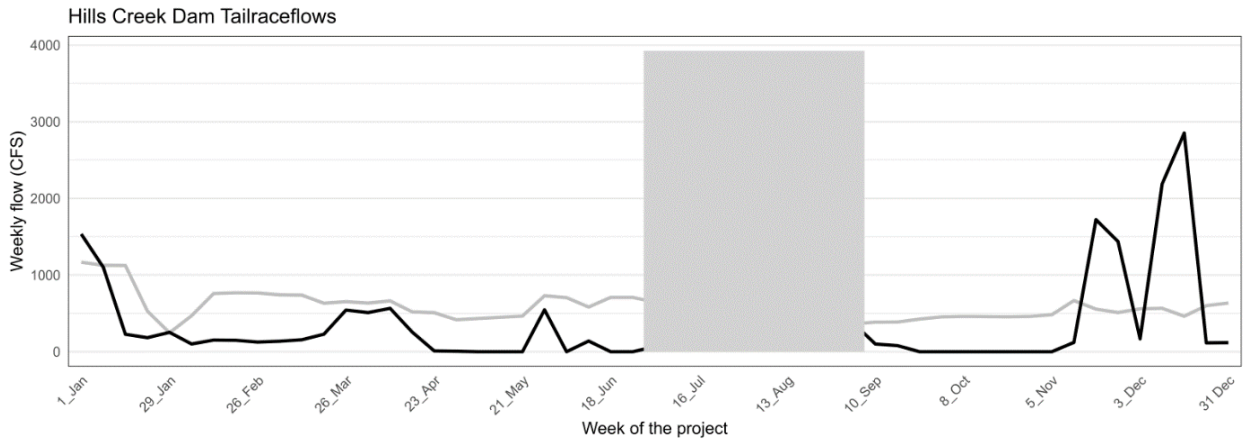

Figure E-28. Hills Creek Dam powerhouse flow (gray line) and spill flow (black line) for 2023.

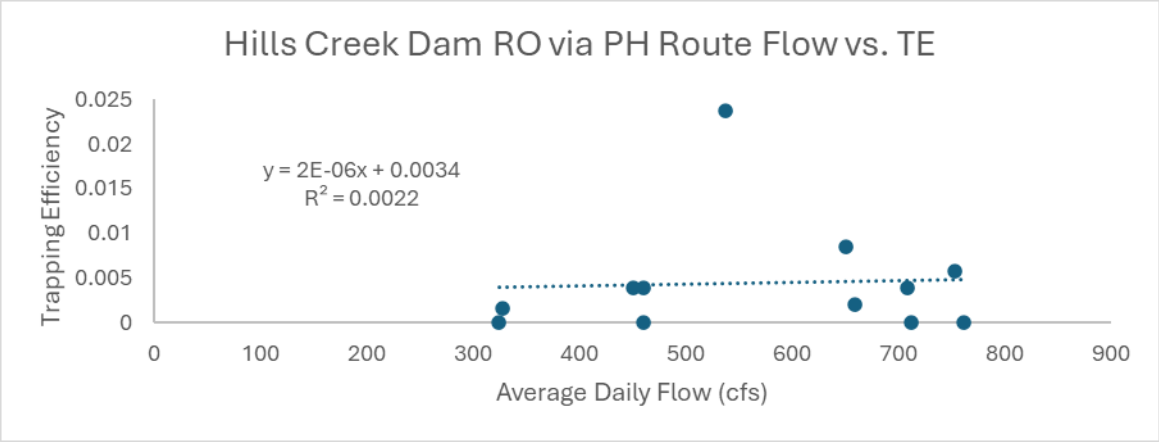

Figure E-29. Hills Creek RO trapping efficiency versus powerhouse flows.

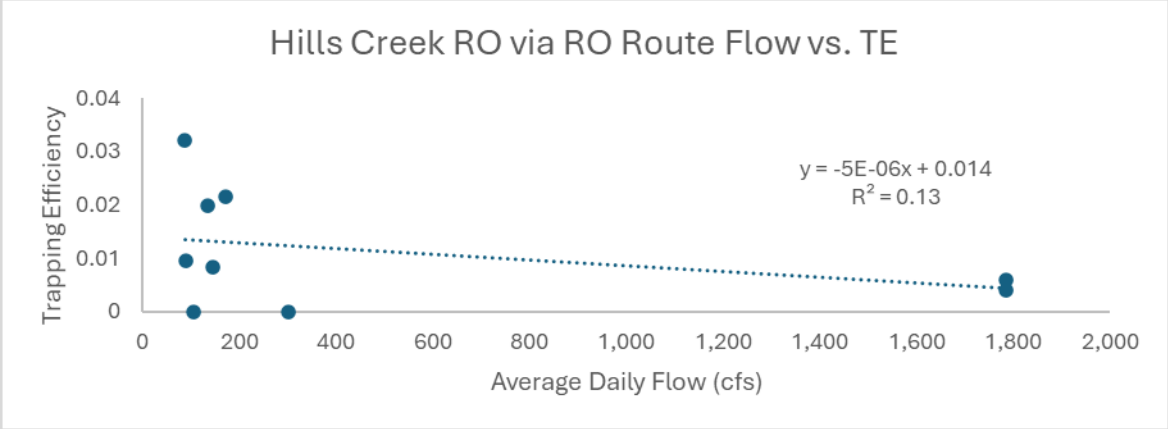

Figure E-30. Hills Creek RO trapping efficiency versus flow levels from the RO.

Table E-1. Summary table of marked hatchery Chinook released in the Willamette Valley for trapping efficiency trials since 2023.

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Breitenbush River	6/21/2023	749	53	7.1%
Breitenbush River	7/6/2023	763	25	3.3%
Breitenbush River	8/2/2023	791	12	1.5%
Breitenbush River	9/20/2023	756	7	0.9%
Breitenbush River	10/5/2023	789	18	2.3%
Breitenbush River	10/25/2023	750	51	6.8%
Breitenbush River	11/10/2023	750	152	20.3%
Breitenbush River	11/21/2023	900	55	6.1%
Big Cliff Dam Tailrace*	12/22/2021	997	39	3.9%
Big Cliff Dam Tailrace*	5/25/2022	995	21	2.1%
Big Cliff Dam Tailrace*	8/9/2022	1000	92	9.2%
Big Cliff Dam Tailrace*	9/30/2022	995	48	4.8%
Big Cliff Dam Tailrace*	10/13/2022	500	15	3.0%
Big Cliff Dam Tailrace*	10/24/2022	535	25	4.7%
Big Cliff Dam Tailrace*	11/2/2022	949	40	4.2%
Big Cliff Dam Tailrace*	11/16/2022	509	15	2.9%
Big Cliff Dam Tailrace*	12/14/2022	502	60	12.0%
Big Cliff Dam Tailrace*	12/19/2022	1010	92	9.1%
Big Cliff Dam Tailrace*	12/21/2022	1014	33	3.3%
Big Cliff Dam Tailrace*	12/27/2022	704	47	6.7%
Big Cliff Dam Tailrace*	12/29/2022	452	22	4.9%
Big Cliff Dam Tailrace*	1/25/2023	500	56	11.2%
Big Cliff Dam Tailrace*	2/17/2023	499	38	7.6%
Big Cliff Dam Tailrace**	3/7/2023	2,968	61	2.1%
Big Cliff Dam Tailrace	3/10/2023	541	112	20.7%
Big Cliff Dam Tailrace	4/28/2023	498	34	6.8%
Big Cliff Dam Tailrace	5/23/2023	500	6	1.2%
Big Cliff Dam Tailrace	6/21/2023	500	8	1.6%
Big Cliff Dam Tailrace	7/5/2023	500	33	6.6%
Big Cliff Dam Tailrace*	8/3/2023	474	42	8.9%
Big Cliff Dam Tailrace*	9/19/2023	424	64	15.1%
Big Cliff Dam Tailrace*	10/6/2023	500	56	11.2%
Big Cliff Dam Tailrace	10/25/2023	633	99	15.6%
Big Cliff Dam Tailrace	11/16/2023	527	0	0.0%
Big Cliff Dam Tailrace	11/21/2023	500	30	6.0%
Big Cliff Dam Tailrace	12/28/2023	550	56	10.2%
Detroit Head of Reservoir- North Santiam River	6/6/2023	540	28	5.2%
Detroit Head of Reservoir- North Santiam River	6/20/2023	750	61	8.1%
Detroit Head of Reservoir- North Santiam River	7/6/2023	750	13	1.7%
Detroit Head of Reservoir- North Santiam River	8/2/2023	750	19	2.5%
Detroit Head of Reservoir- North Santiam River	9/6/2023	700	19	2.7%
Detroit Head of Reservoir- North Santiam River	10/5/2023	750	24	3.2%
Detroit Head of Reservoir- North Santiam River	10/25/2023	757	72	9.5%
Detroit Head of Reservoir- North Santiam River	11/10/2023	813	91	11.2%
Detroit Head of Reservoir- North Santiam River	11/21/2023	1,014	111	10.9%
Green Peter Head of Reservoir- Middle Santiam (dead fish)	6/7/2023	1,000	0	0.0%
Green Peter Head of Reservoir- Middle Santiam	6/7/2023	750	1	0.1%
Green Peter Head of Reservoir- Middle Santiam	7/28/2023	750	0	0.0%

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Green Peter Head of Reservoir- Middle Santiam	8/30/2023	749	0	0.0%
Green Peter Head of Reservoir- Middle Santiam	9/27/2023	741	0	0.0%
Green Peter Head of Reservoir- Middle Santiam	10/11/2023	750	0	0.0%
Green Peter Head of Reservoir- Middle Santiam	10/31/2023	750	0	0.0%
Green Peter Head of Reservoir- Middle Santiam (dead fish)	10/31/2023	1,000	0	0.0%
Green Peter Head of Reservoir- Middle Santiam	11/15/2023	749	1	0.1%
Green Peter Dam Tailrace- Spill*	3/29/2022	643	4	0.6%
Green Peter Dam Tailrace- Spill*	4/30/2022	518	9	1.7%
Green Peter Dam Tailrace- Spill (Dead Fish)*	5/11/2023	1,001	0	0.0%
Green Peter Dam Tailrace- Spill*	5/11/2023	999	9	0.9%
Green Peter Dam Tailrace- PWR*	5/25/2023	1,000	10	1.0%
Green Peter Dam Tailrace- PWR	6/30/2023	1,000*	9	0.90%
Green Peter Dam Tailrace- PWR	6/30/2023	1,000	10	1.00%
Green Peter Dam Tailrace- PWR*	7/27/2023	1,009	13	1.3%
Green Peter Dam Tailrace- PWR*	8/16/2023	1,008	7	0.7%
Green Peter Dam Tailrace- PWR*	8/31/2023	1,000	8	0.8%
Green Peter Dam Tailrace- PWR*	10/4/2023	1,005	0	0.0%
Green Peter Dam Tailrace*	11/1/2023	1,000	22	2.2%
Green Peter Dam Tailrace*	11/14/2023	1,000	7	0.7%
Green Peter Dam Tailrace- Spill*	11/29/2023	1,000	28	2.8%
Green Peter Dam Tailrace- Spill (Dead Fish)*	11/29/2023	3,999	11	0.3%
Green Peter Dam Tailrace	12/8/2023	1,000	25	2.5%
Green Peter Dam Tailrace- Spill	12/19/2023	1,000	3	0.3%
Foster Dam Head of Reservoir*	9/29/2022	1,063	0	0.0%
Foster Dam Head of Reservoir*	10/25/2022	821	116	14.1%
Foster Dam Head of Reservoir*	11/1/2022	1006	263	26.1%
Foster Dam Head of Reservoir*	11/9/2022	1007	68	6.8%
Foster Dam Head of Reservoir*	11/15/2022	1009	55	5.5%
Foster Dam Head of Reservoir*	11/22/2022	933	163	17.5%
Foster Dam Head of Reservoir*	2/27/2023	1,002	21	2.1%
Foster Dam Head of Reservoir*	3/9/2023	995	62	6.2%
Foster Dam Head of Reservoir*	3/15/2023	1,025	0	0.0%
Foster Dam Head of Reservoir*	5/11/2023	985	20	2.0%
Foster Dam Head of Reservoir*	6/2/2023	1,003	79[a]	7.9%
Foster Dam Head of Reservoir*	6/29/2023	1,000	22	2.2%
Foster Dam Head of Reservoir*	7/27/2023	989	0	0.0%
Foster Dam Head of Reservoir*	8/31/2023	1,000	0	0.0%
Foster Dam Head of Reservoir*	9/27/2023	1,000	6	0.6%
Foster Dam Head of Reservoir*	10/10/2023	1,016	55	5.4%
Foster Dam Head of Reservoir*	11/14/2023	1,000	102	10.2%
Foster Dam Head of Reservoir*	11/22/2023	1,001	79	7.9%
Cougar Dam Powerhouse Channel*	1/19/2022	997	37	3.7%
Cougar Dam Powerhouse Channel*	4/20/2022	1000	67	6.7%
Cougar Dam Powerhouse Channel*	7/19/2022	535	148	27.7%
Cougar Dam Powerhouse Channel*	8/11/2022	949	29	3.1%
Cougar Dam Powerhouse Channel*	1/12/2023	843	159	18.9%
Cougar Dam Powerhouse Channel*	3/23/2023	500	49	9.8%
Cougar Dam Powerhouse Channel*	3/30/2023	497	95	19.1%
Cougar Dam Powerhouse Channel*	4/18/2023	297	14	4.7%
Cougar Dam Powerhouse Channel*	5/10/2023	499	5	1.0%
Cougar Dam Powerhouse Channel*	6/6/2023	507	65	12.8%
Cougar Dam Powerhouse Channel*	7/26/2023	510	63	12.4%

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Cougar Dam Powerhouse Channel*	9/21/2023	500	53	10.6%
Cougar Dam Powerhouse Channel*	10/11/2023	500	83	16.6%
Cougar Dam Regulating Outlet Channel*	1/19/2022	995	26	2.6%
Cougar Dam Regulating Outlet Channel*	4/20/2022	995	16	1.6%
Cougar Dam Regulating Outlet Channel*	5/15/2022	500	64	12.8%
Cougar Dam Regulating Outlet Channel*	10/14/2022	509	49	9.6%
Cougar Dam Regulating Outlet Channel*	11/22/2022	504	24	4.8%
Cougar Dam Regulating Outlet Channel*	12/13/2022	502	42	8.4%
Cougar Dam Regulating Outlet Channel*	12/15/2022	1010	56	5.5%
Cougar Dam Regulating Outlet Channel*	12/20/2022	1014	61	6.0%
Cougar Dam Regulating Outlet Channel*	12/28/2022	704	14	2.0%
Cougar Dam Regulating Outlet Channel*	1/30/2023	509	6	1.2%
Cougar Dam Regulating Outlet Channel*	3/23/2023	511	3	0.6%
Cougar Dam Regulating Outlet Channel*	3/30/2023	491	31	6.3%
Cougar Dam Regulating Outlet Channel*	4/18/2023	501	2	0.4%
Cougar Dam Regulating Outlet Channel*	5/10/2023	499	0	0.0%
Cougar Dam Regulating Outlet Channel*	10/11/2023	518	14	2.7%
Cougar Dam Regulating Outlet Channel*	11/8/2023	508	43	8.5%
Cougar Dam Regulating Outlet Channel*	11/30/2023	505	26	5.1%
Cougar Dam Regulating Outlet Channel	12/18/2023	505	2	0.4%
Cougar Dam Head of Reservoir*	3/18/2022	806	40	5.0%
Cougar Dam Head of Reservoir*	5/19/2022	498	23	4.6%
Cougar Dam Head of Reservoir*	6/23/2022	486	7	1.4%
Cougar Dam Head of Reservoir*	9/22/2022	551	56	10.2%
Cougar Dam Head of Reservoir*	10/5/2022	608	47	7.7%
Cougar Dam Head of Reservoir*	11/10/2022	704	33	4.7%
Cougar Dam Head of Reservoir*	11/16/2022	719	28	3.9%
Cougar Dam Head of Reservoir*	11/23/2022	752	48	6.4%
Cougar Dam Head of Reservoir*	11/29/2022	620	48	7.7%
Cougar Dam Head of Reservoir*	4/14/2023	506	10	2.0%
Cougar Dam Head of Reservoir*	5/10/2023	508	7	1.4%
Cougar Dam Head of Reservoir*	5/16/2023	497	23	4.6%
Cougar Dam Head of Reservoir*	6/8/2023	510	23	4.5%
Cougar Dam Head of Reservoir*	7/27/2023	758	27	3.6%
Cougar Dam Head of Reservoir+	8/30/2023	5,151	127	2.5%
Cougar Dam Head of Reservoir*	9/21/2023	745	41	5.5%
Cougar Dam Head of Reservoir*	10/19/2023	750	42	5.6%
Cougar Dam Head of Reservoir*	11/14/2023	756	21	2.8%
Cougar Dam Head of Reservoir*	11/28/2023	760	67	8.8%
Fall Creek Dam Regulating Outlet*	6/8/2022	517	11	2.1%
Fall Creek Dam Regulating Outlet*	6/30/2022	513	0	0.0%
Fall Creek Dam Regulating Outlet*	7/13/2022	498	0	0.0%
Fall Creek Dam Regulating Outlet*	5/11/2023	998	0	0.0%
Fall Creek Dam Regulating Outlet*	6/28/2023	992	0	0.0%
Fall Creek Dam Regulating Outlet	10/3/2023	1,020	0	0.0%
Fall Creek Dam Regulating Outlet	10/17/2023	1,011	14	1.4%
Fall Creek Dam Regulating Outlet	7/11/2023	1,006	0	0.0%
Fall Creek Head of Reservoir*	5/5/2023	756	15	2.0%
Fall Creek Head of Reservoir*	5/10/2023	750	23	3.1%
Fall Creek Head of Reservoir*	5/18/2023	511	7	1.4%
Fall Creek Head of Reservoir*	5/24/2023	760	4	0.5%
Dexter Dam Powerhouse*	7/21/2022	976	2	0.2%
Dexter Dam Powerhouse*	10/26/2022	1007	1	0.1%

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Dexter Dam Powerhouse*	11/1/2022	755	1	0.1%
Dexter Dam Powerhouse*	11/17/2022	991	4	0.4%
Dexter Dam Powerhouse*	12/6/2022	1010	10	1.0%
Dexter Dam Powerhouse*	12/15/2022	1025	1	0.1%
Dexter Dam Powerhouse*	3/16/2023	1,200	2	0.2%
Dexter Dam Powerhouse*	5/25/2023	4,003	14	0.3%
Dexter Dam Powerhouse*	6/7/2023	4,010	4	0.1%
Dexter Dam Powerhouse*	6/21/2023	4,028	15	0.4%
Dexter Dam Powerhouse*	7/6/2023	4,000	5	0.1%
Dexter Dam Powerhouse*	8/2/2023	1,505	3	0.2%
Dexter Dam Powerhouse*	8/23/2023	4,012	14	0.3%
Dexter Dam Powerhouse*	9/6/2023	4,037	13	0.3%
Dexter Dam Powerhouse*	10/4/2023	4,001	5	0.1%
Dexter Dam Powerhouse	12/28/2023	8,032	46	0.6%
Dexter Dam Spillway*	3/23/2022	988	2	0.2%
Dexter Dam Spillway*	5/4/2022	995	43	4.3%
Dexter Dam Spillway*	5/24/2022	1018	67	6.6%
Dexter Dam Spillway*	3/29/2023	1,199	5	0.4%
Dexter Dam Spillway*	10/24/2023	1,514	18	1.2%
Dexter Dam Spillway*	11/1/2023	1,506	9	0.6%
Dexter Dam Spillway*	11/22/2023	1,516	0	0.0%
Dexter Dam Spillway*	12/5/2023	4,006	10	0.2%
Dexter Dam Spillway*	12/12/2023	4,001	13	0.3%
Dexter Dam Spillway-Powerhouse	12/21/2023	4,005	3	0.1%
Lookout Dam Powerhouse*	4/13/2022	998	0	0.0%
Lookout Dam Powerhouse*	5/23/2023	3,999	32	0.8%
Lookout Dam Powerhouse*	6/1/2023	4,011	6	0.1%
Lookout Dam Powerhouse*	6/14/2023	4,010	4	0.1%
Lookout Dam Powerhouse*	6/28/2023	4,010	3	0.1%
Lookout Dam Powerhouse*	7/18/2023	4,012	9	0.2%
Lookout Dam Powerhouse	12/20/2023	16,007	29	0.2%
Lookout Dam Spillway	9/13/2023	3,636	0	0.0%
Lookout Dam Spillway	9/14/2003	3,998	0	0.0%
Lookout Dam Spillway	10/25/2023	4,042	0	0.0%
Lookout Dam Spillway	11/16/2023	4,005	12	0.3%
Lookout Dam Spillway	12/6/2023	8,007	18	0.2%
Lookout Dam Spillway	12/13/2023	8,011	148	1.8%
Lookout Point Head of Reservoir*	4/5/2022	993	53	5.3%
Lookout Point Head of Reservoir*	4/14/2022	987	19	1.9%
Lookout Point Head of Reservoir*	5/18/2022	1004	125	12.5%
Lookout Point Head of Reservoir*	7/20/2022	1005	9	0.9%
Lookout Point Head of Reservoir*	10/27/2022	506	9	1.8%
Lookout Point Head of Reservoir*	11/17/2022	510	0	0.0%
Lookout Point Head of Reservoir*	12/12/2022	510	0	0.0%
Lookout Point Head of Reservoir*	1/13/2023	516	10	1.9%
Lookout Point Head of Reservoir*	6/2/2023	760	15	2.0%
Lookout Point Head of Reservoir*	6/15/2023	765	6	0.8%
Lookout Point Head of Reservoir*	6/29/2023	769	2	0.3%
Lookout Point Head of Reservoir*	7/19/2023	765	0	0.0%
Lookout Point Head of Reservoir*	8/22/2023	677	13	1.9%
Lookout Point Head of Reservoir*	8/31/2023	751	0	0.0%
Lookout Point Head of Reservoir*	9/20/2023	787	1	0.1%
Lookout Point Head of Reservoir*	10/26/2023	755	0	0.0%

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Lookout Point Head of Reservoir*	11/15/2023	755	3	0.4%
Lookout Point Head of Reservoir*	11/29/2023	760	2	0.3%
Lookout Point Head of Reservoir	12/19/2023	1,504	9	0.6%
Hills Creek Dam Powerhouse*	1/6/2022	596	20	3.4%
Hills Creek Dam Powerhouse*	2/16/2022	600	12	2.0%
Hills Creek Dam Powerhouse*	2/25/2022	604	6	1.0%
Hills Creek Dam Powerhouse*	12/7/2022	514	29	5.6%
Hills Creek Dam Powerhouse*	2/25/2023	519	15	2.9%
Hills Creek Dam Powerhouse*	4/26/2023	506	62	12.3%
Hills Creek Dam Powerhouse*	5/17/2023	505	57	11.3%
Hills Creek Dam Powerhouse*	6/3/2023	508	36	7.1%
Hills Creek Dam Powerhouse*	6/27/2023	507	22	4.3%
Hills Creek Dam Powerhouse	9/27/2023	510	9	1.8%
Hills Creek Dam Powerhouse	10/17/2023	509	8	1.6%
Hills Creek Dam Powerhouse	10/31/2023	503	8	1.6%
Hills Creek Dam Powerhouse	11/15/2023	500	46	9.2%
Hills Creek Dam Powerhouse – RO Trial	9/27/2023	510	1	0.2%
Hills Creek Dam Powerhouse – RO Trial	10/17/2023	509	0	0.0%
Hills Creek Dam Powerhouse – RO Trial	10/31/2023	503	2	0.4%
Hills Creek Dam Powerhouse – RO Trial	11/15/2023	500	1	0.2%
Hills Creek Dam Powerhouse – RO*	6/3/2023	508	2	0.4%
Hills Creek Dam Powerhouse – RO Trial*	1/6/2022	596	5	0.8%
Hills Creek Dam Powerhouse – RO Trial*	2/16/2022	600	0	0.0%
Hills Creek Dam Powerhouse – RO Trial*	2/25/2022	604	1	0.2%
Hills Creek Dam Powerhouse – RO Trial*	12/7/2022	514	3	0.6%
Hills Creek Dam Powerhouse – RO Trial*	2/25/2023	519	0	0.0%
Hills Creek Dam Powerhouse – RO Trial*	4/26/2023	506	12	2.4%
Hills Creek Dam Powerhouse – RO Trial*	5/17/2023	505	2	0.4%
Hills Creek Dam Powerhouse – RO Trial*	6/27/2023	507	0	0.0%
Hills Creek Dam Regulating Outlet*	1/6/2022	605	13	2.1%
Hills Creek Dam Regulating Outlet*	2/16/2022	593	19	3.2%
Hills Creek Dam Regulating Outlet*	2/25/2022	625	6	1.0%
Hills Creek Dam Regulating Outlet*	12/13/2022	516	1	0.2%
Hills Creek Dam Regulating Outlet*	2/25/2023	478	0	0.0%
Hills Creek Dam Regulating Outlet*	6/13/2023	760	0	0.0%
Hills Creek Dam Regulating Outlet	11/21/2023	503	3	0.6%
Hills Creek Dam Regulating Outlet	11/29/2023	504	2	0.4%
Hills Creek Dam Regulating Outlet	12/26/2023	505	10	2.0%
Hills Creek Head of Reservoir	5/18/2023	519	44	8.5%
Hills Creek Head of Reservoir	6/19/2023	760	6	0.8%

**Release performed by EAS for the USACE under contract W9127N19D0007. **Release performed by ODFW. +Release performed by Cramer Fish Sciences.*

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Appendix F – Images of Traps

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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)

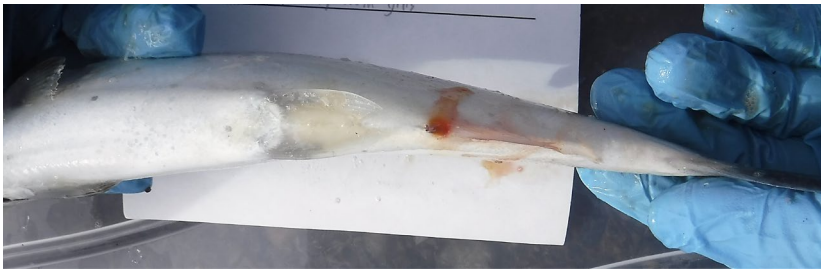

Figure F-4. Bleeding from Vent (BVT)

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

*captured lamprey are a mix of adult and juveniles. Many juveniles cannot accurately be identified to species in the field.

Figure G-2. Juvenile Lamprey

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

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. Cougar Dam – Regulating Outlet at medium (left) and high (right) flow.

Figure H-8. Cougar Dam – Regulating Outlet at medium (left) and high (right) flow.

Figure H-9. Fall Creek Dam Tailrace at low (left) and high (right) flow.

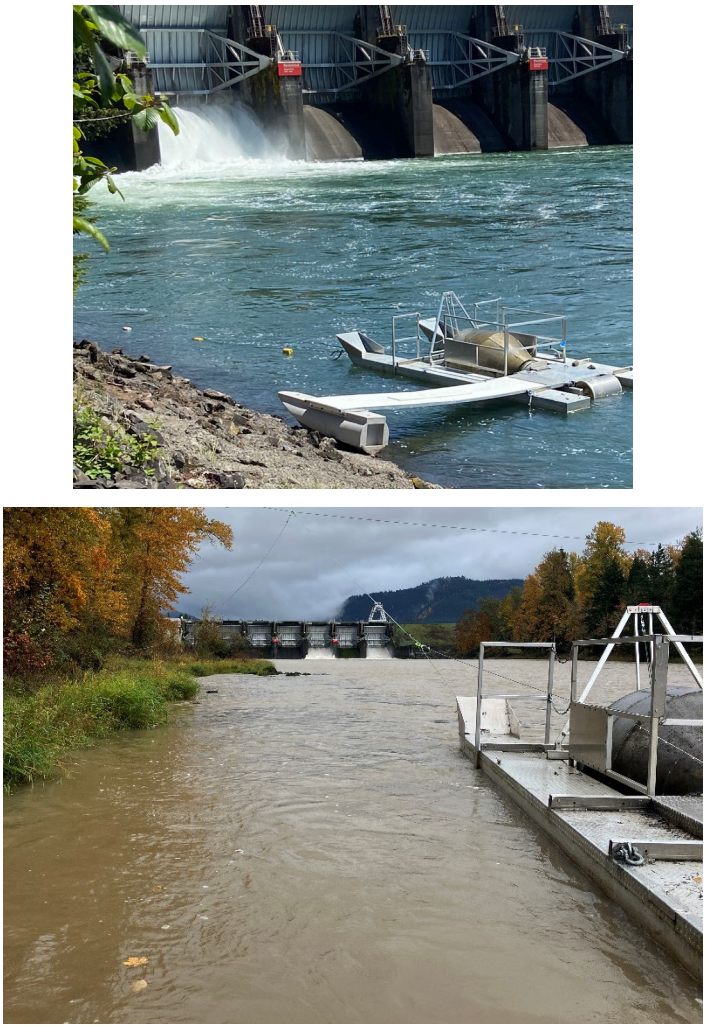

Figure H-10. Dexter Dam Tailrace at the old location (top) and the new location (bottom).

Figure H-11. Lookout Dam Tailrace – Spillway

Figure H-12. 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-13. Lookout Point Head of Reservoir sampling at medium (top) and high (bottom) 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. RST sampling at the Hills Creek Head of Reservoir – Middle Fork Willamette River site in medium flow.

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.

Appendix I – Multi-year Figures of Weekly Chinook Capture for Sites Sampling During the 2021, 2022, and 2023 Seasons

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Appendix I: Multi-year Figures of Weekly Chinook Capture for Sites Sampling During the 2021, 2022, and 2023 Seasons

Figures

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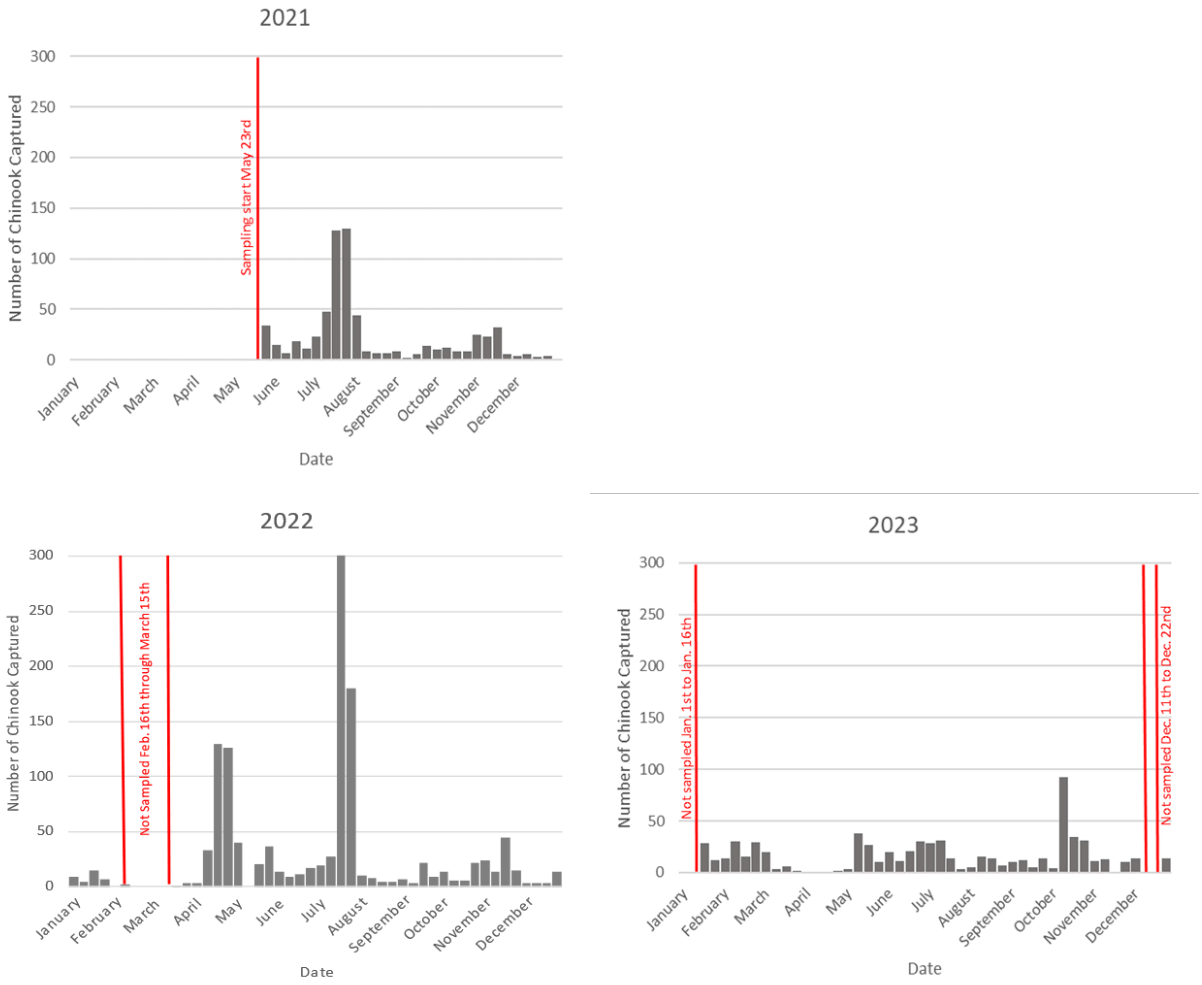

Figure I-1. Weekly Chinook capture at the Big Cliff Dam RST for 2021 through 2023 sampling.

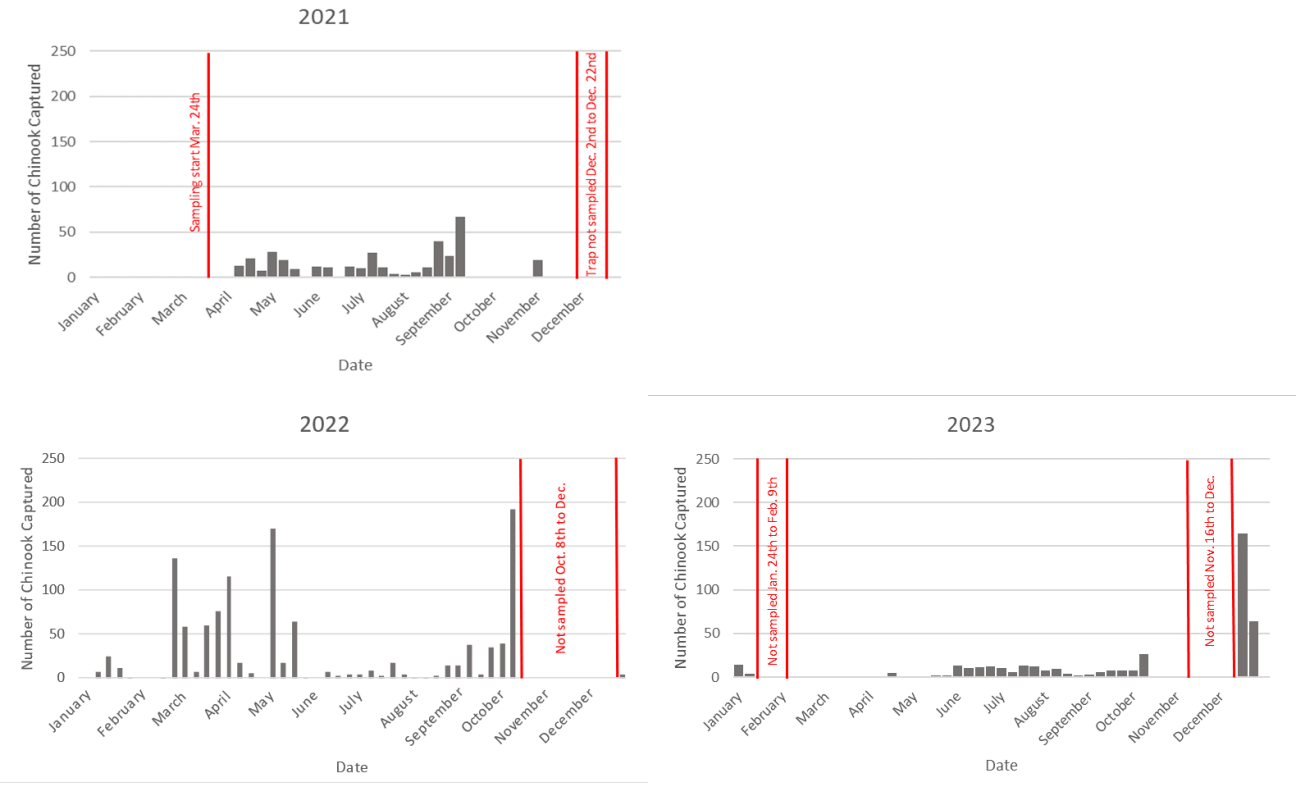

Figure I-2. Weekly Chinook capture at the Cougar Dam PH RSTs for 2021 through 2023 sampling.

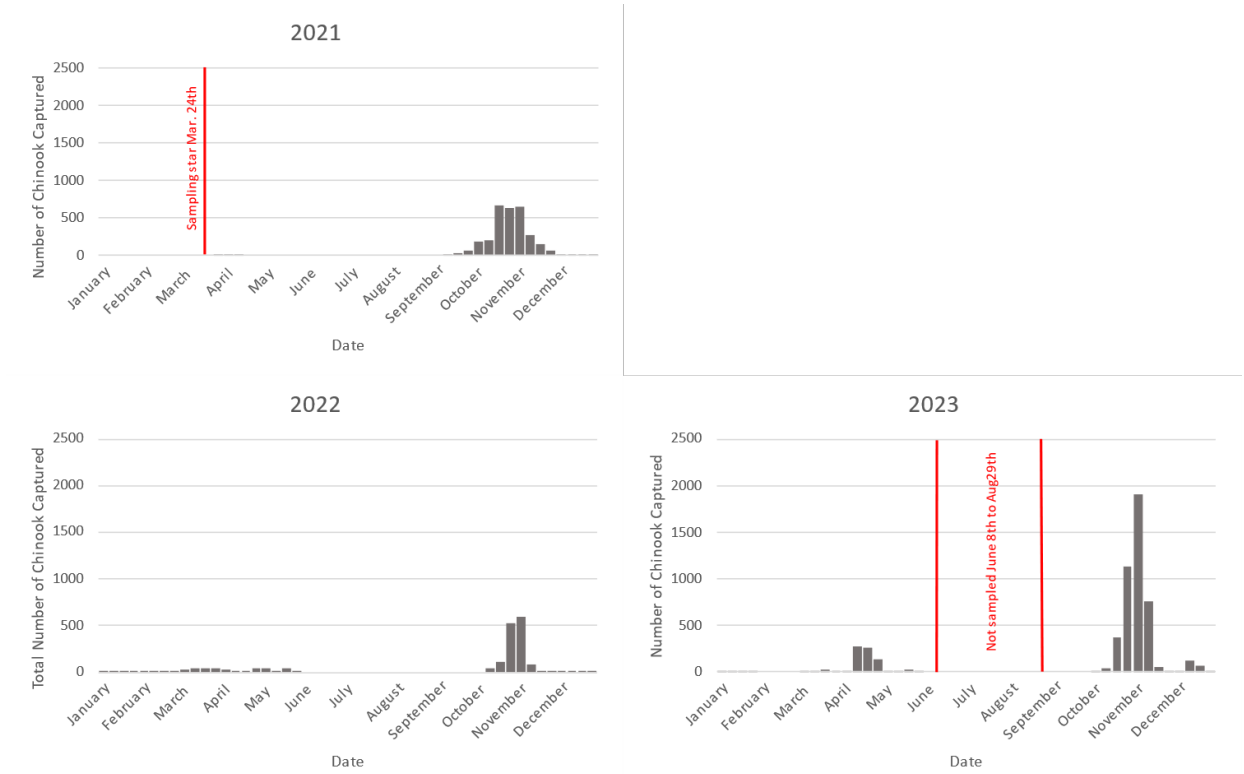

Figure I-3. Weekly Chinook capture at the Cougar Dam RO RST for 2021 to 2023 sampling.

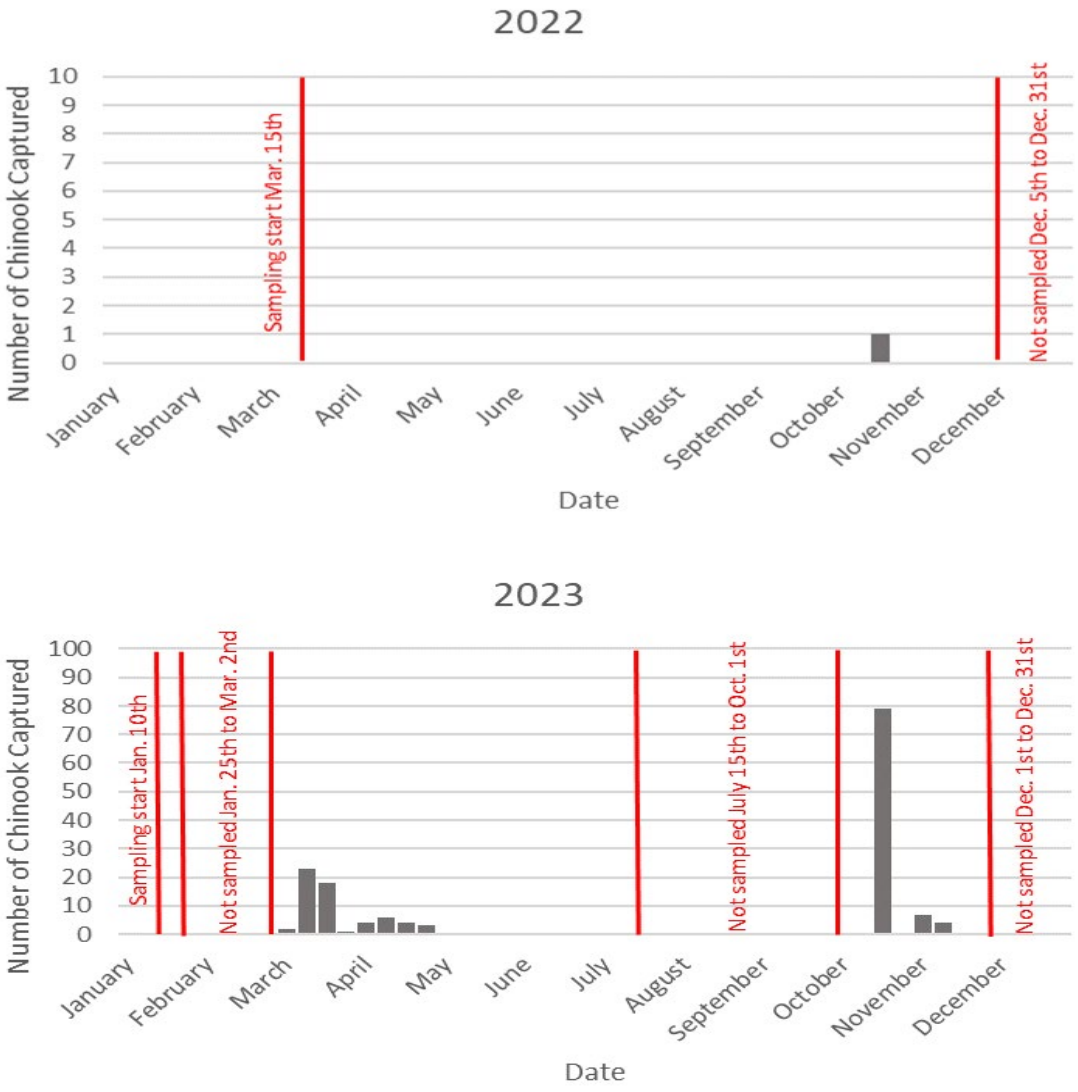

Figure I-4. Weekly Chinook at the Fall Creek Dam RST for 2022 and 2023 sampling.

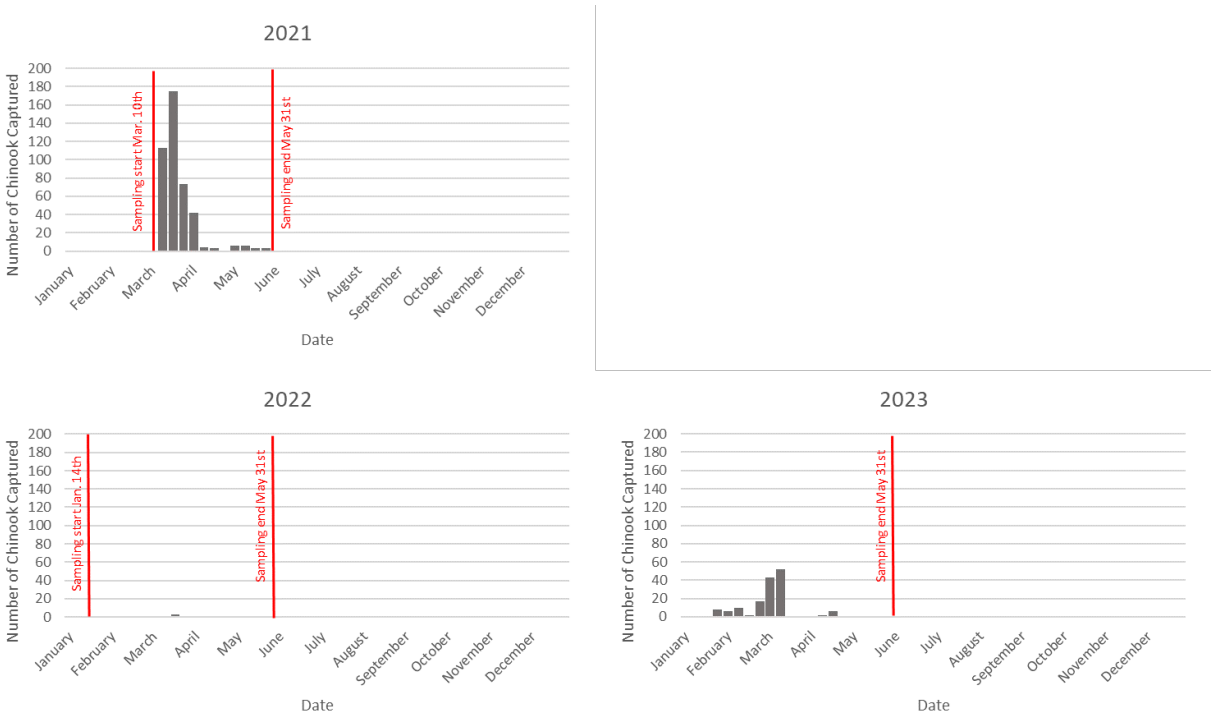

Figure I-5. Weekly Chinook capture at the Fall Creek Head of Reservoir RST for 2021 to 2023 sampling.

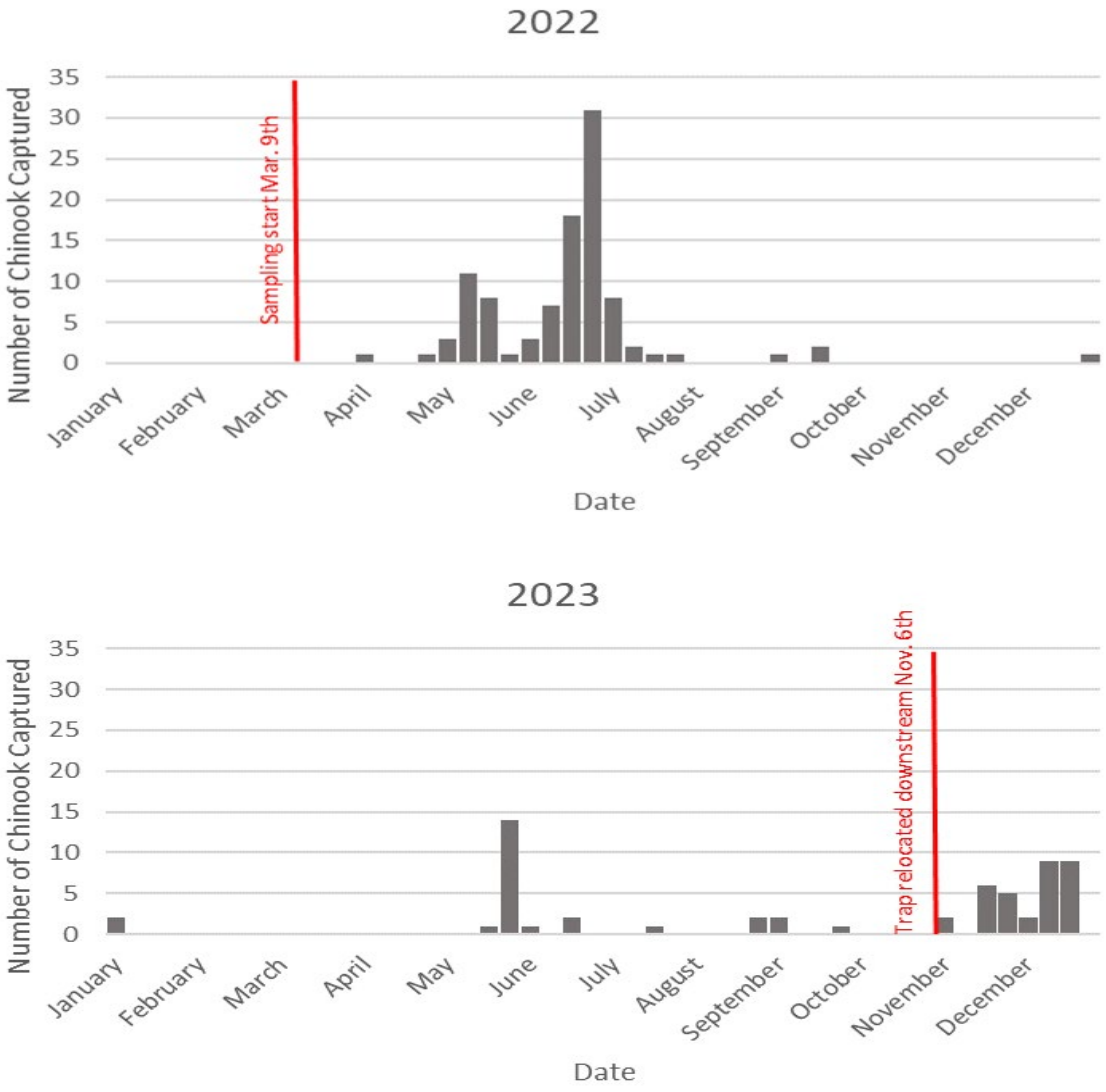

Figure I-6. Weekly Chinook capture at the Dexter Dam RST for 2022 and 2023 sampling.

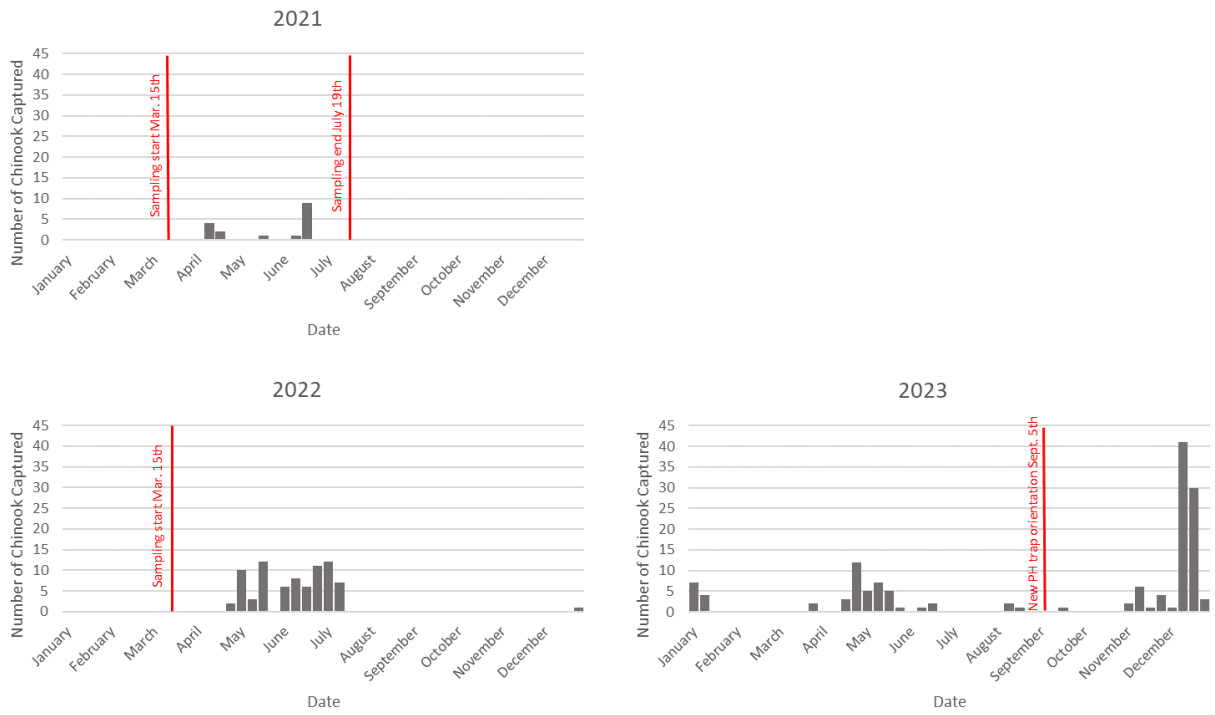

Figure I-7. Weekly Chinook capture at the Lookout Dam RSTs for 2021 to 2023 sampling.

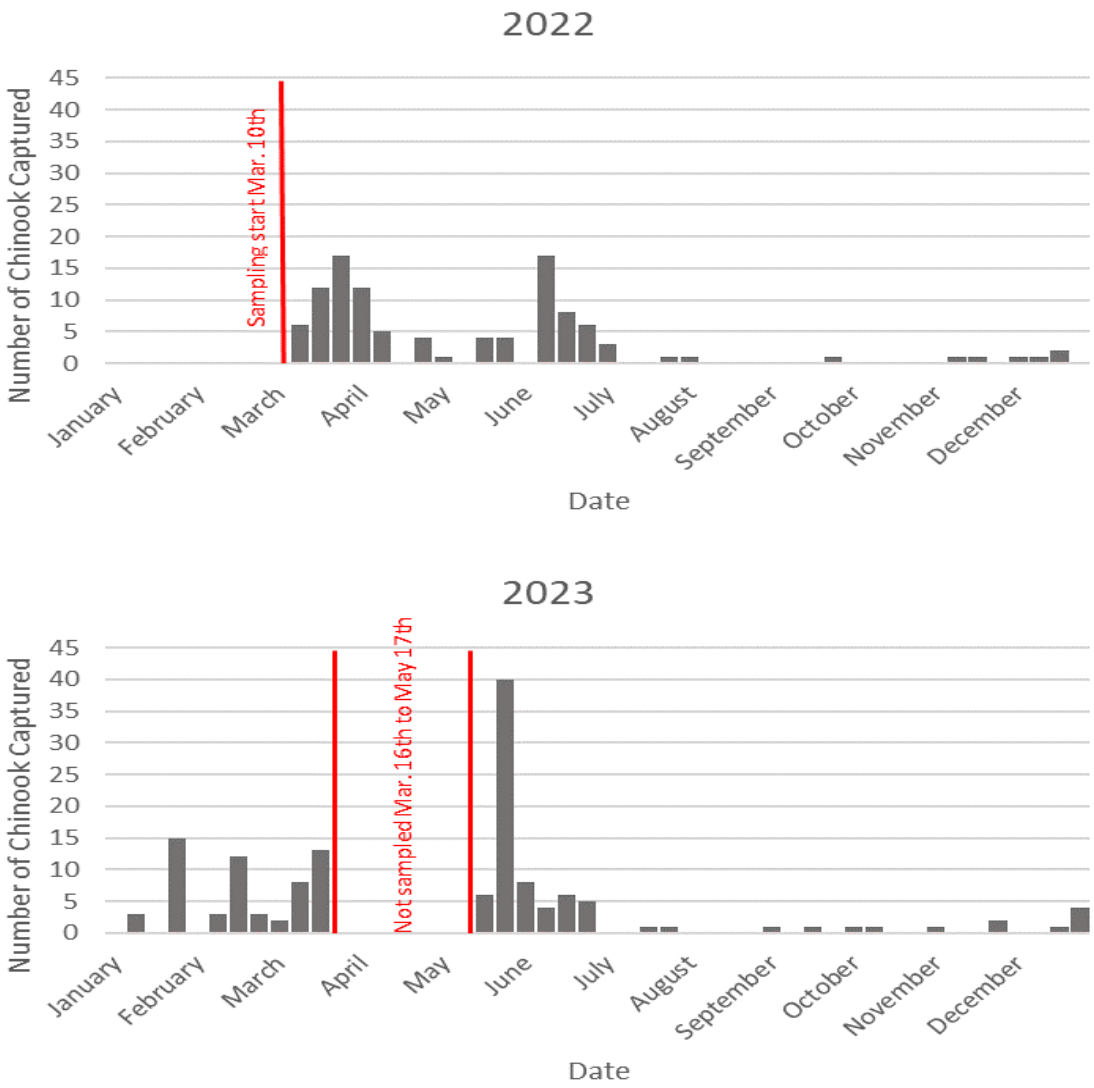

Figure I-8. Weekly Chinook capture at the Lookout Point Head of Reservoir RST for 2022 and 2023 sampling.

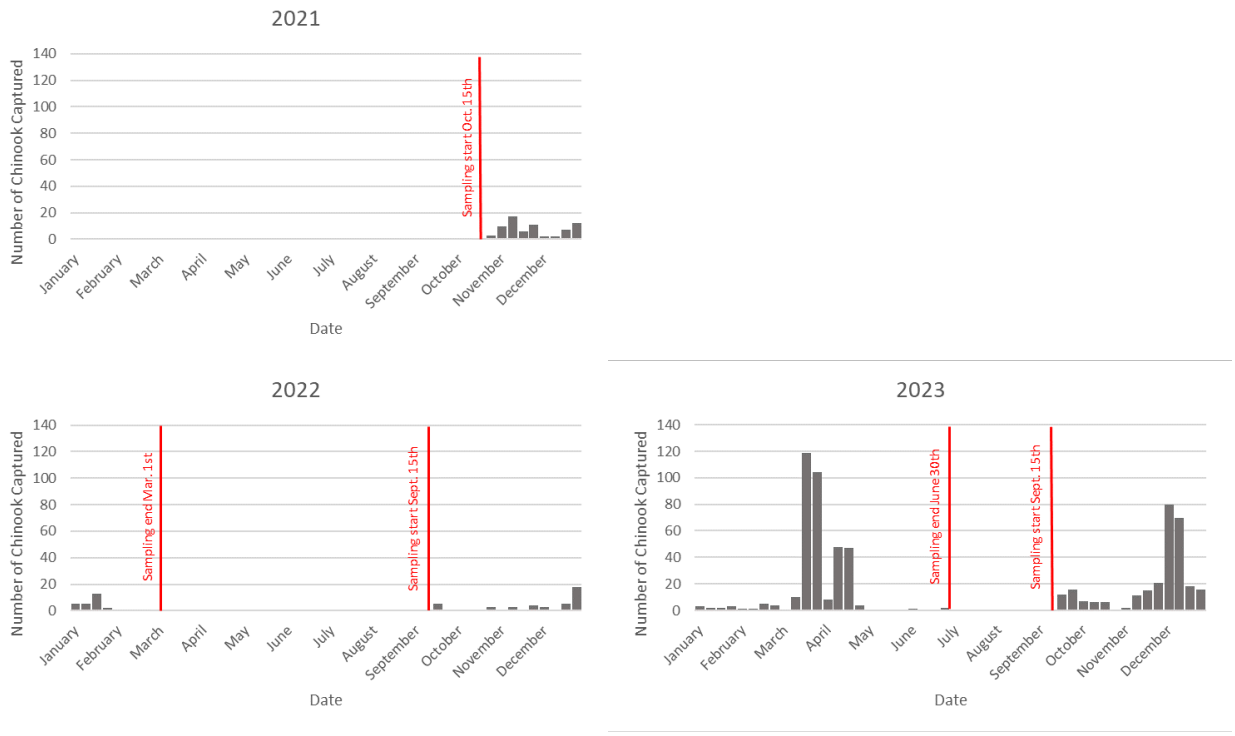

Figure I-9. Weekly Chinook capture at the Hills Creek Dam RSTs for 2021 to 2023 sampling.

Appendix J – USGS 2023 Turbidity Gage for the Middle Santiam River Below Green Peter Dam

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Appendix J: USGS 2023 Turbidity Gage for the Middle Santiam River Below Green Peter Dam

Figures

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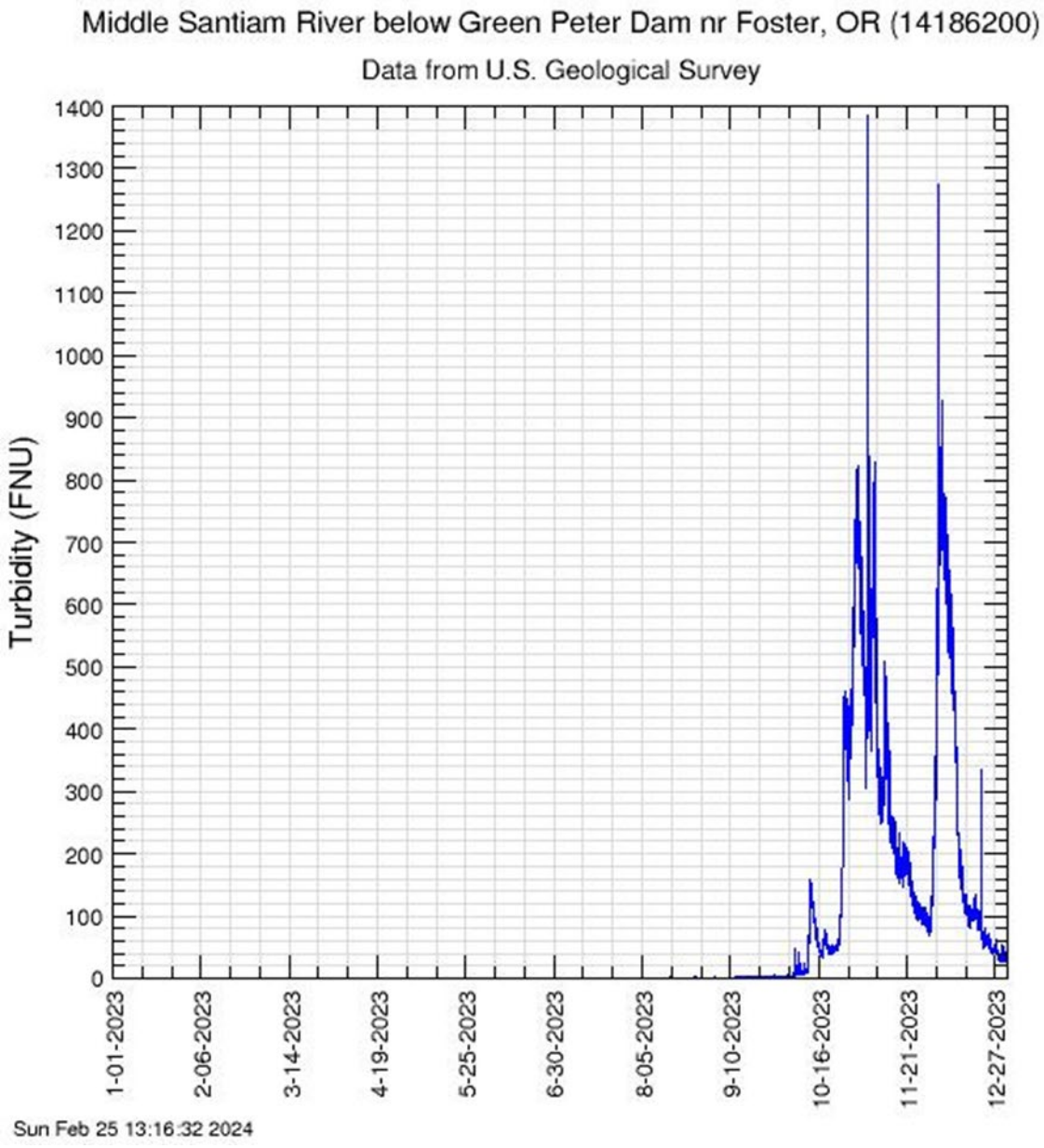

Figure J-1. USGS Turbidity Gage for Calendar Year 2023 for the Middle Santiam River Below Green Peter Dam.

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