FINAL

WILLAMETTE VALLEY FISH PASSAGE MONITORING VIA ROTARY SCREW TRAPS

Annual Report

Prepared for

US Army Corps of Engineers

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Acronyms and Abbreviations

AQI	Air Quality Index
Big Cliff	Big Cliff Dam
BiOp	Willamette Project Biological Opinion
BPA	Bonneville Power Administration
BY	Brood Year
CFS/Cramer	Cramer Fish Sciences
CI	Confidence Interval
Cougar Dam HOR	Cougar Dam Head of Reservoir
Dexter	Dexter Dam Tailrace
EAS	Environmental Assessment Services, LLC
ESA	Endangered Species Act
Fall Creek HOR	Fall Creek Head of Reservoir
Fall Creek TR	Fall Creek Dam Tailrace
Foster HOR	Foster Dam Head of Reservoir – South Santiam River
Green Peter TR	Green Peter Tailrace – Middle Santiam River
HOR	Head of Reservoir
Lookout Dam HOR	Lookout Dam Head of Reservoir
Lookout Dam TR	Lookout Dam Tailrace
NMFS	National Marine Fisheries Service
NOR	Natural Origin
ODFW	Oregon Department of Fish and Wildlife
PH	Powerhouse
PIT	Passive Integrated Transponder
PNNL	Pacific Northwest National Laboratory
PTAGIS	PIT Tag Information System
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 (UWR) Chinook salmon and winter steelhead resulted from dam construction circa 1952 from Big Cliff and Detroit dams on the North Santiam River, Cougar Dam on the McKenzie River, Hills Creek Dam and Dexter/Lookout Point Dam on the Middle Fork Willamette River, and circa 1967 from Green Peter Dam on the Middle Santiam River (NMFS 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 (RPA) that set forth specific actions the Action Agencies could implement to satisfy their legal obligations under the ESA to "…avoid the likelihood of jeopardizing the continued existence of the ESA-listed species or the destruction or adverse modification of their designated critical habitat" (NMFS 2008b).

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

In September 2021, the US District Court for the District of Oregon issued an Interim Injunction Order directing the USACE to implement certain interim injunctive measures to improve fish passage and water quality at several WVP dam sites to benefit UWR spring Chinook salmon and winter steelhead. These interim injunctive measures replaced some of the prior interim measures and continued others. This study, in conjunction with other efforts, evaluated the biological effects of these measures that were implemented starting in fall 2021 on downstream passage of emigrating juvenile Chinook salmon (e.g., timing, size at migration, and natural production) 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 reservoirs and dams in rivers upstream of Foster, Cougar, Fall Creek, and Lookout Point reservoirs, and in the tailraces of Big Cliff, Green Peter, Cougar, Fall Creek, Dexter, Lookout and Hills Creek dams. Additional sampling occurred in 2023 at sites in the North Santiam River above Detroit Reservoir, Breitenbush River, Middle Santiam River above Green Peter Reservoir, and the Middle Fork Willamette River above Hills Creek Reservoir and is reported separately (CFS 2024a).

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.

This report contains a summary and analysis of the field study implemented by Environmental Assessment Services, LLC (EAS) under contract with the USACE for RST sampling efforts starting in spring 2023 through December 16, 2023.

RST sampling under EAS base contract number W9127N19D0007 at sites below Big Cliff Dam, Green Peter Dam, Cougar Dam, Fall Creek Dam, Dexter Dam, Lookout Dam, and Hills Creek Dam, as well as the site at Lookout Point Head of Reservoir (HOR) on the Middle Fork Willamette concluded in the fall and winter of 2023 (see Table 1 for sampling period dates). Monitoring at these sites was continued under the Cramer Fish Sciences (CFS) base contract number W9127N19D0009 and the associated data are reported separately (CFS 2024a). Additional RST sampling was conducted by EAS as a subcontractor for CFS under CFS base contract number W9127N19D0009 at HOR sites above Detroit, Green Peter, and Hills Creek Reservoirs in 2023. Additional sampling at the Big Cliff Dam Tailrace, Green Peter Dam Tailrace, Cougar Dam Tailrace, Fall Creek Dam Tailrace, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point HOR, and Hills Creek Dam Tailrace was conducted by EAS as a subcontractor for CFS after sampling periods from contract W9127N19D0007 concluded. Results from sampling at the sites listed are reported separately (CFS 2024a).

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 F.

Traps are 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 check, getting damaged, and preventing fish mortality. Traps were accessed either by wading or with inflatable kayaks. The RSTs used for sampling were manufactured by E.G. Solutions. EAS used a combination of RSTs provided by USACE and procured additional RSTs as necessary to perform sampling tasks. EAS staff made minor repairs throughout the season to ensure that traps sampled efficiently and safely.

RSTs were operated at 11 locations in the southern Willamette River watershed under EAS base contract number W9127N19D0007: Big Cliff Dam Tailrace, Green Peter Dam Tailrace–Middle Santiam River, Foster Dam HOR–South Santiam River, Cougar Dam Tailrace, Cougar HOR, Fall Creek Dam Tailrace, Fall Creek HOR, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point HOR – Middle Fork Willamette River, and Hills Creek Dam Tailrace. Trap deployment locations at each of these sites were placed as close to historical sampling locations as possible. For sites where environmental conditions no longer allowed for a trap to sample in a historic location, an alternative site was selected in an area that allowed for safe sampling while maximizing the trap's capture efficiency. For locations of traps for sampling before and after 2021, please refer to Appendix A. Below is the list of sites where traps were operated:

- At Big Cliff Dam Tailrace, a single 8-foot RST operated in the tailrace from January 1, 2023, to October 15, 2023.
- At the Green Peter Dam Tailrace – Middle Santiam River, a single 8-foot RST operated from March 14, 2023, to November 30, 2023.
- At the Foster Dam HOR – South Santiam River site, a 5-foot trap operated from February 1, 2023, to November 30, 2023.
- At the Cougar Dam Tailrace, three RSTs were operated from January 1, 2023, to November 30, 2023: two 8-foot RSTs in the Powerhouse (PH) channel and one 5-foot RST in the Regulation Outlet (RO) channel.

- At the Cougar HOR site, a single 5-foot RST was deployed in the South Fork McKenzie River from February 1, 2023, to November 30, 2023.
- 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.
- At the Fall Creek HOR site, a single 8-foot RST was deployed from January 18, 2023, to May 31, 2023.
- At the Dexter Dam Tailrace, a 5-foot RST was deployed and sampled from January 1, 2023, to December 15, 2023.
- At the Lookout Dam Tailrace, three 8-foot RSTs were operated from January 1, 2023, to July 31, 2023: two in the PH channel and one in the spill channel.
- At the Lookout Point HOR – Middle Fork Willamette River site, a 5-foot RST operated from January 1, 2023, to December 15, 2023. The RST site is located at the US Forest Service Seed Farm.
- At the Hills Creek Dam, two RSTs were operated from January 1, 2023, to June 30, 2023: one 8-foot RST in the PH channel and one 5-foot RST in the RO channels. Additional RST sampling occurred simultaneously and is reported by EAS within the CFS Annual Report.

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

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

Site	Trap Installation	Contracted Reporting Period[d]
Big Cliff Dam	12/01/2022[a]	01/01/2023–10/15/2023
Green Peter Tailrace – Middle Santiam River	03/14/2023[b]	02/01/2023–11/30/2023
Foster Dam Head of Reservoir – South Santiam River	03/15/2022	02/01/2023–11/30/2023
Cougar Dam PH	12/01/2021[a]	01/01/2023–11/30/2023
Cougar Dam RO	12/01/2021[a]	01/01/2023–11/30/2023
Cougar Dam Head of Reservoir	03/08/2022[c]	02/01/2023–11/30/2023
Fall Creek Dam	03/15/2022[a]	01/01/2023–07/15/2023
Fall Creek Head of Reservoir	01/14/2022[c]	01/01/2023–05/31/2023
Dexter Dam Tailrace	03/03/2022	01/01/2023–12/15/2023
Lookout Point Dam	03/15/2022[a]	01/01/2023–07/31/2023
Lookout Point Head of Reservoir	03/06/2022	01/01/2023–12/15/2023
Hills Creek Dam PH	09/15/2022	01/01/2023–06/30/2023
Hills Creek Dam RO	09/15/2022	01/01/2023–06/30/2023

[a] Trap was installed and sampling prior to EAS management of the current contract and reporting period.
[b] Initiation of sampling delayed until a new anchor system could be installed.
[c] Initiation of sampling delayed while waiting for contract approval.
[d] See Appendix B for more information on sampling outages.

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 United States Geological Survey (USGS) gauges and USACE dam operations data which included inflow, outflow by route, water temperature, and dissolved oxygen concentration where available. Fish were removed from trap live wells and transported to a safe work-up location. Fish were then anesthetized using a prepared Tricaine methanesulfonate solution (Syndel USA Tricaine-S) that was buffered with sodium bicarbonate (Aldon Corporation Sodium Bicarbonate) to neutralize the pH. 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. 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. At sites located in the Santiam basin, all unmarked juvenile *O. mykiss* were treated and reported as winter steelhead.

Biological Data and Tagging

Biological data was collected for each target fish captured. Target fish were juvenile Chinook salmon that did not display any clip, tag, or dye and were presumed to be of NOR. At sites in the Santiam River basin where winter steelhead were target fish, 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 which species are considered targets for each. Data collected included species, fork length to the nearest millimeter, weight to the nearest 0.1-gram, fish condition, lifestage, injuries, and assessment of 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. As this is a subjective delineation, dependent on environmental conditions and life history, there is some overlap on lengths. A list of injury codes used for assessments is provided in Table 2. In addition to the injury codes

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
Operculum 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

listed, we also enumerated the number of adult gravid female copepods (*Salmincola californiensis*) 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 Cramer for the Bulk Mark Release study, Reservoir Distribution study (CFS 2023c), 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 into a 24-hour hold study, were marked with a Passive Integrative Transponder (PIT) tag 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 species encountered, and injuries were collected throughout the sampling periods and are provided in Appendix D. A summary of data collected by site is provided in Table 3.

Table 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)
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
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-hour holds	No
Foster Dam Head of Reservoir – South Santiam	Yes, Run of River Fish, Hatchery Fish in Fall	Spring Chinook and *O. mykiss*	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	No
Cougar 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-hour holds	No
Cougar Dam Head of Reservoir	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
Fall Creek Dam	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes	No
Fall Creek Head of Reservoir	Yes, Run of River	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	No	Yes	Yes
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-hour holds	No

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)
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-hour holds	Yes, on fish not included in 24-hour 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, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), F.L. (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hour holds	Yes, on fish not included in 24-hour holds

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, Peck, and Vining (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 selected 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: Foster Dam HOR, Cougar PH, Cougar RO, and Green Peter Dam have no apparent association, while Dexter Dam Tailrace lacks samples but appears to have a positive association with flow.
3) Unable to determine passage at Fall Creek Dam 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 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 2023, under contract W9127N19D0007, EAS conducted 115 TE trials releasing a total of 159,516 fish. Of these fish, the cumulative direct mortality due to handling was 0.0036%, or 586 fish in total. 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 or 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 the nearest 0.1 grams, and had injury assessments performed prior to release. Hatchery fish were collected either from ODFW hatcheries or from Oregon State University's Smith Farms fish facility. Water temperature and dissolved oxygen levels were continuously monitored during fish transportation and corrected as necessary. Upon arrival 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 PH, Spill, or RO outlet as 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. Additional information related to TE trials is provided in Appendix E.

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 that alternated weekly between the lower or upper lobe and then 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 to fish for TE trail recapture verification. 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 NOR juvenile Chinook salmon (or *O. mykiss* where applicable) were held for 24 hours to assess post-capture or delayed mortality. Biological data was collected on captured fish per normal protocol as described in the *Biological Data and Tagging* section. Fish placed in the hold trial were not PIT tagged or VIE marked in order 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 RO or spill route were prioritized for hold. At most sites, hold tanks were created using perforated buckets that were attached to the RSTs 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 3,669 start/stop times with an average duration of 23.97 hours between checks (standard deviation of 2.37 hours). Trap sampling time between checks ranged from 15.7 and 32.93 hours. In all instances 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. Additionally, data was excluded (<3%) from further analysis if a trap was not functioning upon arrival, typically due to debris clogging. Adjusted daily catch was calculated with the following equation:

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

where:

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

Weekly standardized catch was calculated from the standardized daily catch rates.

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

where:

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

Abundance Estimates of Out-Migrating Target Species

Building on the previous work in the area conducted by Keefer et al. (2013), Romer et al. (2012–2017), and CFS (2023), we calculated trap capture efficiency by marking hatchery Chinook salmon for each TE trial. Fish were released upstream ~500 m from the trap, or as far upstream as possible at the below dam sites. Fish for TE releases were uniquely marked for each trial individually, or in combination with PIT tags, fin clips (adipose, vent right or left, and caudal upper or lower), and 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 (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 EAS has attempted to account for flow rates. Water flow has been shown to be the dominant factor affecting TE in multiple RST out-migrating juvenile salmonid studies (Cheng and Gallinat 2004; Dambacher 1991; Rayton and Wagner 2006; Volkhardt et al. 2007; Voss and Poytress 2020). Determining trap efficacy is problematic and likely a large source of error with RST research in this area, especially at sites with wide and/or deep flow channels (e.g., below Lookout Dam). Ideally, ROR TE trials would be conducted weekly, but previous work in the area has shown that releasing enough RST captured fish to obtain the minimum of five recaptures to calculate TE is problematic at most locations. Unfortunately, it is unrealistic to perform weekly trials at sites with hatchery fish as there are not enough fish available for this purpose.

Previous RST work has shown flow rates to be one of the largest factors in TE (Tattam et al. 2013). For this project, EAS started with the assumption that flow would be the best predictor of TE and therefore, attempted to build models based on flows. EAS has since gained further insight with a growing pool of TE trials and has found the response of TE to flow to be on a site-by-site basis. A more comprehensive 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 that were deemed successful (total trials, at specific flow rates, or not enough recaptures) have been conducted to model TE in relation to flows. At other sites, there appears to be no relationship between flow and TE. In those instances, all TE trials (except when trap was non-functional) were pooled to calculate an average TE and 95% confidence intervals based on the standard deviation.

There appear to be linear trends in relation to flow at some sites, but at this time, not enough successful trials have been conducted (particularly at high flows) to model the data at several sites. For example, at Cougar Dam RO, a highly channelized location, the TE for both hatchery and wild 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 and 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 where appropriate, we will be able to build a model over time that can predict TE based on flow rates. This would reduce the overall number of 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 TE, 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 TE trials for a given site, route, and flow rate
- n = Number of TE 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 (5 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 8,891 (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 8 route options (1 PH on/off, 6 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 3 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 eight TE trials in 2023 (CFS 2024a). 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 identified with a unique identification number, location of capture, and date of capture. Fish length and weight were not included, so that it would not bias the reader. Each sample was read by two individuals, independently. For samples with conflicting ages based on independent scale reads, a third read was performed by another reader. Additionally, a random subset of samples was read a third time to confirm age determinations. Fish were aged as either yearlings or sub-yearlings and a BY was assigned based on the age of fish and time of capture. Fish age was then correlated back to individual fish using the unique identification number and used to determine BY for size class of fish throughout the year.

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.

Results

Big Cliff Dam Tailrace

For this reporting period, EAS monitored the single 8-foot RST in the Big Cliff Dam Tailrace from January 1, 2023, to the end of the reporting period on October 15, 2023. Sampling from October 16, 2023, to December 31, 2023, occurred under contract W9127N19D0009 and will be reported in the annual report for that contract. 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 11 TE trials occurred under contract W9127ND007 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 4.

TEs ranged from 1.2% to 20.7%. Trials were grouped by flow 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 provided in Appendix E.

Table 4. Summary table of marked hatchery Chinook salmon releases at Big Cliff Dam Tailrace for trapping efficiency January 1, 2023, to December 31, 2023.

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%

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Big Cliff Dam Tailrace	7/5/2023	1,260	500	33	6.6%
Big Cliff Dam Tailrace	8/3/2023	1,080	474	42	8.9%
Big Cliff Dam Tailrace	9/19/2023	1,580	424	64	15.1%
Big Cliff Dam Tailrace	10/6/2023	1,590	500	56	11.2%
Big Cliff Dam Tailrace	10/25/2023	1,630	633	99	15.6%
Big Cliff Dam Tailrace	11/16/2023	4,200	527	0	0.0%
Big Cliff Dam Tailrace	11/21/2023	3,750	500	30	6.0%
Big Cliff Dam Tailrace	12/28/2023	1,520	550	56	10.2%

*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 Tailrace 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 NOR fish were not available to perform trials.

Target Catch, Passage Estimates and Passage Timing

The trap captured 579 juvenile Chinook salmon and 246 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 therefore reported as such.

Peak capture of juvenile Chinook salmon exiting Big Cliff Dam Tailrace in the spring occurred in May and June (n= 160, 27.6% of total Chinook salmon) while peak capture in the fall occurred in October (n=99, 17.1%) (Figure 1). Peak capture for juvenile *O. mykiss* occurred in July (n=156, 63.4%) (Figure 3). There was also a passage event that occurred in June (n= 48, 19.5%) that coincided with surface spill operations at Big Cliff Dam Tailrace and Detroit Dam, which commenced at that time. (Figure 2).

Chinook salmon catch consisted of three BY classes: BY 2020, BY 2021, and BY 2022 (Figure 4). The first BY 2022 sub-yearling Chinook salmon was captured on January 31, 2023, significantly earlier in the spring than was observed in 2022, when the first fry was captured on April 29th. A total of 156 BY 2022 Chinook 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 Tailrace 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, through October 15, 2023, consisted of 256 individuals (44.2% 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 instead, will report size metrics on the two BYs together. There were two BY 2020 Chinook salmon captured in August at this site. Fork length and size for all BYs encountered at the Big Cliff Dam Tailrace RST site are summarized below in Table 5. Using TEs by flow category, we estimate that 8,759 (95% CI: 7,055 to 11,838) juvenile Chinook salmon passed the trapping site during the reporting period (Figure 2).

Peak capture of Chinook salmon at Big Cliff Dam Tailrace in the spring coincided with spill operations at Detroit Dam Tailrace and Big Cliff Dam Tailrace which occurred in January, late April, and May. EAS 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 2). 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 a table of adult Chinook out planting numbers above Detroit Reservoir from 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 Tailrace in the spring consisted of three BYs, BY 2021, BY 2022, and BY 2023 (Figure 4). The first BY 2023 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). Ten fish from BY 2022 were captured between February and June along with two BY 2021 *O. mykiss.*

Fall capture of *O. mykiss* consisted of 169 fish from BY 2021 and BY 2023. A single fish from BY 2021 was captured on July 5, 2023. BY 2023 comprised the majority of the *O. mykiss* catch in the fall with 168 individuals. Peak capture of BY 2023 *O. mykiss* occurred in July. Information on fork lengths and weights of each BY captured is provided in Table 5.

Table 5. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* at the Big Cliff Dam Tailrace RST site by brood year from January 1, 2023, through October 15, 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	7/1/2023–10/15/2023	20	2	217	199	235	N/A	105.3	89.6	120.9	N/A
Chinook	7/1/2023–10/15/2023	21 and 22	254	131.7	100	176	131	26.9	10.0	63.1	25.1
O. mykiss	1/1/2023–6/30/2023	21	3	297	274	335	282	185.2	134.1	254.4	167.0

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	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	7/1/2023–10/15/2023	21	1	295	295	295	N/A	226.5	226.5	226.5	N/A
O. mykiss	7/1/2023–10/15/2023	23	168	30.8	24	86	28	N/A	N/A	N/A	N/A

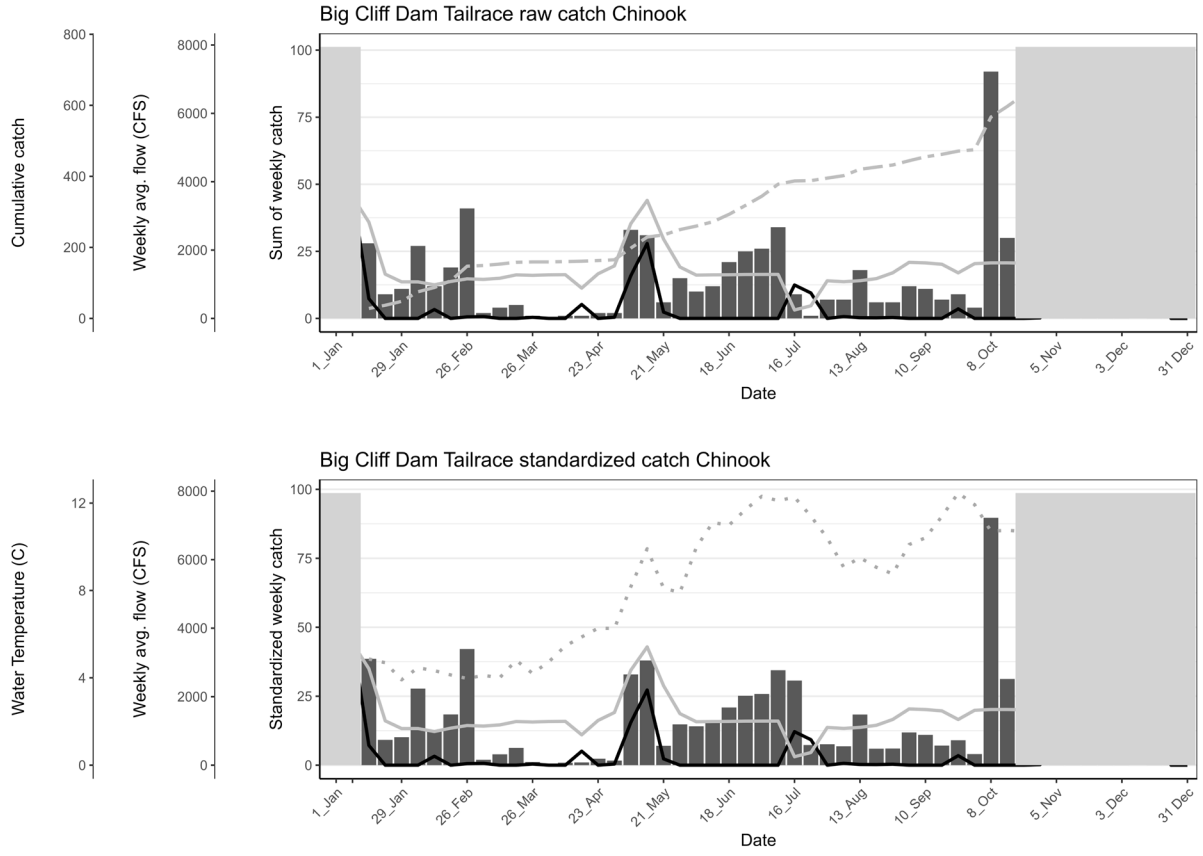

Figure 1. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at Big Cliff Dam Tailrace with spill (black line), Powerhouse flow (gray line), cumulative catch (gray dot dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, through October 15, 2023.

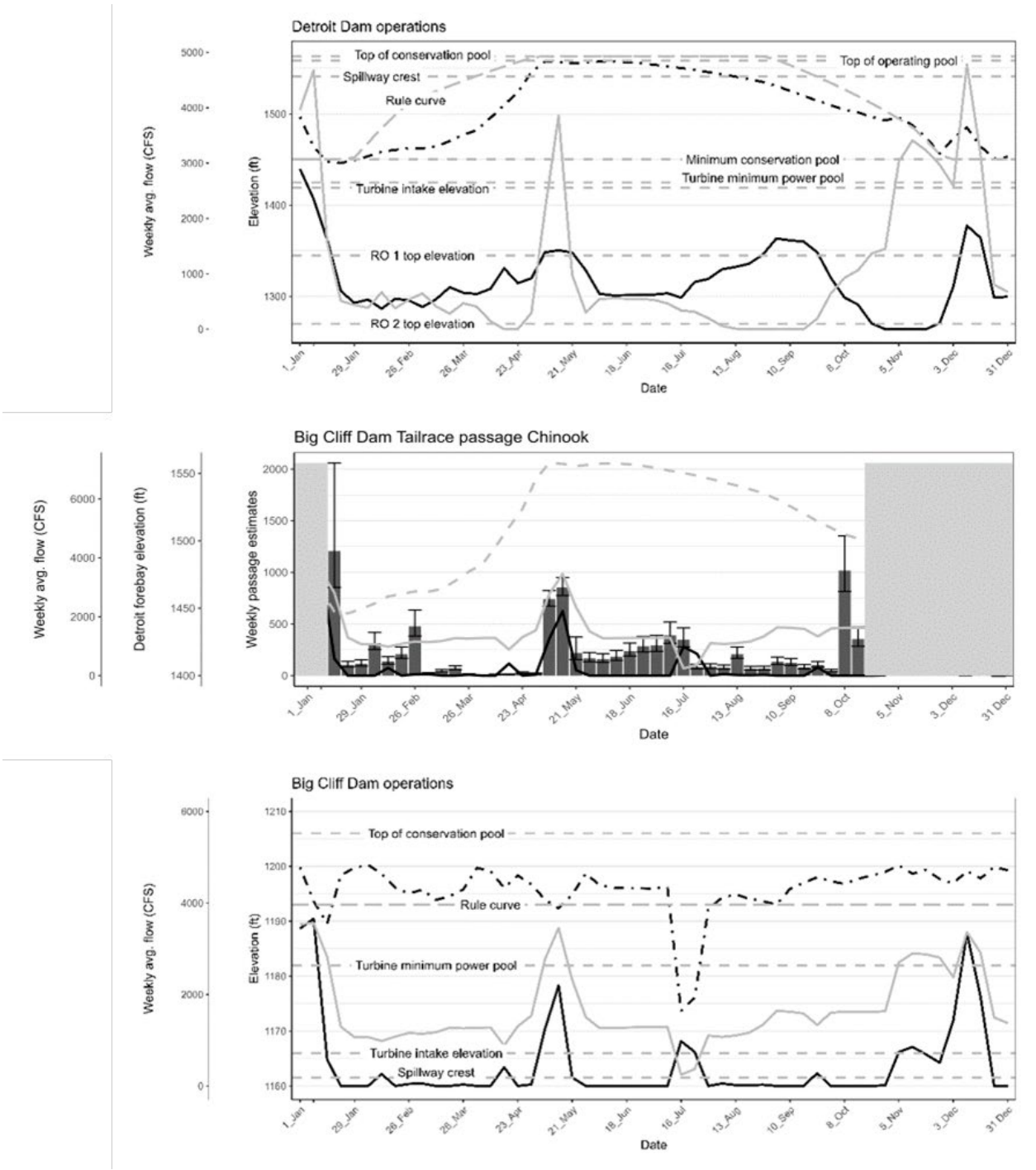

Figure 2. Detroit Dam (top panel) and Big Cliff Dam Tailrace (bottom panel) operations with rule curve (gray long dash line), forebay elevation (black dot dash line), spill/RO outflow (black line) and Powerhouse outflow (gray line). Passage estimates with 95% confidence for juvenile Chinook salmon at Big Cliff Dam Tailrace (middle panel) with spill at Big Cliff Dam Tailrace (black line), Powerhouse outflow from Big Cliff Dam Tailrace (gray line), Detroit Dam forebay elevation (gray dash line), and non-sampling weeks shaded out (gray) for January 1, 2023, to October 15, 2023.

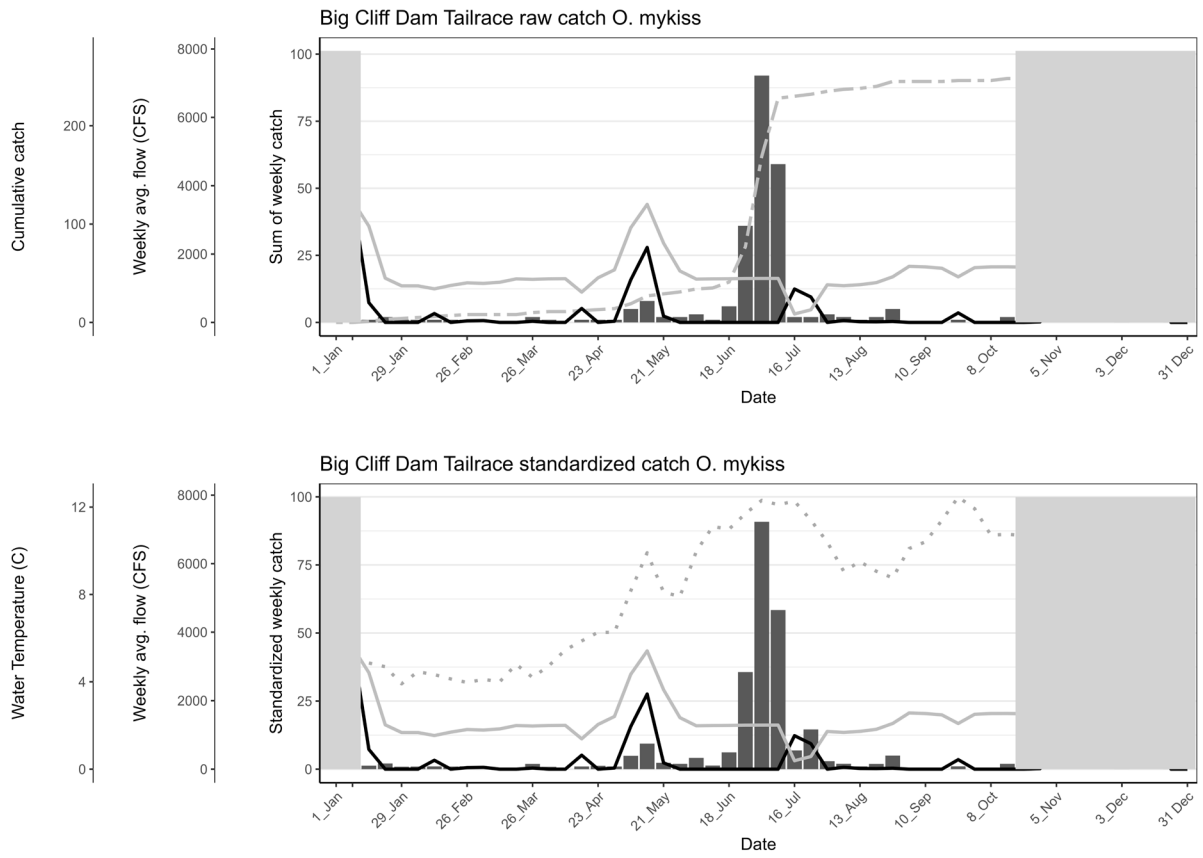

Figure 3. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile *O. mykiss* at Big Cliff Dam Tailrace with spill (black line), Powerhouse flow (gray line), cumulative catch (gray dot dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, through October 15, 2023.

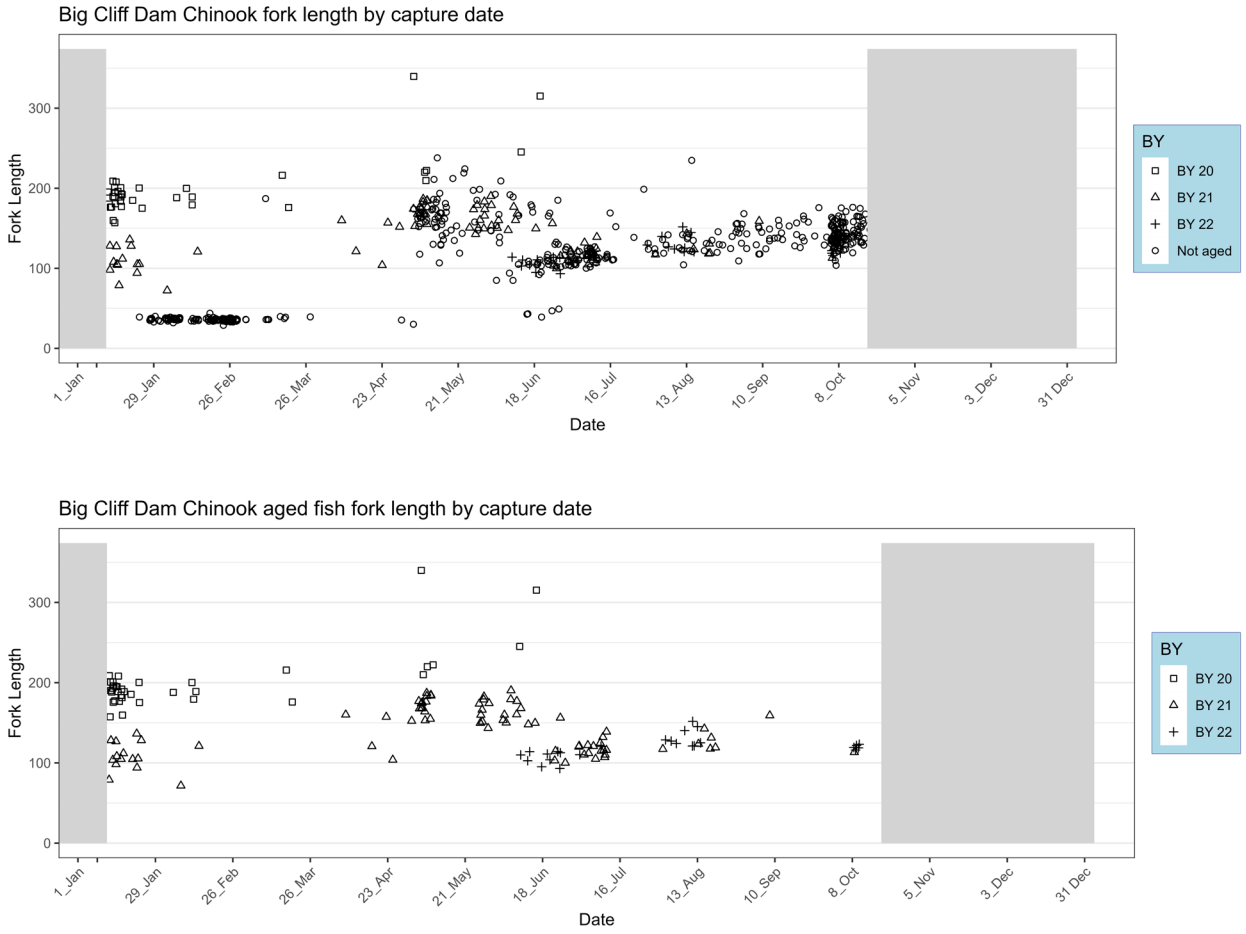

Figure 4. Length-frequency of juvenile Chinook salmon at the Big Cliff Dam Tailrace site from January 1, 2023, through October 15, 2023. Top panel shows all fish and bottom panel shows only the aged fish.

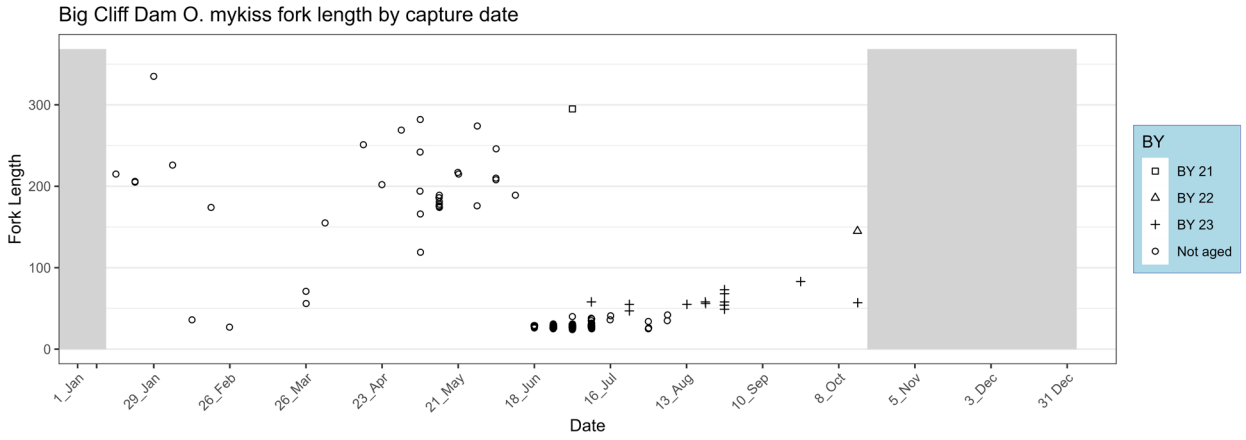

Figure 5. Length-frequency of juvenile *O. mykiss* at the Big Cliff Dam Tailrace site from January 1, 2023, through October 15, 2023.

Injury Data

A total of 467 juvenile Chinook salmon (80.7% of total Chinook salmon catch) and 46 juvenile *O. mykiss* (18.7% of total *O. mykiss* catch) displayed at least one of the injury code conditions, other than copepods, listed in Table 2. 40 Chinook salmon (6.9%) and ten *O. mykiss* (4.1%) 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 (Tables 6 and 7).

Injury was also collected for captured PIT tagged Chinook salmon that were associated with CFS bulk mark releases as well. However, the sample size for this group was relatively small (n=4) and likely not an accurate representation of injuries incurred by these fish during passage.

Additionally, EAS also observed 39 Chinook salmon (12.1% of total Chinook salmon catch) and 12 *O. mykiss* (15.6% of total *O. mykiss* catch) with 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 Tailrace (Figure 6). A total of 165 juvenile Chinook salmon and 23 juvenile *O. mykiss* were infected with copepods at time of capture (Figures 7 and 8). Copepod presence on captured Chinook salmon shows a positive correlation with the size of fish, similar to observations made by previous studies (CFS 2022; Monzyk et al. 2015) (Figure 7). This is likely a relationship 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 EAS also observed in *O. mykiss* captured at the Big Cliff Dam Tailrace site (Figure 8).

Findings from bulk marked and recaptured Chinook salmon illustrated a higher amount of descaling both greater than and less than 20% as compared to their TE released counterparts (Table 6). It is worth noting that while TE release injuries at the Big Cliff Dam Tailrace site were assessed using more than 500 Chinook salmon, the bulk marking recapture injuries were seen in only four individual Chinook salmon. Additional assessment and increased sample sizes will help 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 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 6. 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 Tailrace from January 1, 2023, through October 15, 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=500)	TE Recapture Injuries (proportion of total) (n=415)	Proportional Percent Change	Observed Chinook Injuries (n=516)	PIT Tagged Bulk Mark Release Recapture Injuries (proportion of total) (n=4)
NXI	44.2%	1.0%	-43.2%	19.4%	0.0%
MUNK	0.0%	0.0%	0.0%	0.2%	0.0%
DS<2	26.6%	92.5%	65.9%	56.4%	25.0%
DS>2	1.6%	3.1%	1.5%	20.7%	75.0%
BLO	0.0%	0.0%	0.0%	0.7%	0.0%

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=500)	TE Recapture Injuries (proportion of total) (n=415)	Proportional Percent Change	Observed Chinook Injuries (n=516)	PIT Tagged Bulk Mark Release Recapture Injuries (proportion of total) (n=4)
EYB	0.0%	0.0%	0.0%	6.8%	0.0%
BVT	0.0%	0.0%	0.0%	2.6%	0.0%
FVB	0.0%	0.0%	0.0%	5.2%	0.0%
GBD	0.0%	2.6%	2.6%	7.3%	0.0%
POP	0.0%	0.0%	0.0%	1.6%	0.0%
HIN	0.0%	0.2%	0.2%	5.2%	0.0%
OPD	0.6%	8.9%	8.3%	10.8%	25.0%
TEA	0.0%	0.5%	0.5%	4.2%	25.0%
BRU	0.0%	0.7%	0.7%	8.9%	0.0%
HBP	0.0%	0.0%	0.0%	0.9%	0.0%
HO	0.0%	0.0%	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%	0.5%	0.0%
HBO	0.0%	0.0%	0.0%	0.2%	0.0%
FID	44.4%	92.3%	47.9%	59.5%	75.0%
PRD	0.0%	0.0%	0.0%	0.5%	0.0%
COP	0.0%	0.0%	0.0%	66.7%	100.0%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.2%	0.7%	0.5%	2.1%	0.0%

Table 7. Count and percentages of *O. mykiss* displaying injury by type at Big Cliff Dam Tailrace RST site from January 1, 2023, to October 15, 2023.

Injury Code	*O. mykiss* Injuries (n=246)
NXI	81.3%
MUNK	0.0%
DS<2	8.1%
DS>2	4.9%
BLO	0.0%
EYB	2.0%
BVT	1.2%
FVB	3.7%
GBD	4.9%
POP	0.4%
HIN	2.8%
OPD	3.7%
TEA	1.6%
BRU	3.3%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.4%
FID	14.2%
PRD	0.4%
COP	9.8%
BKD	0.0%
FUN	0.4%

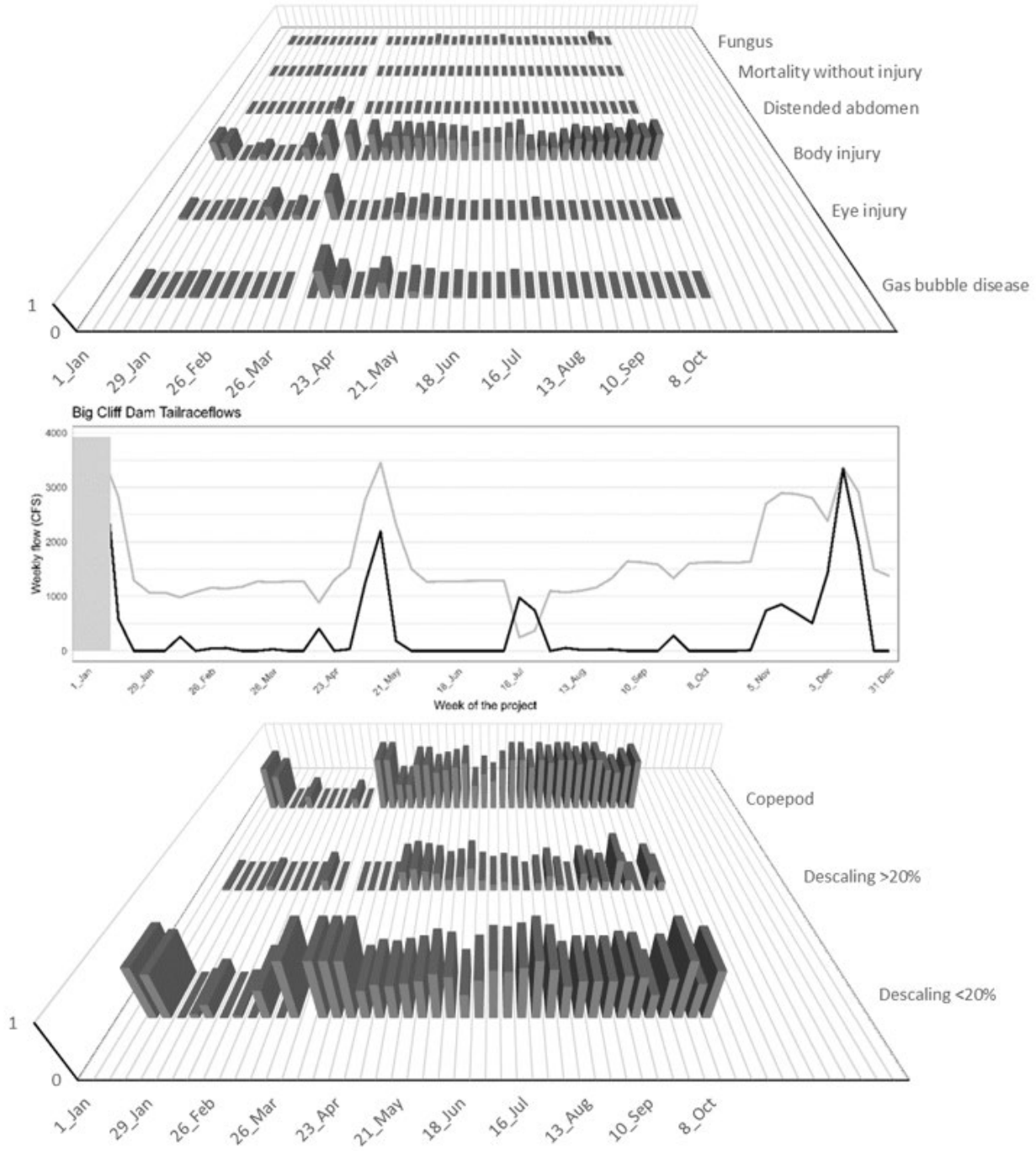

Figure 6. Injury rate of captured Chinook salmon below Big Cliff Dam Tailrace displaying proportion of fish with injuries by type (top panel) and descaling injuries and copepod presence (bottom panel). The middle panel shows spill (black line) and Powerhouse flow (gray line) at Big Cliff Dam Tailrace from January 1, 2023, through October 15, 2023.

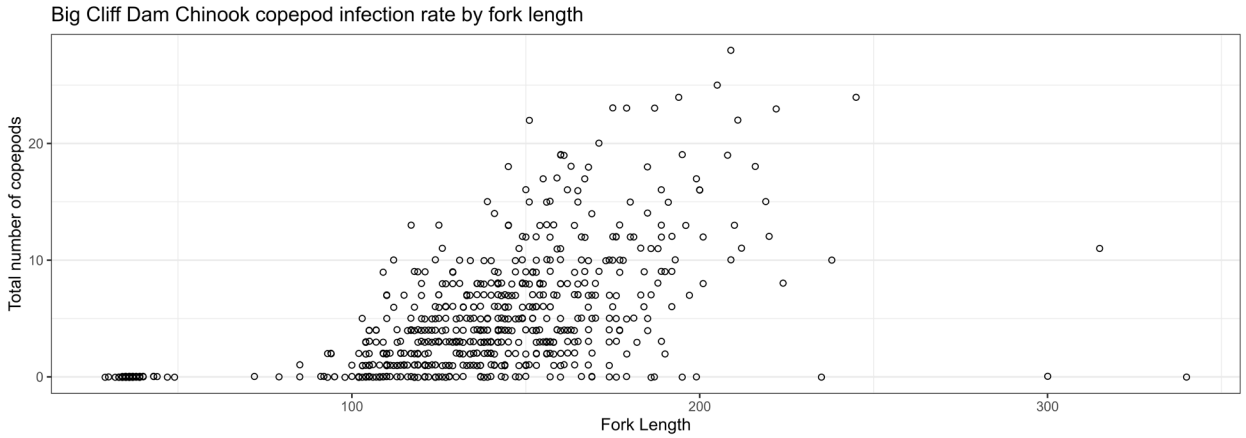

Figure 7. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon below Big Cliff Dam Tailrace from January 1, 2023, through October 15, 2023.

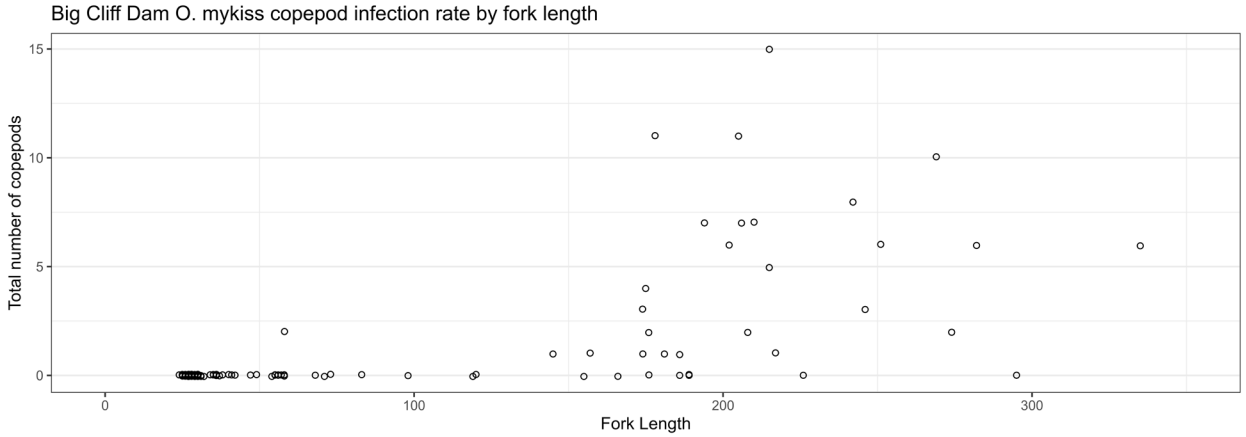

Figure 8. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile *O. mykiss* below Big Cliff Dam Tailrace from January 1, 2023, through October 15, 2023.

24-Hour Hold Trials

24-hour hold trials were performed on NOR 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 643 fish, 489 Chinook salmon and 154 *O. mykiss*, were held in 2023 (Table 8). A total of 57 fish died during hold (8.9%), 54 of the 489 Chinook salmon (11.0%) and 3 of the 154 *O. mykiss* (1.9%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100%.

Table 8. Summary of 24-hour hold trials for fish captured in the RST at the Big Cliff Dam Tailrace site from January 1, 2023, through October 15, 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%
2/1/2023–2/15/2023	Chinook	43	1	97.7%
2/1/2023–2/15/2023	O. mykiss	3	0	100%
2/16/2023–2/28/2023	Chinook	43	0	100%
2/16/2023–2/28/2023	O. mykiss	1	0	100%
3/1/2023–3/15/2023	Chinook	22	0	100%
3/1/2023–3/15/2023	O. mykiss	1	1	0%
3/16/2023–3/31/2023	Chinook	7	0	100%
3/16/2023–3/31/2023	O. mykiss	1	1	0%
4/1/2023–4/15/2023	Chinook	1	0	100%
4/1/2023–4/15/2023	O. mykiss	2	0	100%
4/16/2023–4/30/2023	Chinook	3	0	100%
4/16/2023–4/30/2023	O. mykiss	1	0	100%
5/1/2023–5/15/2023	Chinook	38	7	81.6%
5/1/2023–5/15/2023	O. mykiss	7	0	100%
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%
6/16/2023–6/30/2023	Chinook	49	1	98.0%
6/16/2023–6/30/2023	O. mykiss	37	0	100%
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%
10/1/2023–10/15/2023	Chinook	67	19	71.6%
10/1/2023–10/15/2023	O. mykiss	0	0	--

PIT Tagged fish and Downstream Detections

A total of 53 fish were PIT tagged at the Big Cliff Dam Tailrace site in 2023, 50 juvenile Chinook salmon and three juvenile *O. mykiss*. The first 60 Chinook salmon and *O. mykiss* 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 the reporting period. 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. The RST below Big Cliff Dam captured 4 adipose clipped and PIT tagged Chinook salmon from these releases in October. For more information regarding release groups, dates, and other redetections, please refer to *Cramer Fish Science's Bulk Mark Release and Reservoir Distribution Study Annual Report* and *Rotary Screw Trap Monitoring Report*.

Non-Target Capture Data

We captured 319 non-target fish in addition to natural origin juvenile Chinook salmon and *O. mykiss* (Table 9). The most common non-targets captured were kokanee and pumpkinseed.

Table 9. Summary of non-target species captured at the Big Cliff Dam RST site January 1, 2023, through October 15, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	43	9
Brown Bullhead	6	2
Chinook (adult)	1	1
Kokanee	200	39
Kokanee (adipose clipped)	11	3
O. mykiss (adipose clipped)	6	2
Pumpkinseed	43	10
Unknown	1	1
Mountain Whitefish	6	1
Crappie	1	0
Dace	1	0
Totals	319	68

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

Green Peter Dam Tailrace – Middle Santiam River

EAS began monitoring a single 8-foot RST in the Green Peter Dam Tailrace on March 14, 2023, and continued sampling to November 30, 2023. Sampling from December 1, 2023, through the end of the year occurred under contract W9127N19D0009 and the data from this work is presented in the associated report (CFS 2024a). 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. The trap was raised to the non-sampling position from March 23, 2023, through 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. Additionally, in calendar years 2022 and 2023, 800 adult Chinook salmon were released in tributaries above Green Peter Reservoir to spawn, 200 in Quartzville Creek, and 600 in the Middle Santiam River (CFS 2023b).

Trapping Efficiency Trials

A total of 14 TE trials occurred using hatchery reared Chinook salmon in the Green Peter Dam Tailrace for this contract in 2023. A total of 17 trials have occurred at this site since sampling initiated in 2022. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 10.

TEs for live fish releases ranged from 0.0% to 2.8%. Trap efficiency used to calculate passage was 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 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 and cone flux for all trials are provided in Appendix E.

Table 10. Summary table of marked hatchery Chinook salmon releases in the Green Peter Dam Tailrace for trapping efficiency from January 1, 2023, through November 30, 2023.

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*	5/11/2023	1,910	1,001*	0	0%
Green Peter Dam Tailrace – Spill	5/11/2023	1,910	999	9	0.9%
Green Peter Dam Tailrace – Powerhouse	5/25/2023	1,980	1,000	10	1.0%
Green Peter Dam Tailrace – Powerhouse*	6/30/2023	2190	1,000*	9	0.9%
Green Peter Dam Tailrace – Powerhouse	6/30/2023	2190	1,000	10	1.0%
Green Peter Dam Tailrace – Powerhouse	7/27/2023	50	1,009	13	1.3%
Green Peter Dam Tailrace – Powerhouse	8/16/2023	50	1,008	7	0.7%
Green Peter Dam Tailrace – Powerhouse	8/31/2023	1970	1,000	8	0.8%
Green Peter Dam Tailrace – Powerhouse	10/4/2023	2930	1,005	0	0.0%
Green Peter Dam Regulating Outlet	11/1/2023	1800	1000	22	2.2%
Green Peter Dam Regulating Outlet	11/14/2023	1300	1,000	7	0.7%
Green Peter Dam Regulating Outlet	11/29/2023	630	1,000	28	2.8%
Green Peter Dam Regulating Outlet	11/29/2023	630	3,999	11	0.3%

*indicates dead fish release

Run of River Trapping Efficiency Trials

No TE trials using run of river 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 and are not tagged. Thus, sufficient numbers of ROR fish were not available to perform run of river 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. *O. mykiss* captured at this location are likely progeny of resident trout as winter steelhead have not been transported above Green Peter Dam in recent years. However, all 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 9). Peak capture of juvenile *O. mykiss* also occurred in May (n=8, 66.6% of total *O. mykiss* catch) (Figure 10). Chinook salmon catch was composed entirely of BY 2022 sub-yearlings (Figure 11). The *O. mykiss* captured consisted of two-year olds (n=5, 41.7%), one-year olds (n=6, 50.0%), and a sub-yearling (n=1, 8.3%) fish (Figure 12). Descriptive statistics on fork length and size of fish captured at Green Peter Dam by BY is provided below in Table 11.

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 feet of elevation and again once the drawdown had reached its lowest elevation in November (Figure 9 and Figure 10). During this time, the water in the tailrace of Green Peter Dam became increasingly turbid and kokanee dominated the catch (see Appendix J, Fig. 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. We 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 9).

Table 11. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* 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

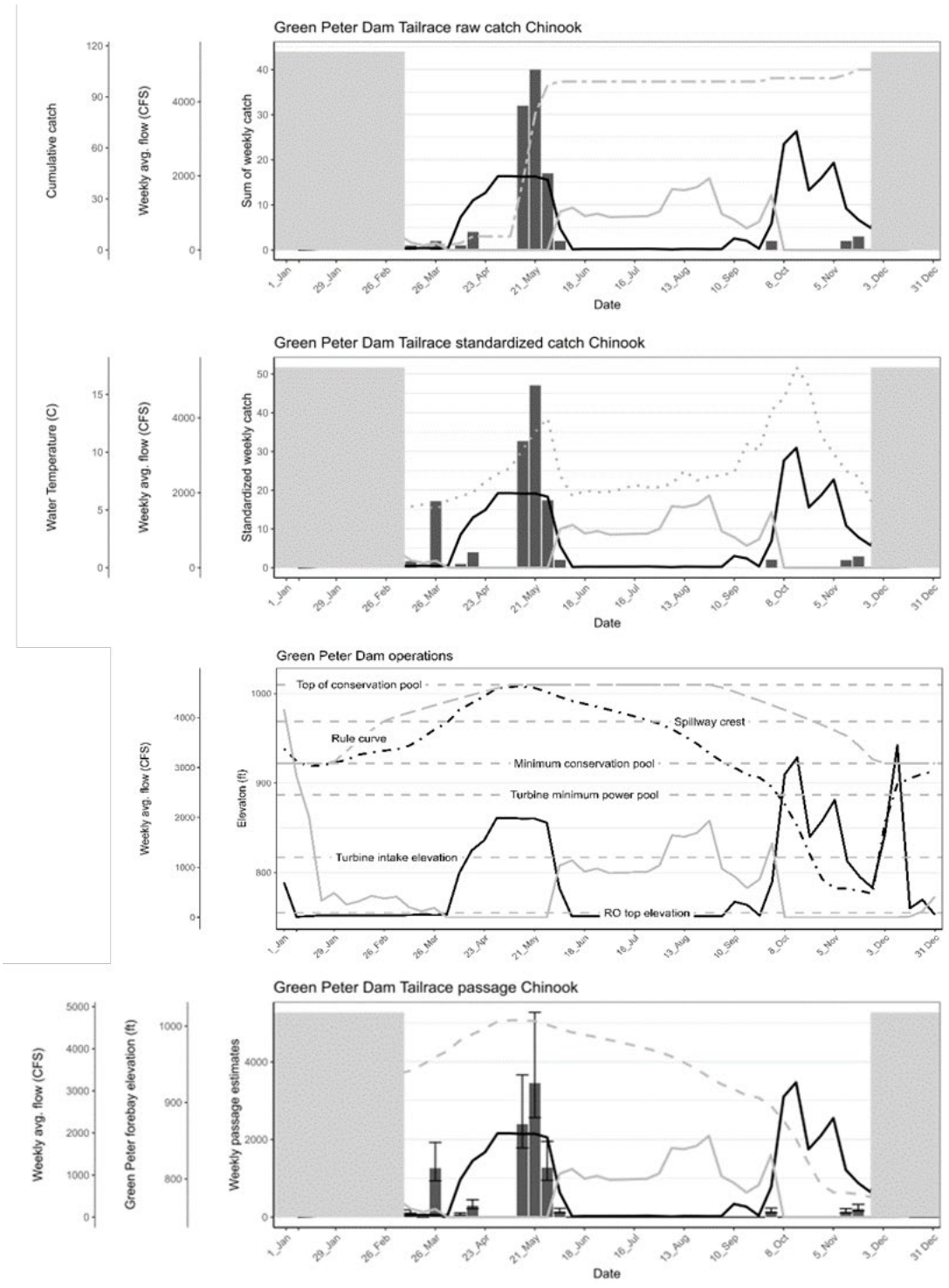

Figure 9. Raw catch (top panel), weekly standardized catch (second panel), and weekly passage estimates (bottom panel) of natural origin juvenile Chinook salmon at Green Peter Dam Tailrace with spill (black line), Powerhouse flow (gray line), cumulative catch (gray two dash line) stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for January 1, 2023, through November 30, 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.

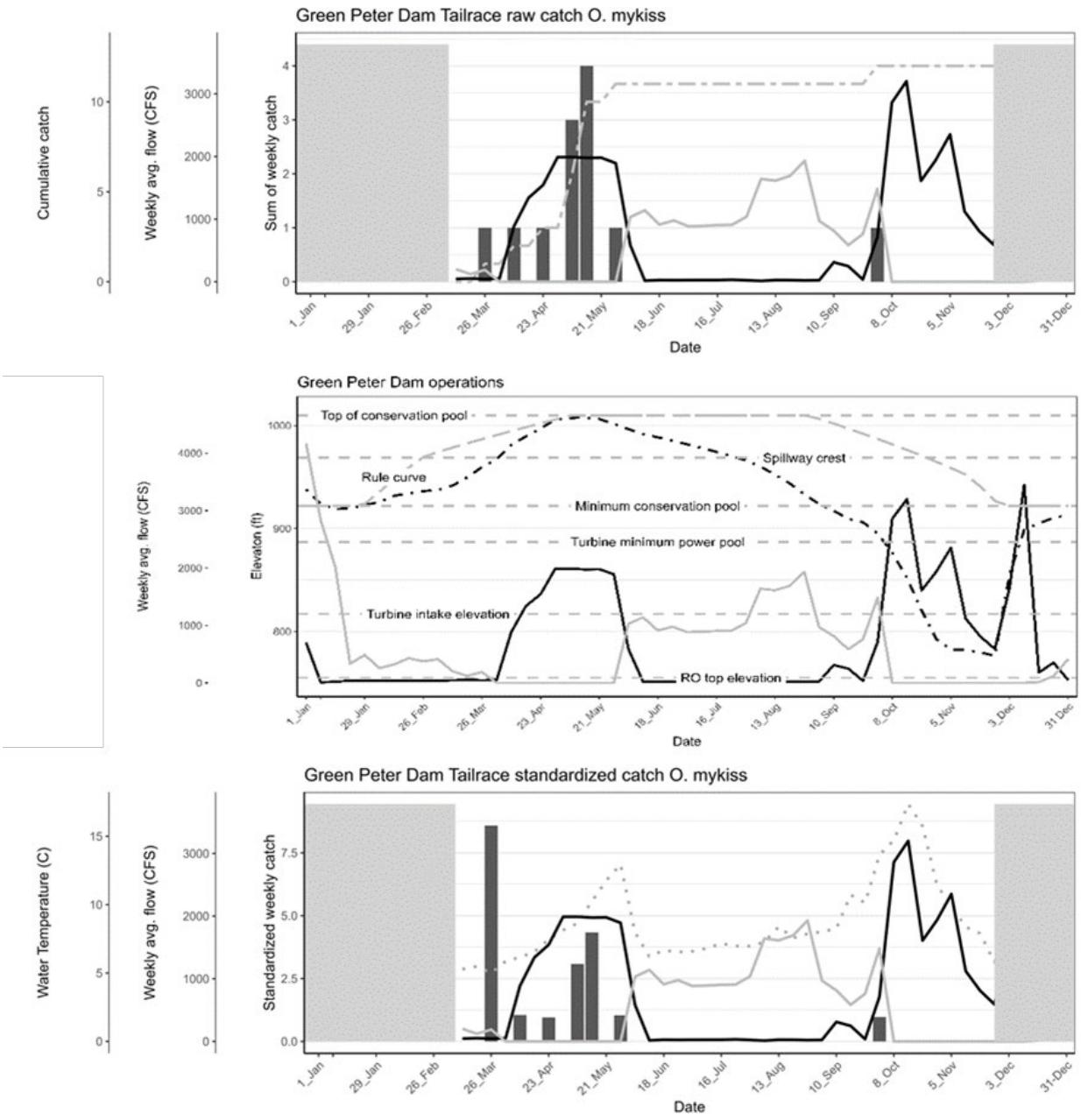

Figure 10. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile *O. mykiss* at Green Peter Dam Tailrace with spill (black line) and Powerhouse flow (gray line), cumulative catch (gray two dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, through November 30, 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.

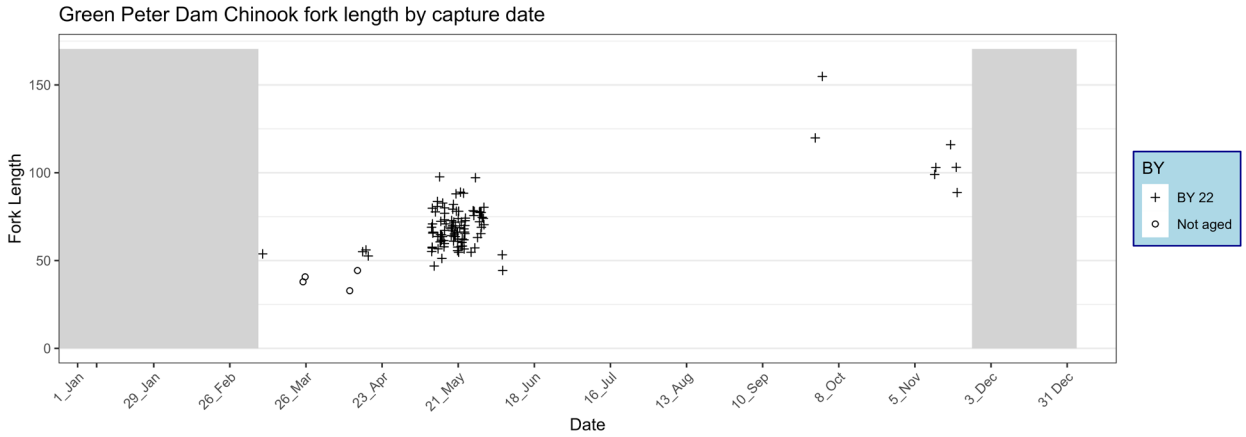

Figure 11. Age length-frequency for captured natural origin Chinook salmon at the Green Peter Dam Tailrace site for March 14, 2023, through November 30, 2023.

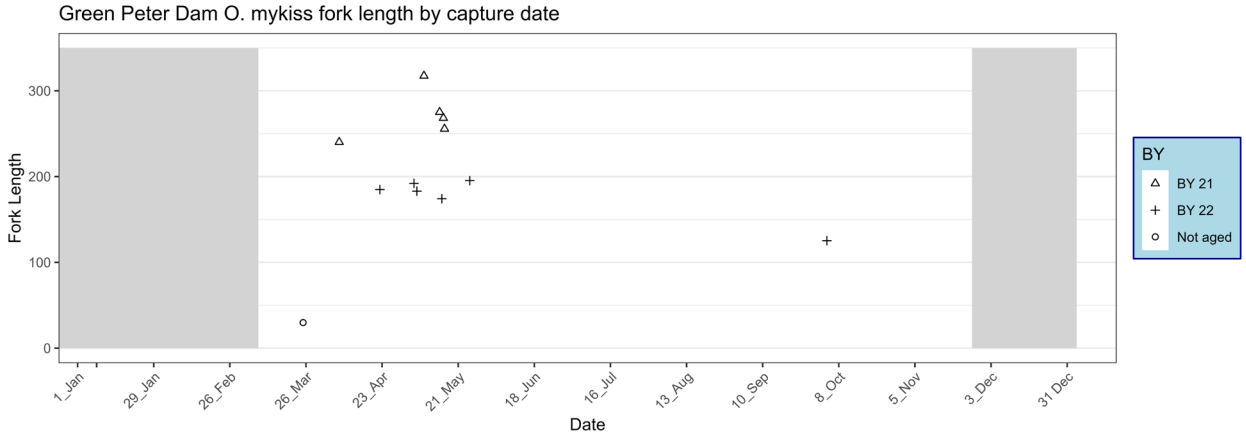

Figure 12. Age length-frequency for captured natural origin *O. mykiss* at the Green Peter Dam Tailrace site for March 14, 2023, through November 30, 2023.

Injury Data

A total of 99 juvenile Chinook salmon (93.4%) 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 and fin damage were observed at higher rates, in addition to gas bubble disease, operculum damage, and bruising (Table 12). 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 12).

The most common injuries observed on NOR juvenile Chinook salmon and *O. mykiss* at this site include descaling, fin damage and gas bubble disease (Table 12 and Figure 13). Figures 14 and 15 illustrate that there is no discernable relationship between overall size of Chinook salmon and *O. mykiss* and the presence of copepods.

Figure 13 illustrates that increases in the proportion of fish displaying injury often coincided with spill operations at Green Peter Dam Tailrace. Increases in flow from the spill at Green Peter Dam Tailrace affects overall bodily injury and gas bubble disease (Figure 13). Furthermore, it is evidenced that as spill at Green Peter Dam Tailrace increases, so does descaling less than 20% in juvenile Chinook salmon (Figure 13). 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.

Observations in relation to injury and flow, predominantly from the spill, are based off 106 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 Chinook salmon (19.6%) and six *O. mykiss* (50.0%) were dead at the time of trap check. A summary of injury type by species is included in Table 12. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 12. Summary of injuries for natural origin Chinook salmon, natural origin *O. mykiss,* and PIT tagged bulk mark release Chinook salmon at Green Peter Dam from 2023.

Injury Code	Chinook Injuries (NOR) (n=106)	*O. mykiss* Injuries (NOR) (n=12)	Chinook Injuries (PIT tagged bulk mark release recaptures) (n=32)
NXI	30.7%	1.4%	-29.3%
MUNK	0.0%	0.0%	0.0%
DS<2	49.1%	68.0%	19.0%
DS>2	3.2%	16.3%	13.2%
BLO	0.0%	0.0%	0.0%
EYB	0.0%	0.7%	0.7%
BVT	0.0%	0.7%	0.7%
FVB	0.0%	2.7%	2.7%
GBD	0.0%	17.7%	17.7%
POP	0.0%	0.0%	0.0%
HIN	0.0%	2.0%	2.0%
OPD	0.6%	11.6%	11.0%
TEA	0.0%	0.0%	0.0%
BRU	0.2%	4.8%	4.5%
HBP	0.1%	0.0%	-0.1%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	36.6%	92.5%	55.9%
PRD	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%
BKD	0.0%	0.0%	0.0%
FUN	0.1%	0.7%	0.6%

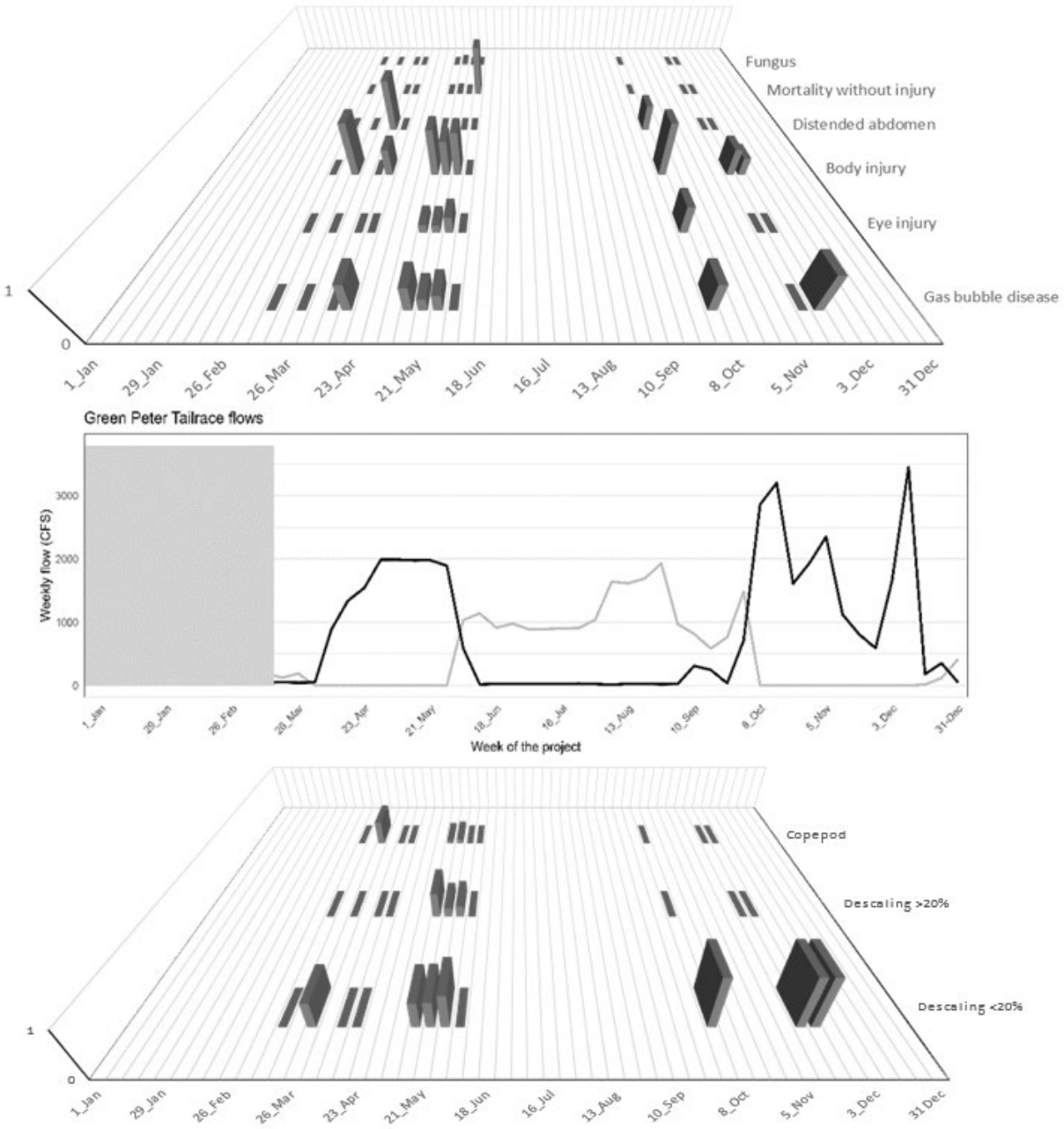

Figure 13. Injury rate of captured Chinook salmon below Green Peter Dam displaying proportion of fish with injuries by type (top panel) and descaling injuries and copepod presence (bottom panel). The middle panel shows spill (black line) and Powerhouse flow (gray line) at Green Peter Dam from 2023.

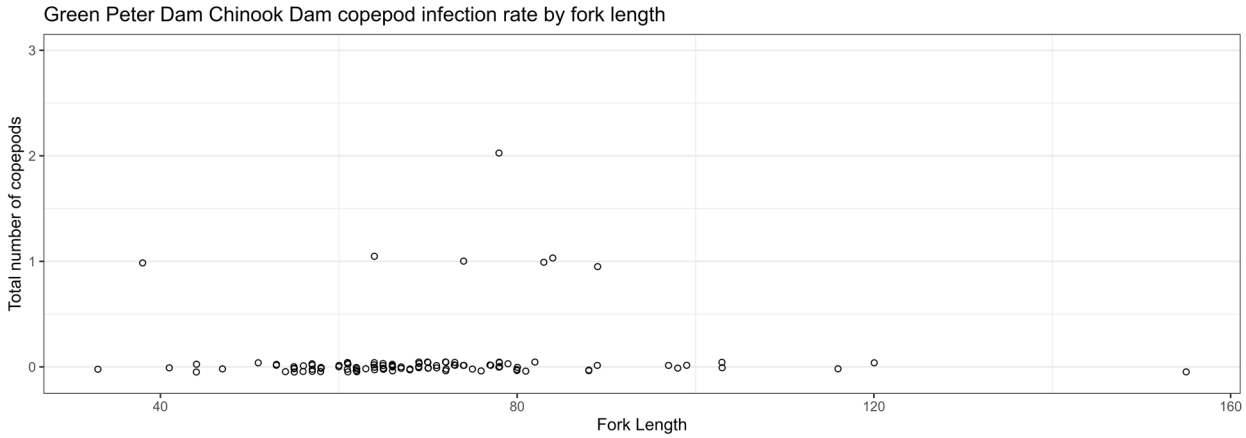

Figure 14. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon below Green Peter Dam from March 14, 2023, through November 30, 2023.

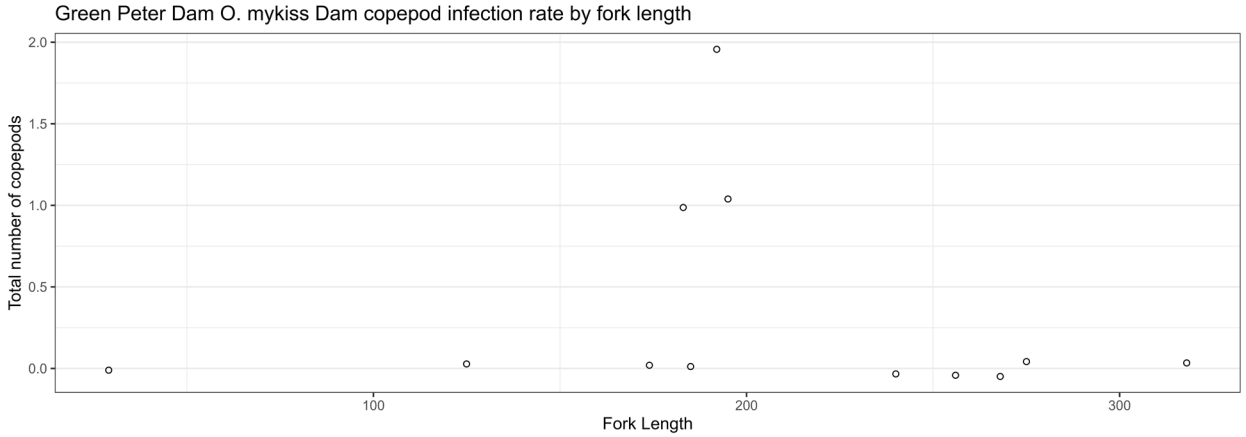

Figure 15. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile *O. mykiss* below Green Peter Dam from March 14, 2023, through November 30, 2023.

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 88 fish, 82 Chinook salmon and 6 *O. mykiss*, were held in 2023 (Table 13). A total of 47 fish died during hold (53.4%), 45 of the 82 Chinook salmon (54.9%) and 2 of the 6 *O. mykiss* (33.3%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100.0%.

Table 13. Summary of 24-hour hold trials for fish captured in the RST at the Green Peter Dam Tailrace site March 14, 2023, through November 30, 2023.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
3/16/2023–3/31/2023	Chinook	1	0	100%
4/1/2023–4/15/2023	Chinook	2	1	50%
4/1/2023–4/15/2023	O. mykiss	2	2	0%
4/16/2023–4/30/2023	Chinook	4	0	100%
4/16/2023–4/30/2023	O. mykiss	1	0	100%
5/1/2023–5/15/2023	O. mykiss	1	0	100%
5/16/2023–5/31/2023	Chinook	71	43	39.4%
5/16/2023–5/31/2023	O. mykiss	2	0	100%
6/1/2023–6/15/2023	Chinook	2	0	100%
10/1/2023–10/15/2023	Chinook	2	1	50.0%

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 RST sampling through December 31, 2023, release groups, dates, and other redetections, please refer to *Cramer Fish Science's Bulk Mark Release and Reservoir Distribution Study Annual Report* and *Rotary Screw Trap Annual Report* (CFS 2024).

Non-Target Capture Data

27,486 non-target fish were captured in addition to natural origin juvenile *O. mykiss* in the Green Peter Dam Tailrace RST in 2023 (Table 14). The most common species captured were bluegill and kokanee.

Table 14. Summary of non-target fish capture at the Green Peter Dam Tailrace RST.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	1,468	251
Crappie	903	250
Dace	3	1
Kokanee	24,906	13,347
Kokanee (adipose clipped)	15	6
Largemouth Bass	1	0
O. mykiss (adult)	6	1
O. mykiss (adipose clipped)	31	7
Sculpin	5	1
Smallmouth Bass	32	10
Largescale Sucker	2	1
Unknown Bass	89	84
Brown Bullhead	18	1
Mountain Whitefish	1	1
Northern Pikeminnow	4	0
Spotted Bass	2	2
Totals	27,486	13,963

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

Foster Dam Head of Reservoir – South Santiam River

A single 5-foot RST was deployed in the South Santiam River above Foster Reservoir on February 1, 2023, and sampled through November 30, 2023, when it was removed for the remainder of the year. Sampling outages that resulted from high flows and debris are listed in Appendix B.

Trapping Efficiency Trials

A total of 12 TE trials occurred using hatchery reared Chinook salmon in the South Santiam River above Foster Reservoir in 2023. A total of 18 TEs have been performed by EAS with hatchery fish at this site since sampling initiated in 2022. A summary of fish release numbers, recaptures, and flow level for each trial conducted in 2023 is provided in Table 15.

TEs ranged from 0.0% to 10.2%. Trap efficiency used to calculate passage was the pooled average of 11 trials,/ 6.0% with 95% CI of 2.83%. Of note, one trial failed to yield any recaptures, and another saw a delayed capture event suggesting that during low flow in the late spring, hatchery fish may hold at the release site instead of migrating downstream past the trap. It is also important to note that late spring/summer flows often result in the trap rotating slowly, allowing fish to easily avoid capture. As described in the methods section, it is assumed that fish migrate past the trap within one week of release. In low flow conditions, fish may hold in deep pools instead of actively migrating, resulting in failed TE trials. Plots displaying trap efficiency in relation to flow and cone flux are provided in Appendix E.

Table 15. Summary table of marked hatchery Chinook salmon releases at the Foster Dam Head of Reservoir site for trapping efficiency for January 1, 2023, through November 30, 2023.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Foster Dam Head of Reservoir	2/27/2023	376	1,002	21	2.1%
Foster Dam Head of Reservoir	3/9/2023	313	995	62	6.2%
Foster Dam Head of Reservoir	3/15/2023	966	1,025	0	0%
Foster Dam Head of Reservoir	5/11/2023	1,130	985	20	2.0%
Foster Dam Head of Reservoir	6/2/2023	313	1,003	79[a]	7.9%
Foster Dam Head of Reservoir	6/29/2023	93	1,000	22	2.2%
Foster Dam Head of Reservoir	7/27/2023	49	989	0	0.0%
Foster Dam Head of Reservoir	8/31/2023	35	1,000	0	0.0%
Foster Dam Head of Reservoir	9/26/2023	50	1,000	6	0.6%
Foster Dam Head of Reservoir	10/10/2023	52	1,016	55	5.4%
Foster Dam Head of Reservoir	11/14/2023	431	1,000	102	10.2%
Foster Dam Head of Reservoir	11/22/2023	321	1,001	79	7.9%

[a] *Denotes that most recaptures occurred outside of the one-week period following fish release.*

Run of River Trapping Efficiency Trials

A total of 138 Chinook salmon and 65 *O. mykiss* were released upstream for run of river TE trials in 2023. A total of two fish were recaptured in the 5-foot RST, one Chinook salmon and one *O. mykiss*. ROR trials with larger groups of fish and more recaptures are necessary in order to provide meaningful insight on ROR capture efficiencies. Additional trials will be performed in the future to provide additional data for this purpose. A summary of run of river TE trials by month is provided in Table 16.

Table 16. Summary table of run of river releases at the Foster Dam Head of Reservoir site for trapping efficiency for 2023.

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

Target Catch, Passage Estimates and Passage Timing

A total of 609 juvenile Chinook salmon and 124 juvenile *O. mykiss* were captured in 2023. Peak capture of juvenile Chinook salmon entering Foster Reservoir in the spring occurred during February and March (n=473, 77.7% of total Chinook salmon catch) (Figure 16). BY 2021 yearling (n=21, 3.6% of total Chinook salmon catch in the spring) and BY 2022 sub-yearling (n=555, 96.4% of total Chinook salmon catch in the spring) Chinook salmon were captured at the trap during the spring monitoring period (Figure 18). Spring passage timing of yearling Chinook salmon was similar to previous studies occurring during March and April with peak capture occurring in March (n=14, 66.7%) (Romer et al. 2015). BY 2022 fish passed the trap throughout the monitoring period with peak capture occurring in February and March (n=457, 82.3%). The first BY 2022 Chinook salmon sub-yearling was captured on February 2, 2023. Previous studies by Romer (2015) captured the most sub-yearling Chinook salmon in January and February. They also noted that fry emergence in the South Santiam above Foster Reservoir in 2015 was earlier than other basins and that the fish they captured late in the spring were significantly larger than their counterparts in other areas. Past observations combined with our fry capture on the first day of sampling suggest that we missed Chinook salmon fry passing through the trap site prior to the initiation of sampling. For raw weekly Chinook capture at the Foster Dam Head of Reservoir – South Santiam RST site for sampling from 2022 and 2023, please refer to Appendix I.

A total of 33 juvenile Chinook salmon were captured in the fall with fish being captured from October 11, 2023, through November 29, 2023. All Chinook salmon captured during this time were BY 2022 sub-yearlings (Figure 18). Chinook salmon catch in the fall coincided with increases in flow similar to observations from previous sampling efforts.

Using trapping efficiencies pooled averages, we estimate that 13,650 (95% CI: 9,295 to 25,685) juvenile Chinook salmon passed the trapping site in 2023 (Figure 16). However, given the small sample size (n=11) 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* in the spring monitoring period occurred in May (n=17, 13.7% of total *O. mykiss* catch), while peak capture in the fall monitoring period occurred in October (n=80, 64.5% of total *O. mykiss* catch) (Figure 17). *O. mykiss* catch in the spring was composed of three BYs, BY 2021 (n=10, 26.3% of total spring *O. mykiss* catch), BY 2022 (n=21, 55.3%), and BY 2023 (n=7, 18.4%) (Figure 19). BY 2021 fish were captured March through June and BY 2022 fish were captured April through June. BY 2023 *O. mykiss* were captured February through May with the first fish caught on February 14, 2023. This timing is considerably earlier than previous studies observed in the basin (Romer et al. 2010–2016). Sub-yearling fry capture during the spring period could potentially be progeny of a reservoir stock of rainbow trout or that of cutthroat trout. Due to the size of collected fry, crews were unable to distinguish between these possibilities and thus treated all captured trout fry as potential winter steelhead. Passage timing and size of age 1- and 2-year-old *O. mykiss* closely resemble observations from catch in this basin in previous studies (Romer et al. 2012–2015).

Fall capture of *O. mykiss* primarily occurred in October and November when 83 fish were captured (96.5% of total capture for the period) and was composed of individuals from BY 2022 (n=56, 65.2% of fall *O. mykiss* capture) and BY 2023 (n=30, 34.8%) (Figures 17 and 19). Information regarding length and weight for each BY is summarized in Table 17. Similar to observations from RST sampling in 2022, fall passage of *O. mykiss* coincided with increases in flow. *O. mykiss* capture in recent years is much lower than catch from previous efforts from 2010 through 2015 (Romer et al. 2016, Table 2). This is likely related to the total number of adults out planted above Foster Reservoir.

Table 17. Summary of fork length and weight observed on juvenile Chinook salmon and *O. mykiss* at the Foster Dam Head of Reservoir RST site by brood year from January 1, 2023, through November 30, 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	21	108.6	93	134	109	14.9	8.0	24.3	15.0
Chinook	2/1/23-6/30/23	22	555	37.8	30	95	36	N/A	N/A	N/A	N/A
Chinook	7/1/23-11/30/23	22	33	105.3	63	123	107	12.8	3.7	20.3	12.7
O. mykiss	2/1/23-6/30/23	21	10	172.6	139	199	176.5	49.6	29.2	91.0	44.5
O. mykiss	2/1/23-6/30/23	22	21	107.8	84	138	104	16.9	8.5	33.1	13.8
O. mykiss	2/1/23-6/30/23	23	7	35.4	29	51	35	N/A	N/A	N/A	N/A
O. mykiss	7/1/23-11/30/23	22	56	142.9	115	158	143	29.8	15.6	48.5	28.9
O. mykiss	7/1/23-11/30/23	23	30	76.6	22	104	83	7.9	1.4	28.0	6.7

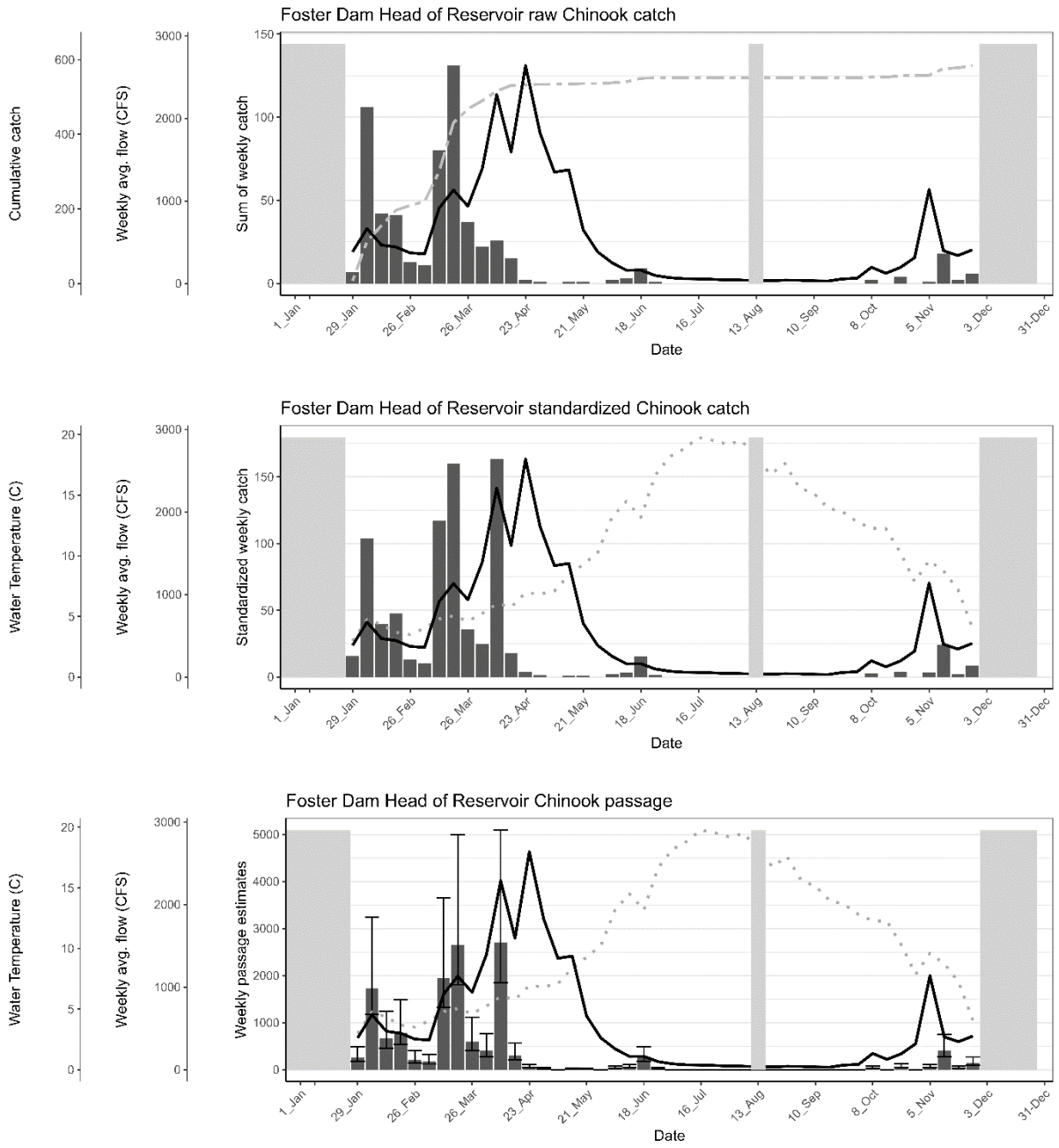

Figure 16. Raw catch (top panel), standardized catch (middle panel), and weekly passage estimates (bottom panel) overlayed with flow (black line), cumulative catch (gray dot dash line), stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for juvenile Chinook salmon at the Foster Dam Head of Reservoir site for 2023.

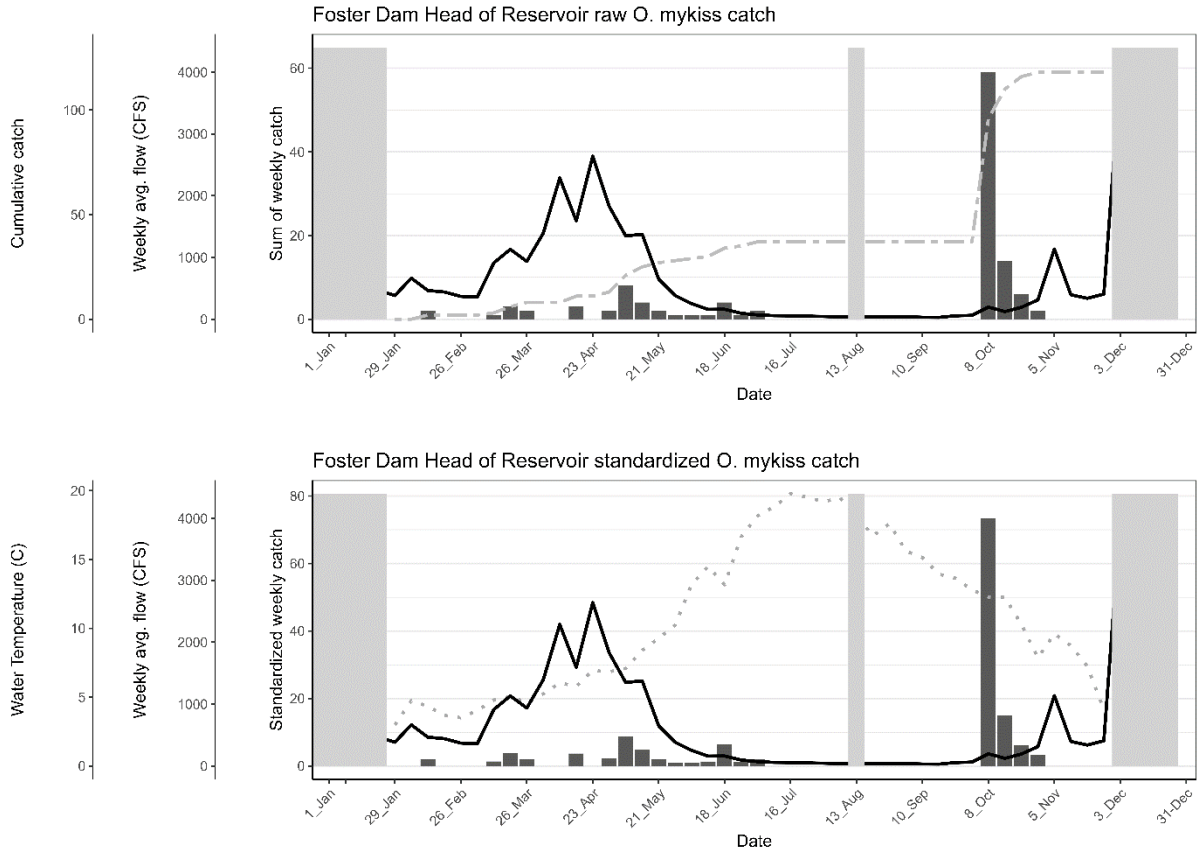

Figure 17. Shows raw (top panel) and weekly standardized (bottom panel) catch of juvenile *O. mykiss* overlayed with stream flow (black line), cumulative catch (gray two dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, November 30, 2023.

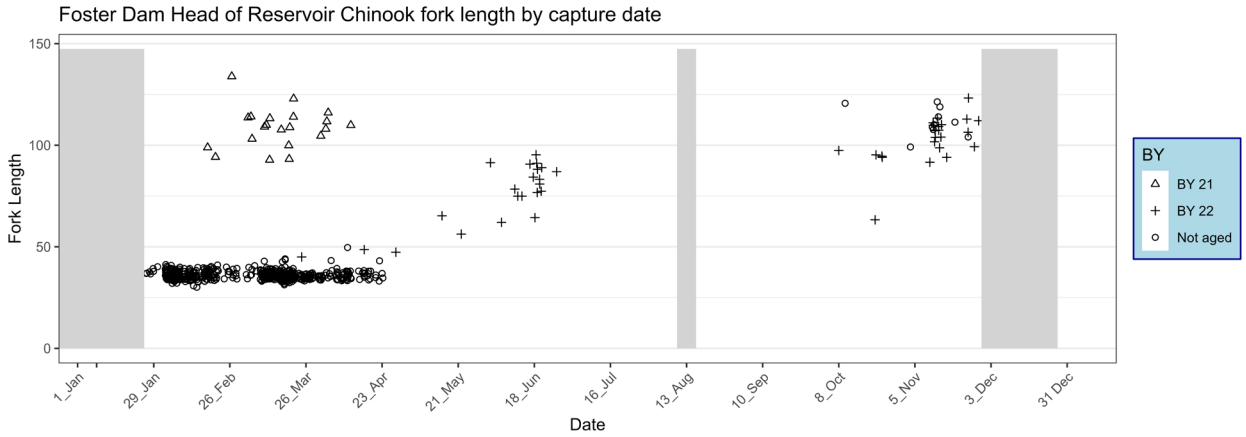

Figure 18. Length-frequency analysis for juvenile Chinook salmon at the Foster Dam Head of Reservoir site for 2023.

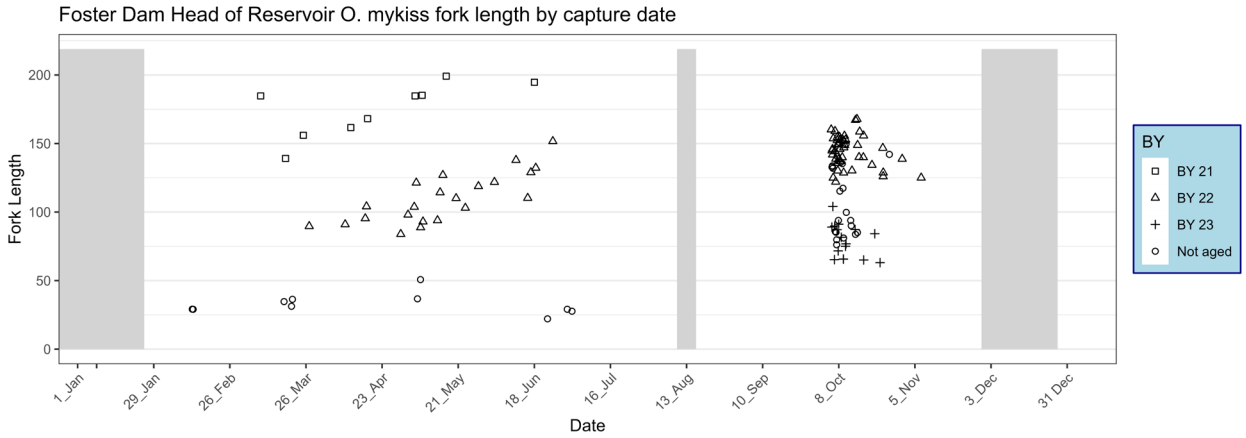

Figure 19. Shows length-frequency analysis by brood year for juvenile *O. mykiss* at the Foster Dam Head of Reservoir site for 2023.

Injury Data

A total of 89 juvenile Chinook salmon (14.6% of total Chinook salmon catch) and 90 juvenile *O. mykiss* (72.6% of total *O. mykiss* 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% and fin damage. These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. Furthermore, 19 Chinook salmon (3.2%) and 2 *O. mykiss* (1.6%) were dead at the time of trap check.

Additionally, *O. mykiss* at the site were evidenced to exhibit a higher proportion of injuries as compared to juvenile Chinook salmon (Table 18). The O. mykiss encountered at Foster Dam Head of Reservoir were found to have a higher copepod infection rate than their Chinook salmon counterparts (Figures 20 and 21). Table 18 provides a summary of injuries observed on Chinook salmon and *O. mykiss* at the Foster Dam Head of Reservoir site.

Table 18. Summary of injuries observed on juvenile Chinook salmon and *O. mykiss* at the Foster Dam Head of Reservoir RST site January 1, 2023, through November 30, 2023.

Injury Code	Chinook Injuries (NOR) (n=89)	*O. mykiss* Injuries (NOR) (n=90)
NXI	85.4%	27.4%
MUNK	0.0%	0.0%
DS<2	9.7%	60.5%
DS>2	1.0%	0.0%
BLO	0.0%	0.0%
EYB	0.3%	1.6%
BVT	0.7%	0.0%
FVB	0.3%	0.0%
GBD	0.0%	0.0%
POP	1.0%	0.8%
HIN	2.6%	2.4%
OPD	0.8%	0.8%
TEA	2.0%	0.8%
BRU	1.0%	0.0%
HBP	0.0%	0.0%
HO	0.2%	0.0%
BO	0.2%	0.0%
HBO	0.0%	0.0%
FID	8.9%	57.3%
PRD	0.2%	0.0%
COP	0.2%	4.0%
BKD	0.0%	0.0%
FUN	0.0%	2.4%

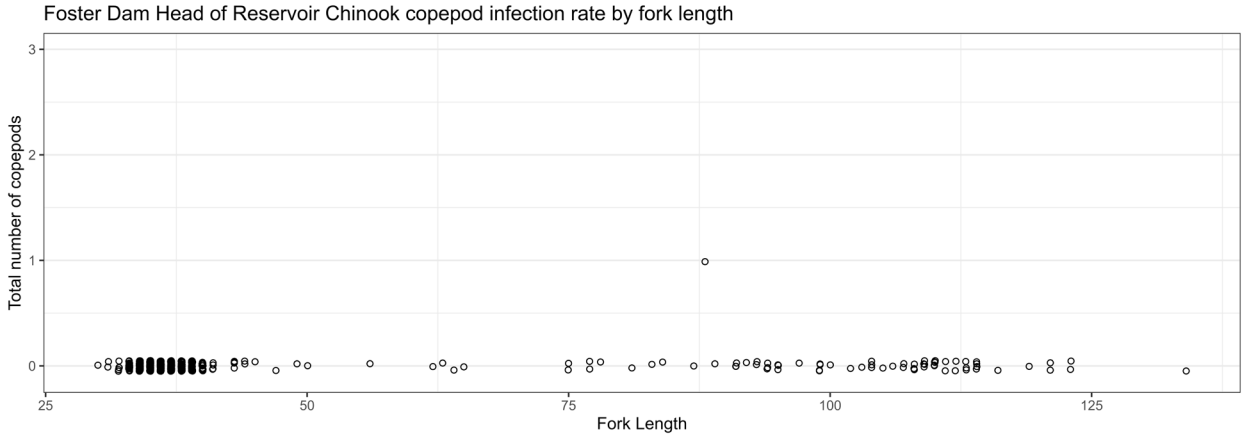

Figure 20. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Foster Dam Head of Reservoir for 2023.

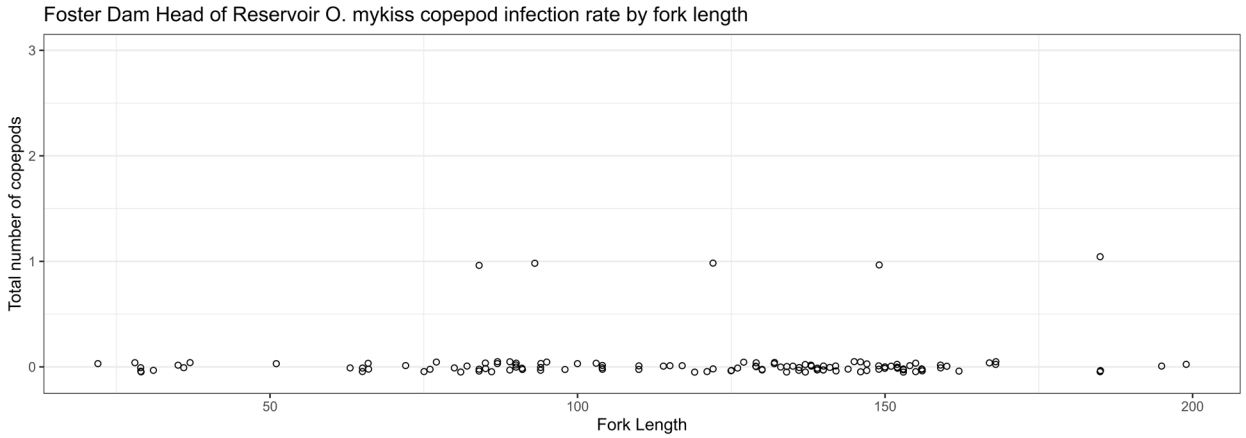

Figure 21. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile *O. mykiss* at Foster Dam Head of Reservoir for 2023.

PIT Tagged Fish and Downstream Detections

A total of 65 juvenile Chinook salmon and 112 juvenile *O. mykiss* were PIT tagged and released at the Foster Dam Head of Reservoir site in 2023. A total of three fish were detected at downstream sites, one Chinook salmon and two *O. mykiss.* The one tagged Chinook salmon was detected downstream on the TWX-Estuary Towed Array (Exp.), 60 days after release at the RST site. The 2 *O. mykiss* were detected at Lebanon Dam 54 days and 69 days after release at the RST site. Table 19 shows a summary of the fish detected at downstream sites. Information regarding the redetections at the RST and other sites can be found in Appendix C.

Table 19. Summary of PIT tagged fish downstream redetections for the Foster Dam Head of Reservoir site in 2023.

PIT Tag #	Mark Date	Mark Site	Redetection Date	Recap Site
3DD.003BD226FB	3/19/2023	SSANTR – South Santiam River, Oregon	5/18/2023	TWX – Estuary Towed Array (Exp.)
3DD.003BD22B4C	10/11/2023	SSANTR – South Santiam River, Oregon	12/19/2023	LD2 – Lebanon Dam North Ladder
3DD.003BD22B5C	10/11/2023	SSANTR – South Santiam River, Oregon	12/4/2023	LD3 – Lebanon Dam Diversion Bypass

Non-Target Capture Data

We captured 593 non-target fish in addition to natural origin juvenile Chinook salmon and *O. mykiss* at the Foster Dam Head of Reservoir site (Table 20). Dace and Largescale Sucker were the most encountered non-target species.

Table 20. Summary of non-target fish capture at the Foster Dam Head of Reservoir – South Santiam River site.

Species	Season Total	Season Total Mortality (subset of total)
Cutthroat Trout	2	0
Dace	341	11
Largescale Sucker	149	20
Sculpin	13	1
Unknown*	6	4
Northern Pikeminnow	81	2
O. mykiss (adipose clipped)	1	0
Totals	593	38

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

Cougar Dam Tailrace

EAS began monitoring the three RSTs (two 8-foot RSTs in the PH channel and one 5-foot RST in the RO channel) below Cougar Dam on December 1, 2021. Monitoring from January 1, 2023, through November 30, 2023, is further included within this report. Sampling from December 1, 2023, through the end of the year was performed and reported under contract W9127N19D0009.

There were two short periods of time when the PH traps did not sample due to low flows out of the PH that prevented them from being lowered into the sampling position. The RO at Cougar Dam was offline from June through August 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 17 TE trials occurred using hatchery reared Chinook salmon below Cougar Dam for this contract in 2023: eight in the RO channel, and nine in the PH channel. A total of 31 trials have occurred since sampling started in December of 2021.

Trapping efficiencies 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 21.

At this time, there appears to be no relationship with flow rate for both the PH and RO channels as linear models fit 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 (5 or more recaptures) BY, lifestage (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 lifestage differences in TE, hatchery TE trials were grouped by lifestage 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 21. Summary table of marked hatchery Chinook salmon releases at Cougar Dam for trapping efficiency January 1, 2023, through November 30, 2023.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
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	4	0.8%
Cougar Dam Powerhouse Channel	3/30/2023	490	497	12	2.4%
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%
Cougar Dam Powerhouse Channel	6/6/2023	370	507	65	12.8%
Cougar Dam Powerhouse Route	7/26/2023	370	510	63	12.4%
Cougar Dam Powerhouse Route	9/21/2023	340	500	53	10.6%
Cougar Dam Powerhouse Route	10/11/2023	290	500	14	2.8%
Cougar Dam Regulating Outlet Channel	10/11/2023	350	518	14	2.7%
Cougar Dam Regulating Outlet Channel	11/8/2023	1100	508	43	8.5%
Cougar Dam Regulating Outlet Channel	11/30/2023	310	505	26	5.1%

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 1,682 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 (5 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 22. Summary table of run of river releases at the Cougar Dam site for trapping efficiency for January 1 to November 30, 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%
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 5,269 juvenile Chinook salmon were captured at the Cougar Dam Tailrace during the reporting period. A total of 198 Chinook salmon were captured in the PH traps (3.8% of total catch) (Figure 22) and 5,071 in the RO trap (91.6% of total catch) (Figure 23). Peak capture in the PH traps occurred in June (n= 45, 22.7% of total PH catch). Peak capture in the RO channel in the spring occurred in May (n= 675, 13.3% 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, through June 30, 2023, consisted of two BYs, BY 2021 yearlings (n= 802, 92.8% of spring catch) and BY 2022 sub-yearlings (n= 62, 7.2% of spring catch) (Figure 24). Of note, catch of yearling Chinook salmon below Cougar Dam during this period was significantly higher this year than had been observed in the past by previous monitoring efforts (Romer et al. 2016; CFS, 2022). 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 increase 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, through November 30, 2023, consisted of 4,405 (83.6% 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 125 Chinook salmon were captured in the PH traps (2.8% of fall catch) and 4,280 were captured in the RO trap (97.2% of fall catch). A total of 141 BY 2020 Chinook salmon were captured during this period along with 4,264 BY 2021 and BY 2022 Chinook salmon. Peak capture of Chinook salmon occurred in October and November (n=4,314, 81.9% of total Chinook salmon catch). A summary of fork length and weight data by BY is provided in Table 23.

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 1,532 and below. We estimate that 83,198 (95% CI: 65,856 to 112,938) Chinook salmon passed through the RO and 1,617 (95% CI: 1,226 to 2,372) passed through the PH from January 1, 2023, through November 30, 2023 (Figure 22 and Figure 23). Total passage for this period at Cougar Dam is estimated to be 84,815 (95% CI: 67,002 to 115,310) juvenile Chinook salmon.

Table 23. Summary of fork length and weight observed on juvenile Chinook salmon at the Cougar Dam RST sites by brood year from January 1, 2023, through November 30, 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 22	4264	115.2	53	176	115	17.7	1.2	93.3	16.7

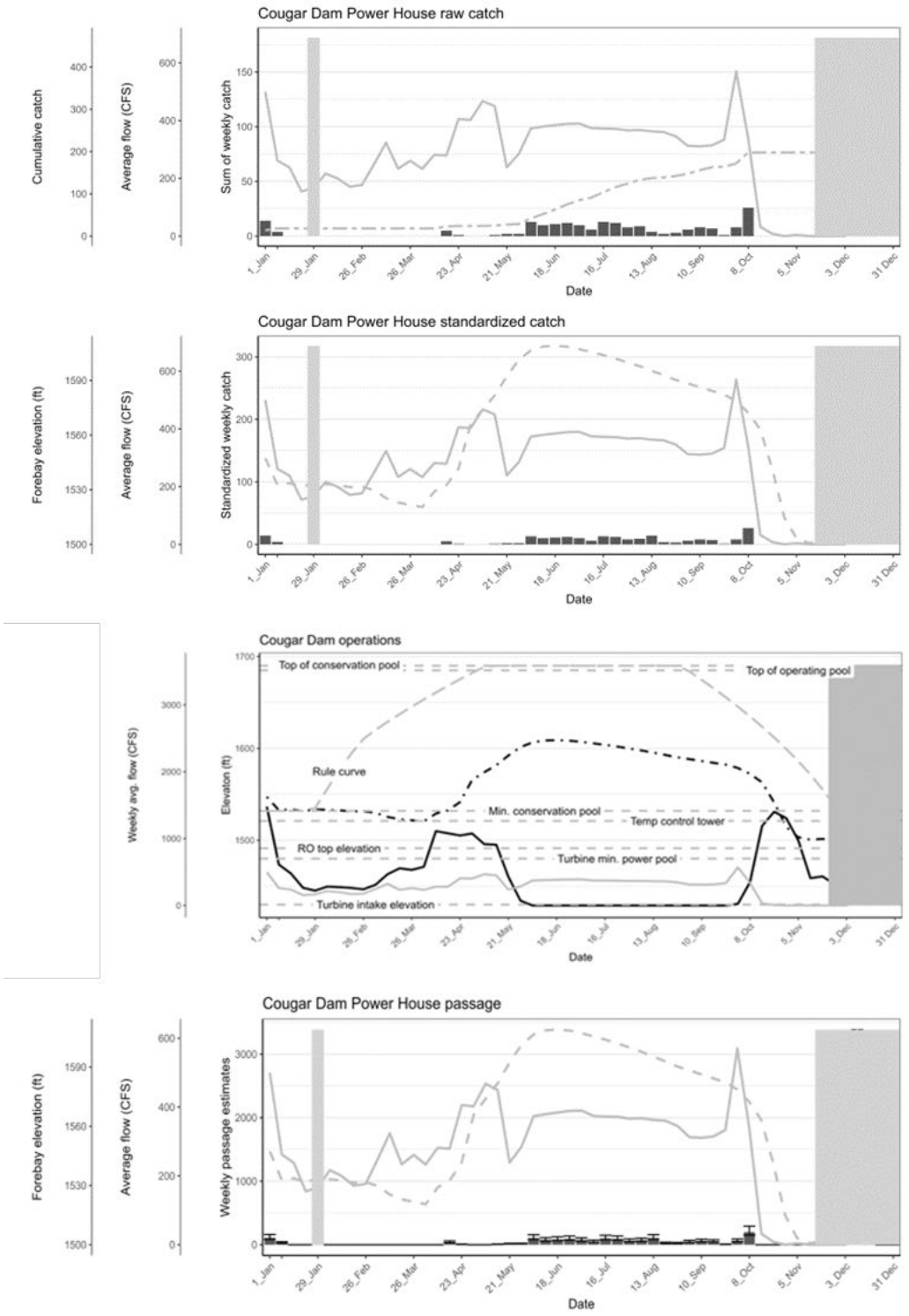

Figure 22. Raw catch (top panel), weekly standardized catch (second panel), Cougar Dam operations (third panel), and weekly passage estimates (bottom panel) overlayed with Powerhouse outflow (gray line), cumulative catch (gray dash dot line), forebay elevation (black dot dash line), water temperature (gray dot line), and non-sampling weeks shaded out (gray) and non-sampling weeks shaded out (gray) for the Powerhouse traps at Cougar Dam from January 1, 2023, through November 30, 2023.

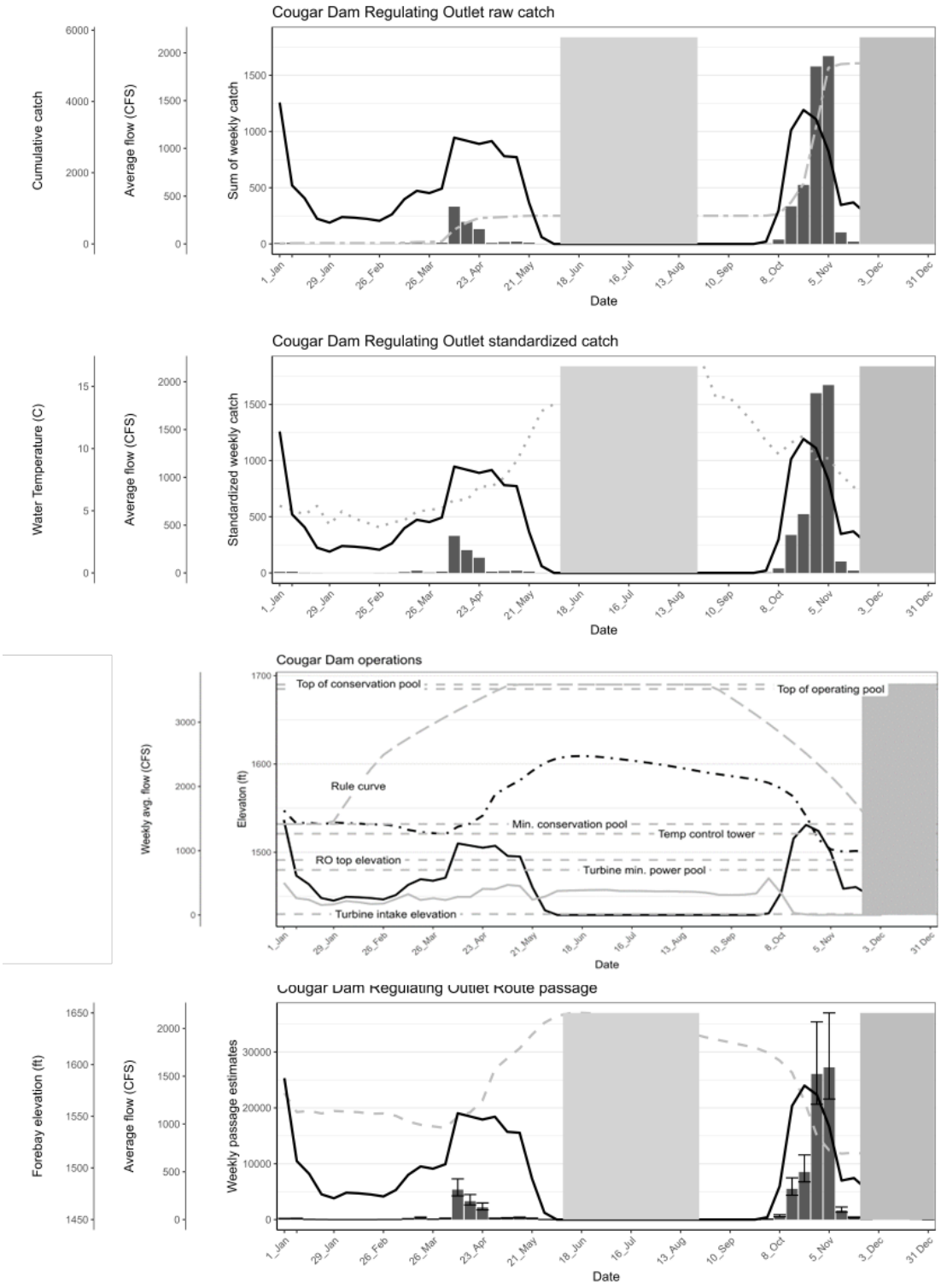

Figure 23. Raw catch (top panel) and weekly standardized catch (second panel), Cougar Dam Operations (third panel), and weekly passage estimates (bottom panel) overlayed with regulating outlet outflow (black line), cumulative catch (gray dash dot line), forebay elevation (black dot dash line), water temperature (gray dot line), and non-sampling weeks shaded out (gray) for the RO trap at Cougar Dam January 1, 2023, through November 30, 2023.

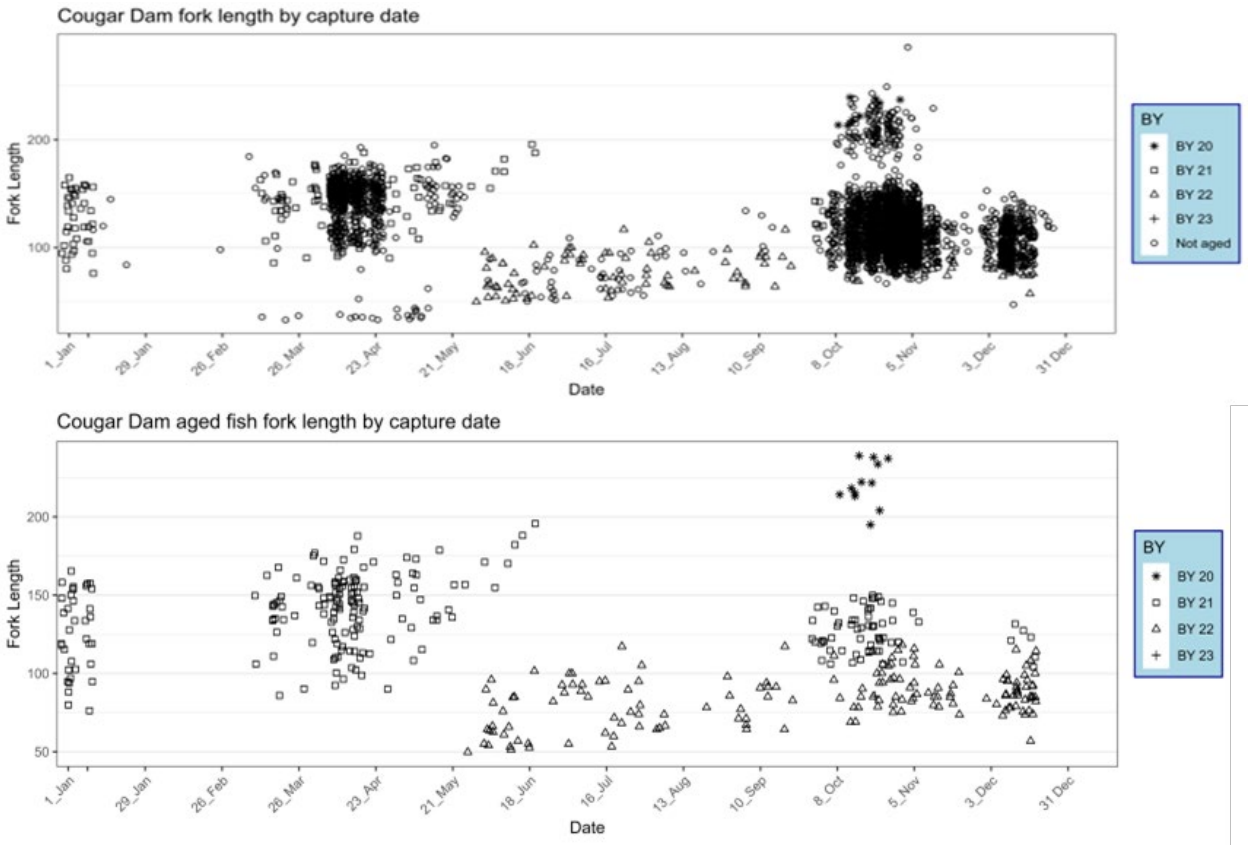

Figure 24. Length-frequency age analysis for juvenile Chinook salmon captured below Cougar Dam from January 1, 2023, through November 30, 2023. The top panel shows all fish and bottom panel shows only the aged fish.

Injury Data

A total of 5,216 juvenile Chinook salmon (98.9% of total Chinook salmon catch), 5,037 captured in the RO trap (99.3% of total RO catch) and 179 captured in the PH traps (90.4% of total PH catch), displayed at least one of the injury code conditions listed in Table 2. Additionally, 496 (9.4% of total Chinook salmon catch) were dead at the time of trap check.

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 utilized to provide information on 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 NOR Chinook captured in the RSTs include descaling less than 20%, descaling greater than 20%, operculum damage, and fin damage.

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 also show a positive association 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 24 and 25 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 25. Furthermore, associations between spill at Cougar Dam Tailrace and bodily injury, descaling, and copepod presence of Chinook salmon are indicated in Figure 37. A total of 680 juvenile Chinook salmon (78.7% of total Chinook salmon catch) were infected with copepods at time of capture (Figure 26). Copepod presence on captured Chinook salmon was

evidenced to increase with the size of fish similar to observations made by previous studies (CFS 2022; Monzyk et al. 2015). This is likely a connection between time spent rearing in the reservoir rather than the size of the fish (Figure 26). 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 similar to findings from both Big Cliff Dam Tailrace and Green Peter Dam Tailrace, Chinook salmon less than 60 mm were found to exhibit fewer injuries that their larger counterparts ranging from 60 mm to 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 24. 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 January 1 through November 30, 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=198)	Bulk Marking Recapture Injuries (proportion of total) (n=71)
NXI	42.0%	33.7%	-8.3%	9.6%	0.0%
MUNK	0.0%	0.0%	0.0%	0.5%	0.0%
DS<2	50.0%	61.3%	11.3%	63.1%	69.0%
DS>2	5.6%	1.0%	-4.6%	12.1%	31.0%
BLO	0.4%	0.7%	0.2%	2.0%	7.0%
EYB	0.4%	0.7%	0.2%	3.0%	4.2%
BVT	0.0%	0.0%	0.0%	5.6%	4.2%
FVB	0.0%	0.0%	0.0%	6.1%	8.5%
GBD	0.0%	0.0%	0.0%	1.5%	2.8%
POP	0.0%	0.0%	0.0%	0.0%	2.8%
HIN	0.7%	0.0%	-0.7%	3.0%	4.2%
OPD	0.2%	0.0%	-0.2%	5.6%	14.1%
TEA	0.2%	0.7%	0.4%	7.6%	7.0%
BRU	1.1%	0.3%	-0.8%	7.6%	7.0%
HBP	0.0%	0.0%	0.0%	2.5%	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%	0.0%	0.0%
FID	50.7%	55.7%	5.0%	47.0%	0.0%
PRD	0.0%	0.0%	0.0%	1.0%	0.0%
COP	0.0%	0.0%	0.0%	54.5%	19.7%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.3%	0.3%	2.5%	4.2%

Table 25. 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 January 1 through November 30, 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=300)	TE Recapture Injuries (proportion of total) (n=58)	Proportional Percent Change	Observed Chinook Injuries (n=5,071)	Bulk Marking Recapture Injuries (proportion of total)
NXI	33.7%	3.4%	-30.2%	0.7%	0.5%
MUNK	0.0%	0.0%	0.0%	0.0%	0.0%
DS<2	61.3%	87.9%	26.6%	73.0%	82.9%
DS>2	1.0%	0.0%	-1.0%	18.8%	12.9%
BLO	0.7%	0.0%	-0.7%	0.5%	0.3%
EYB	0.7%	0.0%	-0.7%	10.8%	6.0%
BVT	0.0%	0.0%	0.0%	2.8%	1.1%
FVB	0.0%	0.0%	0.0%	14.1%	8.2%
GBD	0.0%	0.0%	0.0%	29.7%	19.8%
POP	0.0%	0.0%	0.0%	1.1%	0.7%
HIN	0.0%	0.0%	0.0%	4.2%	2.5%
OPD	0.0%	0.0%	0.0%	15.8%	11.9%
TEA	0.7%	1.7%	1.1%	5.7%	1.6%
BRU	0.3%	0.0%	-0.3%	5.6%	3.6%
HBP	0.0%	0.0%	0.0%	3.4%	0.5%
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	55.7%	89.7%	34.0%	83.5%	93.7%
PRD	0.0%	0.0%	0.0%	0.3%	0.4%
COP	0.0%	0.0%	0.0%	91.3%	18.8%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.3%	0.0%	-0.3%	10.0%	4.2%

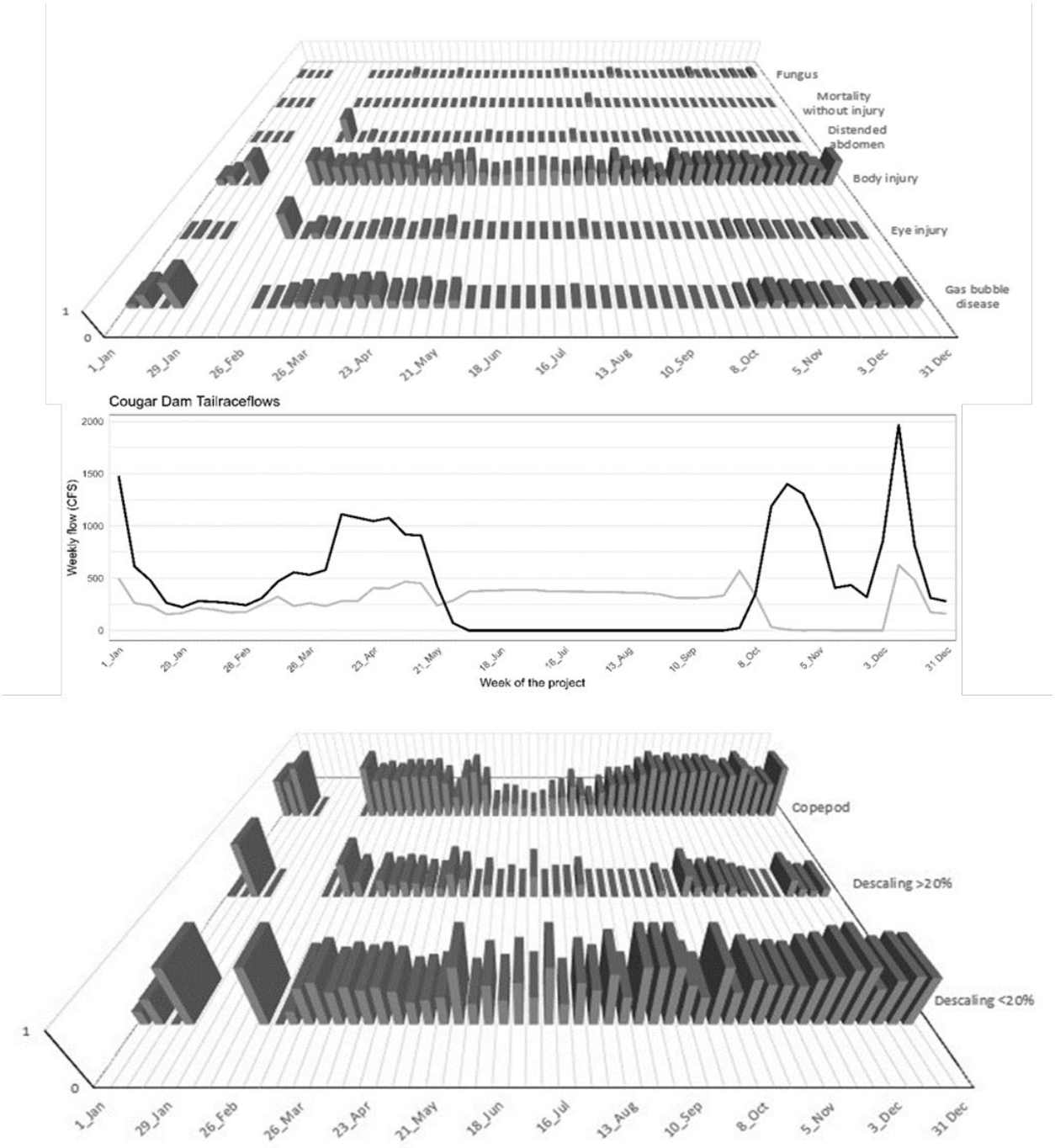

Figure 25. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data from Cougar Dam showing cfs of spill (black line) and Powerhouse flow (gray line) outflows (middle panel), and proportion of captured juvenile Chinook salmon displaying descaling and copepod injuries (bottom panel) from January 1, 2023, through November 30, 2023.

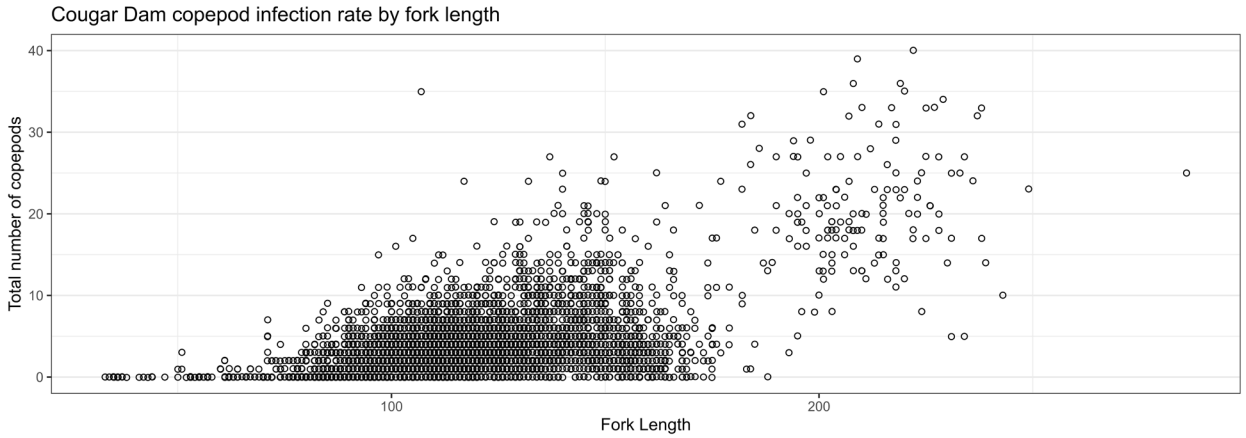

Figure 26. Copepod presence vs fork length on juvenile Chinook salmon captured at Cougar Dam January 1, 2023, through November 30, 2023.

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 834 fish, 664 from the RO and 170 from the PH, were held (Table 26). A total of 83 fish died during hold (10.0%), 68 of the 664 RO Chinook salmon (10.2%) and 15 of the 170 PH Chinook salmon (8.8%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 66.7%.

Table 26. Summary of 24-hour hold trials for Chinook salmon captured in the RSTs at the Cougar Dam site January 1 through November 30, 2023.

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

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 3,915 natural origin juvenile Chinook salmon were PIT tagged and released at the Cougar Dam sites for 2023, this number does not include Cramer hatchery PIT tagged bulk marked fish. Six PIT tags were redetected downstream in the Columbia River Estuary. Five VIE marked Chinook salmon were encountered this year at the Cougar Dam RST sites. These fish were VIE marked by EAS at the Cougar Dam Head of Reservoir RST in May of 2023. As of December 31, 2023, data from the ODFW PIT array at Cougar Dam has not been uploaded to PTAGIS or been received directly from ODFW. Table 27 shows summary data of the fish redetected at downstream sites. Information regarding the redetections at the RST site can be found in Appendix C.

Table 27. Summary of redetections of fish PIT tagged at the Cougar Dam sites.

PIT Tag #	Mark Date	Mark Site	Redetection Date	Recap Site
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's bulk mark release project. For information regarding bulk mark releases and detection data, refer to *Cramer Fish Science's 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 2,837 non-target fish were captured at the Cougar Dam sites in 2023. A summary of species and catch is provided below in Table 28. The most commonly captured non-target species were dace and sculpin. Information regarding captured Bull Trout is provided in Appendix C.

Table 28. Summary of non-target fish capture for the Cougar Dam RSTs from January 1, 2023, through November 30, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bull Trout	2	0
Chinook (clipped)	552	22
Chinook (adult)	3	1
Cutthroat Trout	18	0
Dace	1,784	3
Largescale Sucker	8	0
Mountain Whitefish	23	3
O. mykiss	126	2
Sculpin	272	5
Bluegill	1	0
Lamprey	3	0
Smallmouth Bass	7	1
Spotted Bass	34	0
Unknown Bass	4	0
Totals	2,837	37

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

Cougar Dam Head of Reservoir

Monitoring of a single 5-foot RST in the South Fork McKenzie River above Cougar Reservoir began on February 1, 2023, and continued sampling through November 30, 2023. The trap was not sampled from February 20, 2023, through March 14, 2023, due to a snowstorm that blocked access to the site. A list of sampling outages for each site is available in Appendix B.

Trapping Efficiency Trials

A total of ten TE trials occurred using hatchery reared Chinook salmon at the Cougar Dam Head of Reservoir site in 2023. One TE trial was performed by Cramer as part of a bulk marked release. A total of 19 TE trials (18 successful) have been performed at this site since 2022. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 29. TEs ranged from 1.4% to 8.8%. TE used to calculate passage was the pooled average of 18 trials 4.9% with 95% CI of 1.12%.

In previous reports trials were grouped by flow (cfs) for the purpose of creating passage estimates across the range of flows sampled. A linear model had shown decreasing TE with increasing flow, but that model broke down with additional trials (see Appendix E). The sample size remains under 30 trials, making it difficult to detect assumption violations, and results could change with more data. Plots displaying TE in relation to flow and cone flux for all trials are displayed in Appendix E.

Table 29. Summary table of marked hatchery Chinook salmon releases at the Cougar Dam Head of Reservoir site for trapping efficiency from February 1, 2023, through November 30, 2023.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Cougar Dam Head of Reservoir	4/14/2023	980	506	10	2.0%
Cougar Dam Head of Reservoir	5/10/2023	1,170	508	7	1.4%
Cougar Dam Head of Reservoir	5/16/2023	1,700	497	23	4.6%
Cougar Dam Head of Reservoir	6/8/2023	503	510	23	4.5%
Cougar Dam Head of Reservoir	7/27/2023	223	758	27	3.6%
Cougar Dam Head of Reservoir*	8/29/2023	204	5151	127	17.0%
Cougar Dam Head of Reservoir	9/21/2023	194	745	41	5.5%
Cougar Dam Head of Reservoir	10/19/2023	211	750	42	5.6%
Cougar Dam Head of Reservoir	11/14/2023	340	756	21	2.8%
Cougar Dam Head of Reservoir	11/28/2023	261	760	67	8.8%

**Release performed by Cramer Fish Sciences.*

Run of River Trapping Efficiency Trials

A total of 75 Chinook salmon were released for run of river TE trials in 2023. A total of three fish were recaptured in the 5-foot trap. A summary of run of river TE trials by month is provided in Table 30. Additional trials with larger groups of ROR fish will be conducted when conditions allow to provide data for future analyses.

Table 30. Summary table of run of river releases at the Cougar Dam Head of Reservoir site for trapping efficiency for January 1, 2023, through November 30, 2023.

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

Target Catch, Passage Estimates and Passage Timing

The trap captured 5,913 juvenile Chinook salmon during this reporting period. Peak catch of juvenile Chinook salmon above Cougar Reservoir in the spring occurred April through June (n= 4,616, 78.1% of total Chinook salmon catch). This timing is consistent with data from the bi-annual report undertaken by EAS and previous studies (Romer et al. 2016). Figure 27 shows raw and standardized catch overlayed with flow at the Cougar Dam Head of Reservoir site. Chinook salmon catch from February 1, 2023, through June 30, 2023, consisted of two BY classes, BY 2021 (n= 32, 0.7%) and BY 2022 (n= 4,592, 99.3%). BY 2022 sub-yearling Chinook salmon were the dominant age class captured at this site from March through the end of the period (Figure 28). The first BY 2022 Chinook salmon captured at the trap occurred on February 16. Peak capture of BY 2022 sub-yearlings occurred in May when 2,950 Chinook salmon were captured (64.2% of total BY 22 catch). The first BY 2021 yearling was captured on February 7, 2023, and yearling catch continued into early April. Since BY 2021 yearlings were captured so close to the initiation of sampling, it is likely that some early migrants were missed prior to sampling in 2023.

Capture of Chinook salmon in the fall from July 1, 2023, through November 30, 2023, was composed of 1,229 fish (20.8% of total Chinook salmon catch) consisting of 1 BY 2021 and 1,998 BY 2022 Chinook salmon. Chinook salmon capture did not appear to be related to increases in flow but a modest increase in catch occurred during July (n=631, 51.3% of fall Chinook salmon catch). We estimate that 132,566 (95% CI: 86,443 to 174,027) juvenile Chinook salmon passed the RST site during sampling in 2023 (Figure 27). A summary of fork length and weight data by BY is provided in Table 31.

Table 31. Summary of fork length and weight observed on juvenile Chinook salmon at the Cougar Dam Head of Reservoir 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	2/1/2023	21	32	88.2	73	106	89	7.0	3.2	13.7	6.8
Chinook	2/1/2023–6/30/2023	22	4,592	36.2	25	64	36	N/A	N/A	N/A	N/A
Chinook	7/1/2023–11/30/2023	21	1	104	104	104	N/A	10.3	10.3	10.3	N/A
Chinook	7/1/2023–11/30/2023	22	1,228	58.4	36	98	56	2.8	1.0	12.4	2.2

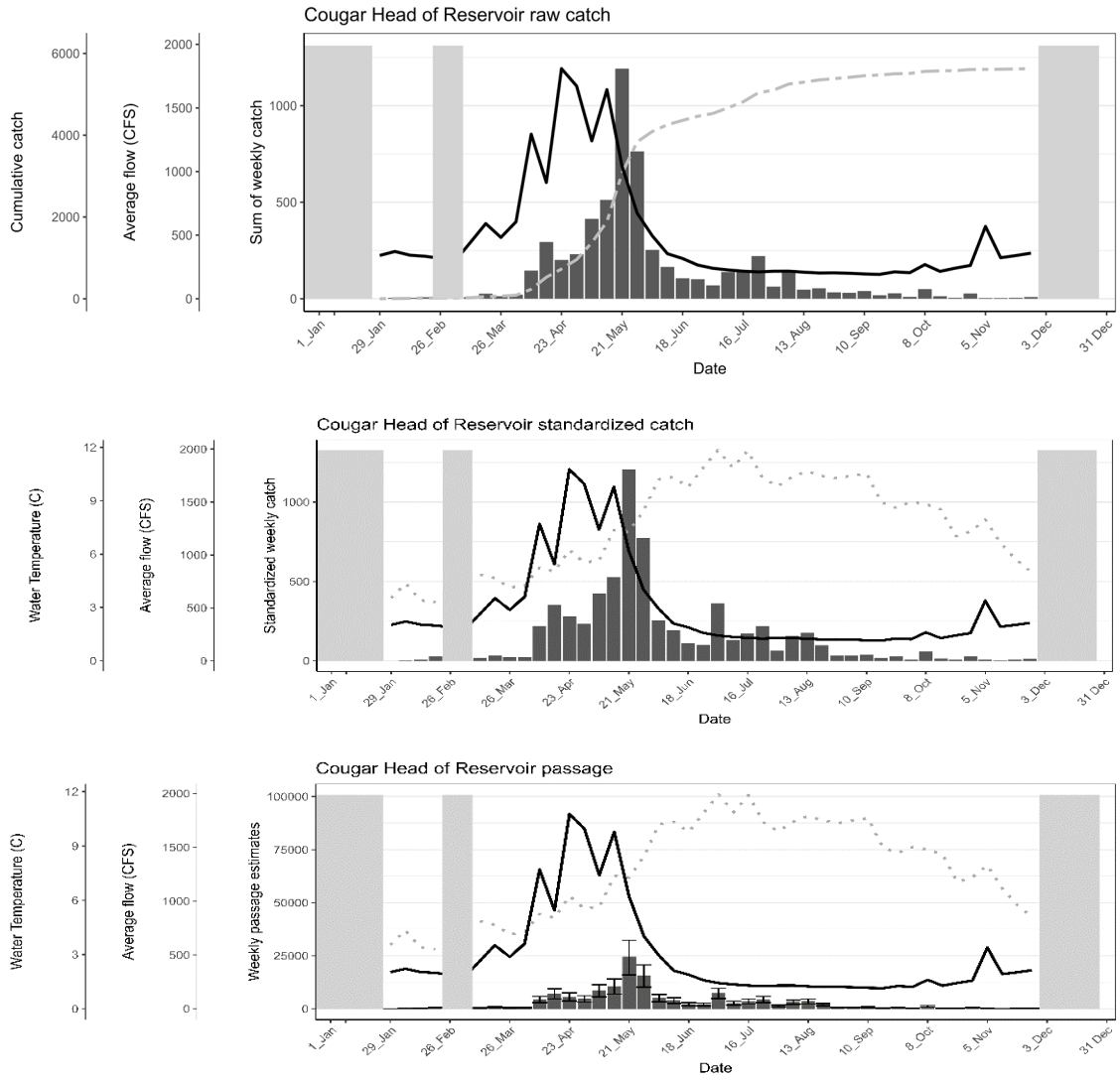

Figure 27. Raw catch (top panel), weekly standardized catch (middle panel), and weekly passage estimates (bottom panel) of natural origin juvenile Chinook salmon at the Cougar Dam Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), water temperature (gray dots), and non-sampling weeks shaded out (gray) from February 1, 2023, through November 30, 2023.

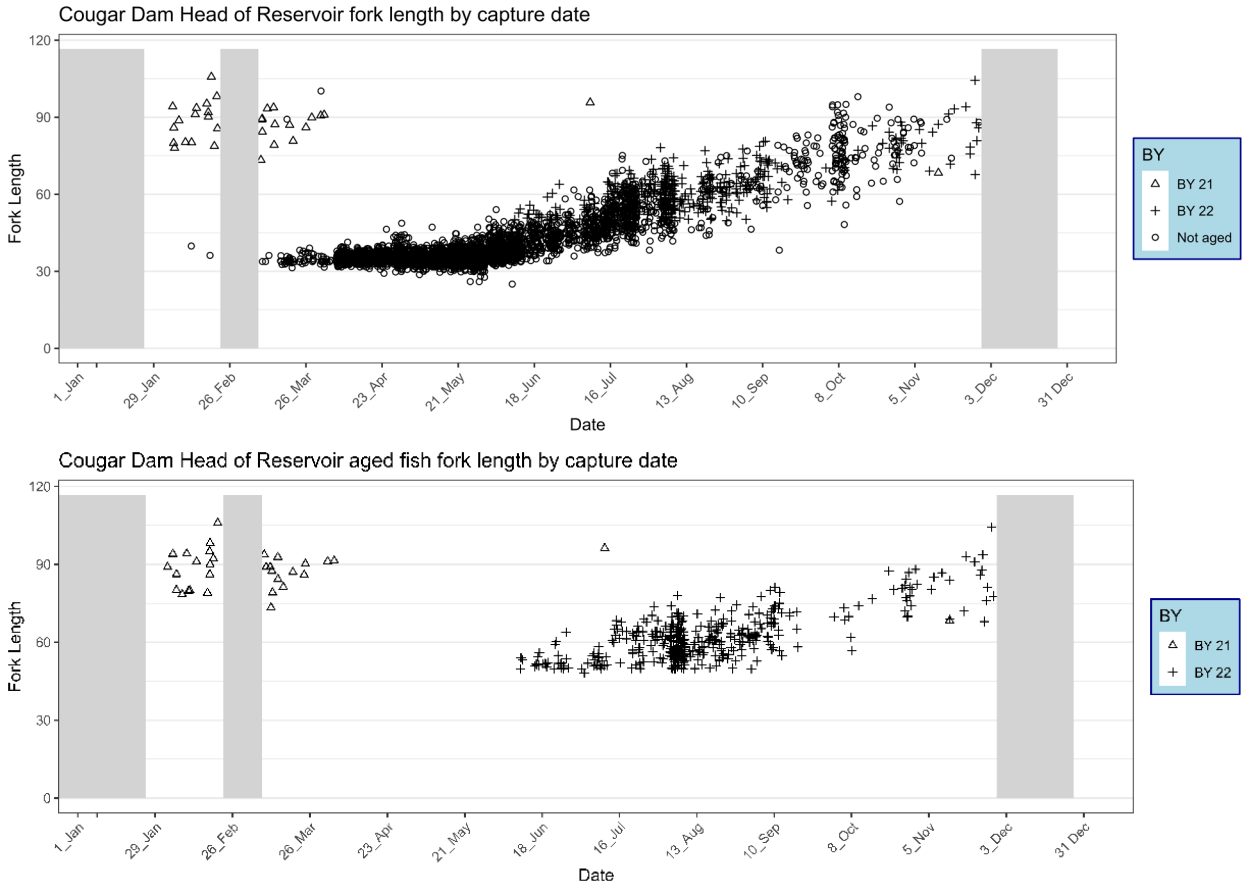

Figure 28. Length-frequency of juvenile Chinook salmon by BY at the Cougar Dam Head of Reservoir site from February 1, 2023, through November 30, 2023. Top panel shows all fish and bottom panel shows only the aged fish.

Injury Data

A total of 663 juvenile Chinook salmon (11.2% 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% and fin damage. These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap.

Copepod presence on captured Chinook salmon showed a positive association with the size of fish similar to observations made by previous studies (CFS 2022; Monzyk et al. 2015). However, this correlation is not as strong as those seen in other basins (Figure 29). No bulk marked PIT tagged fish were captured during the report period. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

There were 103 mortalities (2.6% of total Chinook salmon catch) likely resulting from high debris in the trap. These Chinook salmon were found dead at the time of trap check. A summary of injuries observed at the Cougar Dam Head of Reservoir site is provided in Table 32.

Table 32. Percentage of juvenile Chinook salmon displaying injury by type at the Cougar Head of Reservoir RST site from February 1, 2023, through November 30, 2023.

Injury Code	Chinook Injuries (NOR) (n=5,913)
NXI	89.0%
MUNK	0.1%
DS<2	5.7%
DS>2	1.0%
BLO	0.1%
EYB	0.3%
BVT	0.2%
FVB	0.3%
GBD	0.0%
POP	0.5%
HIN	0.8%
OPD	1.0%
TEA	1.0%
BRU	0.9%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	5.0%
PRD	0.4%
COP	0.6%
BKD	0.0%
FUN	0.1%

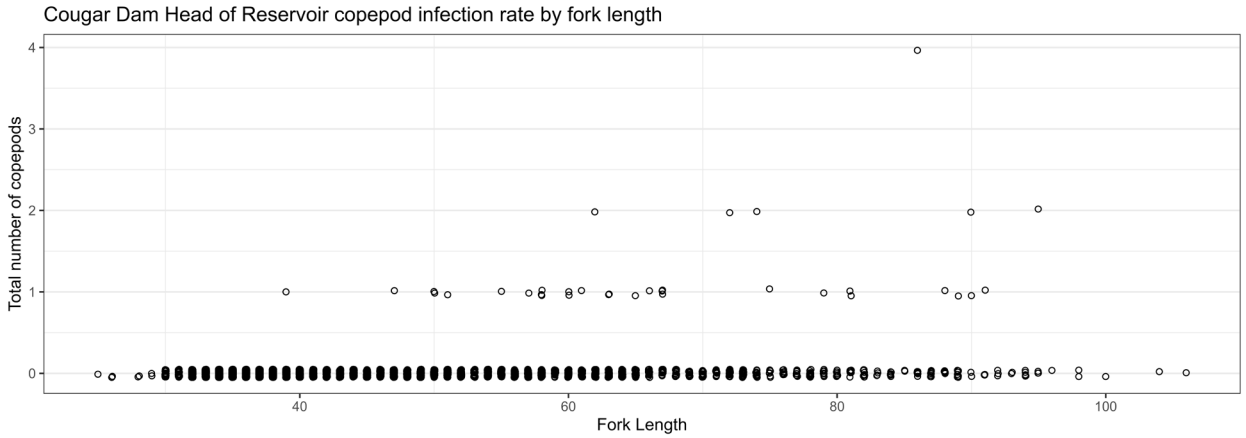

Figure 29. Copepod presence vs fork length on juvenile Chinook salmon captured at Cougar Dam Head of Reservoir from February 1, 2023, through November 30, 2023.

PIT Tagged/VIE Marked fish and Downstream Detections

A total of 301 natural origin Chinook salmon were PIT tagged and 3,881 were VIE marked at Cougar Dam Head of Reservoir site in 2023. These numbers do not include Cramer hatchery PIT tagged groups. The rest of the captured fish were either sac-fry or did not meet minimum length requirements for tagging. Five Chinook salmon smolt with a right dorsal orange VIE mark were captured below Cougar Dam in the RO RST in November of 2023. These fish were tagged in May of 2023 by EAS.

As of December 31, 2023, data from the ODFW PIT arrays at Cougar Dam has not been available on PTAGIS or directly from ODFW. Two Chinook salmon smolt were redetected at the Cougar Dam Tailrace RO trap. For more information on these fish and VIE marked, see Tables 33 and 34 below. See Appendix C for information regarding tags encountered at the Cougar Dam Head of Reservoir site and VIE marked fish.

Table 33. Summary of redetections of fish PIT tagged at the Cougar Dam Head of Reservoir site from February 1 to November 30, 2023.

PIT Tag #	Mark Date	Mark Site	Redetection Date	Recap Site
3DD.003BEE13CA	10/24/2023	MCKESF – Released at the Cougar Head of Reservoir RST	10/31/2023	CGRTAL – CGR Regulating Outlet Trap
3DD.003BD2270E	7/29/2023	MCKESF – Released at the Cougar Head of Reservoir RST	11/9/2023	CGRTAL – CGR Regulating Outlet Trap

Table 34. Summary of VIE marked Chinook salmon at the Cougar Dam Head of Reservoir site from February 1 to November 30, 2023.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured to Date
February 2023	Right Dorsal	Yellow	1	0
March 2023	Right Dorsal	Red	10	0
April 2023	Right Dorsal	Blue	374	0
May 2023	Right Dorsal	Orange	1893	5
June 2023	Right Dorsal	Pink	721	0
July 2023	Right Dorsal	Green	599	0
August 2023	Right Dorsal	Yellow (2x)	233	0
September 2023	Right Dorsal	Red (2x)	42	0
August 2023	Right Dorsal	Blue (2x)	10	0

Willamette Valley Projects Encounters

133 adipose clipped and PIT tagged Chinook salmon were captured in the Cougar Dam Head of Reservoir trap in 2023. These fish were a part of a Cramer Fish Science's bulk mark release project that were released above the RST site for a TE trial. One juvenile Bull Trout and one adult rainbow trout were captured containing Cramer Fish Science's PIT tags. These PIT tags were associated with the bulk mark release Chinook tagged and released by Cramer. As trout were not tagged and released by Cramer, it is assumed that these fish predated on the bulk mark released Chinook. Additionally, a group of PIT tagged Chinook salmon that were originally slated for use above Cougar Reservoir were released from Leaburg due to extenuating circumstances. One fish from this group was redetected at the PD6 – Columbia River Estuary Array 93 days after release.

Non-Target Capture Data

We captured 611 non-target fish in addition to natural origin juvenile Chinook salmon. A summary of species and numbers of fish caught are provided in Table 35. The most captured non-target species were *O. mykiss*. Additionally, the RST captured 14 Bull Trout. All Bull Trout were measured and scanned for PIT tags. Eight Bull Trout were tagged by EAS staff. All information gathered was provided to ODFW. Additional information on captured Bull Trout is provided in Appendix C.

Table 35. Summary of non-target species capture at the Cougar Dam Head of Reservoir RST site for February 1, 2023, through November 30, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bull Trout	14	0
Chinook (adult)	1	0
Cutthroat Trout	7	0
Dace	4	0
Mountain Whitefish	5	1
O. mykiss	561	3
Sculpin	18	1
Unknown	1	0
Totals	611	5

*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. 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. EAS monitored the Fall Creek Dam Tailrace RST within this report period from January 1, 2023, through July 15, 2023. 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. Sampling from July 16, 2023, through the end of the year can be found in report under contract W9127N19D0009. Additional details regarding sampling dates and trap outages can be found in Appendix B.

Trapping Efficiency Trials

A total of three TE trials occurred using hatchery reared Chinook salmon in the RO channel of Fall Creek Dam in 2023. Collectively, a total of eight trials have occurred here since monitoring began in 2022. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 36. Trapping efficiencies were all 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 completed trials in total.

Due to limitations on 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 at these flow levels allowing fish to easily avoid the trap.

Table 36. Summary table of marked hatchery Chinook salmon releases at Fall Creek Dam Tailrace for trapping efficiency January 1, 2023, through July 15, 2023.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Fall Creek Dam Regulating Outlet	5/11/2023	83	998	0	0%
Fall Creek Dam Regulating Outlet	6/28/2023	89	992	0	0%
Fall Creek Dam Regulating Outlet	7/11/2023	103	1,006	0	0%

Run of River Trapping Efficiency Trials

No TE trials using run of river 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 or utilized for run of river TE trials.

Target Catch and Passage Timing

The trap in the RO channel below Fall Creek Dam Tailrace captured 61 juvenile Chinook salmon during sampling in 2023. Capture of juvenile Chinook salmon occurred in March and April (Figure 30). Peak capture occurred in March (n=44, 72.1%). This timing is later than previous monitoring efforts observed when 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 Tailrace later in the spring than RST capture indicates as the RST is very inefficient in low flows. Chinook catch 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 reporting period (Figure 31). Sampling from 2022 captured one yearling Chinook in October as the reservoir was being drawn down. The cone was raised from December 5, 2022, through January 10, 2023, due to sediment filling the RO channel where the trap samples to the point where the RST could not operate. It is possible that juvenile Chinook salmon out-migrated during this period while sampling could not be performed. Fork length and weight data by BY for Chinook salmon captured at Fall Creek Dam Tailrace is provided below in Table 37.

Table 37. Summary of fork length and weight observed on juvenile Chinook salmon at the Fall Creek Dam RST site by brood year from January 1, 2023, through July 15, 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

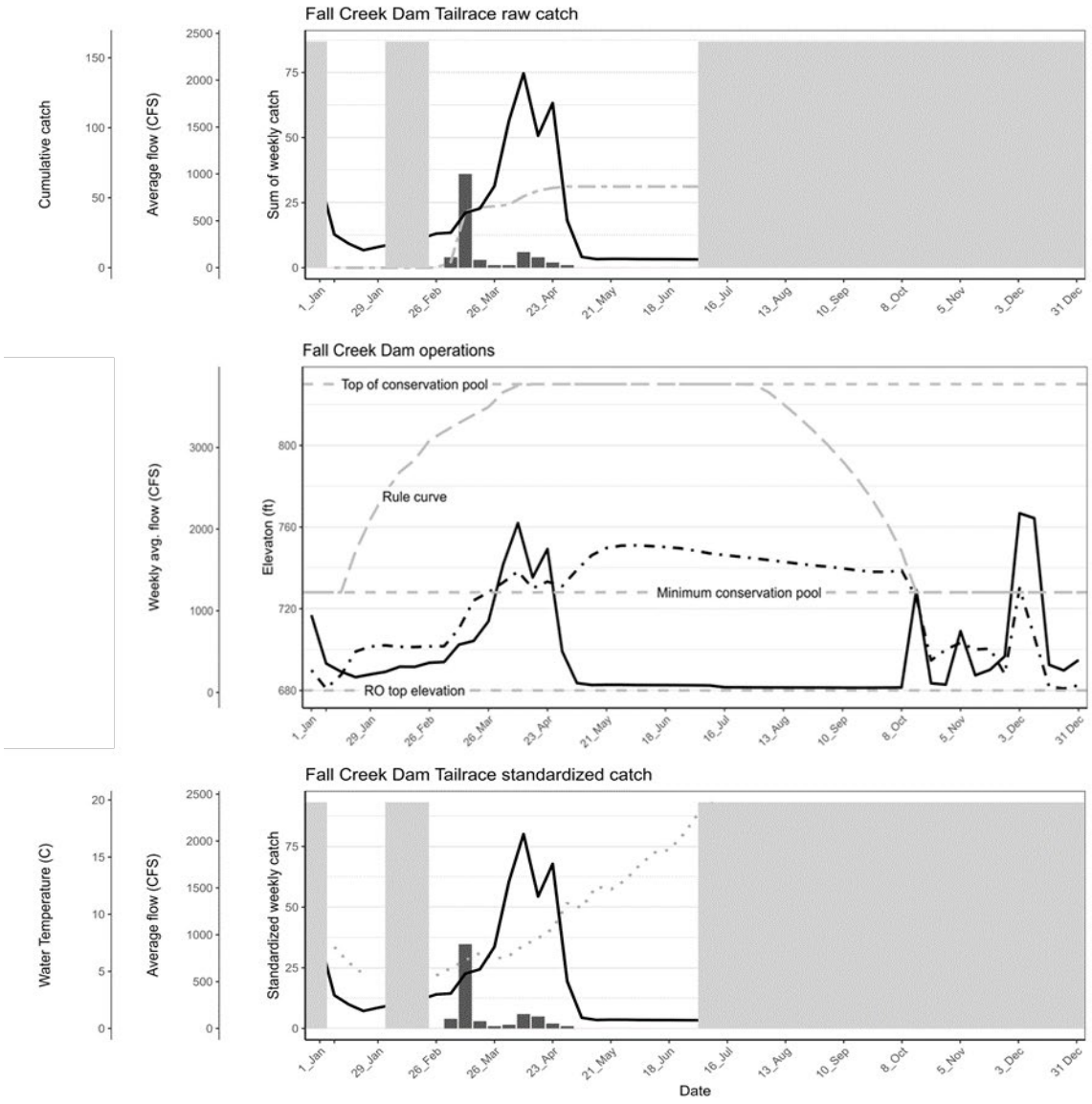

Figure 30. Raw catch (top panel), Fall Creek Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at the Fall Creek Dam Tailrace site with RO outflow (black line), forebay elevation (black dot dash line), intake elevations (gray dash line), cumulative catch (gray dot dash line), stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for January 1, 2023, through July 15, 2023.

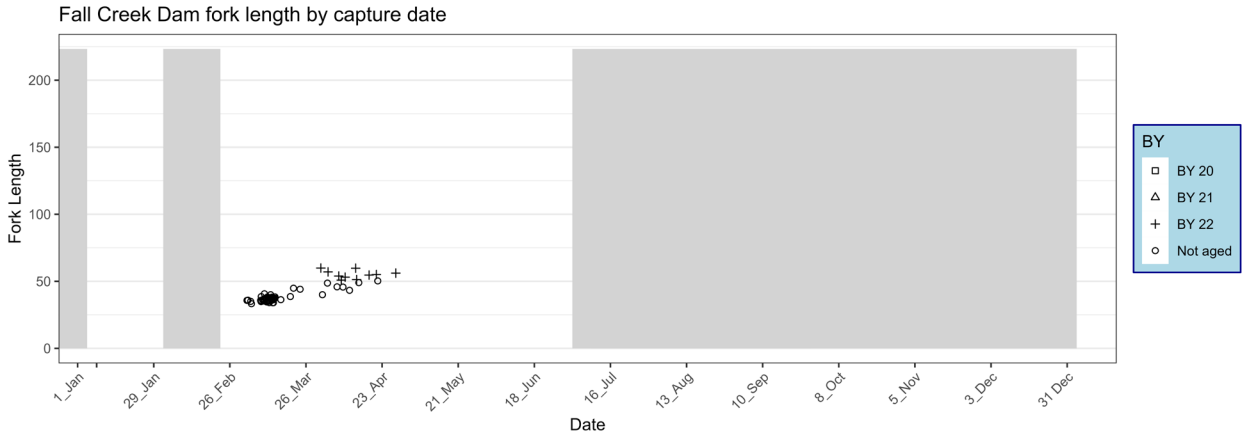

Figure 31. Length-frequency of juvenile Chinook salmon at the Fall Creek Dam Tailrace site for January 1, 2023, through July 15, 2023.

Injury Data

In total, 12 juvenile Chinook salmon (19.7% 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% and fin damage.

Comparatively, juvenile Chinook salmon that were of 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 38).

There were 2 (3.3% of total Chinook salmon catch) mortalities at the time of trap check. A summary of injuries by type is shown in Table 38.

Table 38. Percentage of juvenile Chinook salmon and PIT tagged Chinook salmon displaying injury by type at the Fall Creek Tailrace site January 1, 2023, through July 15, 2023.

Injury Code	Chinook Injuries (NOR) (n=61)	Chinook Injuries (PIT tagged bulk mark release recaptures) (n=435)
NXI	82.0%	0.0%
MUNK	0.0%	0.0%
DS<2	6.6%	72.6%
DS>2	0.0%	26.9%
BLO	1.6%	2.5%
EYB	3.3%	1.4%
BVT	1.6%	1.4%
FVB	0.0%	10.1%
GBD	3.3%	1.4%
POP	0.0%	0.5%
HIN	3.3%	1.4%
OPD	1.6%	12.6%
TEA	1.6%	0.5%
BRU	1.6%	1.6%
HBP	1.6%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	6.6%	99.5%
PRD	0.0%	0.0%

Injury Code	Chinook Injuries (NOR) (n=61)	Chinook Injuries (PIT tagged bulk mark release recaptures) (n=435)
COP	0.0%	6.9%
BKD	0.0%	0.0%
FUN	0.0%	0.7%

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 58 Chinook salmon were held in 2023 (Table 38). One Chinook salmon died during hold (1.7%).

Table 39. Summary of 24-hour trials for fish captured in the RST at the Fall Creek Dam Tailrace site from January 1, 2023, through July 15, 2023.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
3/1/2023–3/15/2023	Chinook	33	0	100%
3/16/2023–3/31/2023	Chinook	9	0	100%
4/1/2023–4/15/2023	Chinook	10	1	90%
4/16/2023–4/30/2023	Chinook	6	0	100%

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.

Non-Target Capture Data

The Fall Creek Dam Tailrace trap captured 406 non-target fish in addition to natural origin juvenile Chinook salmon. A summary of species and numbers of fish caught is provided in Table 40. The most commonly captured non-target species were dace and *O. mykiss*.

Table 40. Summary of non-target fish catch at the Fall Creek Dam Tailrace RST from January 1, 2023, through July 15, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Brook Lamprey	15	0
Brown Bullhead	36	11
Cutthroat Trout	26	0
Dace	138	8
Largescale Sucker	11	3
Northern Pikeminnow	1	0
O. mykiss	141	5
O. mykiss (clipped)	16	1
Pacific Lamprey	1	0
Lamprey	15	0
Sculpin	6	0
Totals	406	28

Fall Creek Head of Reservoir

The trap at the Fall Creek Head of Reservoir site was installed on January 18, 2023, and began sampling the same day. EAS began monitoring the single 8-foot RST from January 1, 2023, to May 31, 2023. Additional information regarding trap sample dates and outages can be found in Appendix B.

Trapping Efficiency Trials

A total of four TE trials occurred using hatchery reared Chinook salmon at the Fall Creek Head of Reservoir site in 2023. Due to limitations in the availability of BY 2021 and 2022 hatchery Chinook salmon, EAS was unable to test the efficiency of the RST to the extent previously planned. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 41. TEs ranged from 0.5% to 3.1%. Passage estimates are based on the average of successful trials (n=3) and 95% CIs are estimated from the standard deviations. However, given the small sample size 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. Plots displaying TE and flow for all successful trials are displayed in Appendix E.

Table 41. Summary table of marked hatchery Chinook salmon releases at Fall Creek Head of Reservoir Site for trapping efficiency.

Release Location	Date of Release	Gauge Height at Release (ft)	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Fall Creek Head of Reservoir	5/5/2023	3.82	756	15	2.0%
Fall Creek Head of Reservoir	5/10/2023	3.78	750	23	3.1%
Fall Creek Head of Reservoir	5/18/2023	3.51	511	7	1.4%
Fall Creek Head of Reservoir	5/24/2023	3.28	760	4	0.5%

Run of River Trapping Efficiency Trials

A total of 35 Chinook salmon were VIE marked and released for ROR TE trials in 2023. One fish was recaptured in the 8-foot trap. A summary of ROR TE trials by month is provided in Table 42.

Table 42. Summary table of run of river releases at the Fall Creek Dam Head of Reservoir site for trapping efficiency for January 1, 2023, through May 31, 2023.

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

Target Catch and Passage Timing

The trap at Fall Creek Head of Reservoir captured 148 juvenile Chinook salmon (Figure 32). Peak passage of Chinook salmon entering Fall Creek Reservoir occurred in March (n= 96, 64.9% of total catch). Scale samples show that fish captured at this site consisted entirely of BY 2022 sub-yearlings (Figure 33). Absence of BY 2021 catch above and below Fall Creek Reservoir in 2022 and 2023 suggests a year-class failure occurred (EAS 2023). Capture of yearling fish in the spring period above Fall Creek Reservoir usually accounted for about 1% of total catch for the site annually (Keefer et al. 2012). Prior study above Fall Creek Reservoir found that most fish migrated into the reservoir December through the early summer months. Our observations are consistent with past monitoring efforts. We estimate that 7,100 (95% CI: 4,883 to 13,010) Chinook salmon migrated past the sample site into Fall Creek Reservoir during the sampling period (Figure 32). A summary of fork lengths and weight data is provided in Table 43.

In calendar year 2022, a total of 139 adult Chinook were out planted above Fall Creek Reservoir. Sub-yearling Chinook catch in 2023 was approximately a third of that observed from sampling in 2021 (CFS 2023) and no sub-yearlings were observed during sampling in 2022 suggesting that adult outplants in 2022 had higher spawning success than those in 2021. A total of 119 adult Chinook were out planted in 2023 and spawning ground surveys, which were limited due to wildfires in the basin, suggest that spawning success for this group was very low.

Table 43. Summary of fork length and weight observed on juvenile Chinook salmon at the Fall Creek Head of Reservoir 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	1/1/2023–5/31/2023	22	148	36.7	31	86	34	N/A	N/A	N/A	N/A

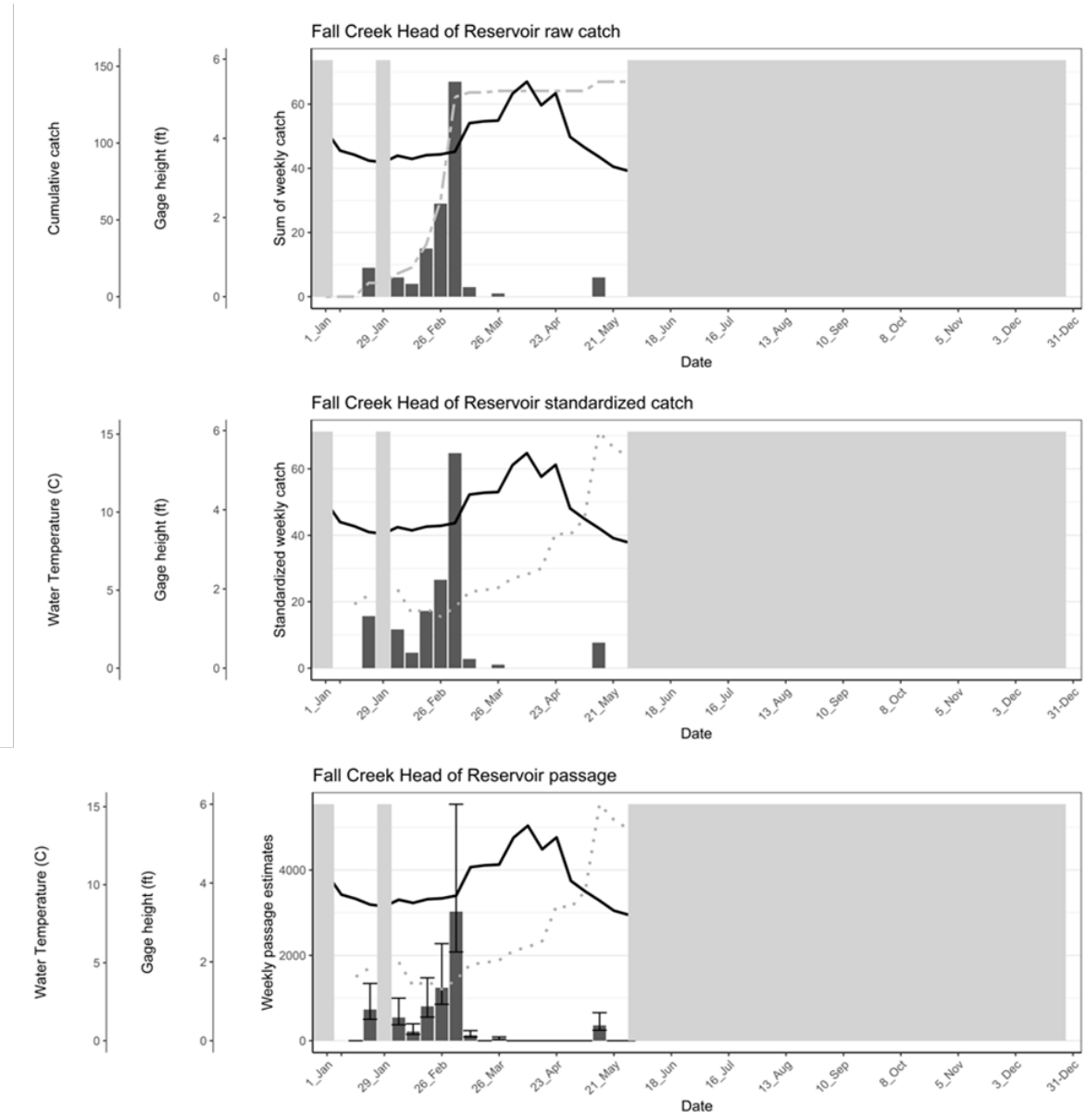

Figure 32. Raw catch (top panel), weekly standardized catch (middle panel), and weekly passage estimates (bottom panel) of natural origin juvenile Chinook salmon at the Fall Creek Head of Reservoir site with stream flow (black line), cumulative catch (gray dashed line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, through May 31, 2023.

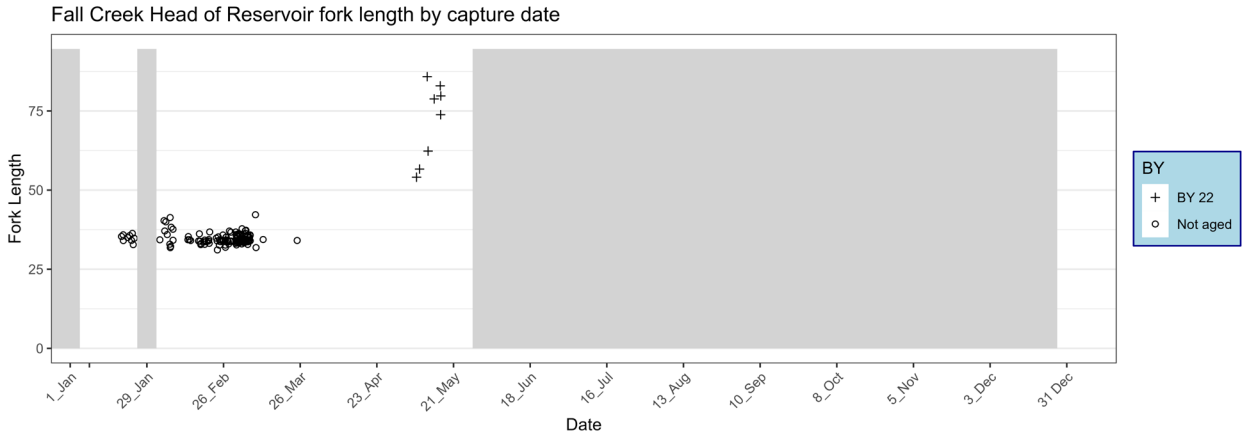

Figure 33. Length-Frequency of juvenile Chinook salmon at Fall Creek Head of Reservoir from January 1, 2023, through May 31, 2023.

Injury Data

A total of eight juvenile Chinook salmon (5.4% of total Chinook salmon capture) captured at the Fall Creek Head of Reservoir site displayed injuries at the time of capture. These injuries were likely the result of contact with debris or trap surfaces upon capture. The predominant injuries encountered within these juvenile Chinook salmon were descaling less than 20%, descaling greater than 20% and fin damage (Table 44).

A total of five Chinook salmon (3.4%) were dead at the time of trap check and were associated with periods of high debris. No Chinook salmon were observed with copepods at the Fall Creek Head of Reservoir site in 2023. A summary of injuries at this site can be found in Table 44.

Table 44. Percentage of juvenile Chinook salmon displaying injury by type at the Fall Creek Head of Reservoir RST site.

Injury Code	Chinook Injuries (NOR) (n=148)
NXI	94.6%
MUNK	0.0%
DS<2	2.7%
DS>2	1.4%
BLO	0.7%
EYB	0.0%
BVT	0.0%
FVB	0.0%
GBD	0.0%
POP	0.7%
HIN	0.7%
OPD	0.0%
TEA	1.4%
BRU	0.7%
HBP	0.7%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	2.7%
PRD	0.0%
COP	0.0%
BKD	0.0%
FUN	0.0%

PIT Tagged/VIE Marked fish and Downstream Detections

A total of four NOR fish were PIT tagged at the Fall Creek Head of Reservoir site in 2023. As of December 31, 2023, none of the PIT tagged fish were redetected at downstream sites. A total of 46 NOR Chinook salmon were captured and VIE marked at the Fall Creek Head of Reservoir site in 2023. All other fish captured were either sac-fry or determined too small to mark. No VIE marked fish were redetected downstream at the Fall Creek Dam site. A summary of VIE marked Chinook salmon by month at this site is provided in Table 45. Further information on tagged and VIE marked fish at this site is available in Appendix C.

Table 45. Summary of VIE marked Chinook salmon at the Cougar Dam Head of Reservoir site from 2023.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured to Date
January 2023	Left Dorsal	Blue	6	0
February 2023	Right Dorsal	Yellow	4	0
March 2023	Right Dorsal	Red	33	0
May 2023	Right Dorsal	Orange	3	0

Non-Target Capture Data

The Fall Creek Head of Reservoir trap captured 829 non-target fish in addition to natural origin juvenile Chinook salmon. The most commonly captured non-target species were dace and *O. mykiss*. A summary of species and numbers of fish caught are provided in Table 46.

Table 46. Summary of non-target fish catch at the Fall Creek Head of Reservoir RST.

Species	Season Total	Season Total Mortality (subset of total)
Brook Lamprey	37	1
Cutthroat Trout	69	0
Dace	115	1
Largescale Sucker	9	0
O. mykiss	477	0
O. mykiss (clipped)	47	0
Pacific Lamprey	11	0
Sculpin	1	1
Unknown Lamprey	63	0
Totals	829	3

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

Dexter Dam Tailrace

Monitoring of a single 5-foot RST in the Dexter Dam Tailrace began on March 7, 2022. EAS sampled the RST from January 1, 2023, through December 15, 2023. Sampling from December 16, 2023, through the end of the year is reported 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. 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 after December 16, 2023, were performed by EAS for the USACE under contract W9127N19D0009. 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 two 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 47. Summary table of marked hatchery Chinook salmon releases at Dexter Dam Tailrace for trapping efficiency January 1 through December 15, 2023.

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

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 54 juvenile Chinook salmon in 2023 (Figure 34). Chinook salmon catch below Dexter Dam in the spring was composed of BY 2021 yearlings (n=15, 75% of spring catch) and BY 2022 sub-yearlings (n=5, 25%) (Figure 36). Peak capture of juvenile Chinook salmon leaving Dexter Reservoir in the spring occurred in May (n= 15, 75%). 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. Peak spring capture at Dexter Dam shows an association with the concurrent surface spill events at Lookout and Dexter Dams (Figures 34 and 35).

Fall capture of Chinook salmon consisted of 34 individuals. Eight Chinook salmon were from BY 2021 (23.5% of fall capture) and 26 BY 2022 (76.5%) Chinook salmon. Peak fall capture at Dexter Dam shows an association with the concurrent spill events at Lookout and Dexter Dams (Figure 35) similar to results observed during previous sampling efforts in 2022 (EAS 2023). A summary of fork lengths and weights for Chinook salmon captured at Dexter Dam by BY is provided in Table 48. Applying TE data, we estimate that 7,376 (95% CI: 5,326 to 23,065) juvenile Chinook salmon passed through Dexter Dam during monitoring in 2023.

Table 48. Summary of fork length and weight observed on juvenile Chinook salmon at the Fall Creek Head of Reservoir 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	21	8	169.1	118	206	167	67.4	23.0	121.7	55.6
Chinook	7/1/2023–12/15/2023	22	26	106.6	84	135	103.5	13.0	5.7	26.0	11.4

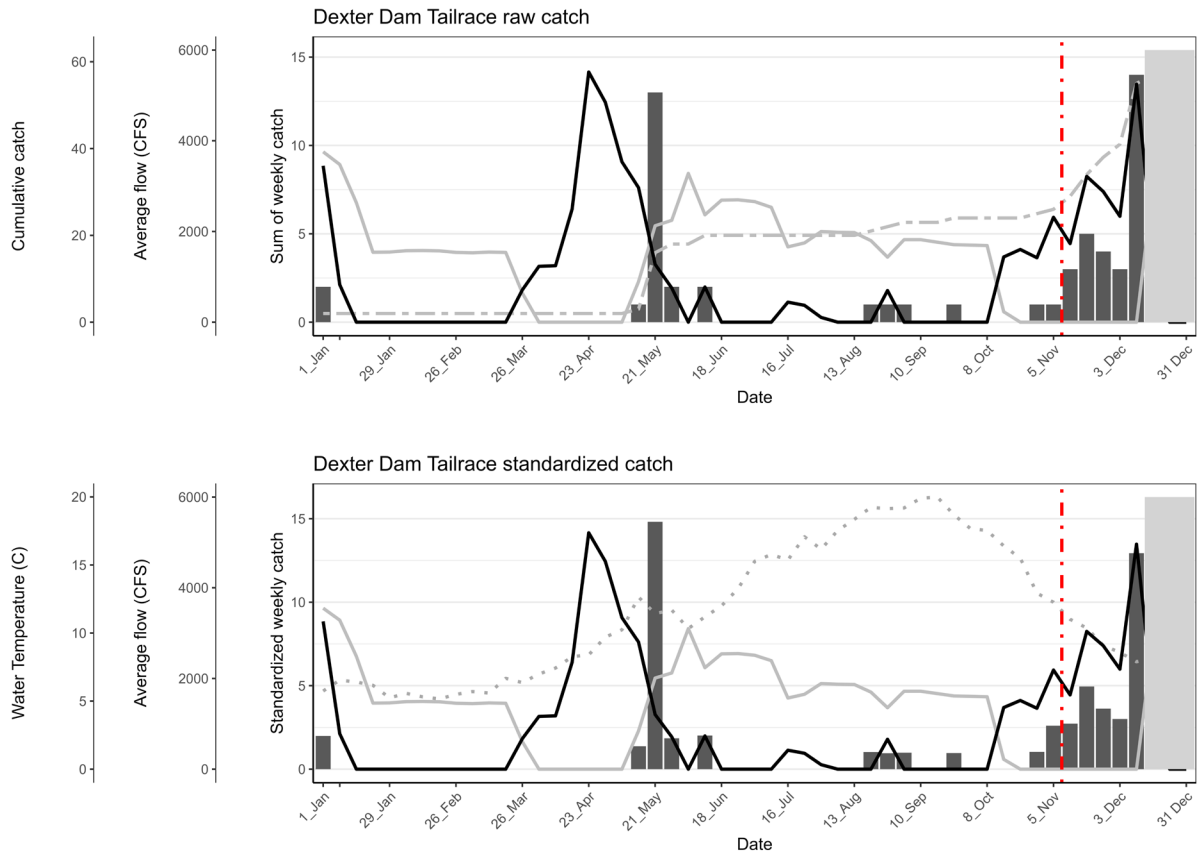

Figure 34. Raw catch Dexter Dam (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at the Dexter Dam Tailrace site with spill (black line), Powerhouse outflow (gray line), cumulative catch (gray dot dash line), forebay elevations (black dot dash line), and water temperature (gray dots) January 1, 2023, through December 15, 2023. The red dot dash line denotes when the trap was moved downstream to the new sampling location due to construction.

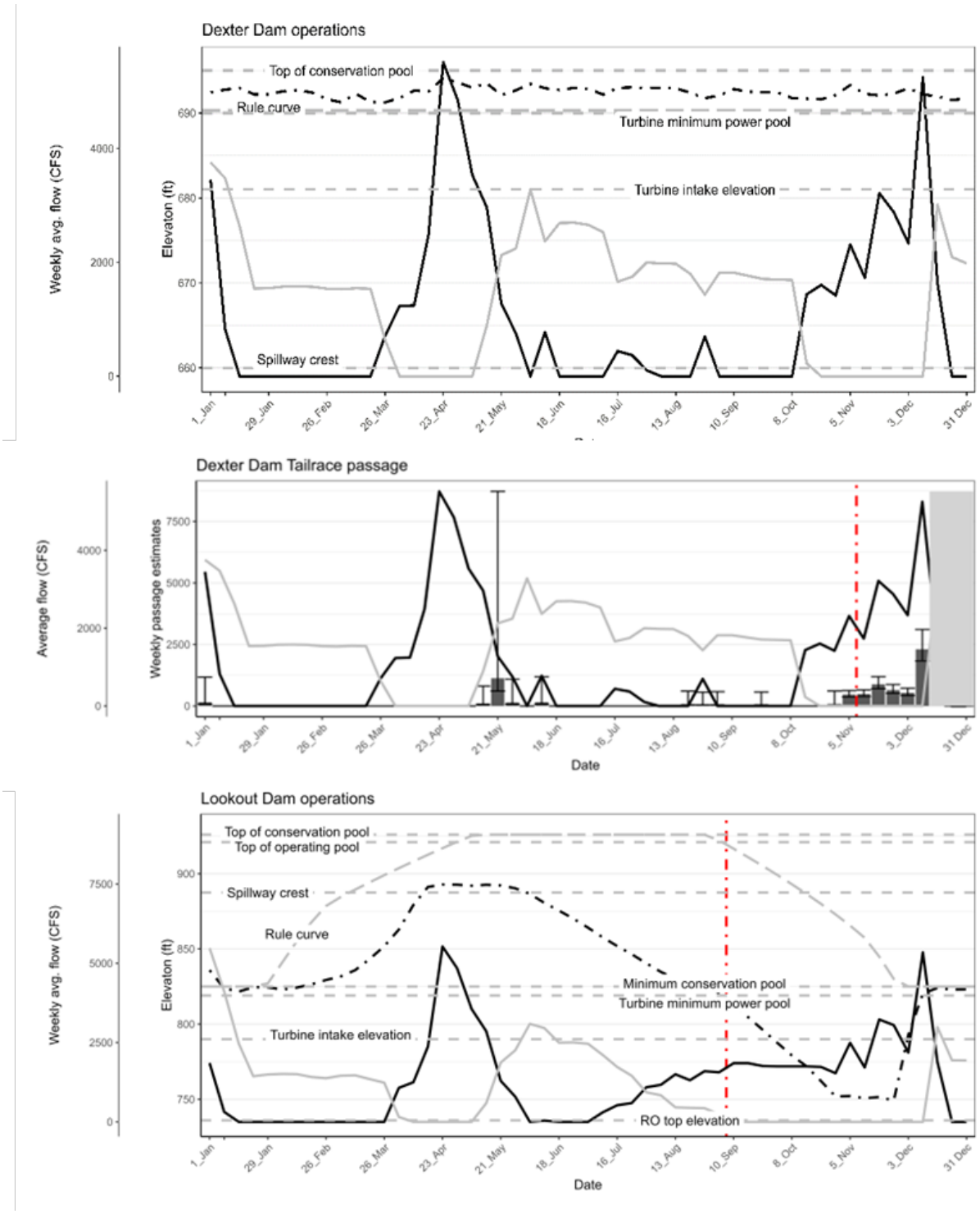

Figure 35. Dexter Dam operations and features of interest (top panel), Lookout Dam operations and features of interest (bottom panel), and weekly passage estimates with a 95% confidence interval for Chinook salmon (middle panel) at the Dexter Dam Tailrace site with spill (black line), Powerhouse outflow (gray line), cumulative catch (gray dot dash line), forebay elevations (black dot dash line), and water temperature (gray dots) January 1, 2023, through December 31, 2023. The red dot dash line denotes when the trap was moved downstream to the new sampling location due to construction.

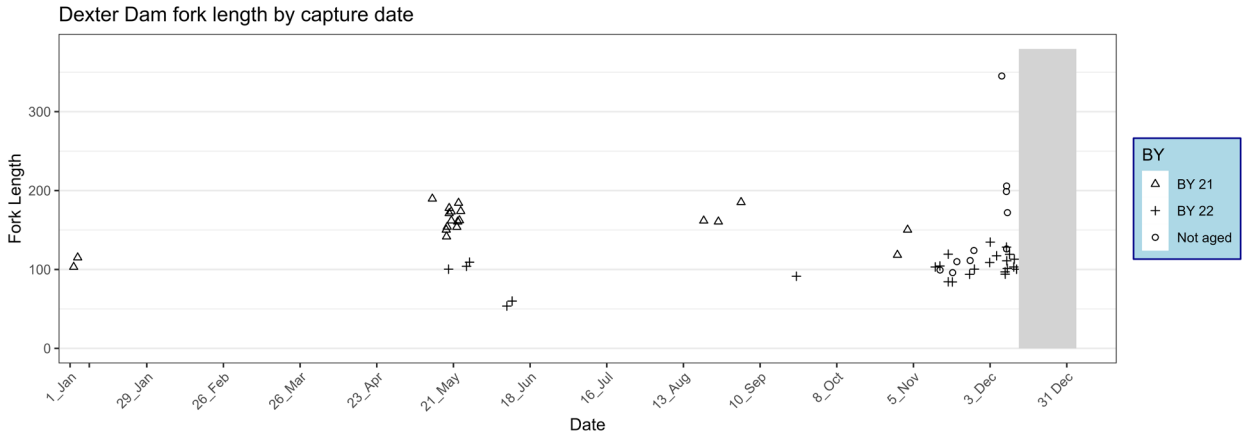

Figure 36. Length-frequency of juvenile Chinook salmon by BY at the Dexter Dam Tailrace site January 1, 2023, through December 15, 2023.

Injury Data

A total of 52 juvenile Chinook salmon (96.3% 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 (9.3% 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 associated with trap capture. The most common injuries observed at this site include descaling less than and greater than 20% and fin damage (Table 49). 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 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 52 individuals that displayed injury. This is a relatively small sample size to take into account and additional data will be collected in 2024.

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 49). Figure 33 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 34). It is likely that observations of gas bubble disease are higher for RST captured fish than those that are not captured in an RST as these fish are often captured and held in areas of higher dissolved gas. 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 were more likely to have no external injuries than those above 60 mm (Appendix D, Table D-6). 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 less than 20% and fin damage (Appendix D, Table D-6).

Table 49. Summary of injuries for Chinook salmon released for trapping efficiency fish, natural origin Chinook salmon, and PIT tagged bulk mark release Chinook salmon at Dexter Dam Tailrace January 1 through December 15, 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=800)	TE Recapture Injuries (proportion of total) (n=136)	Proportional Percent Change	Observed Chinook Injuries (n=37)	Bulk Marking Recapture Injuries (proportion of total) (n=20)
NXI	14.8%	9.6%	-5.1%	5.4%	0.0%
MUNK	0.0%	0.0%	0.0%	0.0%	0.0%
DS<2	74.4%	70.4%	-4.0%	51.4%	71.4%
DS>2	5.1%	17.8%	12.7%	37.8%	23.8%
BLO	0.0%	0.0%	0.0%	0.0%	0.0%
EYB	1.1%	0.7%	-0.4%	10.8%	9.5%
BVT	0.0%	0.0%	0.0%	2.7%	4.8%
FVB	1.6%	0.7%	-0.9%	5.4%	19.0%
GBD	0.0%	4.4%	4.4%	5.4%	28.6%
POP	0.1%	0.7%	0.6%	2.7%	4.8%
HIN	0.0%	0.0%	0.0%	0.0%	4.8%
OPD	0.5%	5.2%	4.7%	13.5%	23.8%
TEA	0.0%	2.2%	2.2%	10.8%	4.8%
BRU	0.9%	0.0%	-0.9%	5.4%	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	77.1%	81.5%	4.4%	73.0%	95.2%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	21.6%	28.6%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.3%	0.0%	-0.3%	0.0%	4.8%

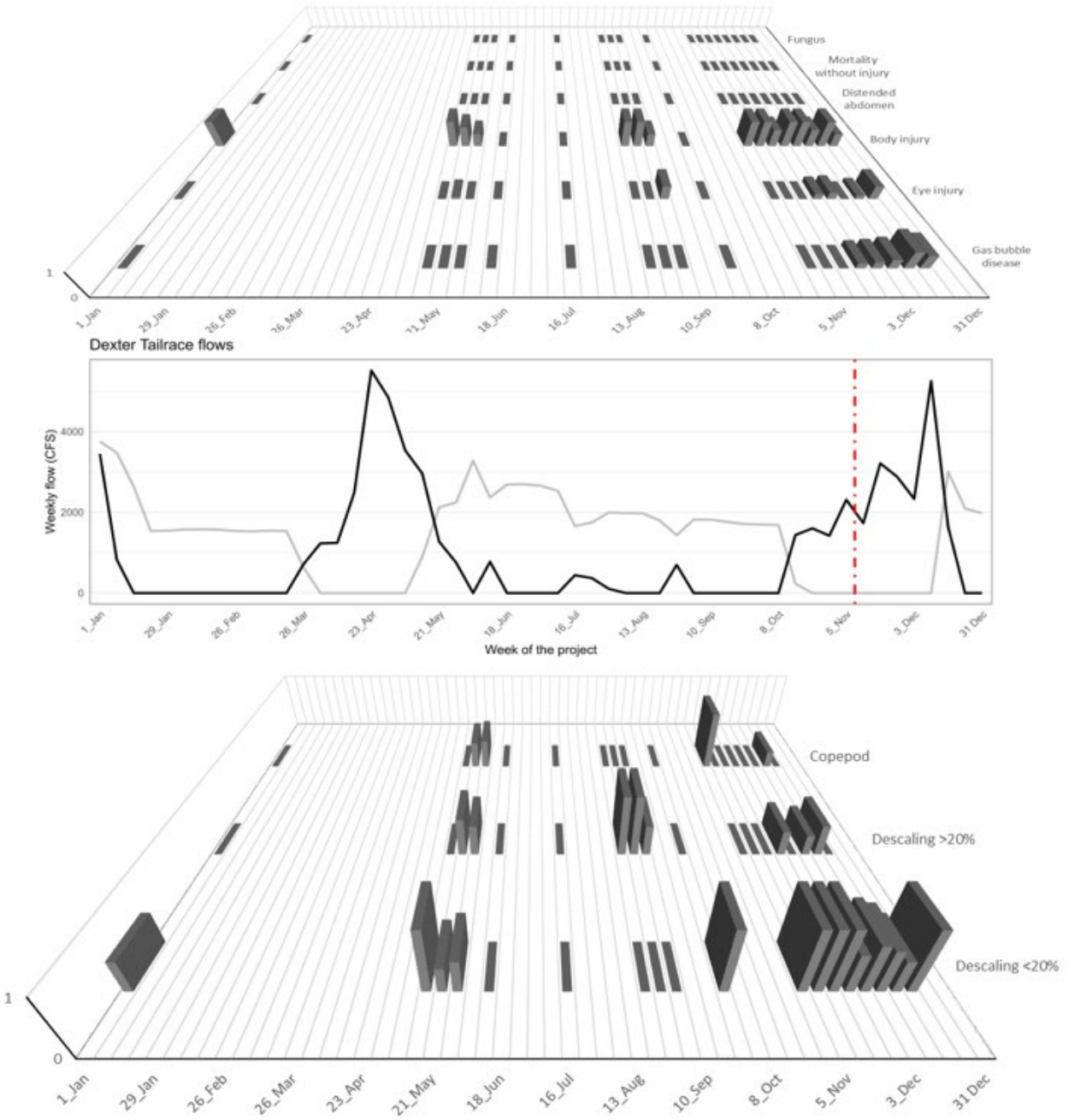

Figure 37. Proportion of captured juvenile Chinook salmon displaying descaling less or greater than 20% descaling (top panel), operations data from Dexter Dam Tailrace showing cfs of spill (black line) and Powerhouse flow (gray line) outflows (middle panel), and proportion of captured juvenile Chinook salmon displaying injuries by type (bottom panel) January 1, 2023, through December 15, 2023.

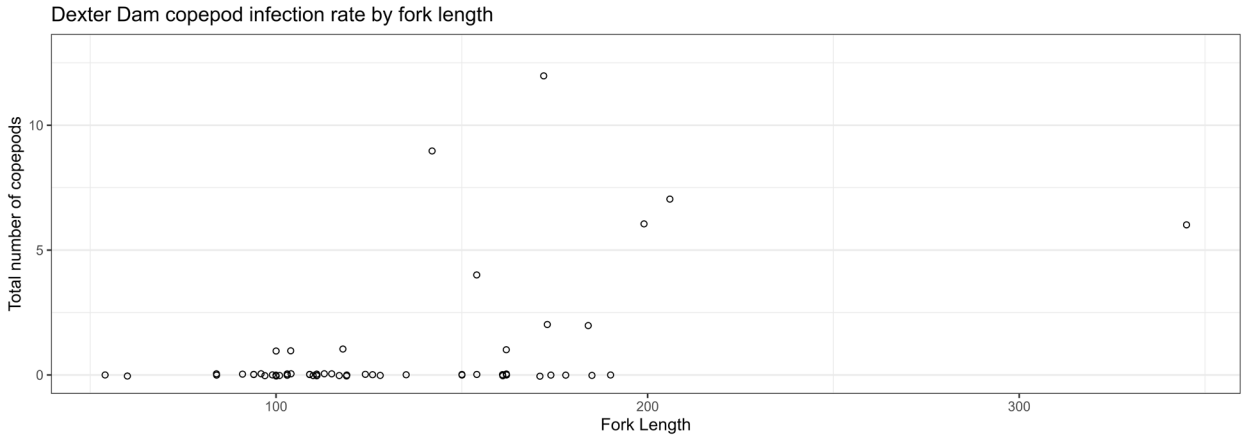

Figure 38. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Dexter Dam Tailrace from January 1, 2023, through December 15, 2023.

24-Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook salmon captured in the Dexter Dam Tailrace to assess delayed mortality from dam passage. Forty-nine Chinook salmon were held in 2023 (Table 50). A total of three Chinook salmon died during hold (6.1%).

Table 50 Summary of 24-hour hold trials for Chinook salmon captured in the RST at the Dexter Dam Tailrace site January 1 through December 15, 2023.

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
1/1/2023–1/15/2023	Chinook	2	0	100%
5/16/2023–5/31/2023	Chinook	15	0	100%
6/1/2023–6/15/2023	Chinook	1	0	100%
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%

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. Twenty of these fish were a part of Cramer Fish Science's bulk marked fish releases. One of these fish also had a suture mark indicating that it was an acoustic tagged fish from a passage study 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 Cramer Fish Sciences Bulk Mark Release and Reservoir Distribution Study Annual Report (CFS 2024).

Non-Target Capture Data

We captured 6,932 non-target fish in addition to natural origin juvenile Chinook salmon. A summary of species and numbers of fish caught are provided in Table 51. The most commonly captured non-target species were crappie, sculpin, and clipped Chinook salmon (escapees from the Dexter Fish Facility).

Table 51. Summary of non-target fish captured in the RST at the Dexter Dam Tailrace site January 1 through December 15, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	143	21
Chinook (clipped)	736	1
Chinook (adult)	2	2
Crappie	3,669	427
Cutthroat Throat	6	0
Dace	34	4
Largescale Sucker	8	2
O. mykiss	18	2
O. mykiss (clipped)	10	0
Redside Shiner	38	1
Sculpin	1,740	119
Smallmouth Bass	38	22
Brown Bullhead	1	0
Largemouth Bass	2	0
Mountain Whitefish	13	0
Northern Pikeminnow	27	0
Walleye	302	46
Unknown Bass	143	38
Unknown	2	0
Totals	6,932	685

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

Lookout Dam Tailrace

Monitoring in the Middle Fork Willamette River in the Lookout Dam Tailrace began on March 15, 2022. There are three 8-foot traps located in the tailrace below Lookout Dam, two in the channel downstream of the PH outlet that are referred to as PH1 and PH2, and one in the channel on the south side of the island that is referred to as the RO, or Spill trap. 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. EAS monitored the three RSTs from January 1, 2023, through July 31, 2023. Results from sampling efforts from August 1, 2023, through the end of the year can be found in the annual report for contract W9127N19D0009 (CFS 2024a). A summary of sampling outages at this site can be found in Appendix B.

Trapping Efficiency Trials

A total of five TE trials occurred using hatchery reared Chinook salmon at the Lookout Dam Tailrace site for this contract in 2023. A total of 13 trials have been performed by EAS at this site since 2022. A summary of fish release numbers, recaptures, and flow level for the trials are provided in Table 52.

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.

P 1 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 PH1 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 52. Summary of trapping efficiency trials below Lookout Point Dam from January 1 through July 31, 2023.

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

Run of River Trapping Efficiency Trials

No TE trials using run of river 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 49 juvenile Chinook salmon were captured in the Lookout Dam Tailrace during the 2023 sampling period, 27 in the PH traps (55.1% of total catch, 15 in PH1, 12 in PH2) (Figures 39 and 40) and 22 in the Spill trap (44.9% of total catch) (Figure 41). Date of capture for 33 of the 49 Chinook salmon occurred between April 21, 2023, and May 31, 2023. In January, Chinook salmon capture comprised individuals from BY 2020 and 2021, while catch for the rest of the period comprised BY 2020, 2021, and 2022 fish (Figure 42). BY 2021 yearlings comprised a majority of the total Chinook salmon catch (n=32, 65.3%). The first BY

2022 sub-yearling was captured on March 28, 2023. A total of 12 sub-yearlings were captured between January 1, 2023, and July 31, 2023.

Our trapping rate in the Lookout Dam Tailrace was approximately 0.3 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 (CFS 2023; 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, 1,142, and 71, respectively.

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). Catch below Lookout Point Dam in the spring of 2023 coincided with surface spill events in the late spring and early summer, in concurrence with previous study's conclusions (Figures 39 through 41). A summary of fork lengths and weights for Chinook salmon captured at Lookout Point Dam by BY is provided in Table 53. For raw weekly catch of Chinook at the Lookout Dam RST sites for sampling from 2021 to 2023, please refer to Appendix I.

Table 53. Summary of fork length and weight observed on juvenile Chinook salmon 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

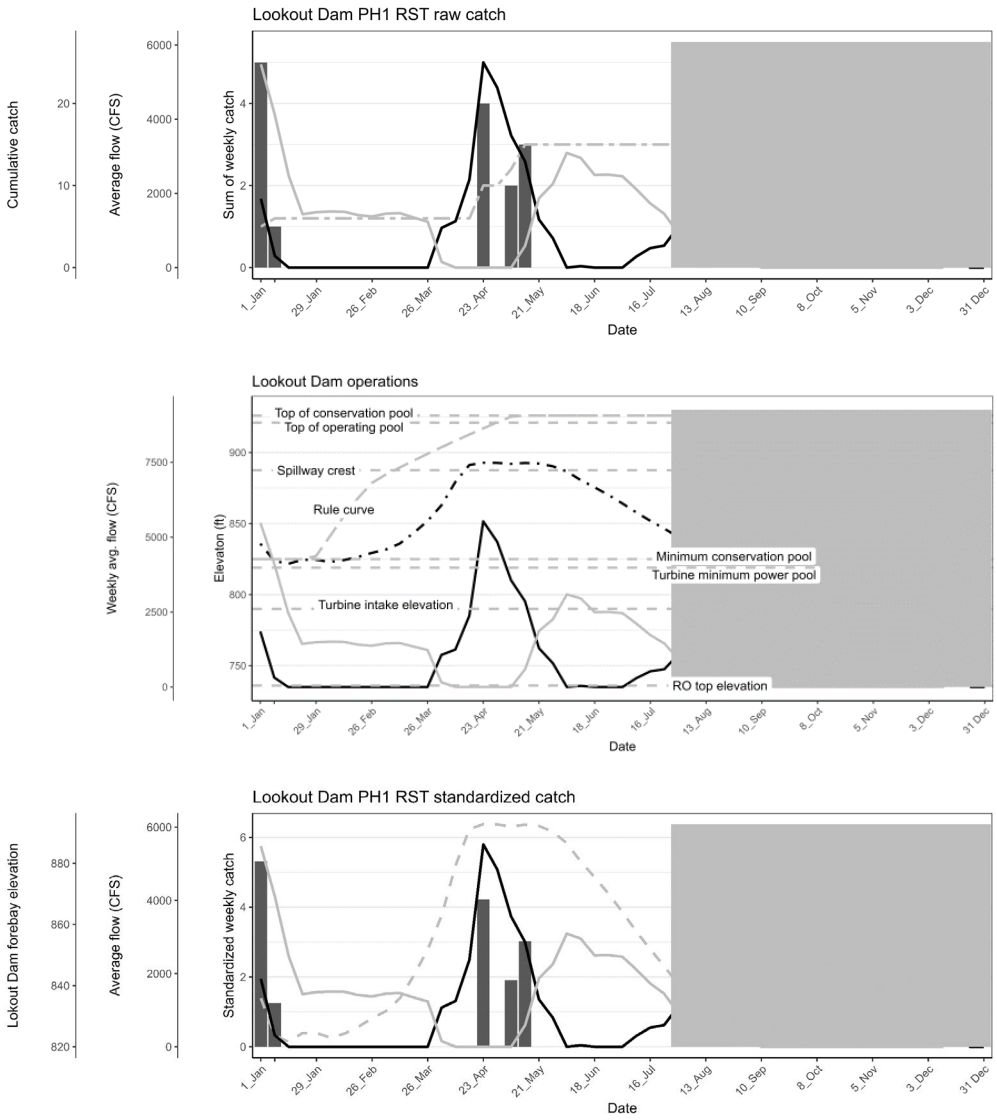

Figure 39. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at Lookout Point Dam Tailrace PH1 trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line cumulative catch (gray dot dash line) from January 1, 2023, through July 31, 2023.

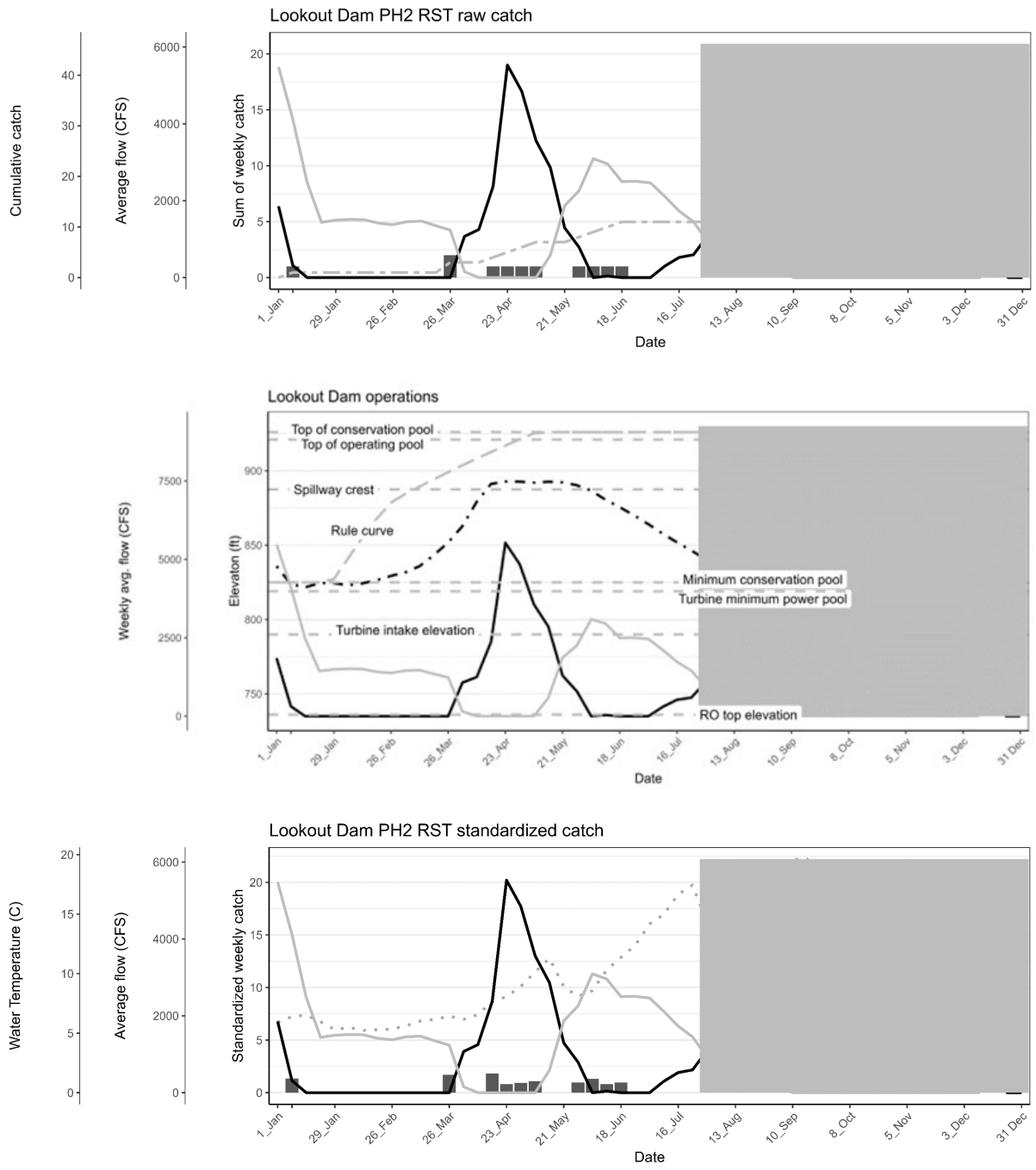

Figure 40. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at Lookout Dam Tailrace PH2 trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) from January 1, 2023, through July 31, 2023.

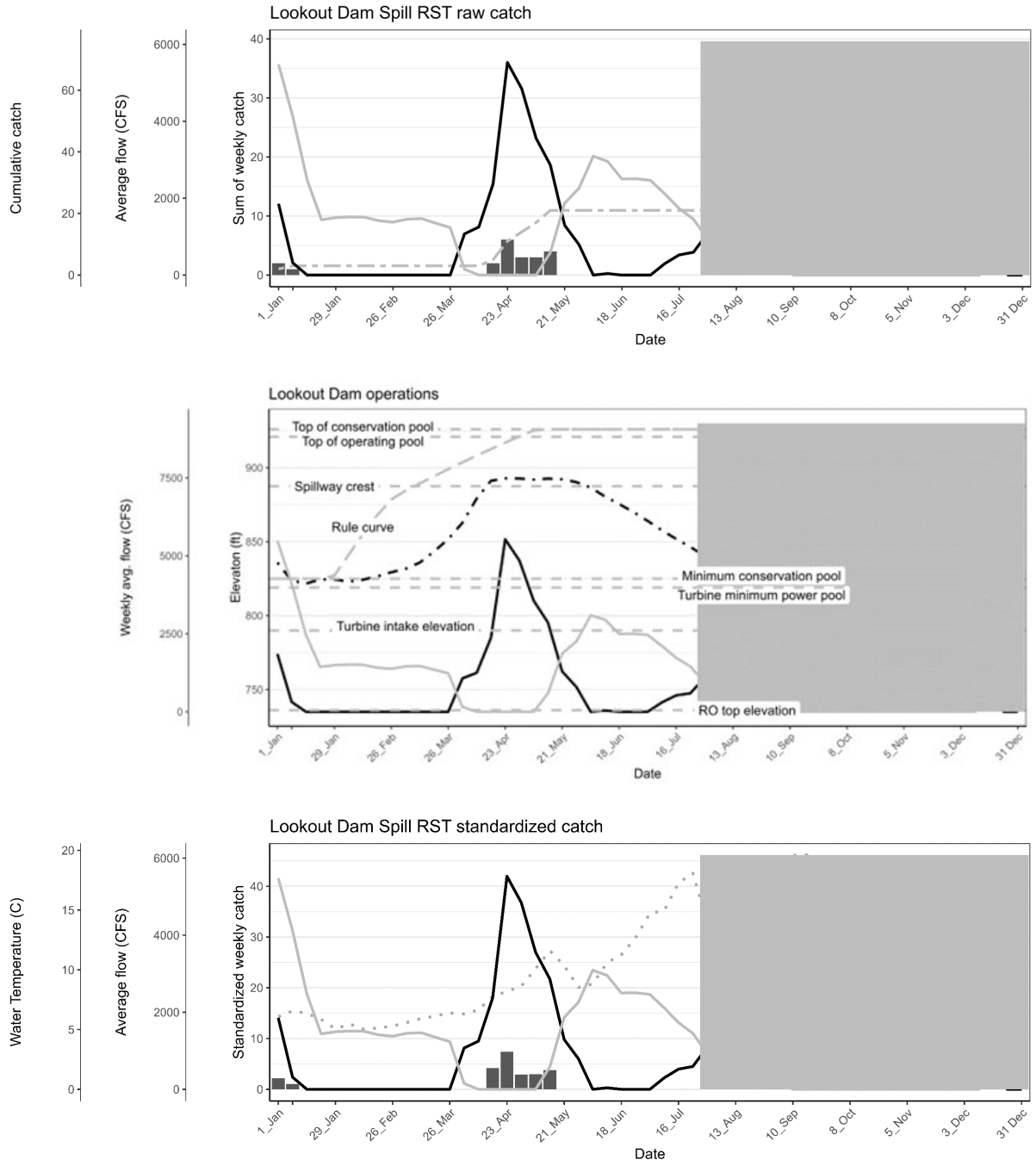

Figure 41. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook salmon at Lookout Dam Tailrace Spill trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) from January 1, 2023, through July 31, 2023.

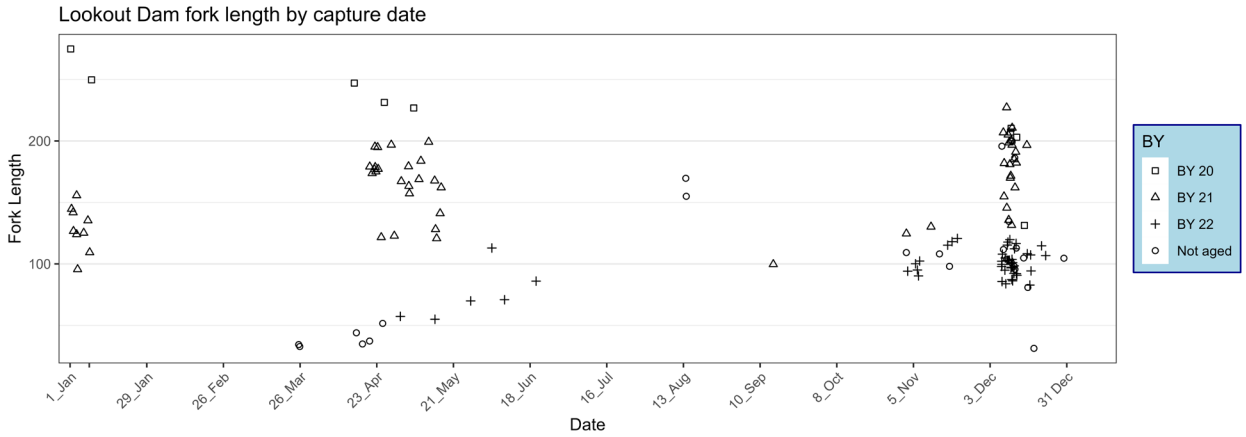

Figure 42. Length-frequency analysis for age of juvenile Chinook salmon captured below Lookout Point Dam from January 1, 2023, through July 31, 2023.

Injury Data

A total of 45 Chinook salmon (91.8% 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 eight juvenile Chinook salmon (16.3% of total Chinook salmon catch) were dead at the time of trap check (three in PH1, two in PH2, and three in Spill). The most common injuries observed at this site include descaling less than 20%, descaling greater than 20%, and fin damage (Table 54).

Figure 43 shows the proportion of captured Chinook salmon 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 2022; Monzyk et al. 2015). However, this correlation is not as strong as those seen in other basins (Figure 44). No bulk marked PIT tagged fish were captured during the report period. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

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

Table 54. Summary of observed injuries on natural origin juvenile Chinook salmon captured in the Lookout Dam Tailrace from January 1 through July 31, 2023.

Injury Code	Chinook Injuries (NOR) (n=49)
NXI	8.2%
MUNK	0.0%
DS<2	40.8%
DS>2	40.8%
BLO	0.0%
EYB	12.2%
BVT	6.1%
FVB	30.6%
GBD	26.5%
POP	0.0%
HIN	18.4%
OPD	10.2%
TEA	14.3%
BRU	16.3%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	77.6%
PRD	0.0%
COP	36.7%
BKD	0.0%
FUN	2.0%

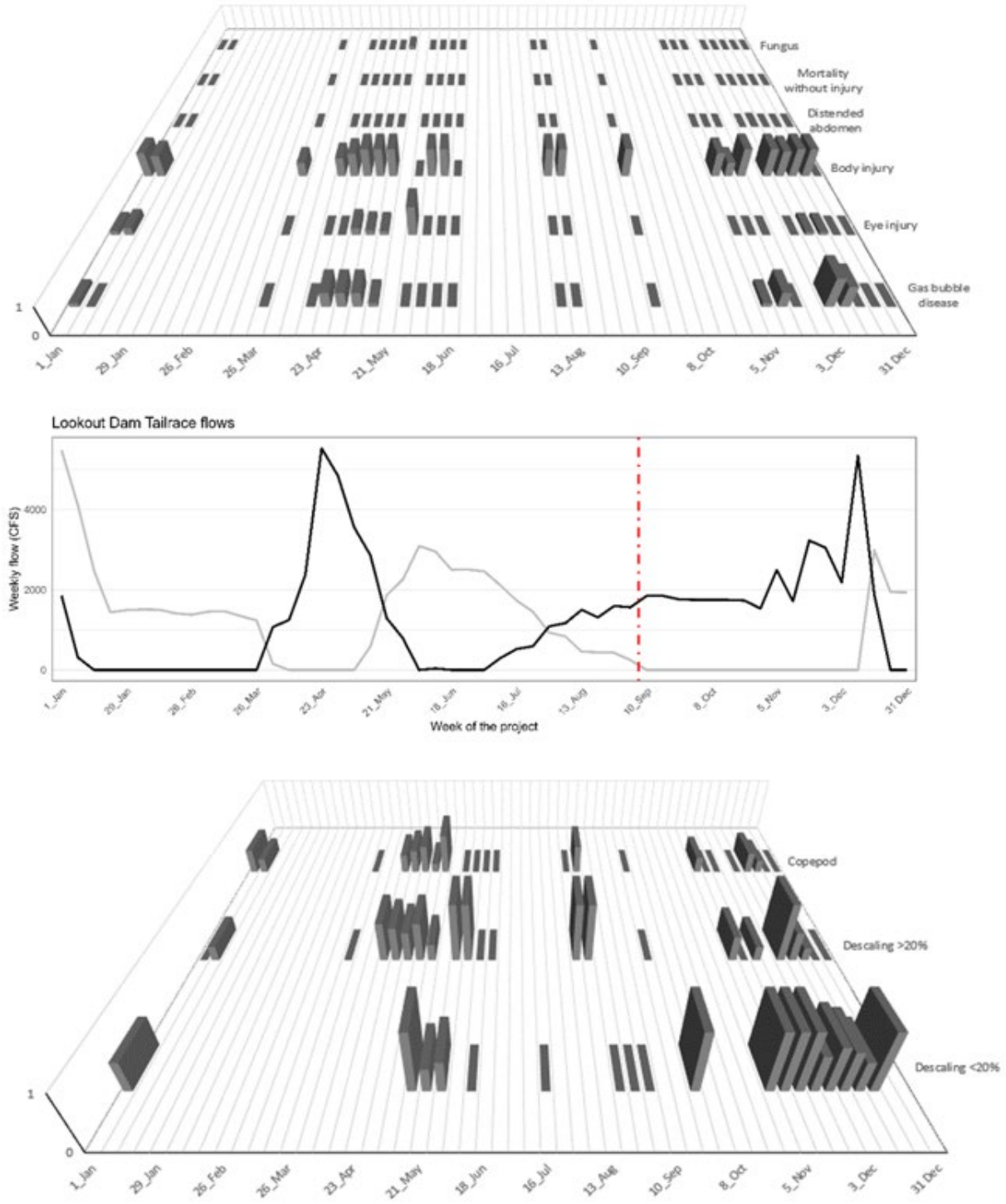

Figure 43. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data from the Lookout Dam Tailrace showing cfs of spill (black line) and Powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook salmon displaying descaling injuries and copepod presence (bottom panel) from January 1, 2023, through July 31, 2023.

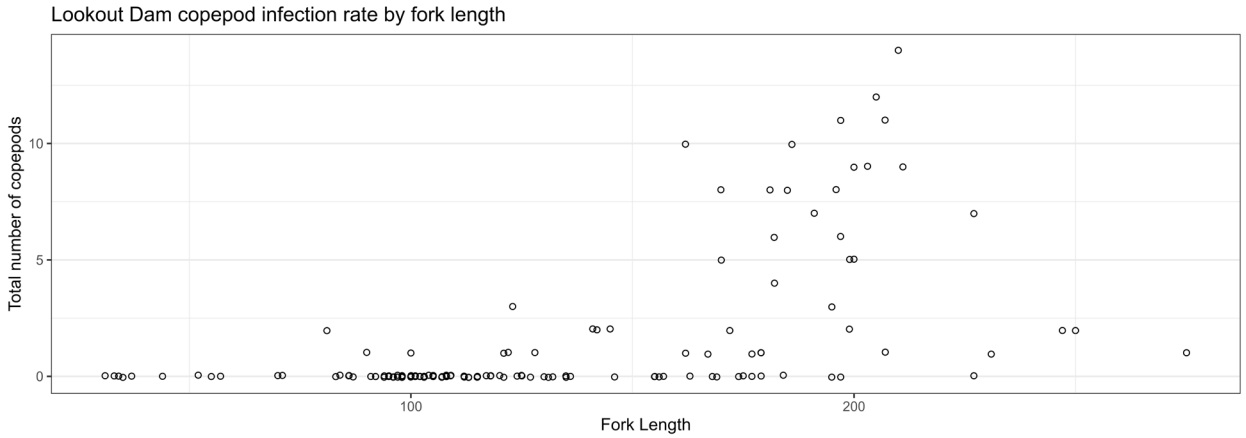

Figure 44. Copepod prevalence vs fork length on juvenile Chinook salmon captured below Lookout Point Dam from January 1, 2023, through July 31, 2023.

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 41 fish, 19 from the Spill and 22 from the Powerhouse traps, were held (Table 55). A total of 10 fish died during hold (24.4%), 5 of the 19 Spill Chinook salmon (26.3%) and 5 of the 22 Powerhouse Chinook salmon (22.7%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100%.

Table 55. Summary of 24-hour hold trials for Chinook salmon captured in the RSTs at the Lookout Dam Tailrace sites from January 1 through July 31, 2023.

Hold Period	Route	Number of Fish Held	Mortalities	% Survived
1/16/2023–1/31/2023	PH	6	0	100%
1/16/2023–1/31/2023	Spill	3	0	100%
3/16/2023–3/31/2023	PH	2	0	100%
4/16/2023–4/30/2023	PH	5	0	100%
4/16/2023–4/30/2023	Spill	8	3	62.5%
5/1/2023–5/15/2023	PH	3	2	33.3%
5/1/2023–5/15/2023	Spill	7	2	71.4%
5/16/2023–5/31/2023	PH	3	1	66.7%
5/16/2023–5/31/2023	Spill	1	0	100%
6/1/2023–6/15/2023	PH	2	1	50.0%
6/16/2023–6/30/2023	PH	1	1	0%

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

No PIT tagged Chinook salmon were encountered at Lookout Point Dam during this sampling period.

Non-Target Species

A total of 172,931 non-target fish were captured in the RSTs below Lookout Point Dam between January 1, 2023, and July 31, 2023 (Table 56). The most common non-target species encountered were crappie and 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 56. Summary of non-target fish capture below Lookout Point Dam.

Species	Season Total	Season Total Mortality (subset of total)
Largemouth Bass	23	23
Bass Unknown	17,825	16,779
Bluegill	59	11
Brown Bullhead	3	2
Chinook (clipped)	60	3
Crappie	154,652	109,656
Largescale Sucker	6	4
Northern Pikeminnow	4	3
O. mykiss	7	1
Pumpkinseed	1	0
Redside Shiner	1	0
Sculpin	133	8
Smallmouth Bass	114	108
Spotted Bass	1	0
Unknown	7	7
Walleye	35	8
Totals	172,931	126,613

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

Lookout Point Head of Reservoir – Middle Fork Willamette River

Monitoring of a single 5-foot RST in the Middle Fork Willamette River above Lookout Point Reservoir began on March 10, 2022. EAS monitored the RST from January 1, 2023, through December 15, 2023. Results from monitoring after December 15, 2023, can be found in the report for contract W9127N19D0009 (CFS 2024a). The trap did not sample from March 16, 2023, through 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 11 TE trials occurred using hatchery reared Chinook salmon at the Lookout Point Head of Reservoir site for this contract in 2023. Collectively, a total of 19 trials have occurred here since monitoring began in 2022. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 57.

Trapping efficiencies 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 that 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. Trap efficiency pooled (restricted to successful trials due to possible predation) average of nine 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 trap efficiency 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 57. Summary of trapping efficiency trials in the Middle Fork Willamette above Lookout Point Dam in 2023.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
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	0.7%
Lookout Point Head of Reservoir	6/29/2023	1,340	769	2	0.3%
Lookout Point Head of Reservoir	7/19/2023	1,180	765	0	0.0%
Lookout Point Head of Reservoir	8/22/2023	1,470	677	13	1.9%
Lookout Point Head of Reservoir	8/31/2023	1,660	751	0	0.0%
Lookout Point Head of Reservoir	9/20/2023	776	787	1	0.1%
Lookout Point Head of Reservoir	10/26/2023	1,190	755	0	0.0%
Lookout Point Head of Reservoir	11/15/2023	1,630	755	3	0.4%
Lookout Point Head of Reservoir	11/29/2023	3,020	760	2	0.3%

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 137 juvenile Chinook salmon. Peak capture of juvenile Chinook salmon entering Lookout Point Reservoir occurred in May (n= 46, 33.6%). 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. Figure 45 shows raw and standardized catch overlayed with flow at the Lookout Point Head of Reservoir site. Chinook salmon catch in the spring consisted of two BY classes, BY 2021 yearlings (n= 5, 3.9% of spring capture) and BY 2022 sub-yearlings (n= 123, 96.1%). BY 2022 Chinook salmon were the dominant age class captured at this site throughout the sampling period (Figure 46). The first BY 2022 sub-yearling captured at the trap occurred on January 12, 2023.

Fall capture of Chinook salmon consisted of nine fish from BY 2022. The first fish in this group was captured on July 15, 2023, and the last on November 29, 2023. Capture in the fall did not appear to correlate with flow or stream temperature. We estimate that 5,869 (95% CI: 3,927 to 11,612) juvenile Chinook salmon passed the sampling site during monitoring in 2023 (Figure 45). A summary of fork lengths and weights for Chinook salmon captured at Lookout Point Head of Reservoir by BY is provided in Table 58.

Table 58. Summary of fork length and weight observed on juvenile Chinook salmon at the Lookout Point Head of Reservoir RST site by brood year from January 1, 2023, through December 15, 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	5	99.8	94	113	97	10.5	7.7	14.5	8.5
Chinook	1/1/2023–6/30/2023	22	123	46.4	30	93	42	N/A	N/A	N/A	N/A
Chinook	7/1/2023–12/15/2023	22	9	102.6	81	126	105	15.1	6.2	38.7	12.9

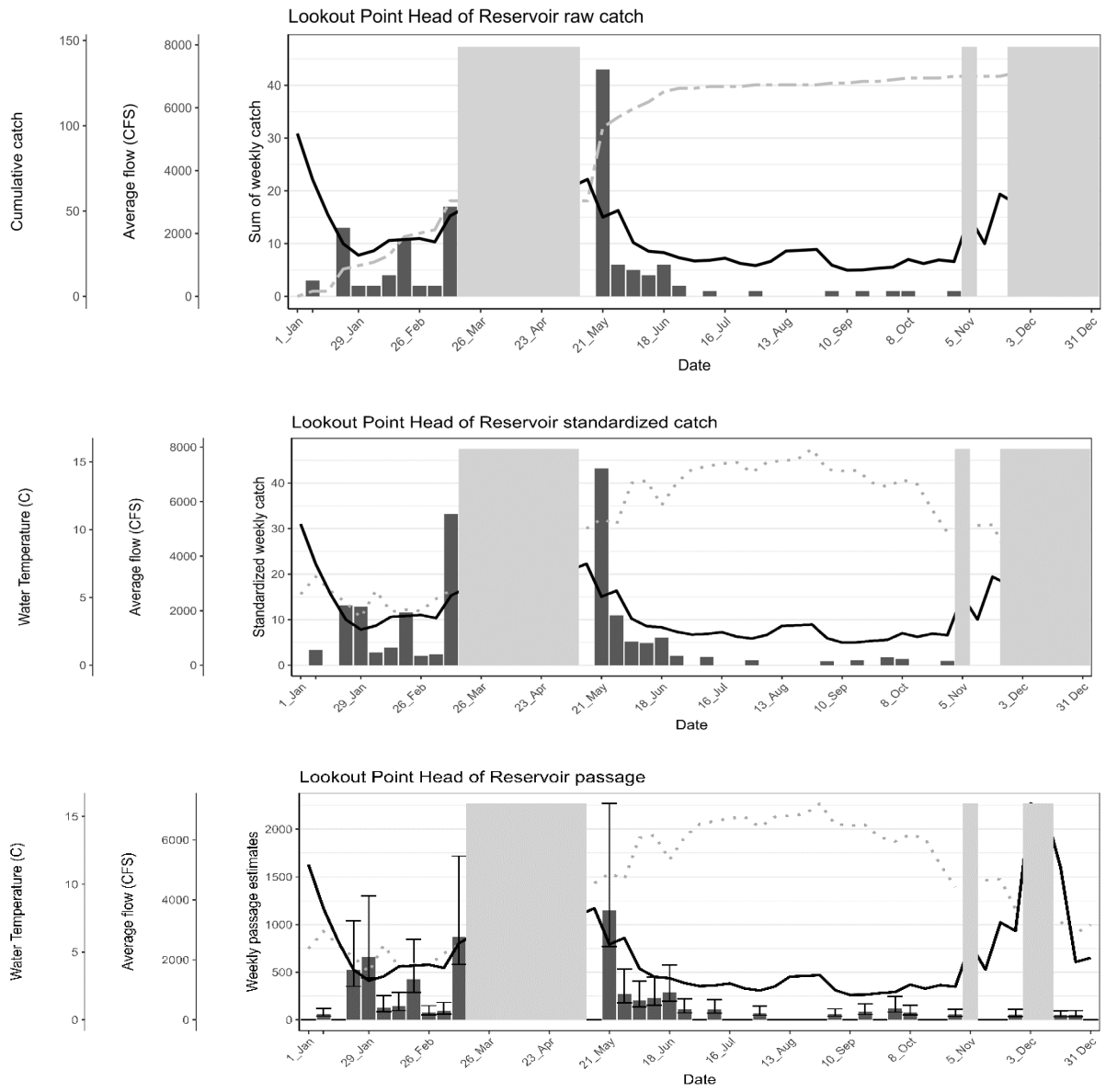

Figure 45. Raw catch (top panel), weekly standardized catch (middle panel), and weekly passage estimates (bottom panel) of natural origin juvenile Chinook salmon at the Lookout Point Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), stream temperature (gray dotted line), and non-sampling weeks shaded out (gray) for January 1, 2023, through December 15, 2023.

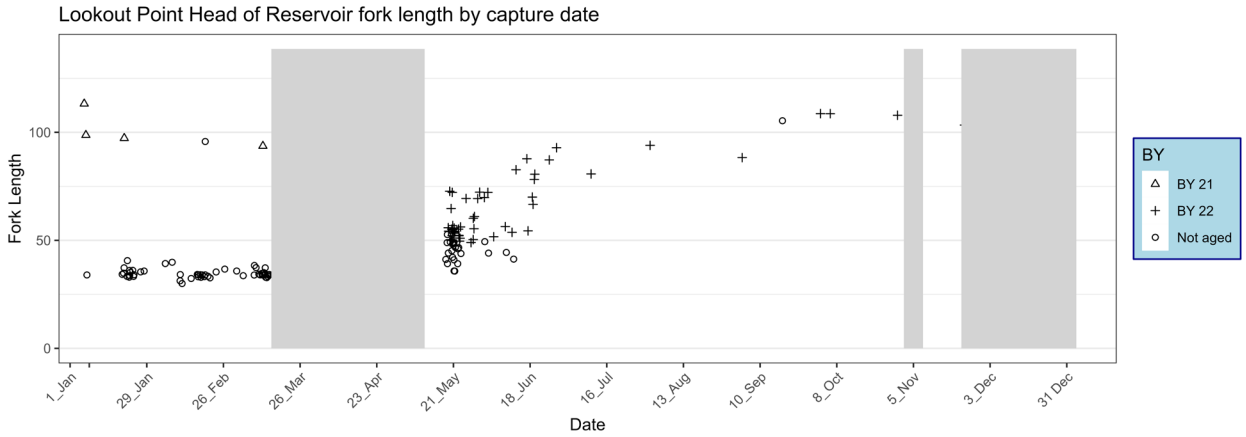

Figure 46. Length-frequency of juvenile Chinook salmon at the Lookout Point Head of Reservoir site from January 1, 2023, through December 15, 2023.

Injury Data

A total of 45 juvenile Chinook salmon (32.6% 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%, operculum damage, and fin damage (Table 59). There were three mortalities (2.2% 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.

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 2022; 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 47). 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 59. 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=137)
NXI	67.9%
MUNK	0.7%
DS<2	18.2%
DS>2	3.6%
BLO	0.7%
EYB	1.5%
BVT	0.0%
FVB	1.5%
GBD	0.0%
POP	0.0%
HIN	0.0%
OPD	2.9%
TEA	2.2%
BRU	2.2%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	16.8%
PRD	0.0%
COP	0.7%
BKD	0.0%
FUN	0.0%

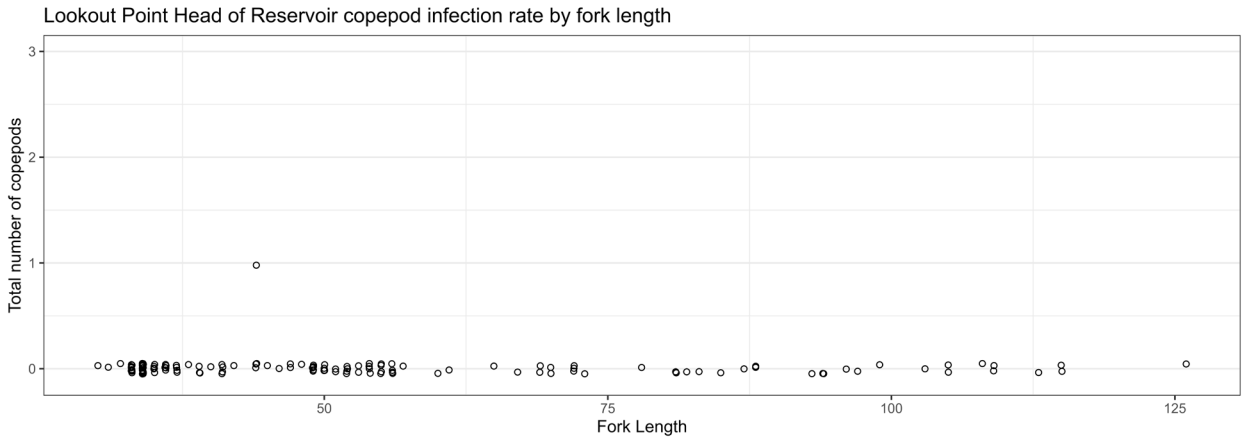

Figure 47. Copepod prevalence vs fork length on juvenile Chinook salmon captured below Lookout Point Head of Reservoir from January 1, 2023, through December 15, 2023.

PIT Tagged/VIE Marked fish and Downstream Detections

A total of 26 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 60 shows a summary of VIE marked fish with the tagging period and mark details.

Table 60. Summary of VIE tagged Chinook salmon at the Lookout Point Head of Reservoir site.

Date Tagged	Tag Location	VIE Color	# Tagged	# Recaptured to Date
1/1/2023–1/31/2023	Left Dorsal	Blue	9	0
2/1/2023–2/28/2023	Right Dorsal	Yellow	3	0
3/1/2023–3/15/2023	Right Dorsal	Red	3	0
5/16/2023–5/31/2023	Right Dorsal	Orange	42	0
6/1/2023–6/30/2023	Right Dorsal	Pink	11	0

Willamette Valley Projects Encounters

One adipose clipped and PIT tagged Chinook salmon was captured at the Lookout Point Head of Reservoir site in 2023. This fish is a part of the Cramer Fish Science's bulk mark release project. For more information on redetections of fish in the bulk mark release study, please refer to *Cramer Fish Science's Bulk Mark Release and Reservoir Distribution Study Annual Report* (CFS 2024).

Non-Target Capture Data

We captured 1,125 non-target fish in addition to natural origin juvenile Chinook salmon. A summary of species and numbers of fish caught are provided in Table 61. The most commonly captured non-target species were dace and rainbow trout.

Table 61. Summary of non-target fish capture at the Lookout Point Head of Reservoir site from January 1, 2023, through December 15, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	61	4
Crappie	12	12
Cutthroat Trout	18	0
Dace	565	20
Largescale Sucker	79	1
Mountain Whitefish	61	16
Northern Pikeminnow	86	28
O. mykiss	203	4
Redside Shiner	4	0
Sculpin	34	1
Bluegill	1	0
Spotted Bass	1	0
Totals	1,125	86

Hills Creek Dam Tailrace

Monitoring in the Middle Fork Willamette River in the Hills Creek Dam Tailrace began on October 15, 2021. For this reporting period, EAS monitored the 5-foot and 8-foot RSTs from January 1, 2023, through June 30, 2023. Sampling from July 1, 2023, through the end of year is reported under contract W9127N19D0009. 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 seven TE trials occurred using hatchery reared Chinook salmon in the Hills Creek Dam sites under this contract in 2023. A total of 35 trials have been performed by EAS at this site since monitoring began in 2021. EAS were unable to test this site to the extent we had planned due to limited availability of BY 2021 hatchery fish and slow growth of BY 2022 hatchery fish delaying trials until late April. Fish released in the PH channel can be captured in the RO trap. Thus, each PH release is treated as a 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 62.

TEs ranged from 2.9 to 12.3% in the PH and 0.0% to 2.4% in the RO.

Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled (Figure 47) for the PH trap PH trap. A linear model for the PH trap had shown a decreasing TE with increasing flow in previous reports, but that has switched to a positive relationship with additional trials (Rsq=0.68 and Pvalue=0.005) (see Appendix E). However, the sample size is small and the intercept had to be set to 0. Results could change with more data as it is difficult to detect model assumption violations. 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 trapping efficiencies varied greatly at for this trap. More trials with larger release groups will be needed to provide sufficient data to calculate passage. Plots displaying TE in relation to flow for all trials with consideration of route for the RO are provided in Appendix E.

Table 62. Summary of trapping efficiency trials below Hills Creek Dam from January 1 through June 30, 2023.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
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%
Hills Creek Dam Regulating Outlet	2/25/2023	920	478	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%
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%

Run of River Trapping Efficiency Trials

No TE trials using run of river fish were performed under this contract at Hills Creek Dam in 2023. The first 60 fish captured each week are prioritized for the 24-hour hold study and not available for use in run of river trials. There were insufficient capture numbers from fish large enough to mark.

Target Catch and Passage Timing

A total of 364 juvenile Chinook salmon were captured in the Hills Creek Dam RSTs during the spring 2023 sampling period, 229 in the PH trap (62.9% of total catch) and 135 in the RO trap (37.1% of total catch) (Figures 48 and 49). Peak capture of juvenile Chinook salmon occurred between March 8, 2023, and April 28, 2023, when 340 fish were captured (98.3% of total Chinook salmon catch). A total of 124 Chinook salmon were captured in the RO trap (36.5% of catch for this period) (Figure 48) and 216 were captured in the Powerhouse trap (63.5% of catch for this period) (Figure 49). Scale age analysis showed that Chinook salmon were captured from four BYs during this sampling period, BY 2019, 2020, 2021, and 2022 (Figure 50). One BY 2019 fish was captured on June 27, 2023. A total of 12 BY 2020 Chinook salmon (3.3% of total Chinook salmon catch) were captured along with a single BY 2021 yearling. BY 2022 sub-yearlings comprised a majority of the catch below Hills Creek Dam (n= 346, 95.1% of total Chinook salmon catch). Based on data from TE trials, we estimate that 4,032 (95% CI: 2,824 to 7,052) juvenile Chinook salmon passed through the PH at Hills Creek Dam during monitoring in 2023 (Figure 49). At this time, we are unable to provide an estimate for RO passage at Hills Creek Dam.

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 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. A majority of the Chinook captured occurred during spring RO operations. However, most fish were captured in the powerhouse suggesting that most fish passing through Hills Creek Dam at this time did so via the powerhouse. Catch in the RO trap also increased during this period but it is known that this trap captures fish from both routes and increased catch could simply be associated with higher numbers Chinook passing through the powerhouse. Further information from TE trials will help interpret catch data from this trap and the associated route of passage these fish are utilizing. A summary of fork lengths and weights for Chinook salmon captured at Fall Creek Head of Reservoir by BY is provided in Table 63. For raw weekly Chinook catch at the Hills Creek Dam RSTs for sampling from 2021 through 2023, please refer to Appendix I.

Table 63. Summary of fork length and weight observed on juvenile Chinook salmon at the Hills 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	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

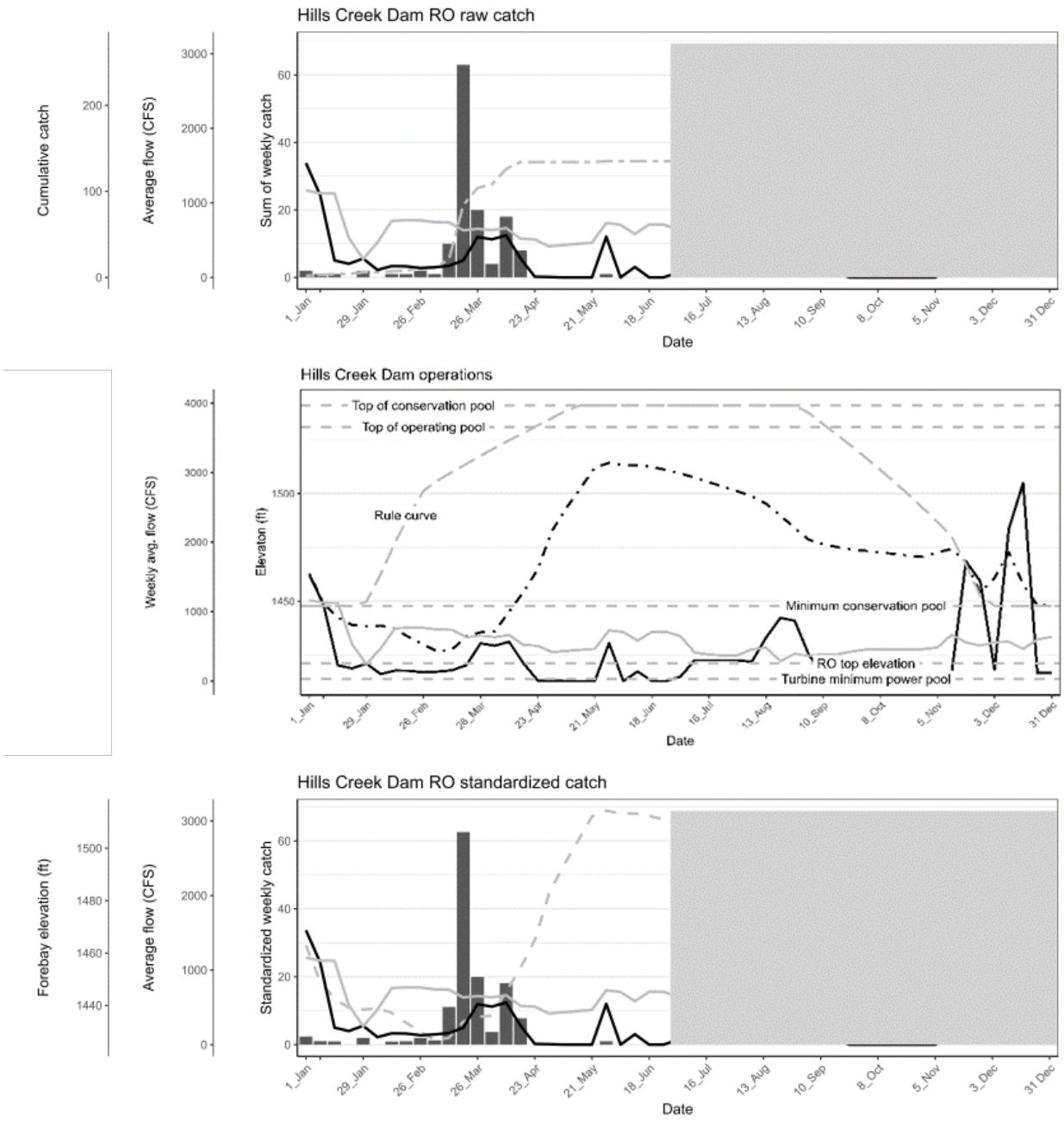

Figure 48. Raw catch (top panel) and weekly standardized catch (bottom panel) overlayed with RO outflow (black line), Powerhouse outflow (gray line), cumulative catch (gray dash dot line), and forebay elevation (gray dash line) for the RO trap below Hills Creek Dam for sampling from January 1, 2023, through June 30, 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).

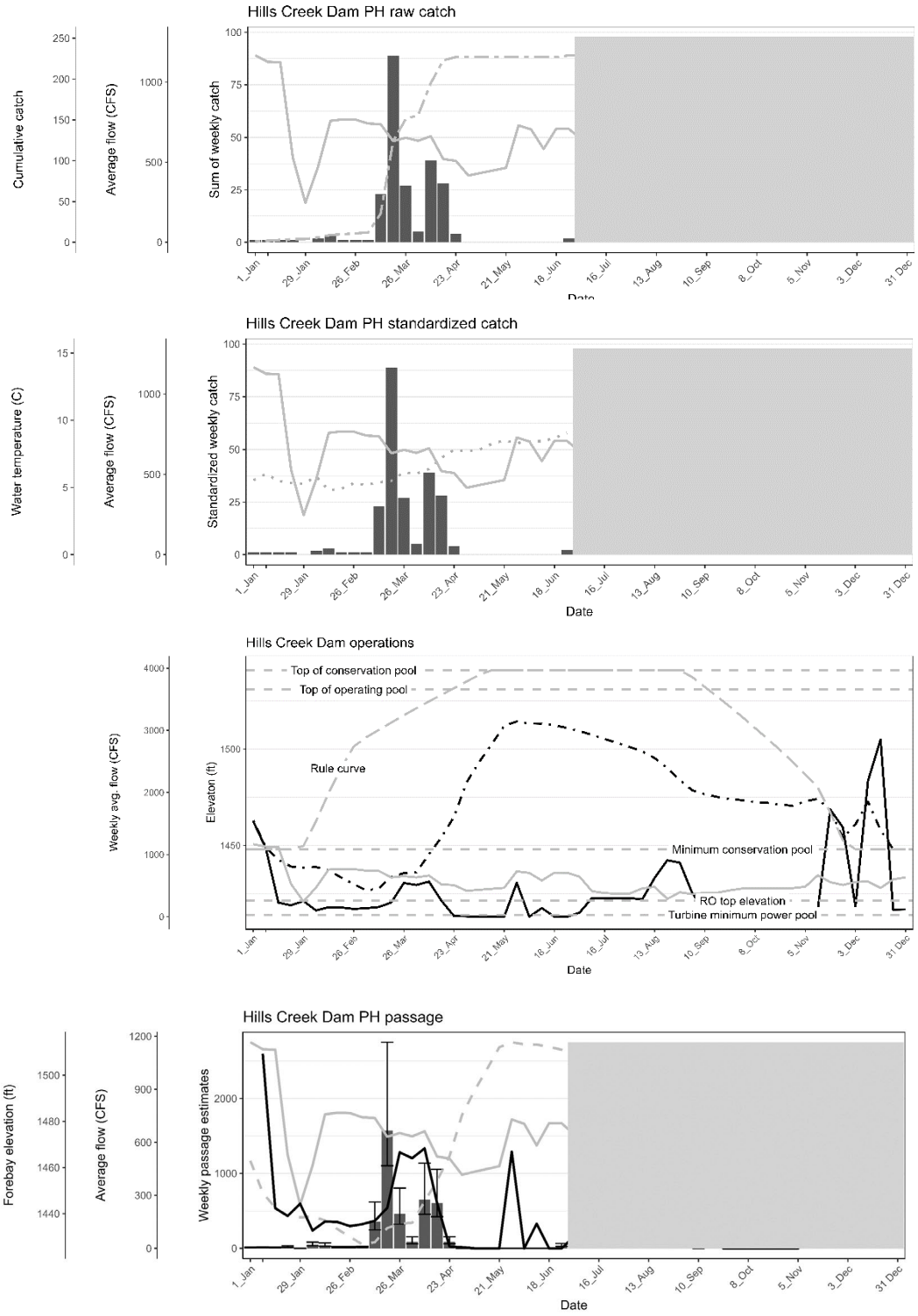

Figure 49. Raw catch (top panel), weekly standardized catch (second panel), Hills Creek Dam operations and features of interest (third panel), and weekly passage estimates (bottom panel) overlayed with Powerhouse outflow (gray line), RO outflow (black line), cumulative catch (gray dash dot line), forebay elevation (black dot dash line) and stream temperature (gray dots) for the PH trap below Hills Creek Dam for sampling from January 1, 2023, through June 30, 2023.

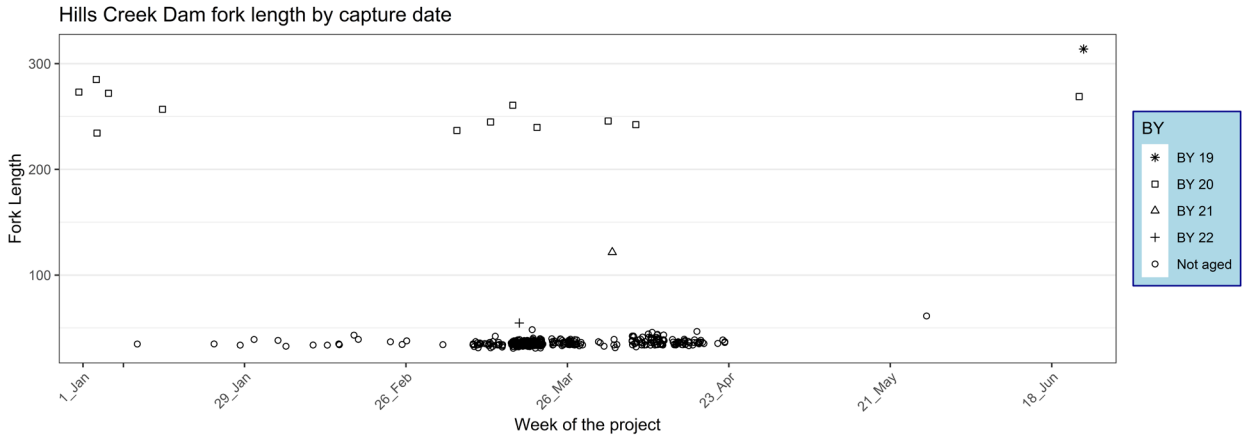

Figure 50. Length-frequency of juvenile Chinook salmon by brood year at the Hills Creek Dam site from January 1, 2023, through June 30, 2023.

Injury Data

A total of 54 juvenile Chinook salmon (14.8% 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 and greater than 20%, bleeding from vent, fin damage, and copepods (Tables 64 and 65). 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 51. Copepod presence on captured Chinook salmon showed a positive correlation with the size of fish (Figure 52).

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 64 and 65). 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 64 and 65).

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. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 64. 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 Powerhouse RST from January 1 through June 30, 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=250)	TE Recapture Injuries (proportion of total) (n=121)	Proportional Percent Change	Observed Chinook Injuries (n=229)	Bulk Marking Recapture Injuries (proportion of total) (n=21)
NXI	66.0%	83.5%	17.5%	85.2%	0.0%
MUNK	0.0%	0.0%	0.0%	0.4%	0.0%
DS<2	24.0%	11.6%	-12.4%	2.2%	20.0%
DS>2	0.4%	1.7%	1.3%	2.2%	80.0%
BLO	0.0%	0.0%	0.0%	0.4%	0.0%
EYB	0.0%	0.0%	0.0%	2.6%	6.7%
BVT	0.0%	0.0%	0.0%	3.1%	20.0%
FVB	0.0%	0.8%	0.8%	0.4%	40.0%
GBD	0.0%	0.0%	0.0%	0.4%	0.0%
POP	0.0%	0.0%	0.0%	1.7%	0.0%
HIN	0.0%	0.0%	0.0%	1.3%	20.0%
OPD	0.8%	1.7%	0.9%	1.7%	26.7%
TEA	0.0%	0.0%	0.0%	2.6%	6.7%
BRU	0.8%	0.0%	-0.8%	4.4%	26.7%
HBP	0.0%	0.0%	0.0%	0.4%	6.7%
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	14.8%	14.0%	-0.8%	3.9%	86.7%
PRD	0.0%	0.0%	0.0%	0.4%	0.0%
COP	0.0%	0.0%	0.0%	3.5%	80.0%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.8%	0.8%	0.0%	0.0%

Table 65. 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 from January 1 through June 30, 2023.

Injury Code	TE Release Injuries (~50 per trial, proportion of total) (n=250)	TE Recapture Injuries (proportion of total) (n=21)	Proportional Percent Change	Observed Chinook Injuries (n=135)	Bulk Marking Recapture Injuries (proportion of total) (n=1)
NXI	66.0%	57.1%	-8.9%	85.2%	0.0%
MUNK	0.0%	0.0%	0.0%	0.7%	0.0%
DS<2	24.0%	23.8%	-0.2%	3.7%	0.0%
DS>2	0.4%	4.8%	4.4%	3.0%	100.0%
BLO	0.0%	0.0%	0.0%	0.0%	0.0%
EYB	0.0%	0.0%	0.0%	0.7%	0.0%
BVT	0.0%	0.0%	0.0%	2.2%	0.0%
FVB	0.0%	0.0%	0.0%	2.2%	100.0%
GBD	0.0%	0.0%	0.0%	2.2%	0.0%
POP	0.0%	0.0%	0.0%	1.5%	0.0%
HIN	0.0%	0.0%	0.0%	2.2%	100.0%
OPD	0.8%	0.0%	-0.8%	3.0%	0.0%
TEA	0.0%	0.0%	0.0%	0.0%	100.0%
BRU	0.8%	0.0%	-0.8%	3.7%	100.0%
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%	0.7%	0.0%
HBO	0.0%	0.0%	0.0%	0.0%	0.0%
FID	14.8%	38.1%	23.3%	5.9%	100.0%
PRD	0.0%	0.0%	0.0%	0.0%	0.0%
COP	0.0%	0.0%	0.0%	5.9%	100.0%
BKD	0.0%	0.0%	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%	0.0%	0.0%

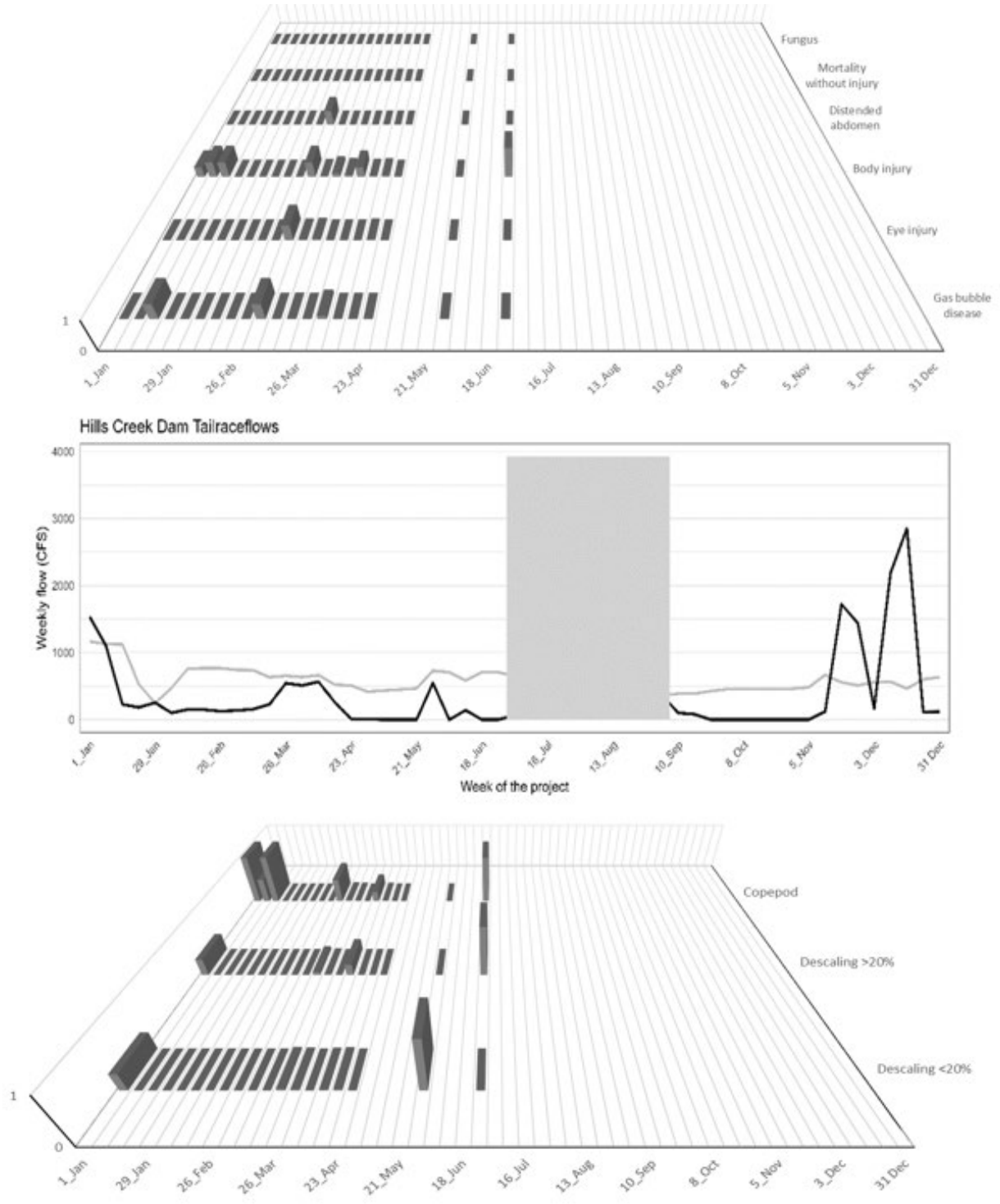

Figure 51. Proportion of captured juvenile Chinook salmon displaying injuries by type (top panel), operations data from the Hills Creek Dam showing cfs of spill (black line) and Powerhouse flow (gray line) outflows (middle panel), and proportion of captured juvenile Chinook salmon displaying descaling injuries and copepods (bottom panel) from January 1, 2023, through June 30, 2023.

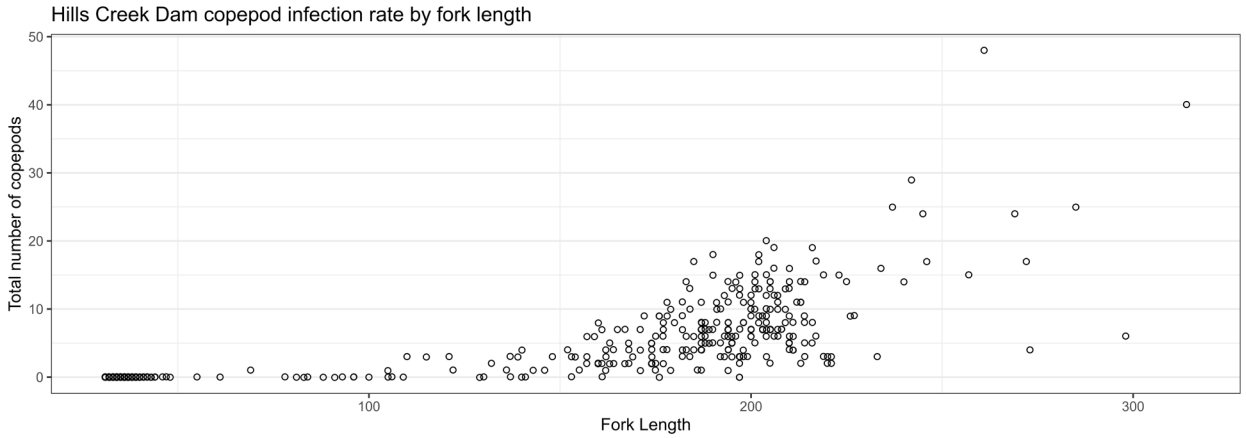

Figure 52. Copepod presence vs fork length on juvenile Chinook salmon captured below Hills Creek Dam from January 1, 2023, through June 30, 2023.

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 260 fish, 93 from the RO and 167 from the PH traps, were held (Table 66). A total of two fish died during hold (0.8%), one of the RO Chinook salmon (1.1%) and one of the Powerhouse Chinook salmon (0.6%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 50.0%.

Table 66. Summary of 24-hour hold trials for Chinook salmon captured in the RST at the Hills Creek Dam site from January 1 through June 30, 2023.

Hold Period	Trap	Number of Fish Held	Mortalities	% Survived
1/1/2023–1/15/2023	PH	2	1	50%
1/1/2023–1/15/2023	RO	2	0	100%
1/16/2023–1/31/2023	PH	1	0	100%
1/16/2023–1/31/2023	RO	3	0	100%
2/1/2023–2/15/2023	PH	3	0	100%
2/16/2023–2/28/2023	PH	4	0	100%
2/16/2023–2/28/2023	RO	4	0	100%
3/1/2023–3/15/2023	PH	6	0	100%
3/1/2023–3/15/2023	RO	3	0	100%
3/16/2023–3/31/2023	PH	75	0	100%
3/16/2023–3/31/2023	RO	54	0	100%
4/1/2023–4/15/2023	PH	45	0	100%
4/1/2023–4/15/2023	RO	18	0	100%
4/16/2023–4/30/2023	PH	31	0	100%
4/16/2023–4/30/2023	RO	8	1	87.5%
6/1/2023–6/15/2023	RO	1	0	100%

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. No VIE tagged fish or PIT tagged fish were redetected downstream as of December 31, 2023 (Table 67).

Table 67. Summary of VIE tagged Chinook salmon at the Hills Creek Dam site from January 1 through June 30, 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

No PIT tagged Chinook salmon were encountered in the RSTs below Hills Creek Dam during this sampling period.

Non-Target Species

In addition to natural origin juvenile Chinook salmon, a total of 1,244 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 68.

Table 68. Summary of non-target catch for the RSTs in the Hills Creek Dam from January 1 through June 30, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bass Unknown	6	4
Bluegill	189	84
Brown Bullhead	6	0
Crappie	437	262
Dace	51	4
Largemouth Bass	5	3
Largescale Sucker	50	7
Northern Pikeminnow	1	0
O. mykiss	59	20
O. mykiss (clipped)	12	6
Redside Shiner	1	1
Sculpin	333	0
Smallmouth Bass	2	2
Spotted Bass	91	47
Unknown	1	1
Totals	1,244	441

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

Citations

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

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

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

Cramer Fish Sciences. 2023a. Downstream Fish Passage Monitoring via Rotary Screw Traps above Detroit, Green Peter, and Hills Creek Reservoirs, 2023 Final Report. Prepared for: United States Army Corps of Engineers under Contract W9127N19D0009-W9127N21F0030. Prepared by: Dillon Alegre, Jason Phillips, and Rachel Ellison of Environmental Assessment Services, Richland Washington. August 2023.

Cramer Fish Sciences. 2023b. 2022 Spring Chinook Salmon Spawning Surveys in Quartzville Creek 2023 Final Report. Prepared for: United States Army Corps of Engineers under Contract W9127N19D009. Prepared by: Cramer Fish Sciences, Portland Oregon. May 2023.

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

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

Environmental Assessment Services. 2023. Willamette Valley Fish Passage Monitoring Via Rotary Screw Traps Annual Report, 2022. Prepared for: United States Army Corps of Engineers under Contract W9127N19D0007. Prepared by: Dillon Alegre, Jason Phillips, and Rachel Ellison of Environmental Assessment Services, Richland Washington. February 2023.

Environmental Assessment Services. 2023a. Willamette Valley Fish Passage Monitoring Via Rotary Screw Traps Bi-Annual Report, Spring 2023. Prepared for: United States Army Corps of Engineers under Contract W9127N19D0007. Prepared by: Dillon Alegre, Jason Phillips, and Rachel Ellison of Environmental Assessment Services, Richland Washington. August 2023.

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

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

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

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

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

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

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

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

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

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

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

Romer, J.D., Monzyk, F.R., Emig, R., and Friesen, T.A. 2015. Juvenile Salmond Outmigration Monitoring at Willamette Valley Project Reservoirs. Prepared by Oregon Department of Fish and Wildlife, Willamette Research, Monitoring, and Evaluation Program for US Army Corps of Engineers, Portland District during 2014 with final report delivered June 2015; Contract W9127N-10-2-0008-0026.

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

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

USACE (United States Army Corps of Engineers). 2022. Willamette Basin Bi-Annual Status Report August 29, 2022. Portland District, Portland Oregon.

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

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

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Appendix A –
Locations of Rotary Screw Traps

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Appendix A: Locations of Rotary Screw Traps

Figures and Tables

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FIGURE A-1
Big Cliff Dam

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-2
Green Peter Tailrace – Middle Santiam River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-3
Foster Dam Head of Reservoir –
South Santiam River

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-4
Cougar Dam Tailrace

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-5
Cougar Dam Head of Reservoir

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-6
Fall Creek Dam Tailrace

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-7
Fall Creek Head of Reservoir

RST Locations

500 Feet

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-8
Dexter Dam Tailrace

- RST 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

RST Locations

500 Feet

N

EAS ENVIRONMENTAL ASSESSMENT SERVICES
Wholly Owned Subsidiary of Natives of Kodiak

FIGURE A-11
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
Green Peter Dam Tailrace	N/A	N/A	44.44844, -122.55004	One 8ft
Foster Head of Reservoir–South Santiam River	44.391496, -122.499065	One 5ft (2010–2016)	44.391496, -122.499065	One 5ft
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
Cougar Head of Reservoir	44.048185, -122.217893	One 5ft (2010–2016)	44.048185, -122.217893	One 5ft
Fall Creek Dam Tailrace	43.945477, -122.760329	One 8ft (2006–2009) (2015–2016)	43.945477, -122.760329	One 8ft
Fall Creek Head of Reservoir	43.96467, -122.61917	One 8ft (2005–2008)	43.96467, -122.61917	One 8ft
Dexter Dam Tailrace	N/A	N/A	43.92527, -122.81147	One 5ft
Lookout Dam Tailrace	43.91442, -122.75658	One 8ft (2007–2008) (2011–2016), Two 8ft (2009–2010)	43.91442, -122.75658	Three 8ft
Lookout Point Head of Reservoir–Middle Fork Willamette River	43.76669, -122.53139	One 5ft (2007–2008) (2010–2016)	43.76669, -122.53139	One 5ft
Hills Creek Dam Tailrace	43.71113, -122.42464	One 8ft (2003–2004)	43.71113, -122.42464	One 8ft
Hills Creek Dam Tailrace RO	43.71208, -122.42340	One 5ft	43.71304, -122.42497	One 5ft

Appendix B –
Sampling Outages by Site

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Appendix B: Sampling Outages by Site

Site	Date(s) of Trap Outage	Reason for Outage
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.
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.
Foster Dam Head of Reservoir	3/13/2023-3/14/2023	The RST cone was raised to its non-fishing position and anchored to the shoreline due to expected rainfall and river flows surpassing 4,000 cfs.
Foster Dam Head of Reservoir	4/10/2023-4/13/2023	The RST cone was raised to its non-fishing position due to elevated water levels and increased debris. A tree was lodged in the RST cone, preventing it from rotating.
Foster Dam Head of Reservoir	4/29/2023-4/30/2023	The RST cone was raised to its non-fishing position due to elevated water levels and increased debris.
Foster Dam Head of Reservoir	8/10/2023-8/19/2023	The RST cone was raised to its non-fishing positions due to wildfires at Wiley Creek. Subsequently, level 2 evacuations along HWY 20 were put into effect and the RSTs were unable to be accessed in a safe manner. Additionally, temperature thresholds were logged at above 21°C and were deemed potentially detrimental to fish that would have been caught and stationed within the RST live well.
Foster Dam Head of Reservoir	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.
Foster Dam Head of Reservoir	11/5/2023-11/8/2023	The RST cone was raised to its non-fishing position due to elevated water levels and high debris.
Foster Dam Head of Reservoir	11/11/2023-11/13/2023	The RST cone was raised to its non-fishing position due to elevated water levels and increased debris.
Foster Dam Head of Reservoir	11/30/2023	The RST was raised and removed from its sampling location at Foster Dam Head of Reservoir due to the completion of its 2023 contract.
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.

Site	Date(s) of Trap Outage	Reason for Outage
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).
Cougar Dam Head of Reservoir	2/20/2023-3/14/2023	The RST cone was raised to its non-fishing position due to a severe winter storm. Access to the RST was checked every day over this time period, but the cone was not lowered due to accessibility issues.
Cougar Dam Head of Reservoir	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 Head of Reservoir	10/11/2023-10/12/2023	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.
Cougar Dam Head of Reservoir	10/25/2023-10/26/2023	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.
Cougar Dam Head of Reservoir	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.
Cougar Dam Head of Reservoir	11/30/2023	The RST was raised and removed from its sampling location at Cougar Dam Head of Reservoir due to the completion of its 2023 contract.
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 EAS deemed it unsafe for fish health and potentially detrimental to RST operations.
Fall Creek Head of Reservoir	1/26/2023-2/6/2023	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 Head of Reservoir	2/21/2023-2/22/2023	The RST cone was raised to its non-fishing position due to a severe winter storm occurrence. The RST cone was lowered to its fishing position the following day.
Fall Creek Head of Reservoir	3/20/2023-3/21/2023	The RST cone was raised to its non-fishing position due to elevated water levels. The RST's stern pontoons were submerged in the flow and the RST was raised for operational concerns.

Site	Date(s) of Trap Outage	Reason for Outage
Fall Creek Head of Reservoir	4/7/2023-4/13/2023	The RST cone was raised to its non-fishing position due to elevated water levels and increased debris. Subsequently, the RST cone was damaged due to elevated flows and high debris.
Fall Creek Head of Reservoir	4/23/2023-4/25/2023	The RST cone was raised to its non-fishing position due to elevated water levels and increased debris. The river was unsafe to kayak at these flows and the RST was inaccessible.
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 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 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 and the RST was secured 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 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 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 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	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

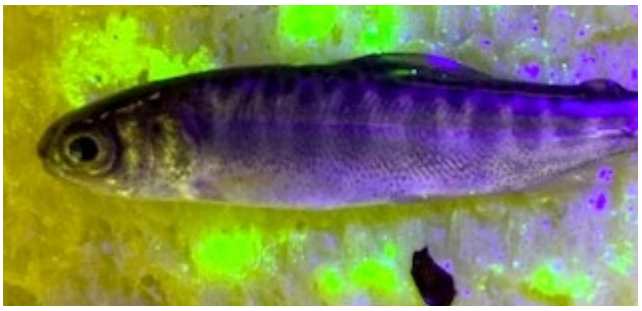

Figure C-1. Example of a VIE marked Chinook salmon. A green fluorescent elastomer mark can be seen along the dorsal fin.

PIT Tags

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

MRR Project Name: WVP – Willamette Valley Downstream Fish Passage Monitoring Via Rotary Screw Traps Data Coordinator: Grant Brink, Environmental Assessment Services		
Site	**UDF**	**MRR Site/Release Site**
Big Cliff Dam Tailrace	BCL	BCLTAL
Green Peter Dam Tailrace – Middle Santiam River	GPD	GPD
Foster Dam Head of Reservoir – South Santiam River	SAN	SSANTR
Cougar Dam Tailrace	CGR	CGRTAL
Cougar Dam Head of Reservoir	SMK	MCKESF
Fall Creek Dam Tailrace	FAL	FALTAL
Fall Creek Head of Reservoir	FCA	FALL2C
Dexter Dam Tailrace	DEX	DEXTAL
Lookout Dam Tailrace	LOP	LOPTAL
Lookout Point Head of Reservoir – Middle Fork Willamette River	LOA	WILRMF
Hills Creek Dam Tailrace	HCR	HCRREG
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 fish PIT tagged at RST sites in 2023.

Tagging Site	Species	Total PIT Tagged	Total VIE Marked	Orphan Tags [a]	Missed Protocol VIE [b]
Big Cliff Dam Tailrace	Chinook	51	0	0	0
	O. mykiss	3	0	0	0
Green Peter Dam Tailrace – Middle Santiam River	Chinook	0	0	0	0
	O. mykiss	0	0	0	0
Foster Dam Head of Reservoir – South Santiam River	Chinook	65	0	1	0
	O. mykiss	112	0	0	0
Cougar Dam Tailrace	Chinook	4,132	0	4	0
Cougar Dam Head of Reservoir	Chinook	301	3,881	0	0
Fall Creek Dam Tailrace	Chinook	0	0	0	0
Fall Creek Head of Reservoir	Chinook	4	46	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 Dam Tailrace	Chinook	1	39	0	0

a Orphan Tags denotes PIT tag numbers that had errors reported in PTAGIS (0.1% error rate)
b Missed protocol VIE marks denotes fish that were accidentally tagged in the wrong location while training new crew members (0.0% 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 Head of Reservoir	4/12/2023	125	None	Unharmed
Cougar Dam Head of Reservoir	4/28/2023	160	None	Unharmed
Cougar Dam Head of Reservoir	6/4/2023	140	None	Unharmed
Cougar Dam Head of Reservoir	7/3/2023	362	Tagged by EAS 132592732	Injured
Cougar Dam Head of Reservoir	7/26/2023	445	Tagged by EAS 132592656	Injured
Cougar Dam Head of Reservoir	8/10/2023	301	Tagged by EAS 132592650	Injured
Cougar Dam Head of Reservoir	9/6/2023	180	3DD.003E4B931C*	Injured
Cougar Dam Head of Reservoir	9/6/2023	278	Tagged by EAS 132592757	Injured
Cougar Dam Head of Reservoir	10/3/2023	335	Tagged by EAS 132592607	Unharmed
Cougar Dam Head of Reservoir	10/4/2023	452	Tagged by EAS 132592594	Unharmed
Cougar Dam Head of Reservoir	10/15/2023	411	Tagged by EAS 132592601	Unharmed
Cougar Dam Head of Reservoir	10/16/2023	325	Tagged by EAS 132592385	Injured
Cougar Dam Head of Reservoir	10/17/2023	310	Tagged by EAS 132589914	Unharmed
Cougar Dam Head of Reservoir	11/20/2023	240	None	Unharmed
Cougar Dam Tailrace	5/29/2023	240	None	Unharmed
Cougar Dam Tailrace	6/5/2023	165	None	Unharmed

*Confirmed predation of a Cramer Fish Sciences bulk mark released Chinook

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
Green Peter Dam Tailrace – Middle Santiam River	8 ft	34	Chinook
Foster Dam Head of Reservoir – South Santiam River	5 ft	0	N/A
Cougar Dam Tailrace	PH	71	Chinook
Cougar Dam Tailrace	RO	1,622	Chinook
Cougar Dam Head of Reservoir	5 ft	8	Chinook
Fall Creek Dam Tailrace	8 ft	435	Chinook
Fall Creek Head of Reservoir	8 ft	0	N/A
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 fish were 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 salmon by size.

Total Chinook (n=576)	<60 mm (n=121)	>60 mm and <110 mm (n=55)	>110 mm (n=400)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
NXI	90.9%	3.8%	0.0%
MUNK	0.8%	0.0%	0.0%
DS<2	4.1%	78.8%	69.6%
DS>2	0.0%	13.5%	27.3%
BLO	0.0%	0.0%	1.0%
EYB	0.8%	5.8%	8.5%
BVT	0.8%	0.0%	3.1%
FVB	0.0%	1.9%	7.5%
GBD	1.7%	0.0%	10.1%
POP	1.7%	1.9%	1.5%
HIN	0.8%	3.8%	6.7%
OPD	0.0%	1.9%	15.5%
TEA	2.5%	0.0%	5.2%
BRU	1.7%	11.5%	11.1%
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%	0.3%
FID	1.7%	59.6%	76.3%
PRD	0.0%	1.9%	0.5%
COP	0.0%	55.8%	88.9%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	1.9%	2.8%
Totals	9.9%	96.2%	100.0%
Average number of injuries per fish (non NXI)	0.2	2.3	3.3

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

Total Chinook (n=100)	<60 mm (n=25)	>60 mm and <110 mm (n=79)	>110 mm (n=3)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
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%
Totals	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 salmon by size.

Total Chinook (n=193)	<60 mm (n=23)	>60 mm and <110 mm (n=118)	>110 mm (n=52)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
NXI	43.5%	6.8%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	30.4%	67.8%	32.2%
DS>2	8.7%	12.7%	5.1%
BLO	4.3%	1.7%	0.8%
EYB	13.0%	0.0%	2.5%
BVT	4.3%	5.1%	3.4%
FVB	4.3%	5.1%	3.4%
GBD	0.0%	0.8%	1.7%
POP	0.0%	0.0%	0.0%
HIN	4.3%	2.5%	1.7%
OPD	13.0%	3.4%	3.4%
TEA	4.3%	11.9%	0.0%
BRU	13.0%	3.4%	6.8%
HBP	0.0%	3.4%	0.8%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	26.1%	49.2%	22.9%
PRD	0.0%	1.7%	0.0%
COP	13.0%	44.9%	41.5%
BKD	0.0%	0.0%	0.0%
FUN	4.3%	1.7%	1.7%
Totals	56.5%	93.2%	100.0%
Average number of injuries per fish (non NXI)	1.4	2.2	2.9

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

Total Chinook (n=5070)	<60 mm (n=18)	>60 mm and <110 mm (n=1395)	>110 mm (n=3657)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
NXI	83.3%	1.0%	0.1%
MUNK	0.0%	0.0%	0.0%
DS<2	5.6%	75.1%	72.5%
DS>2	0.0%	14.4%	20.5%
BLO	0.0%	0.6%	0.4%
EYB	0.0%	12.3%	10.3%
BVT	0.0%	2.7%	2.9%
FVB	5.6%	7.7%	16.6%
GBD	0.0%	19.8%	33.6%
POP	0.0%	2.0%	0.7%
HIN	0.0%	4.7%	4.0%
OPD	0.0%	13.5%	16.8%
TEA	0.0%	8.1%	4.8%
BRU	0.0%	5.2%	5.8%
HBP	0.0%	4.1%	3.1%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	5.6%	80.4%	85.1%
PRD	0.0%	0.4%	0.2%
COP	0.0%	84.5%	94.3%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	8.7%	10.5%
Totals	16.7%	99.0%	99.9%
Average number of injuries per fish (non NXI)	0.2	3.4	3.8

Table D-5. Cougar Dam Regulatory Outlet route injuries for Chinook for October through December of 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 Tailrace injuries for Chinook salmon by size.

Total Chinook (n=61)	<60 mm (n=59)	>60 mm and <110 mm (n=2)	>110 mm (n=0)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
NXI	81.4%	100.0%	--
MUNK	0.0%	0.0%	--
DS<2	6.8%	0.0%	--
DS>2	0.0%	0.0%	--
BLO	1.7%	0.0%	--
EYB	3.4%	0.0%	--
BVT	1.7%	0.0%	--
FVB	0.0%	0.0%	--
GBD	3.4%	0.0%	--
POP	0.0%	0.0%	--
HIN	3.4%	0.0%	--
OPD	1.7%	0.0%	--
TEA	1.7%	0.0%	--
BRU	1.7%	0.0%	--
HBP	1.7%	0.0%	--
HO	0.0%	0.0%	--
BO	0.0%	0.0%	--
HBO	0.0%	0.0%	--
FID	6.8%	0.0%	--
PRD	0.0%	0.0%	--
COP	0.0%	0.0%	--
BKD	0.0%	0.0%	--
FUN	0.0%	0.0%	--
Totals	18.6%	0.0%	--
Average number of injuries per fish (non NXI)	0.3	0.0	--

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

Total Chinook (n=37)	<60 mm (n=1)	>60 mm and <110 mm (n=14)	>110 mm (n=22)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
NXI	100.0%	7.1%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	64.3%	45.5%
DS>2	0.0%	14.3%	54.5%
BLO	0.0%	0.0%	0.0%
EYB	0.0%	7.1%	13.6%
BVT	0.0%	0.0%	4.5%
FVB	0.0%	0.0%	9.1%
GBD	0.0%	7.1%	4.5%
POP	0.0%	0.0%	4.5%
HIN	0.0%	0.0%	0.0%
OPD	0.0%	14.3%	13.6%
TEA	0.0%	7.1%	13.6%
BRU	0.0%	0.0%	9.1%
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%	57.1%	86.4%
PRD	0.0%	0.0%	0.0%
COP	0.0%	14.3%	27.3%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%
Totals	100.0%	92.9%	100.0%
Average number of injuries per fish (non NXI)	0	0.6	1.5

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

Total Chinook (n=49)	<60 mm (n=8)	>60 mm and <110 mm (n=5)	>110 mm (n=36)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
NXI	50.0%	80.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	12.5%	20.0%	41.7%
DS>2	12.5%	20.0%	50.0%
BLO	0.0%	0.0%	0.0%
EYB	12.5%	20.0%	11.1%
BVT	0.0%	0.0%	8.3%
FVB	12.5%	20.0%	38.9%
GBD	0.0%	0.0%	36.1%
POP	0.0%	0.0%	0.0%
HIN	12.5%	20.0%	22.2%
OPD	0.0%	0.0%	13.9%
TEA	25.0%	40.0%	13.9%
BRU	0.0%	0.0%	22.2%
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	25.0%	40.0%	97.2%
PRD	0.0%	0.0%	0.0%
COP	0.0%	0.0%	50.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	2.8%
Totals	50.0%	20.0%	100.0%
Average number of injuries per fish (non NXI)	1.1	2.6	4.1

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

Total Chinook (n=227)	<60 mm (n=220)	>60 mm and <110 mm (n=0)	>110 mm (n=7)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
NXI	88.6%	--	0.0%
MUNK	0.5%	--	0.0%
DS<2	2.3%	--	0.0%
DS>2	0.0%	--	71.4%
BLO	0.0%	--	14.3%
EYB	1.8%	--	28.6%
BVT	2.3%	--	28.6%
FVB	0.0%	--	14.3%
GBD	0.0%	--	14.3%
POP	1.4%	--	14.3%
HIN	0.9%	--	14.3%
OPD	1.4%	--	14.3%
TEA	2.3%	--	14.3%
BRU	2.7%	--	57.1%
HBP	0.0%	--	14.3%
HO	0.0%	--	0.0%
BO	0.0%	--	0.0%
HBO	0.0%	--	0.0%
FID	1.4%	--	85.7%
PRD	0.0%	--	0.0%
COP	0.0%	--	100.0%
BKD	0.0%	--	0.0%
FUN	0.0%	--	0.0%
Totals	11.4%	--	100.0%
Average number of injuries per fish (non NXI)	0.2	--	4.9

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

Total Chinook (n=134)	<60 mm (n=126)	>60 mm and <110 mm (n=1)	>110 mm (n=7)
Injury Code	**Injuries for (%) <60 mm**	**Injuries (%) >60 mm and <110 mm**	**Injuries (%) >110 mm**
NXI	91.3%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	1.6%	100.0%	42.9%
DS>2	0.8%	0.0%	28.6%
BLO	0.0%	0.0%	0.0%
EYB	0.8%	0.0%	0.0%
BVT	0.0%	0.0%	28.6%
FVB	0.8%	0.0%	28.6%
GBD	0.0%	0.0%	28.6%
POP	1.6%	0.0%	0.0%
HIN	2.4%	0.0%	0.0%
OPD	1.6%	0.0%	28.6%
TEA	0.0%	0.0%	0.0%
BRU	2.4%	0.0%	28.6%
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	1.6%	0.0%	71.4%
PRD	0.0%	0.0%	0.0%
COP	0.0%	0.0%	100.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%
Totals	8.7%	100.0%	100.0%
Average number of injuries per fish (non NXI)	0.1	1.0	3.9

Appendix E –
Trap Efficiency Plots

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Appendix E: Trap Efficiency Plots

Figures and Tables

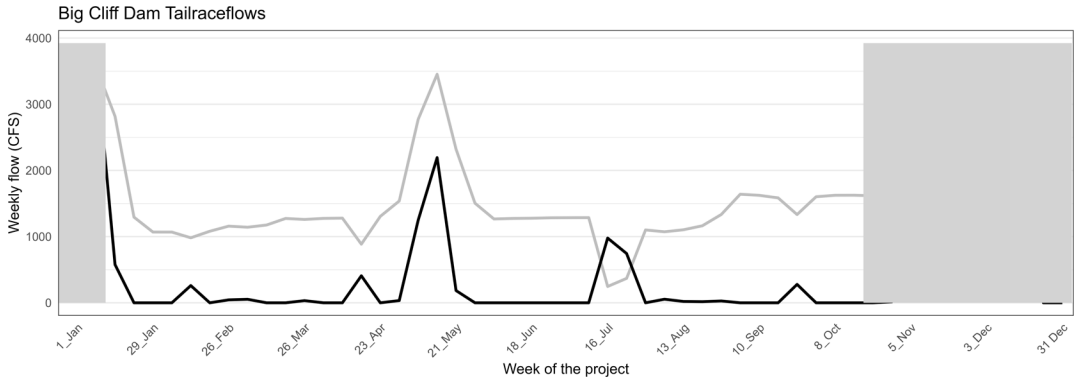

Figure E-1. Big Cliff Dam Tailrace powerhouse outflow (gray line) and spill outflow (black line) for 2023.

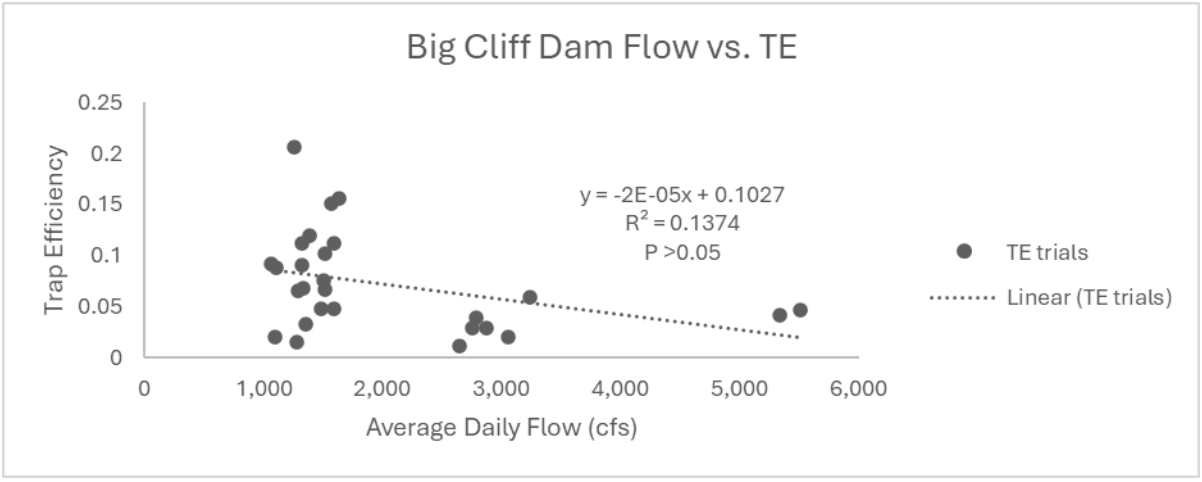

Figure E-2. Big Cliff Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus flow levels.

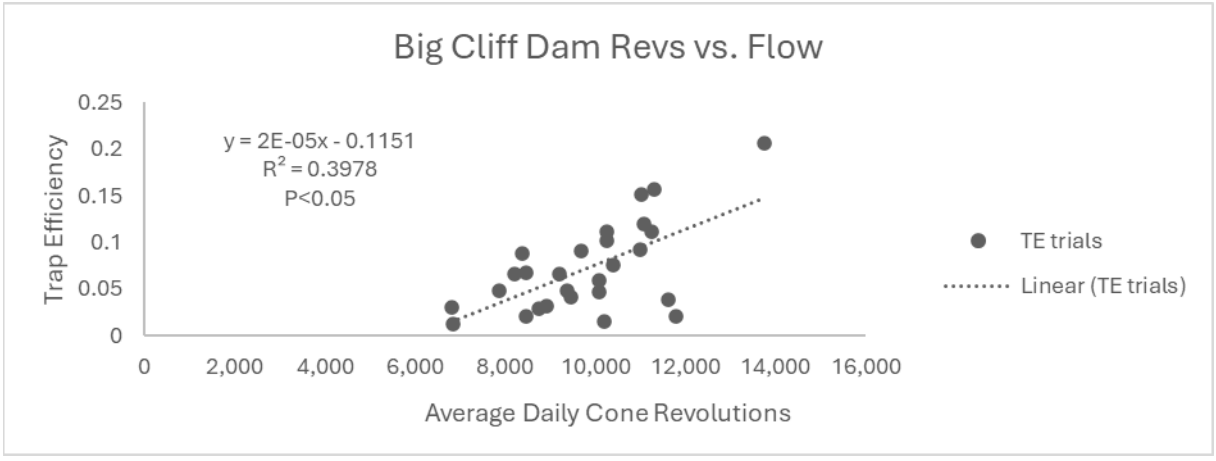

Figure E-3. Big Cliff Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus cone flux the day after fish were released.

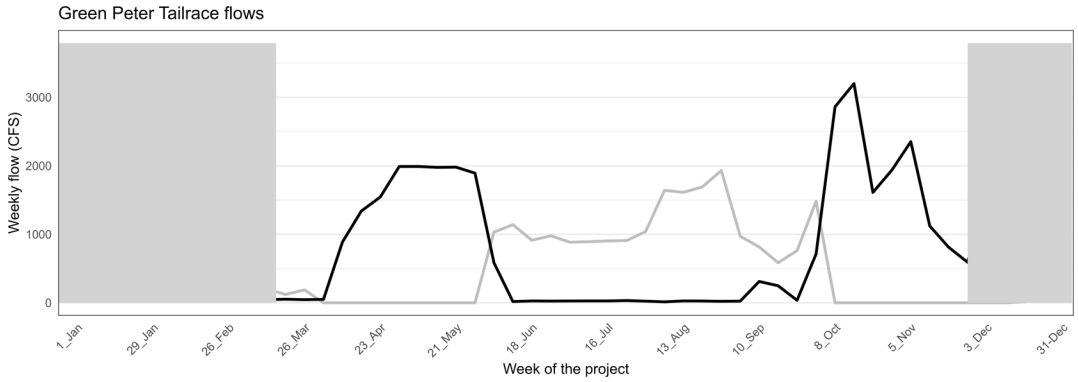

Figure E-4. Green Peter Dam Tailrace powerhouse outflow (gray line) and spill outflow (black line) for 2023.

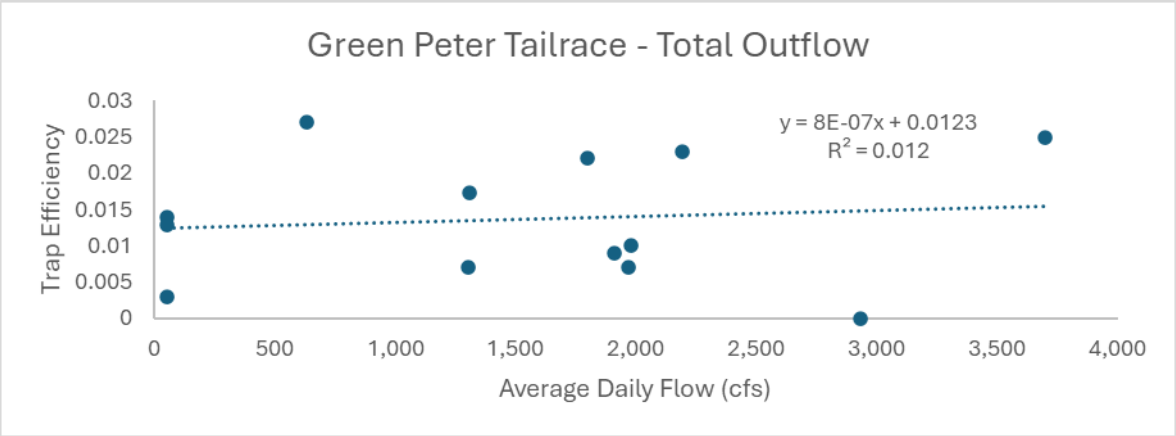

Figure E-5. Green Peter Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus total outflow.

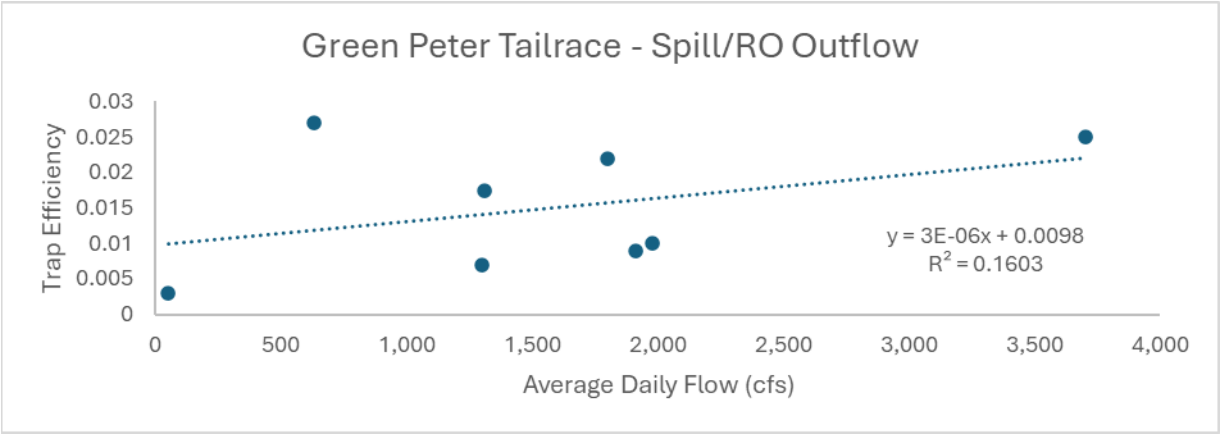

Figure E-6. Green Peter Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus spill/RO flows.

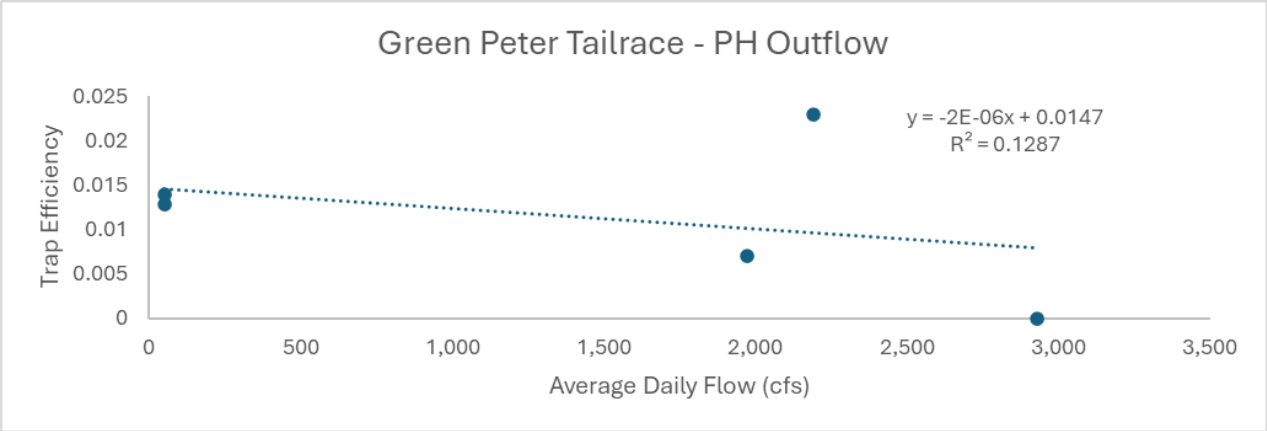

Figure E-7. Green Peter Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus powerhouse flows.

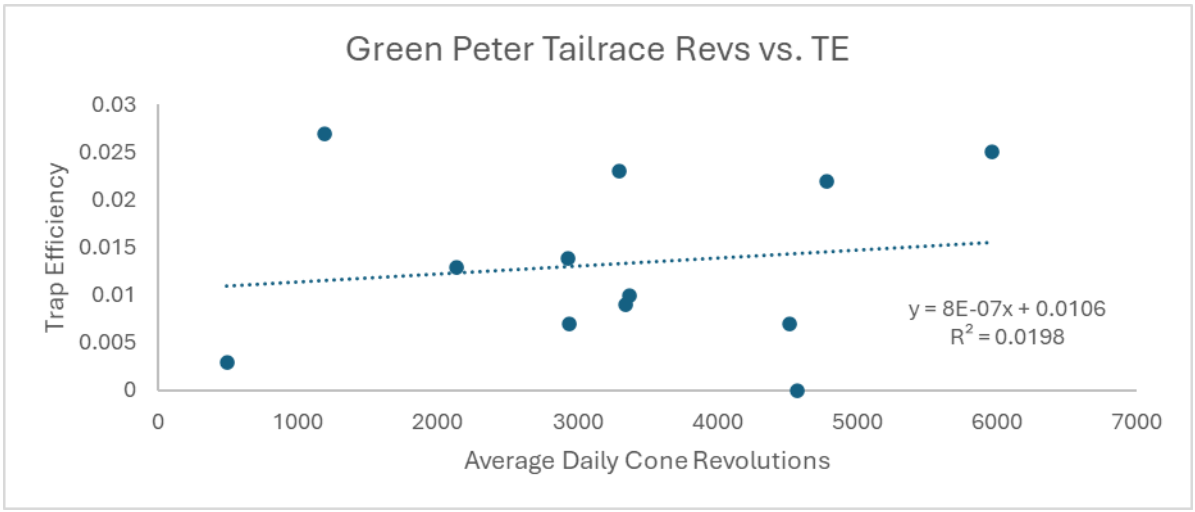

Figure E-8. Green Peter Dam Tailrace trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus cone flux the day after trial fish were released.

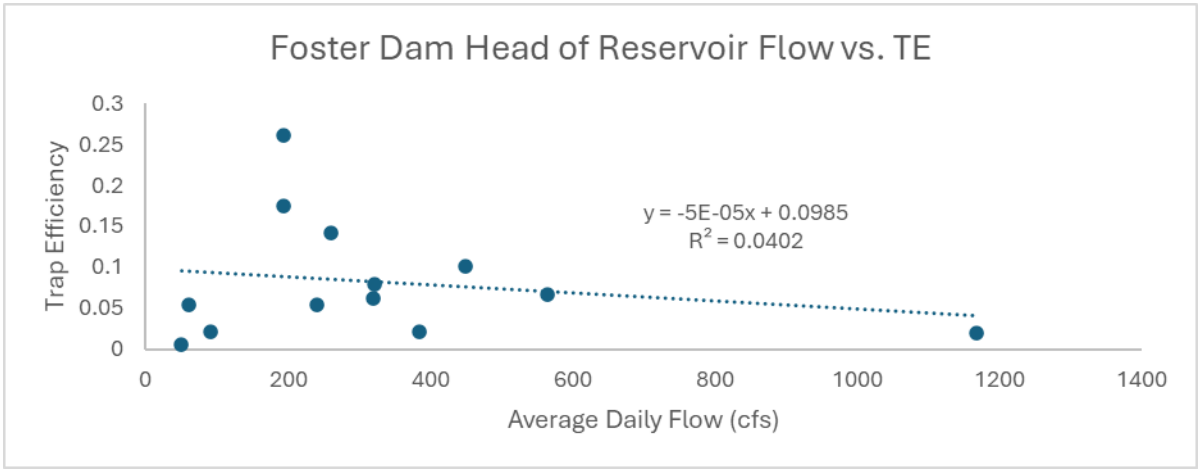

Figure E-9. Foster Dam Head of Reservoir trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus flows.

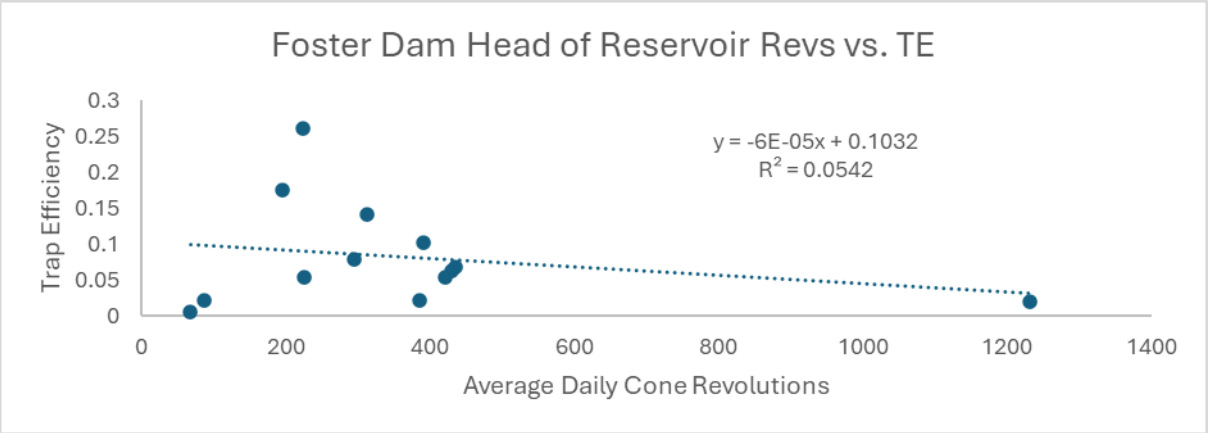

Figure E-10. Foster Dam Head of Reservoir trap efficiency trial plots. Linear regression fit is non-significant. Plot displays trapping efficiencies versus cone flux the day after trial fish were released.

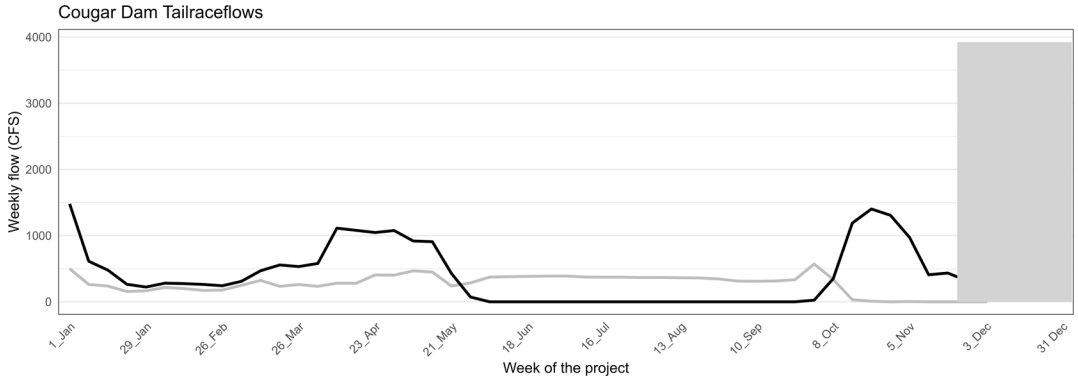

Figure E-11. Cougar Dam Tailrace powerhouse outflow (gray line) and spill outflow (black line) for 2023.

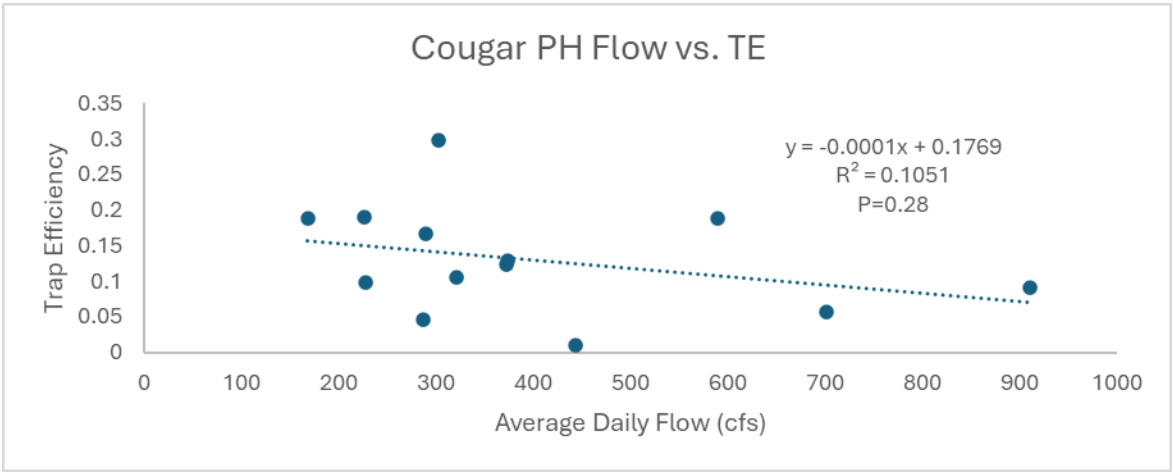

Figure E-12. Cougar Dam trap efficiency trial plots versus flows. Cougar PH linear regression fit is slightly negative with increasing flow.

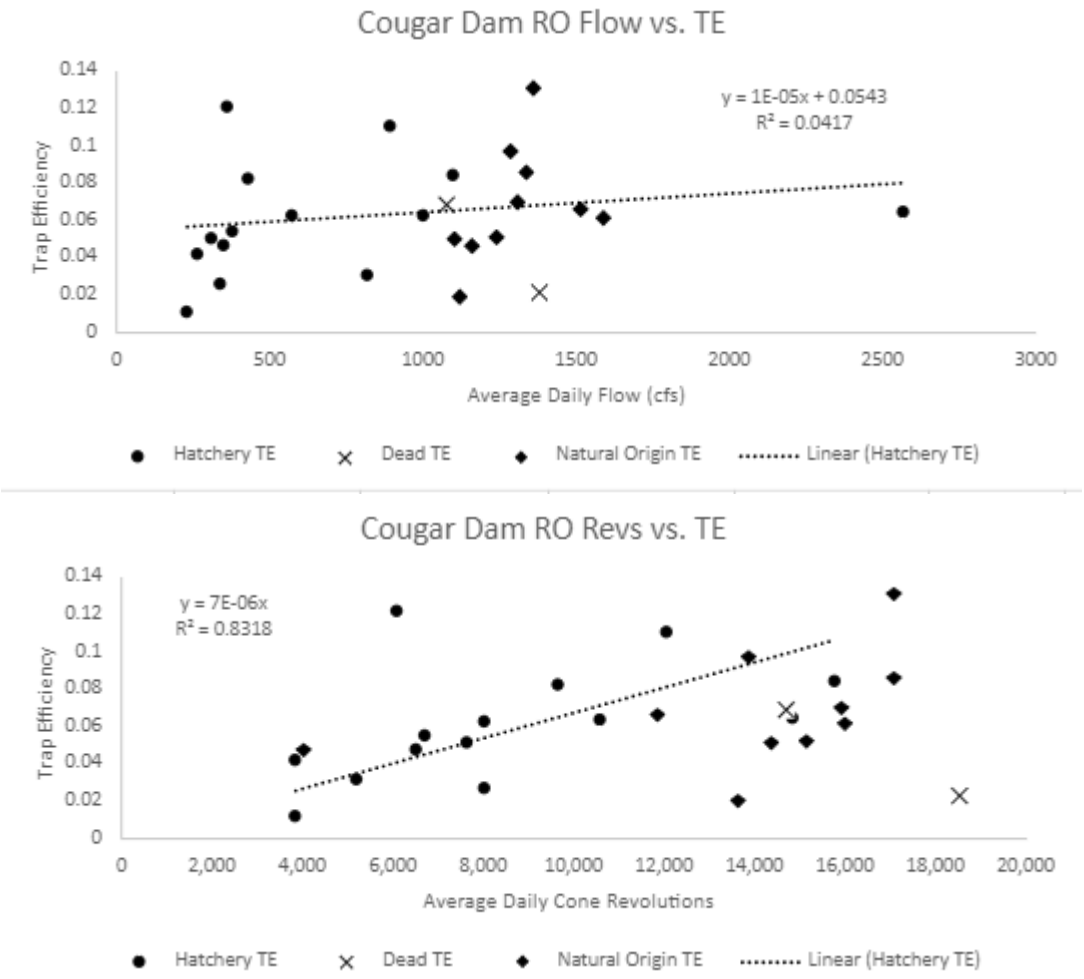

Figure E-13. Cougar Dam Tailrace RO trap efficiency trials versus flows (top panel) and compared to cone flux (bottom panel). Linear regression fit is only to hatchery TE trials in both panels, which is non-significant for flow and significant for cone flux.

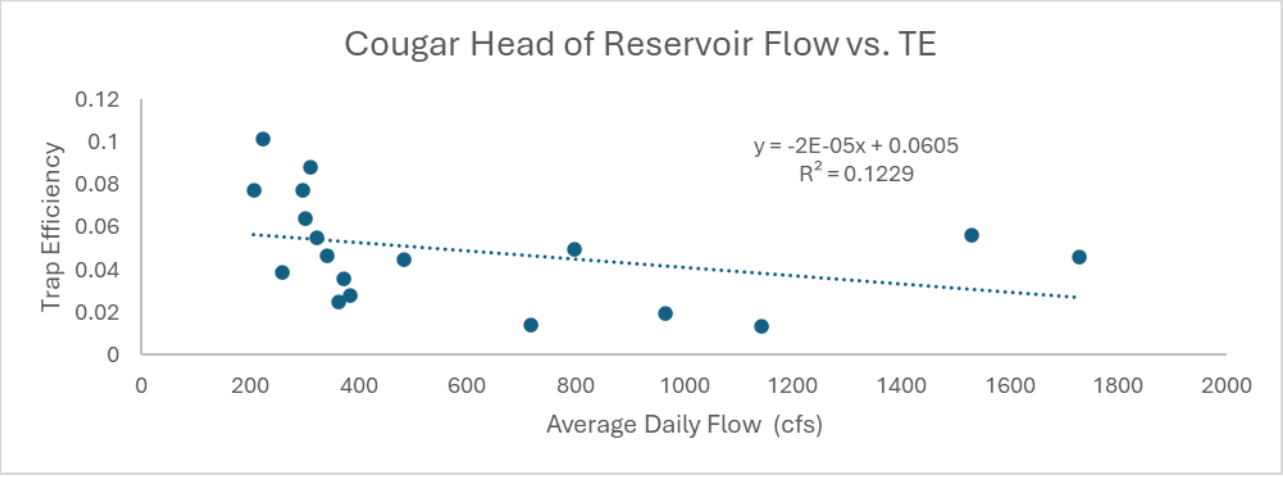

Figure E-14. Cougar Head of Reservoir trap efficiency trials versus flows.

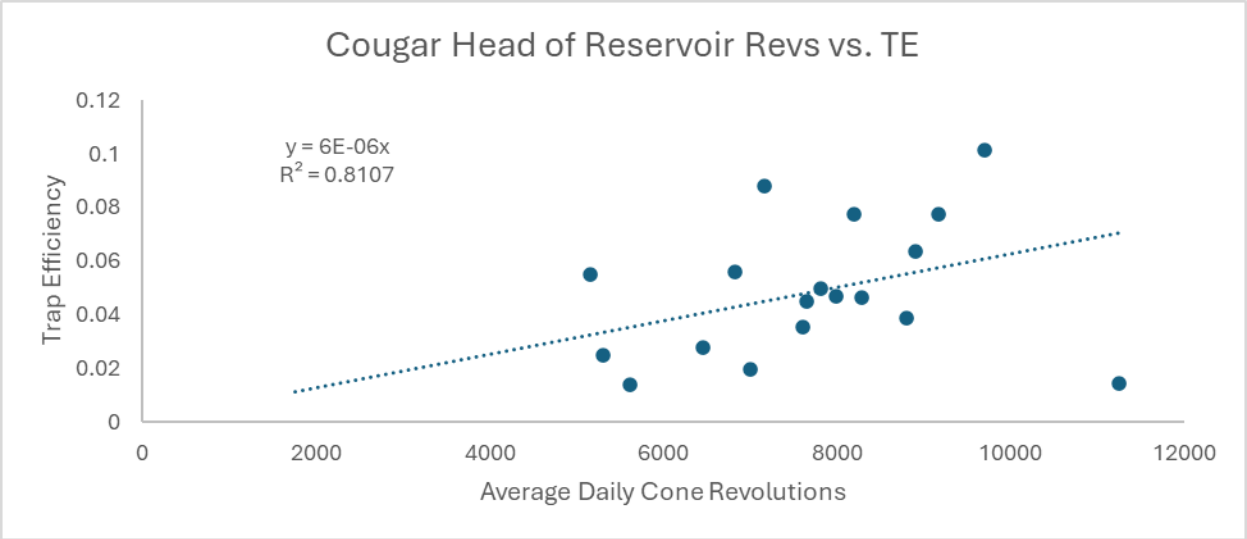

Figure E-15. Cougar Head of Reservoir trap efficiency versus cone flux the day after trial fish were released.

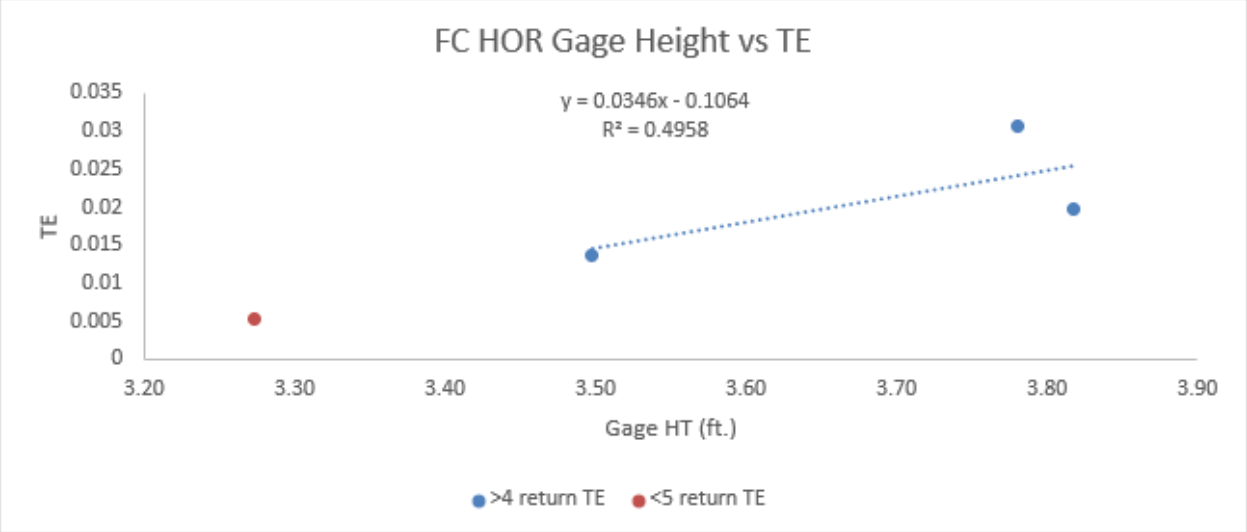

Figure E-16. Fall Creek Head of Reservoir trap efficiency versus gage height.

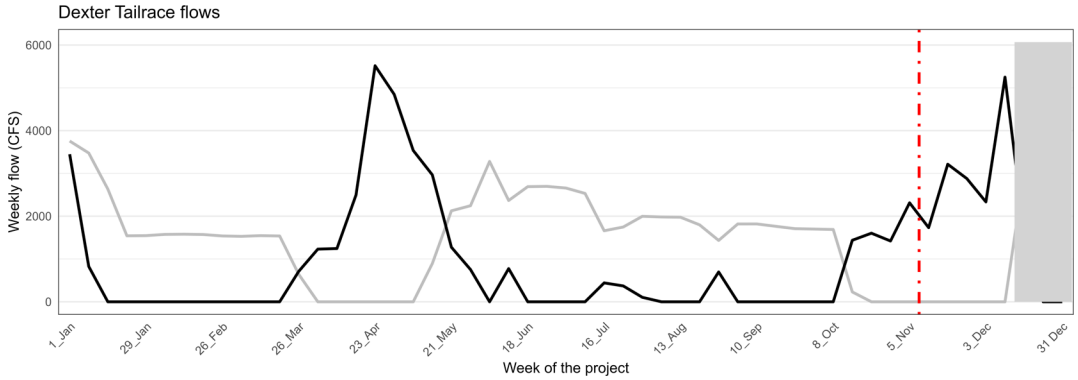

Figure E-17. Dexter Dam Tailrace powerhouse flow (gray line) and spill flow (black line) for 2023. The red dashed line denotes when the RST was moved downstream due to construction.

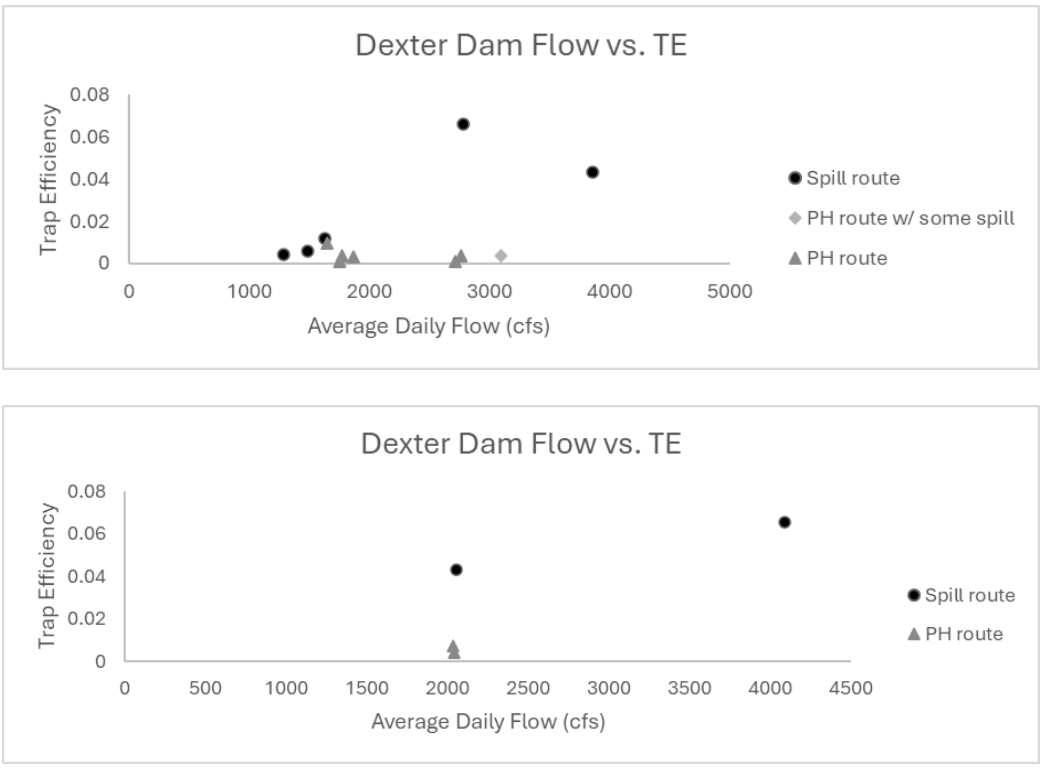

Figure E-18. Dexter Dam Tailrace trap efficiency trial plots versus flow levels for the RST position near the powerhouse (top panel) and downstream near the boat launch (bottom panel).

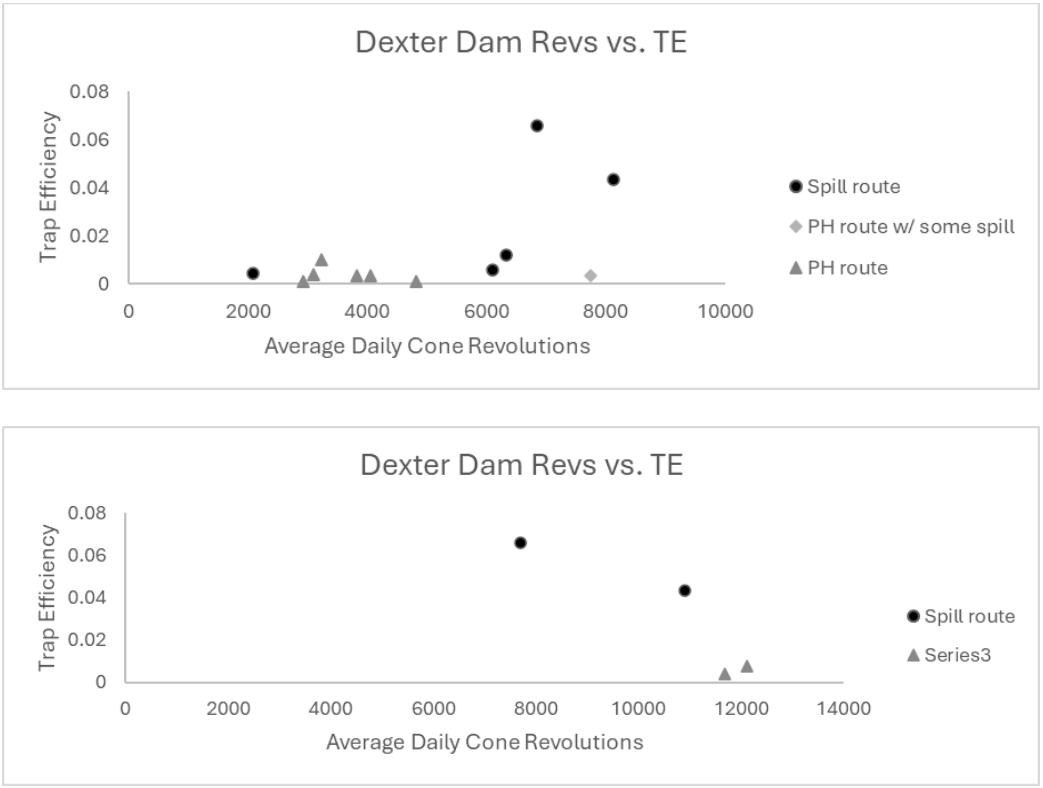

Figure E-19. Dexter Dam Tailrace trap efficiency trial plots versus cone flux for the RST position near the powerhouse (top panel) and downstream near the boat launch (bottom panel).

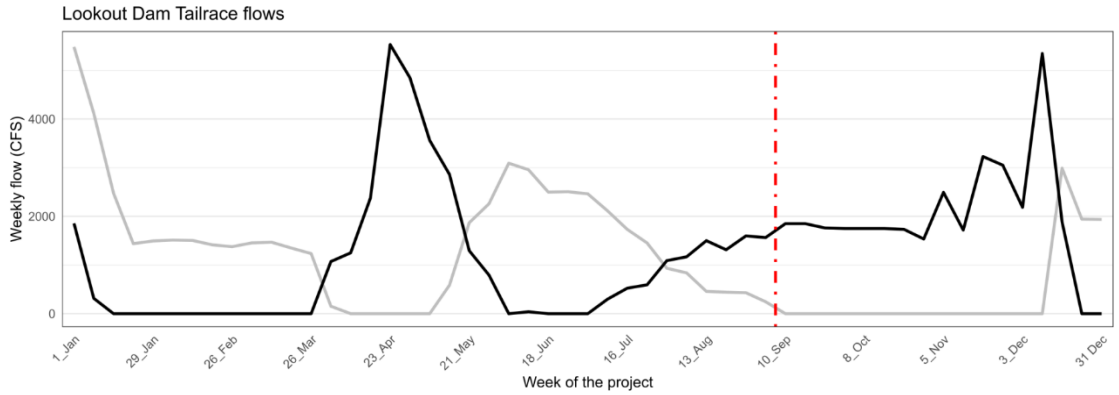

Figure E-20. Lookout Dam Tailrace powerhouse flow (gray line) and spill flow (black line) for 2023. The red dot dashed line denotes when the powerhouse RSTs were moved to a side-by-side orientation for safety.

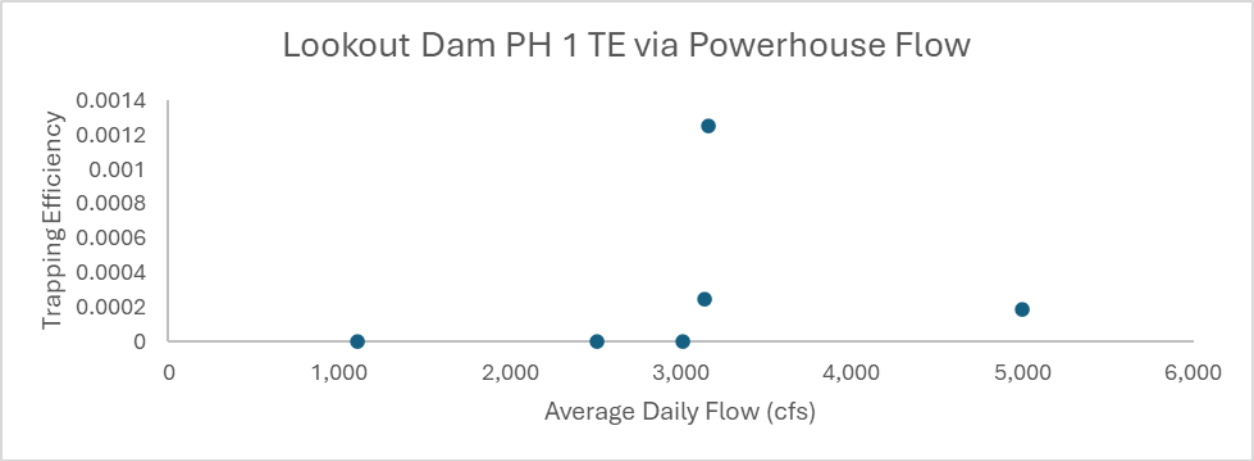

Figure E-21. Lookout Dam Tailrace PH1 trapping efficiency versus the powerhouse flows.

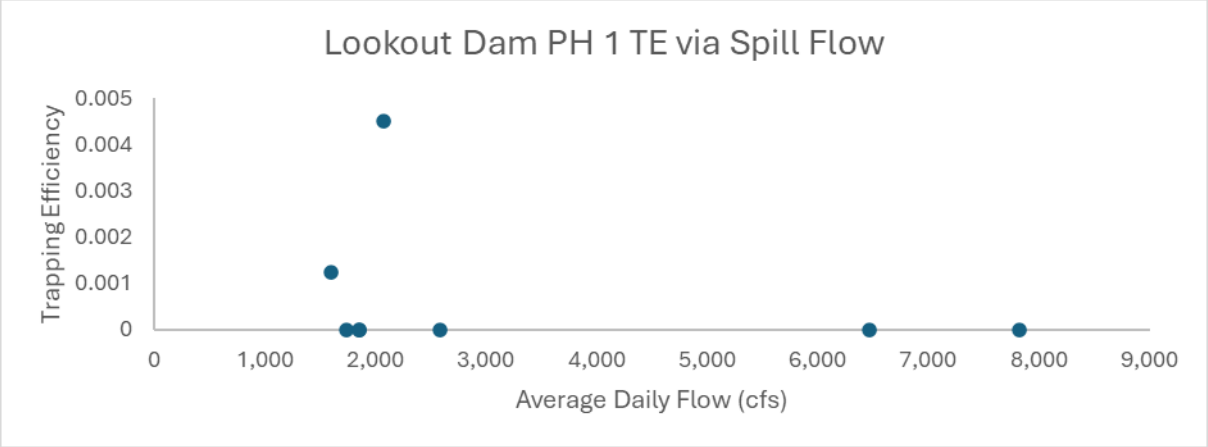

Figure E-22. Lookout Dam Tailrace PH1 trapping efficiency versus spill/RO flows.

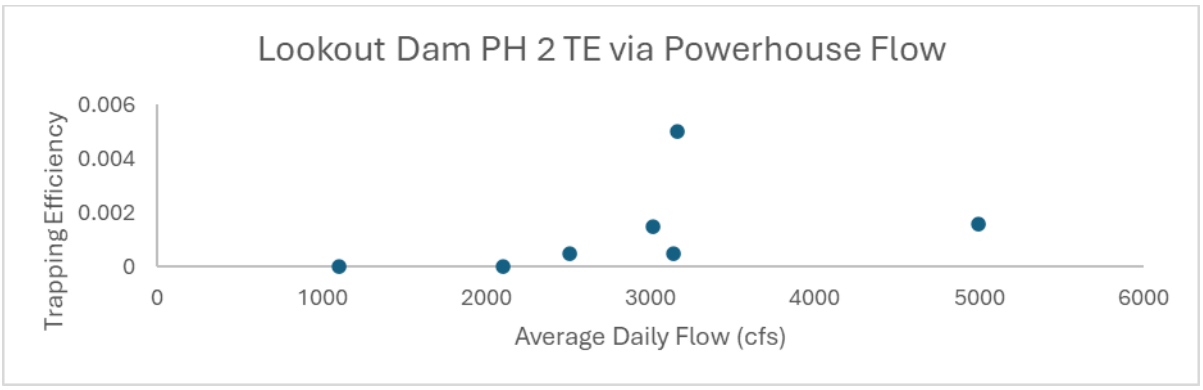

Figure E-23. Lookout Dam Tailrace PH2 trapping efficiency versus powerhouse flows.

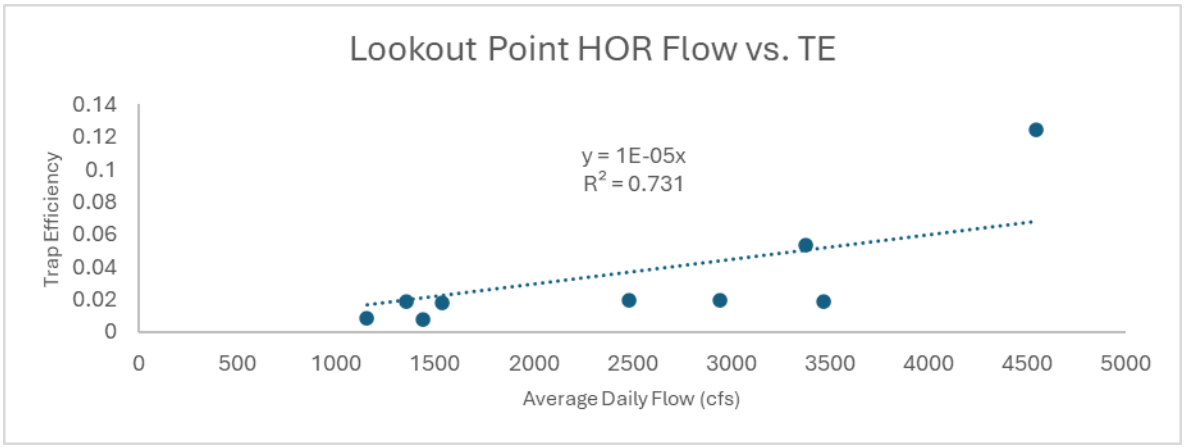

Figure E-24. Lookout Point Head of Reservoir trapping efficiency versus flows.

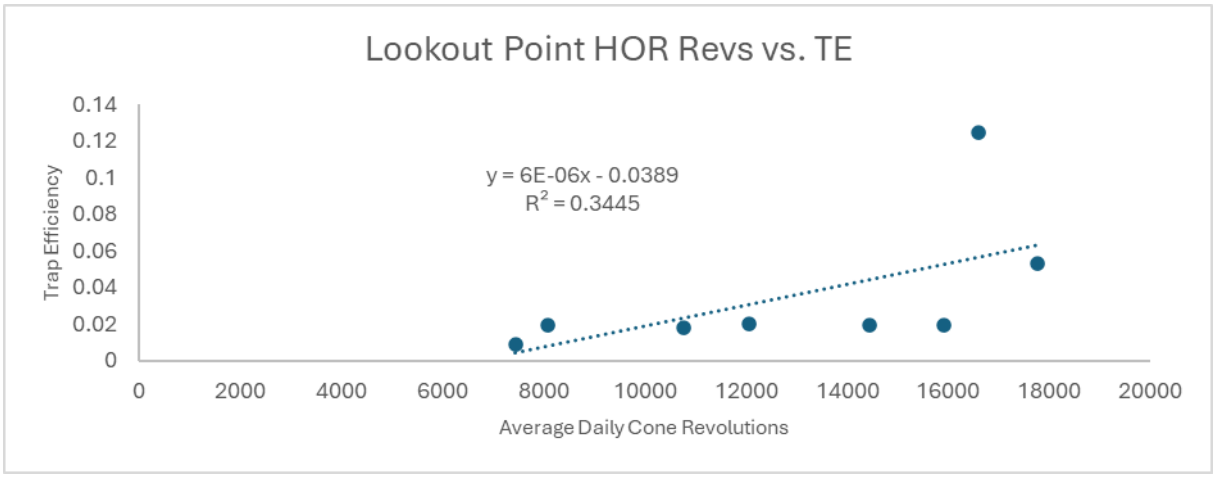

Figure E-25. Lookout Point Head of Reservoir trapping efficiency versus cone flux the day after fish were released.

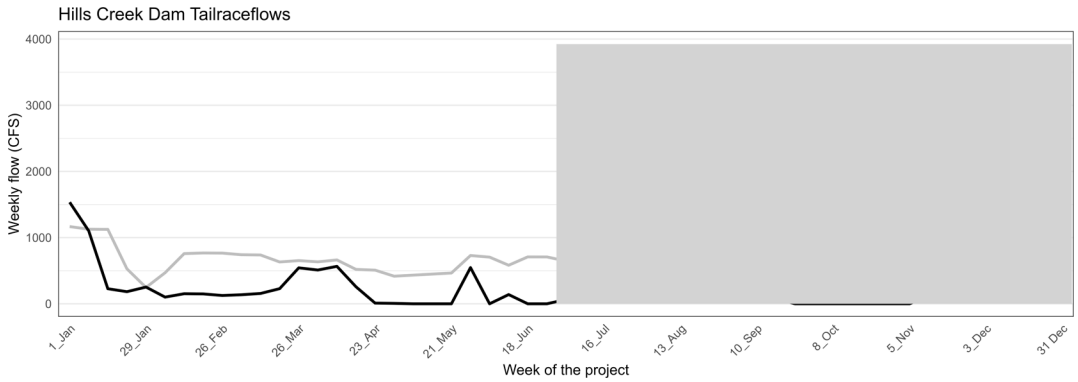

Figure E-26. Hills Creek Dam Powerhouse flow (gray line) and spill flow (black line) for 2023.

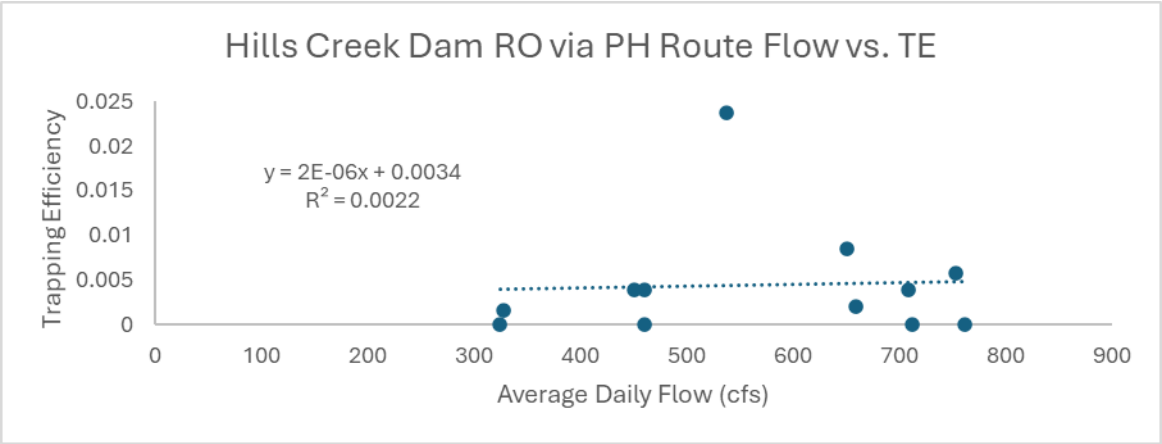

Figure E-27. Hills Creek RO trapping efficiency versus Powerhouse flows.

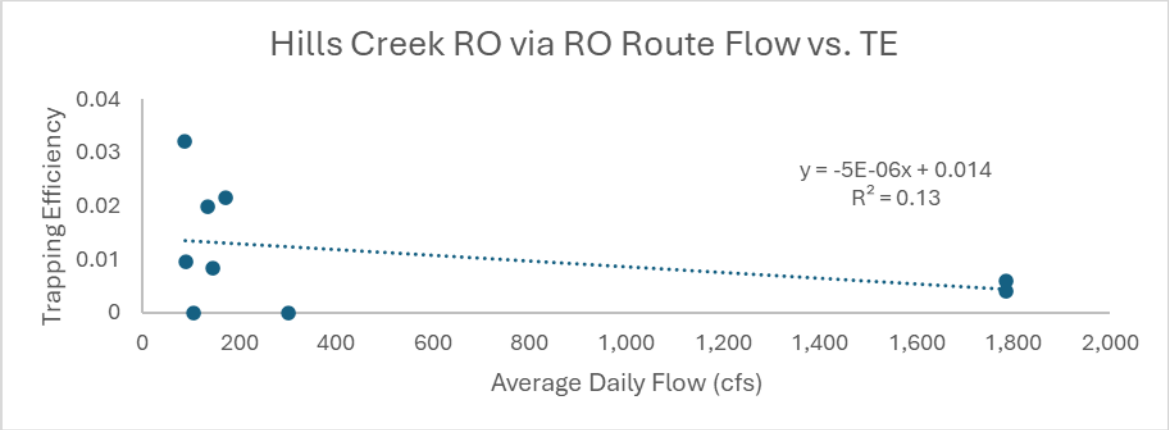

Figure E-28. Hills Creek RO trapping efficiency versus RO flows.

Table E-1. Compiled trapping efficiency releases for 2023.

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
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%
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%
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%

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
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 Regulating Outlet Channel	1/19/2022	995	26	2.6%
Cougar Dam Powerhouse Channel	4/20/2022	1000	67	6.7%
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 Powerhouse Channel	7/19/2022	535	148	27.7%
Cougar Dam Powerhouse Channel	8/11/2022	949	29	3.1%
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 Powerhouse Channel	1/12/2023	843	159	18.9%
Cougar Dam Regulating Outlet Channel	1/30/2023	509	6	1.2%
Cougar Dam Powerhouse Channel	3/23/2023	500	49	9.8%
Cougar Dam Regulating Outlet Channel	3/23/2023	511	3	0.6%
Cougar Dam Powerhouse Channel	3/30/2023	497	95	19.1%
Cougar Dam Regulating Outlet Channel	3/30/2023	491	31	6.3%
Cougar Dam Powerhouse Channel	4/18/2023	297	14	4.7%
Cougar Dam Regulating Outlet Channel	4/18/2023	501	2	0.4%
Cougar Dam Powerhouse Channel	5/10/2023	499	5	1.0%
Cougar Dam Regulating Outlet Channel	5/10/2023	499	0	0.0%

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
Cougar Dam Powerhouse Channel	6/6/2023	507	65	12.8%
Cougar Dam Powerhouse Channel	7/26/2023	510	63	12.4%
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	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 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	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 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 Powerhouse	7/21/2022	976	2	0.2%
Dexter Dam Powerhouse	10/26/2022	1007	1	0.1%
Dexter Dam Powerhouse	11/1/2022	755	1	0.1%
Dexter Dam Powerhouse	11/17/2022	991	4	0.4%

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
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 Spillway	3/29/2023	1,199	5	0.4%
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 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%
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 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%
Lookout Point Head of Reservoir	11/15/2023	755	3	0.4%
Lookout Point Head of Reservoir	11/29/2023	760	2	0.3%
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%

Release Location	Date of Release	# of Fish Released	# of Fish Recaptured	% Efficiency
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 – 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	6/3/2023	508	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%

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Appendix F –
Examples of Injury Photos

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Appendix F: Example of Injury Photos

Figures

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

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

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

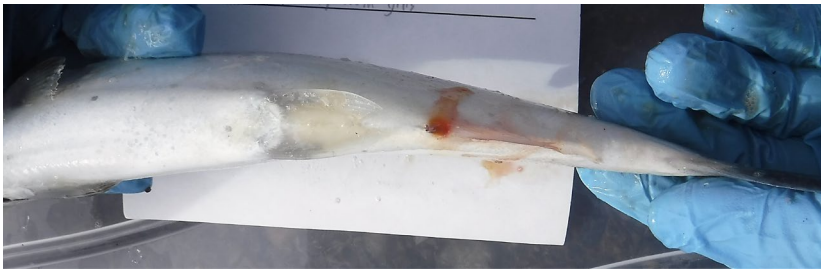

Figure F-4. Bleeding from vent (BVT).

Figure F-5. Fin blood vessels broken (FVB).

Figure F-6. Gas bubble disease (fin ray/eye inclusions) (GBD).

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

Figure F-8. Head injury (HIN).

Figure F-9. Operculum damage (OPD).

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

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

Figure F-12. Hole behind pectoral fin (HBP).

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

Figure F-14. Head only (HO).

Figure F-15. Body only (BO).

Figure F-16. Head barely connected (HBO).

Figure F-17. Fin damage (FID).

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

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

Figure F-20. Fungus (FUN).

Appendix G –
Images of Non-Target Species

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Appendix G: Images of Non-Target Species

Figures

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Figure G-1. Bluegill

Figure G-2. Juvenile Lamprey

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. Labeled image of a rotary screw trap showing parts and terminology.

Images of Traps at Various Flow Levels

Figure H-2. Big Cliff Dam at low flow (left) and high flow (right).

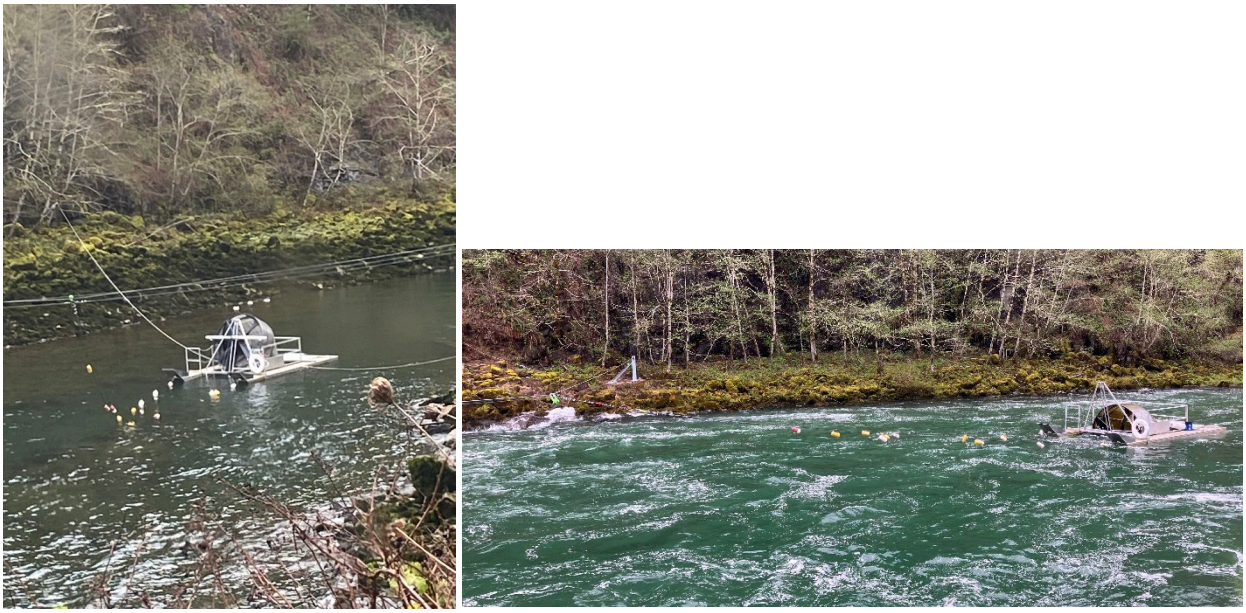

Figure H-3. Green Peter Dam Tailrace – Middle Santiam River at low flow, not sampling, (left) and high flow (right).

Figure H-4. Foster Dam Head of Reservoir – South Santiam River at low (left), medium (middle), and high, not sampling, (right) flow.

Figure H-5. Cougar Dam – Regulating Outlet at medium (left) and high (right) flow.

Figure H-6. Cougar Dam – Powerhouse Channel when not sampling (left) and when sampling with high debris (right).

Figure H-7. Cougar Dam Head of Reservoir not sampling at high flow.

Figure H-8. Fall Creek Dam Tailrace at low (left) and high (right) flow.

Figure H-9. Fall Creek Head of Reservoir at low (left), medium (middle), and high not sampling (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 trap not sampling at high flow.

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.

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
Big Cliff Dam Tailrace	Flows exceeding 5,000 cfs	Debris passage events require the trap 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.
Foster Dam Head of Reservoir – South Santiam	Flows exceeding 5,000 cfs	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.
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.
Cougar Head of Reservoir	Unknown at this time.	Rapid increases in flow bring large amount of debris that damage the RST and captured fish. RST is raised for these events.
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.
Fall Creek Head of Reservoir	Flows exceeding 6.0 ft on the USGS gauge.	Rapid increases in flow even below the 6.0 ft gauge mark result in high debris that can kill captured fish. Fire damage upstream has increased debris load in the system.
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	High flow results in an inability for crew to access the loop line to pull the RO trap into the shore.
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.

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

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

Figures and Tables

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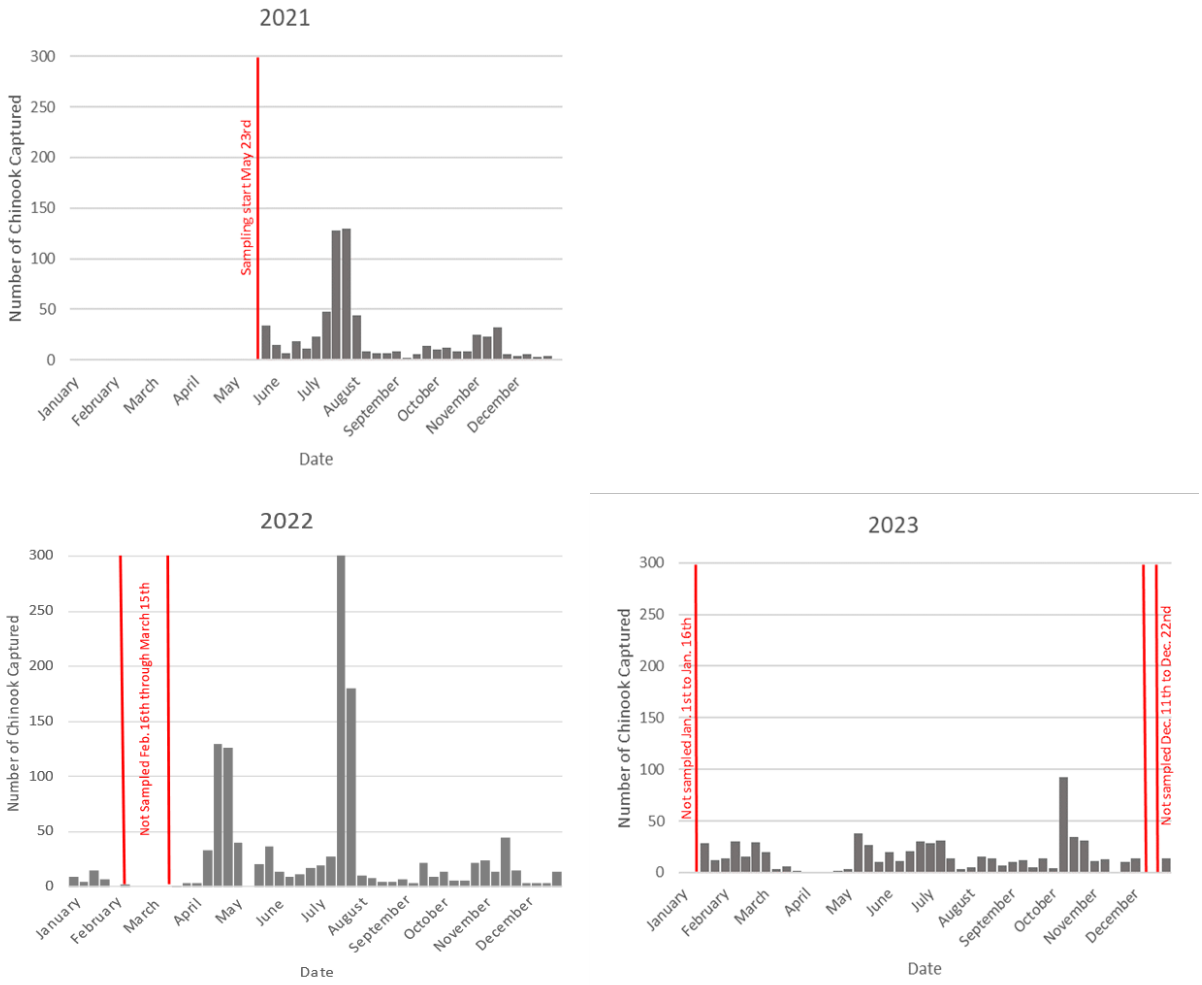

Figure I-1. Weekly Chinook capture at the Big Cliff Dam RST for 2021 through 2023 sampling.

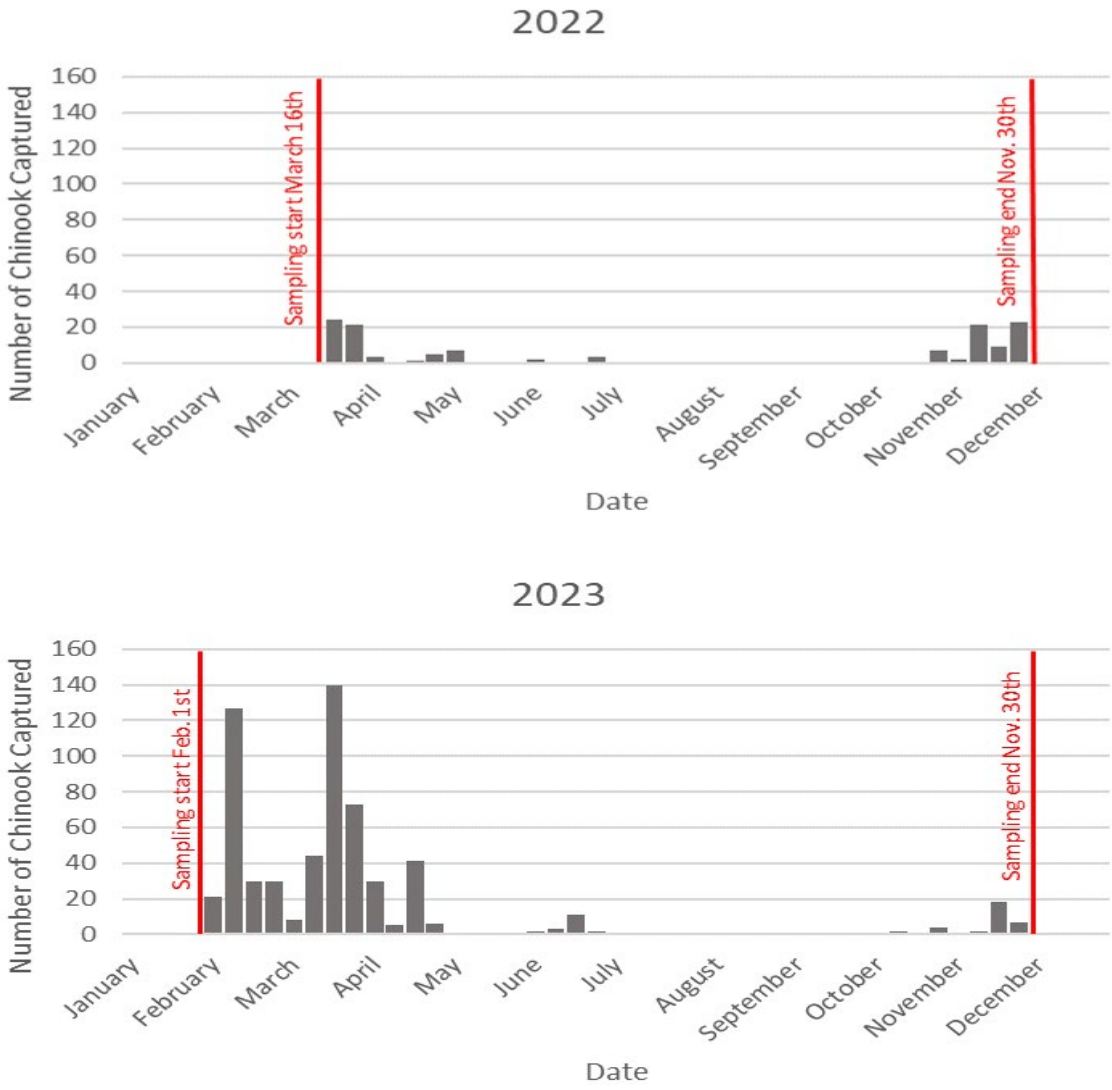

Figure I-2. Weekly Chinook capture at the Foster Dam Head of Reservoir – South Santiam RST for 2022 and 2023 sampling

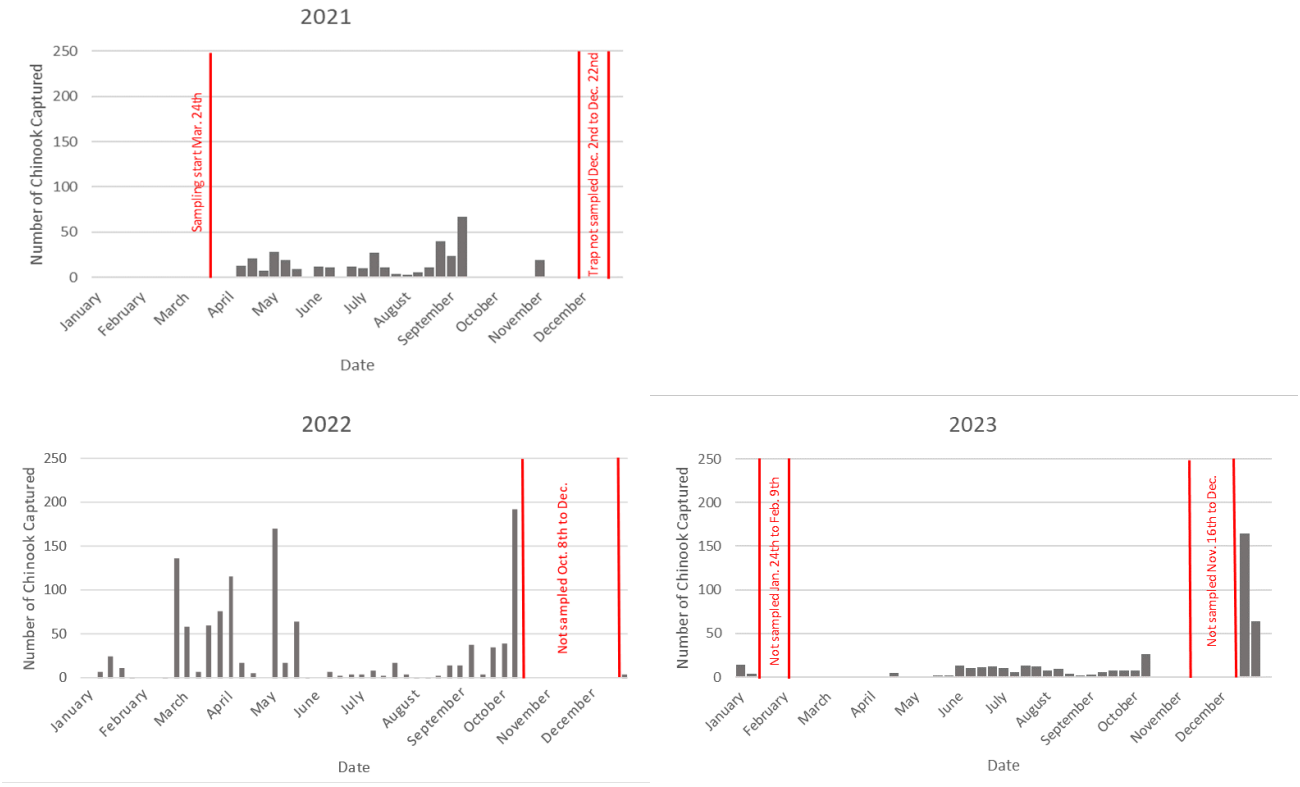

Figure I-3. Weekly Chinook capture at the Cougar Dam PH RSTs for 2021 through 2023 sampling.

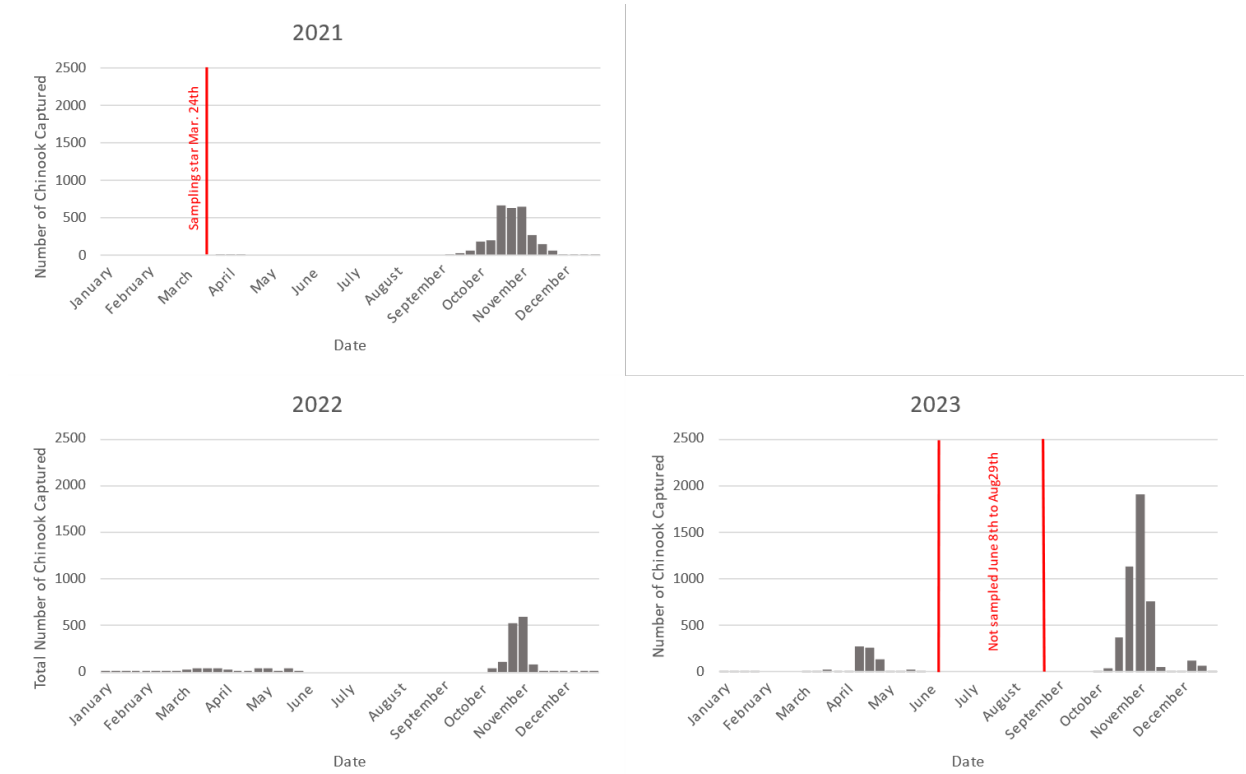

Figure I-4. Weekly Chinook capture at the Cougar Dam RO RST for 2021 to 2023 sampling.

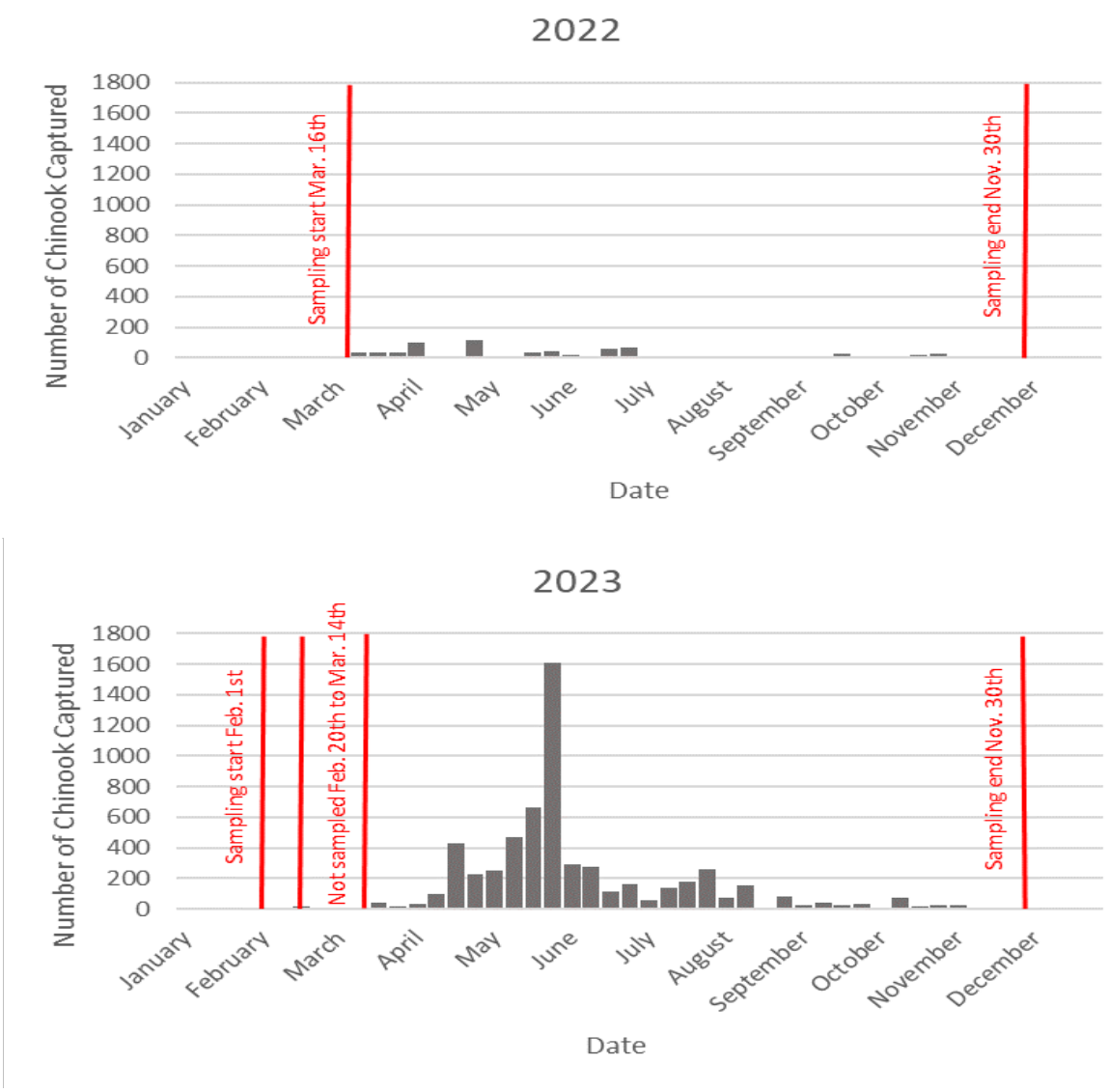

Figure I-5. Weekly Chinook Capture at the Cougar Dam Head of Reservoir RST for 2022 and 2023 sampling.

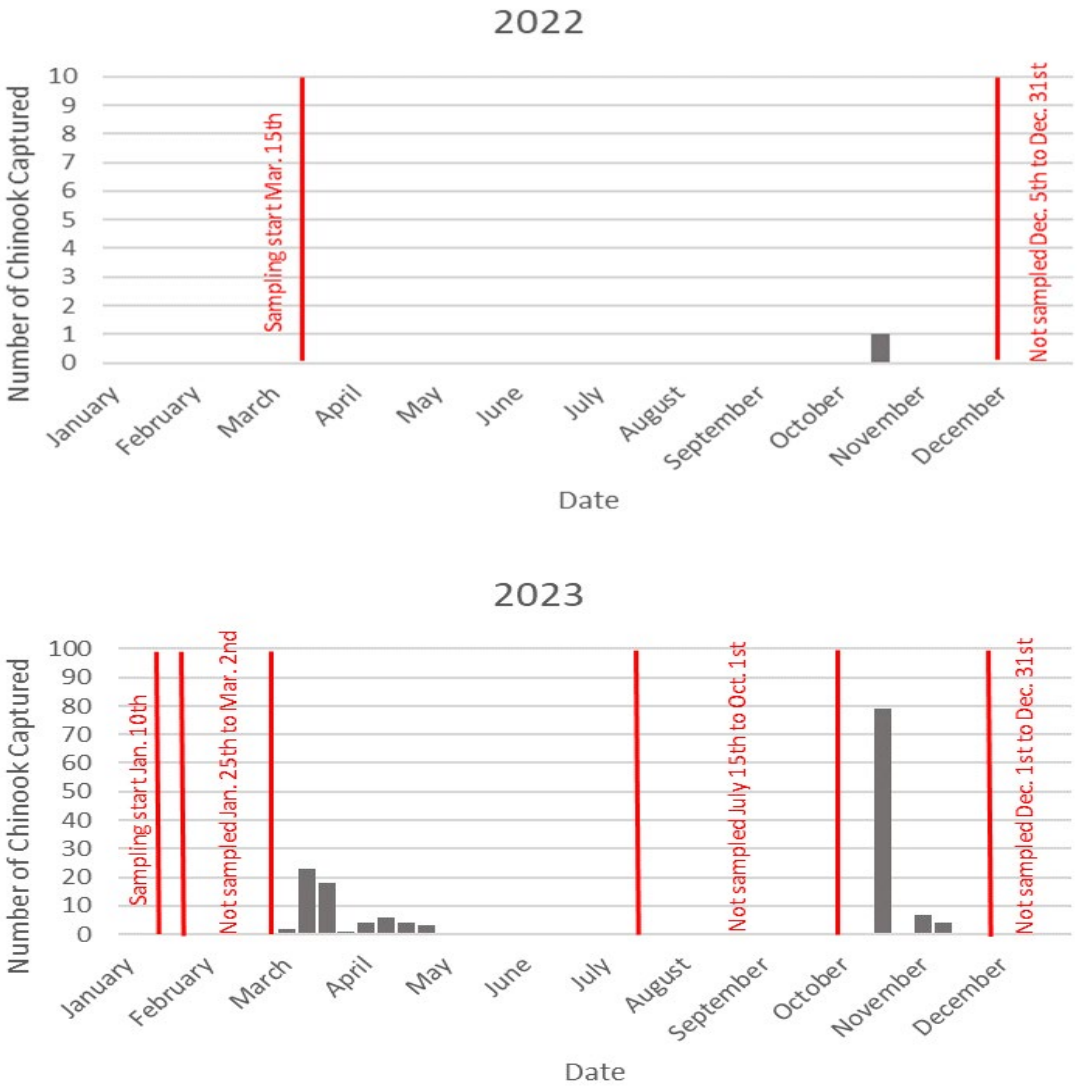

Figure I-6. Weekly Chinook at the Fall Creek Dam RST for 2022 and 2023 sampling.

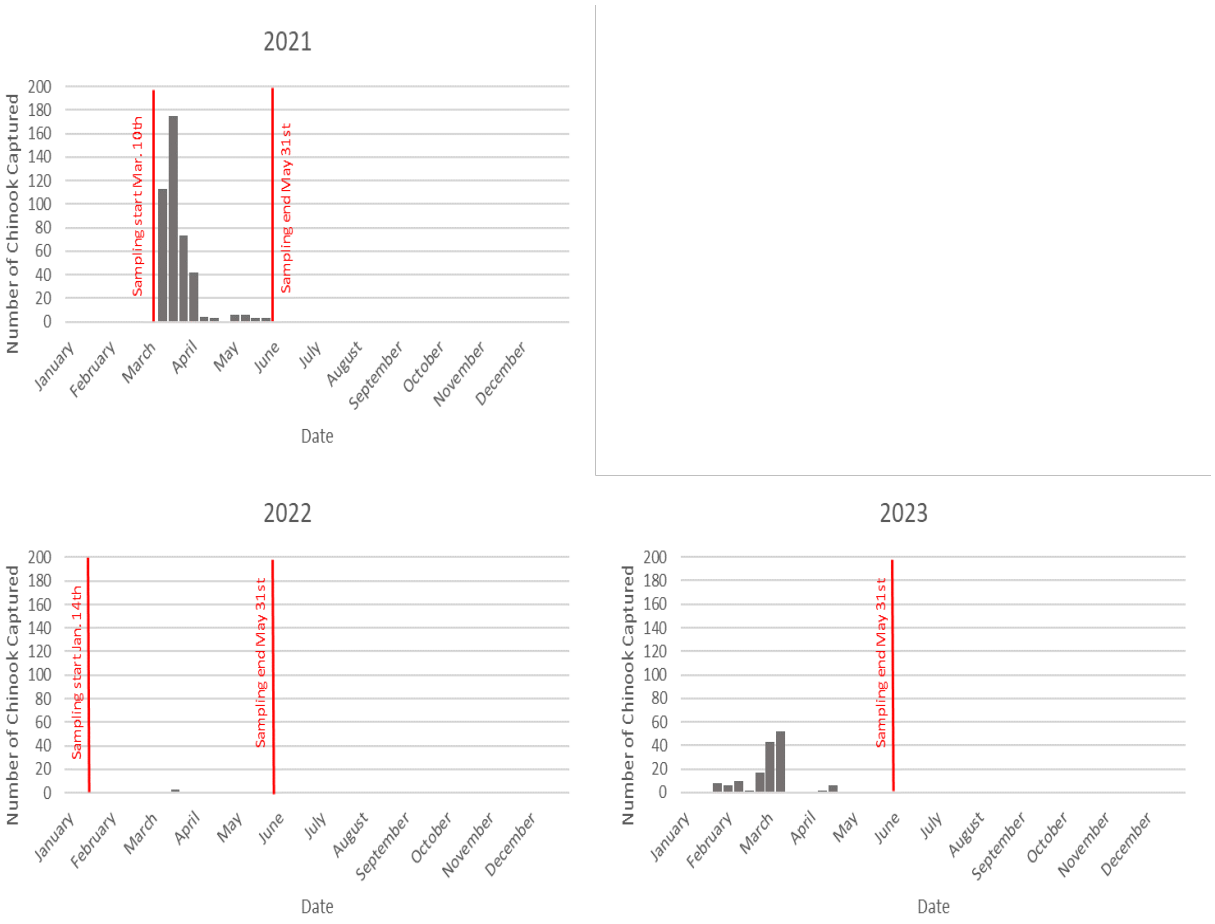

Figure I-7. Weekly Chinook capture at the Fall Creek Head of Reservoir RST for 2021 to 2023 sampling.

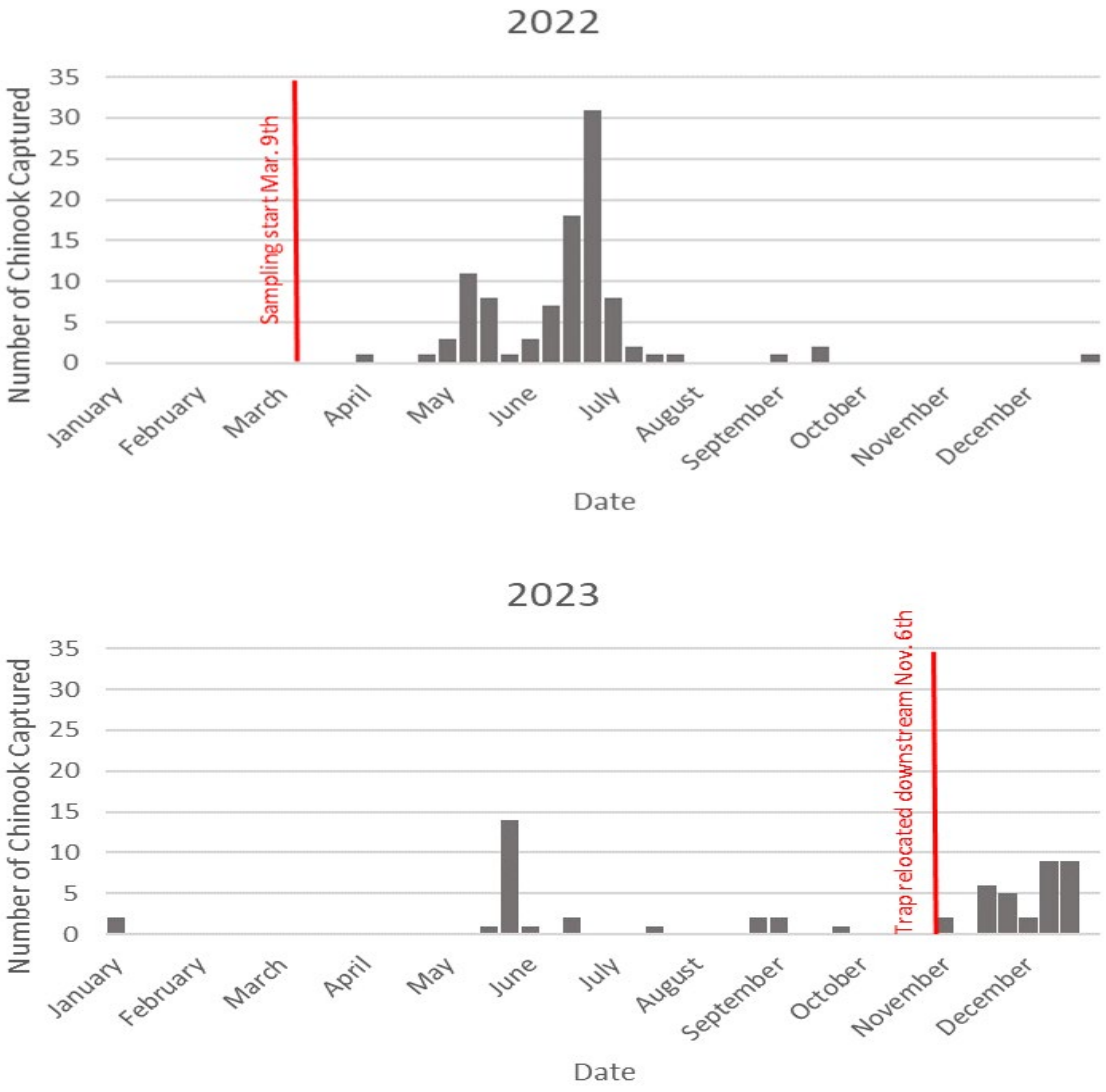

Figure I-8. Weekly Chinook capture at the Dexter Dam RST for 2022 and 2023 sampling.

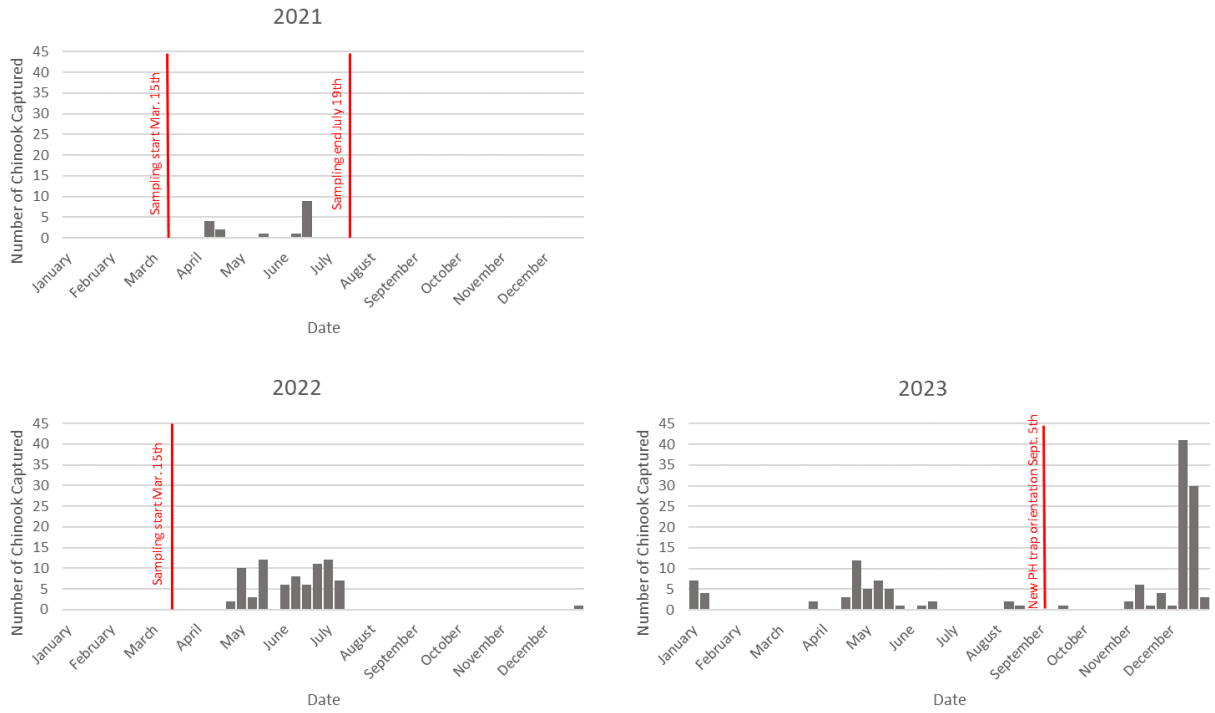

Figure I-9. Weekly Chinook capture at the Lookout Dam RSTs for 2021 to 2023 sampling.

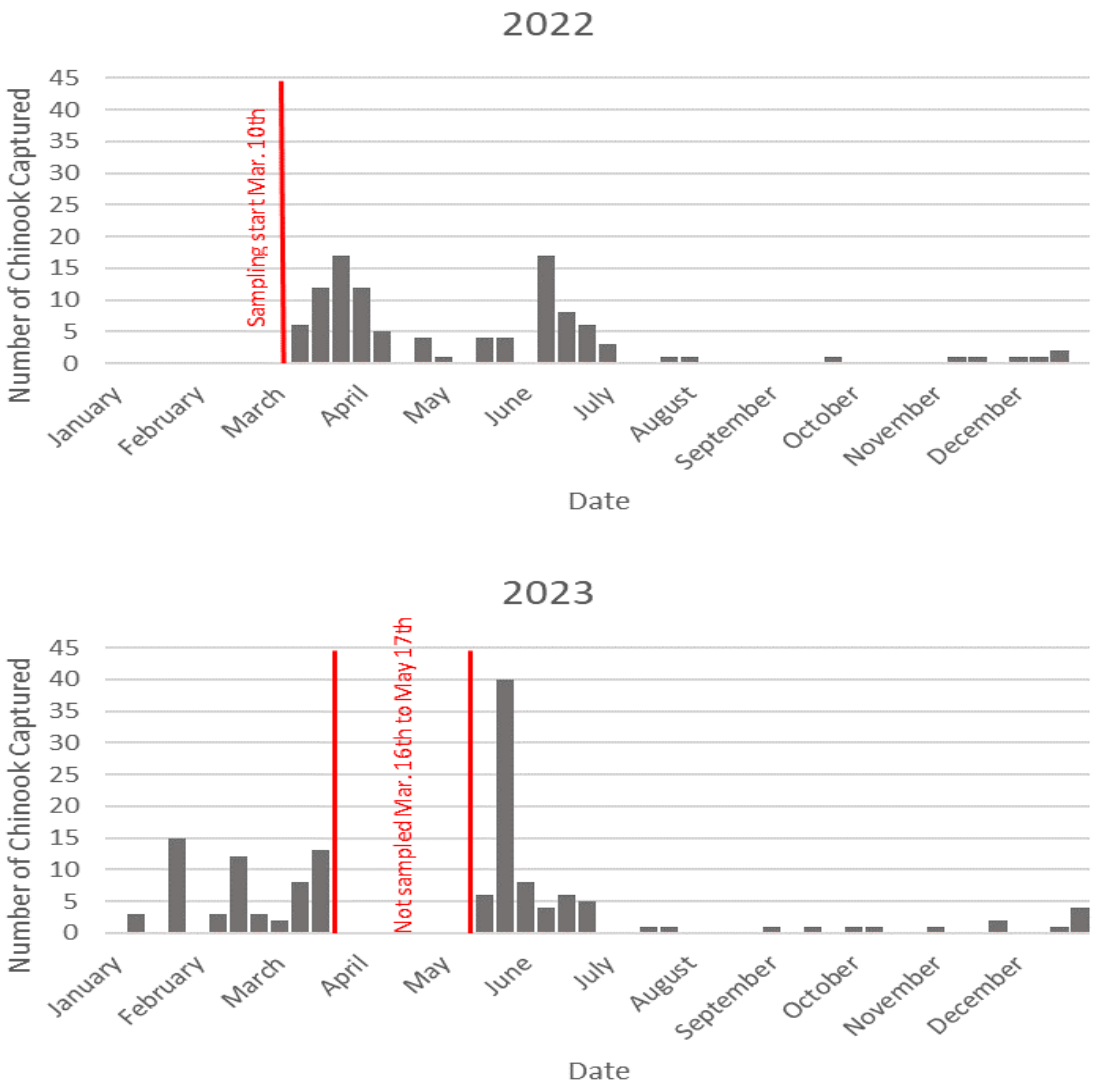

Figure I-10. Weekly Chinook capture at the Lookout Point Head of Reservoir RST for 2022 and 2023 sampling.

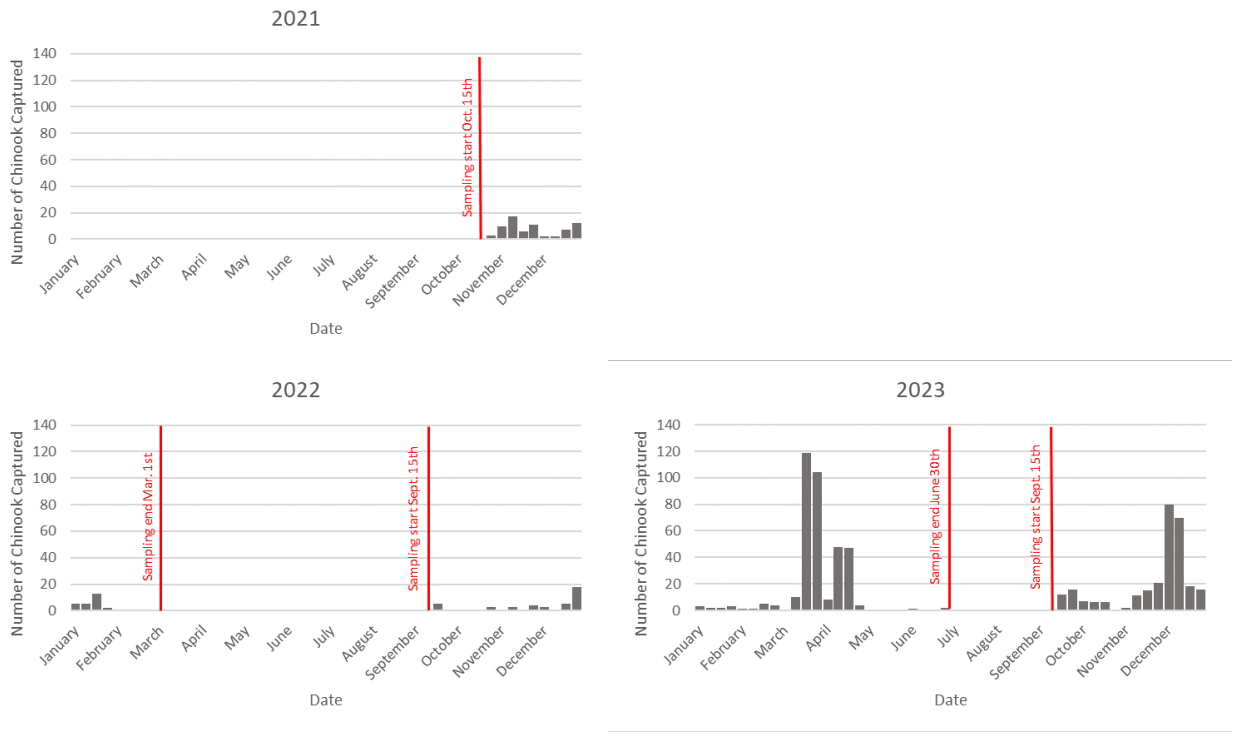

Figure I-11. Weekly Chinook capture at the Hills Creek Dam RSTs for 2021 to 2023 sampling.

Table I-1. Adult Chinook out planting above Detroit Reservoir for 2020 through 2023.

Year	North Santiam R.			Breitenbush		
	Males	Females	Total	Males	Females	Total
2020	1,133	790	1,923	350	341	691
2021	466	288	754	433	127	560
2022	1,472	1,353	2,825	559	550	1,109
2023	708	720	1,428	296	300	596

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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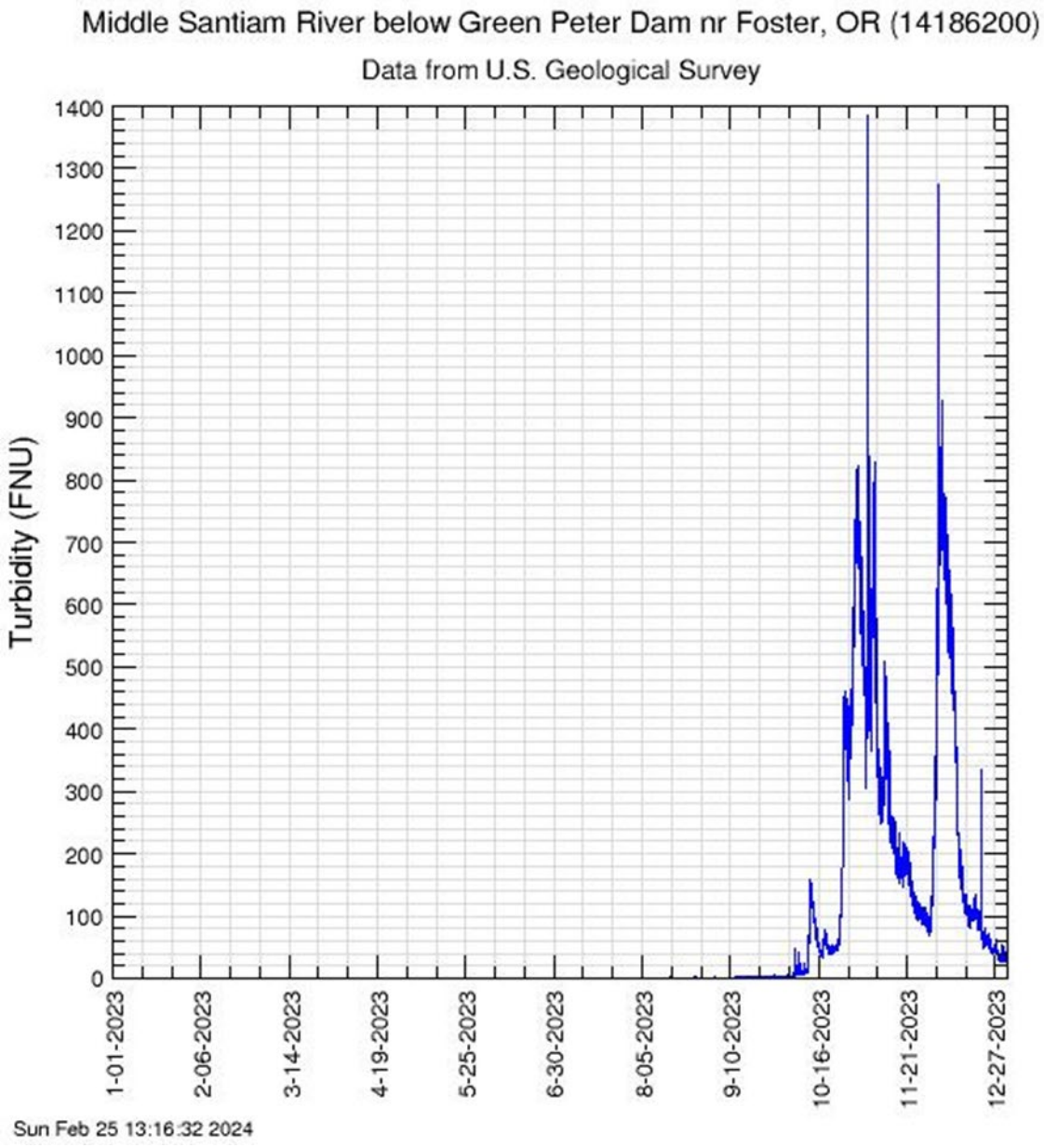

Figure J-1. USGS Turbidity Gage for Calendar Year 2023 for the Middle Santiam River Below Green Peter Dam.

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