

FINAL

**WILLAMETTE VALLEY FISH
PASSAGE MONITORING VIA
ROTARY SCREW TRAPS**

Bi-Annual Report

Prepared for



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Acronyms and Abbreviations

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

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Rotary Screw Trap Program Bi-Annual Report

Introduction

The US Army Corps of Engineers (USACE) operates 13 dams in the largest five Willamette River tributaries for flood risk management, irrigation, recreation, and hydropower. Major habitat blockages of Upper Willamette River (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 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).

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

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

This report contains a summary and analysis of the field study implemented by Environmental Assessment Services, LLC (EAS) under contract with the USACE for RST sampling efforts starting in spring 2023 through June 30, 2023.

Additional RST sampling was conducted by EAS as a sub-contractor for Cramer Fish Sciences under contract W9127N19D0009 at head of reservoir sites above Detroit, Green Peter, and Hills Creek Reservoirs in the spring of 2023. Results from sampling at the head of reservoir sites listed are reported separately (Cramer Fish Sciences 2023a).

Methods

Rotary Screw Traps and Sampling Sites

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

RSTs were operated at 11 locations in the southern Willamette River watershed: Big Cliff Dam Tailrace, Green Peter Dam Tailrace- Middle Santiam River, Foster Dam Head of Reservoir- South Santiam River, Cougar Dam Tailrace, Cougar Head of Reservoir, Fall Creek Dam Tailrace, Fall Creek Head of Reservoir, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point Head of Reservoir- 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. 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 June 30, 2023.
- At the Green Peter Dam Tailrace- Middle Santiam River, a single 8-foot RST operated from March 14, 2023, to June 30, 2023.
- At the Foster Dam Head of Reservoir- South Santiam River site, a 5-foot trap operated from February 1, 2023, to June 30, 2023.
- At the Cougar Dam Tailrace, three RSTs were deployed and operated from January 1, 2023, to June 30, 2023: two 8-foot RSTs in the Powerhouse channel and one 5-foot RST in the Regulation Outlet (RO) channel, and.
- At the Cougar Head of Reservoir site, a single 5-foot RST was deployed in the South Fork McKenzie River from February 1, 2023, to June 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 June 30, 2023.
- At the Fall Creek Head of Reservoir 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 June 30, 2023.
- Below the Lookout Dam Tailrace, three 8-foot RSTs were operated from January 1, 2023, to June 30, 2023: two in the Powerhouse channel and one in the Spill channel.
- At the Lookout Head of Reservoir- Middle Fork Willamette River site, a 5-foot RST operated from January 1, 2023, to June 30, 2023.
- At the Hills Creek Dam, two RSTs were operated from January 1, 2023, to June 30, 2023: one 8-foot RST in the Powerhouse and one 5-foot RST in the RO channels.

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

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

Site	Trap Installation	Sample Reporting Period
Big Cliff Dam	12/01/2022 ^a	01/01/2023–06/30/2023
Green Peter Tailrace- Middle Santiam River	03/14/2023 ^b	02/01/2023–06/30/2023
Foster Dam Head of Reservoir- South Santiam River	01/31/2023	02/01/2023–06/30/2023
Cougar Dam PH	12/01/2021 ^a	01/01/2023–06/30/2023
Cougar Dam RO	12/01/2021 ^a	01/01/2023–06/30/2023
Cougar Dam Head of Reservoir	01/31/2023	02/01/2023–06/30/2023
Fall Creek Dam	03/15/2022 ^a	01/01/2023–06/30/2023
Fall Creek Head of Reservoir	01/18/2023 ^c	01/02/2023–05/31/2023
Dexter Dam Tailrace	03/03/2022	01/01/2023–06/30/2023
Lookout Point Dam	03/15/2022 ^a	01/01/2023–06/30/2023
Lookout Point Head of Reservoir	03/06/2022	01/01/2023–06/30/2023
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 current 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.

Data Collection

Fish Collection, Trap and Environmental Metrics

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

Biological Data and Tagging

Biological data was collected for each target fish we captured. Target fish were those that did not display any clip, tag, or dye and were presumed to be of natural origin. At sites in the Santiam River basin where winter steelhead were target fish, all juvenile *O. mykiss* captured were treated as targets, as it is not possible to accurately distinguish between resident rainbow trout and anadromous steelhead trout. Table 3 lists all sites and which species are considered targets at 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. A list of injury codes used for assessments is provided in Table 2. In addition to the injury codes listed, we also enumerated the number of adult gravid female copepods (*Salmincola 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). 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 category based on the age class determined from scales and time of capture. Fish were reported as sub-yearling or yearling along with the brood year 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 PIT tagged and released. All PIT tag data was uploaded into PTAGIS. Appendix C contains information on PIT tags and tag files. At the 5 sites where fish can be recaptured at another trap site downstream, fish that were non-sac fry, smaller than 65 mm and larger than 35 mm were marked with visible implant elastomer. Photos of species encountered and injuries were collected throughout the sampling periods and are provided in Appendix D. A summary of data collected by site is provided in Table 3.

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

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

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-hr Holds (post collection)	PIT Tagging (>65 mm)	Elastomer Tagging (<65 mm)
Big Cliff Dam	Yes, Hatchery Fish	Spring Chinook and <i>O. mykiss</i>	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No
Green Peter Dam Tailrace-Middle Santiam	Yes, Hatchery Fish	Spring Chinook and <i>O. mykiss</i>	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No
Foster Dam Head of Reservoir-South Santiam	Yes, Run of River Fish, Hatchery Fish in Fall	Spring Chinook and <i>O. mykiss</i>	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	No	Yes	No
Cougar Dam Tailrace	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No
Cougar Dam Head of Reservoir	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	No	Yes	Yes
Fall Creek Dam	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes	No
Fall Creek Head of Reservoir	Yes, Run of River	Spring Chinook	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	No	Yes	Yes
Dexter Dam Tailrace	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	No
Lookout Dam Tailrace	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	Yes, on fish not included in 24-hr holds
Lookout Point Head of Reservoir	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	No	Yes	Yes
Hills Creek Dam	Yes, Hatchery Fish	Spring Chinook	Yes, weight (nearest 0.1 g), FL (mm), Injuries	Yes	Yes	Yes, on fish not included in 24-hr holds	Yes, on fish not included in 24-hr holds

Trapping Efficiency Trials and Approach

Approach

Due to limited hatchery fish availability and inconsistent catch of run of river fish for use in mark recapture studies for trapping efficiency, we used a flow-based approach to evaluate the efficiency of each trap. Flow categories were assigned for each trap that were tailored to the specific location and range of conditions the trap could operate in. Multiple trials with marked hatchery fish were conducted across the range of flows in a category and pooled together to calculate weekly estimates for each specific location based on the flows occurring during that time period. When sufficient numbers of run of river fish were available, captured fish were marked with a caudal clip that alternated weekly between the lower or upper lobe and released

upstream of the trap. We also tracked trials based on size of hatchery fish used. This allowed us to evaluate differences in capture efficiency by flow, fish size, and origin. Using this approach, we can also use historical data to supplement our efficiency calculations and continue to add to data in subsequent years as more trials are performed. It is important to note that rotary screw traps are designed to capture fish actively out-migrating and generally, do not capture fish that are moving upstreaming or rearing near sampling sites. Many sites experience a wide range of flows throughout the sampling period and the performance of the trap 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 traps effectively sample. Furthermore, it is assumed that all fish released for efficiency trials migrate downstream past the trapping site within a one-week period. Additional assumptions are provided in the subsequent trapping efficiency trial sections.

Trapping Efficiency Trials

Hatchery Fish. Due to environmental conditions and fish availability, we were unable to test each site to the extent we had planned. We performed trapping efficiency trials with large groups of marked hatchery fish at Big Cliff Dam Tailrace, Green Peter Dam Tailrace – Middle Santiam River, Foster Dam Head of Reservoir- South Santiam River, Cougar Dam Tailrace, Cougar Head of Reservoir, Fall Creek Dam Tailrace, Dexter Dam Tailrace, Lookout Dam Tailrace, Lookout Point Head of Reservoir, and Hills Creek Dam Tailrace.

In order to utilize trapping efficiencies from hatchery fish to calculate run of river passage, we have to assume that hatchery fish and run of river fish have the same probability of being captured in an RST. When possible, we performed run of river fish trials to interrogate this assumption. All hatchery fish utilized in trapping efficiency trials were adipose clipped at minimum. Additional fin clips and Bismarck brown dye were utilized at sites to differentiate fish by release location and route. Fifty fish from each trial had their fork length measured to the nearest millimeter, weighed to nearest 0.1 grams, and had injury assessments performed prior to release. Hatchery fish were collected either from ODFW hatcheries or from Oregon State University's Smith Farms fish facility. Water temperature and dissolved oxygen levels were continuously monitored during fish transportation and corrected as necessary. Upon arrival 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 approximately 500 meters above the trap, or as far upstream as possible at below dam sites. Marked fish recaptured within one week of release were considered as recaptured fish regarding the trap's efficiency. Those captured outside of the one-week period were not included in the efficiency calculation.

Run of River Fish. Run of river fish were captured, marked, and released upstream of the trapping sites to assess the capture efficiency of the trap. These run of river trials only occurred at sites where hatchery fish were not allowed for release and at locations when sufficient numbers of natural origin fish were captured to allow for trials to be performed. For the Fall Creek Head of Reservoir site 2022 sampling period, run of river trapping efficiency trials were the only type of trapping efficiency trial we could perform as our permits did not allow us to utilize hatchery fish at this site. Run of river trials were utilized at the Foster Dam Head of Reservoir - South Santiam River and Cougar Dam sites to supplement the hatchery fish trials and allow us to compare between hatchery and run of river capture efficiencies. At the Cougar Dam site, run of river trapping efficiency trials were performed when sufficient numbers of natural origin fish were being collected weekly to allow for enough fish to be released so that at least five recaptures would occur. For fish used in trials, data was collected on captured fish as normal, fish were then tagged and marked with a caudal clip that alternated weekly between the lower or upper lobe and then were released approximately 500 meters upstream of the trap. We are unable to utilize VIE marked fish for run of river trapping efficiency trials as we cannot uniquely mark fish for this purpose without biasing results of downstream recaptures of VIE marked fish. Marked fish recaptured within one week of release were considered as recaptured fish regarding the trap's efficiency. Those captured outside of the one-week period were not included in the

efficiency calculation. A summary of trap efficiency trials performed at each site is provided in subsequent results and discussion sections.

24 Hour Post-Capture Holding Trials

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

Data Analysis

Passage Estimates

Catch Evaluations. Where possible, daily catch rates were standardized to 24-hour sampling intervals based on trap start and stop times (time between trap checks). At Cougar Powerhouse, Cougar regulating outlet, and Hills Creek Powerhouse raw daily catch numbers were used. At those three locations, operations frequently cycled within 24 hours (i.e., the RO cycles regularly during a fish passage operation, but the trap samples the entirety of the operation between checks) and resulted in discrete flow time windows the traps sampled between checks. Due to RST operations in these situations, standardization of catch was not necessary, and an alternative equation was used. Refer to equations detailed below. Operations cycled at other sites, such as Big Cliff, but those traps were in the tailrace and experienced continuous flow, allowing us to standardize catch to 24-hour periods. Across all sites, traps were fished a total of 2608 start/stop times with an average duration of 23.97 hours between checks (st dev. 2.60 hours) from January 1, 2023 through June 30, 2023. Trap sampling time between checks ranged from 0.5 and 49.87 hours. In almost all instances (>99%) traps were fished overnight, but due to logistics trap checks occurred at various times the following day. This resulted in sampling duration that included overnight effort ranging from approximately 12 to 35 hours. In a few instances (n=3) traps were not fished overnight, typically during high flows due to safety/debris clogging issues classified as weather event checks and excluded from analysis. In one instance a trap was fished for two nights because it was impossible to reach trap sites due to extreme weather. Additionally, data was excluded (<3% n=65) 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.

$$C_w = C_{adj} * (7/D_f)$$

or

$$C_w = C_r * (7/D_f)$$

where:

- C_w = Adjusted weekly catch
- C_{adj} = Weekly sum of adjusted daily catch
- C_r = Weekly sum of raw catch at locations that had discrete flows
- D_f = Days fished in a week.

Abundance Estimates of Out-Migrating Target Species

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

$$N_{mf} = C_w / e_m$$

and

$$e_m = r/m.$$

where:

- N_{mf} = weekly estimated out-migrants, based on flow levels (low, medium, and high) where possible.
- C_w = Adjusted weekly catch
- e_m = average measured trap efficiency, based on flow levels (low, medium, and high) where possible
- r = number of recaptured marked fish
- m = number of marked fish released.

One novel difference from previous work in this area is that we attempt to account for flow rates. Water flow has been shown to be the dominant factor affecting trap efficiency in multiple RST out-migrating juvenile salmonid studies (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, run of River TE trials would be conducted weekly, but previous work in the area has shown that releasing enough RST captured fish to obtain the minimum of five recaptures to calculate TE is problematic at most locations. Unfortunately, it is unrealistic to perform weekly trials at sites with hatchery fish as there are not enough fish available for this purpose.

Flow rates are likely a major factor in trap efficiency, but the response appears to be on a site-by-site basis. Details about specific TE trials are reported in the results section, and successful TE trials are presented in Appendix E. For most sites too few successful TE trials (total trials, at specific flow rates, or not enough recaptures) have been conducted to model TE in relation to flows. In those instances, all TE trials were pooled if trials had enough capture returns. There appear to be linear trends at some sites, but at this time not enough trials have been conducted (particularly at high flows) to model the data. At Cougar RO, a highly channelized location, the TE for both hatchery and wild fish appears to be unaffected by flow, but more trials are needed at flows above 2000 CFS to confirm. Additionally, we theorize trap efficiency functionally changes at different flow rates for Big Cliff similar to Dambacher (1991, 2023). For example, the

performance of the trap at Big Cliff Tailrace appears to change depending on flow rate, and roughly corresponds to low (<2 k CFS), medium (<2-4 k CFS), and high flows (>4 k CFS). Therefore, we believe that by pooling TE trails, possibly including historical studies if sampling methodology overlaps, we will be able to build a model overtime that can predict TE based on flow rates. This would reduce the overall number of required TEs and decrease error estimates.

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

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

and

$$e_{95} = e_m$$

where:

- N_{95} = Estimated 95% weekly CI for out-migrants, based TE trials at flow levels (Low, medium, and high) where possible.
- C_w = Adjusted weekly catch
- e_m = Average measured trap efficiency, based on flow levels (low, medium, and high) where possible
- e_{95} = Upper and lower 95% TE CI, based on TE trials at flow levels (low, medium, and high) where possible
= 0.05 level of significance
- s = Standard deviation of trap efficiency trials for a given site, route, and flow rate
- n = Number of trap efficiency trials for a given site, route, and flow rate

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

More trials have been conducted in the six months since the annual 2022 report was published. Unfortunately, in many instances not enough additional trials have been conducted yet 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) trap efficiency is so low that the majority of TE trails are not successful even with releases as high as 4,000 fish. Lookout PH1 had multiple TE releases of 4,000 fish, yet 1 in 4 of those TEs were successful. This is a concern because if 4,000 fish releases keep occurring with less than 5 returns trials it might skew the calculated TE higher than it is (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 about 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) fish would need to be released to have confidence in capturing at least 5 returns. Since releasing that many fish at once is not realistically possible for the purpose of conducting TE trials, pooling multiple TE trials (passing and failing) under similar flow conditions might better reflect actual TE.

Where possible, linear regressions were used to model TE in relation to flow. Cougar head of reservoir, Hills Creek PH, and Lookout Point head of reservoir all had linear fits with P-value cutoffs of 0.05, but sample sizes are at a minimum so the relationship may not hold with additional samples (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 more trials would be needed to run logistic models. Some sites, such as Big Cliff and Dexter, appear to be discrete with distinct changes at different flows/paths. For the remainder of the sites linear models failed and were non-significant with P-values >0.05. See Appendix E for plots of successful TE trials in relation to flow with linear model fits, where possible.

At the remaining sites either there is no apparent pattern in relation to flow and/or not enough TE trials have been conducted yet. It is also possible the TE rates are multivariate and/or other variables besides flow play a role. In the case where linear models failed an average TE was calculated based on all successful trials and 95% C.I.s 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.

We would like to note that currently 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 model the TE in relation to flows (or possibly other variables) and rerun previously collected data with better models.

Brood Year

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

Trapping Injuries

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

Results

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 June 30, 2023. The trap sampled 163 days during the reporting period. 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.

Target Catch and Passage Timing

The trap captured 323 juvenile Chinook salmon and 77 juvenile *O. mykiss* during the reporting period. It is assumed that *O. mykiss* captured at this site are primarily composed of resident rainbow trout since steelhead are not transported to spawn above Detroit Reservoir. However, due to the difficulty in distinguishing between resident trout and anadromous steelhead, all unmarked *O. mykiss* were treated as target fish and reported as such. Peak capture of juvenile Chinook salmon exiting Big Cliff Dam in the spring occurred in May and June ($n = 160$, 49.5% of total Chinook) (Figure 1). Peak capture for juvenile *O. mykiss* occurred in June ($n = 48$, 62.3%) (Figure 2).

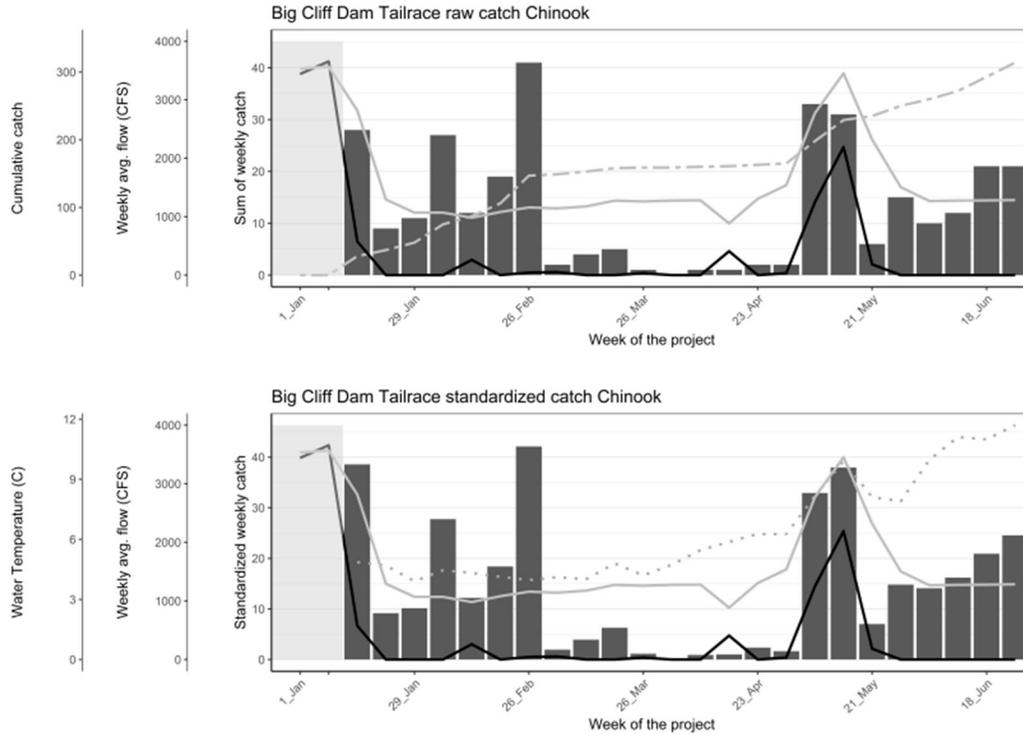


Figure 1. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Big Cliff Dam with spill (black line), Powerhouse (gray line), cumulative catch (grey dot dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

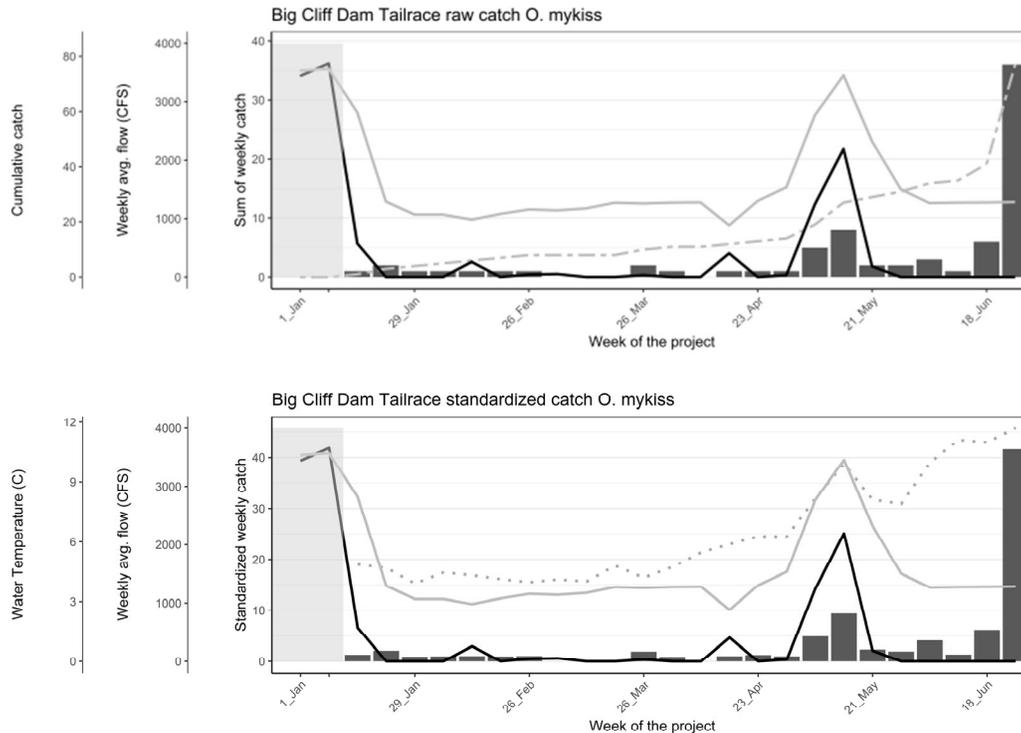


Figure 2. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile *O. mykiss* at Big Cliff Dam with spill (black line), Powerhouse (gray line), cumulative catch (grey dot dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

Chinook catch consisted of three BY classes: BY 2020, BY 2021, and BY 2022 (Figure 3). The first BY 2022 sub-yearling Chinook was captured on January 31st, 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 (48.3% of total Chinook catch) with the peak migration event occurring in February ($n=82$, 52.6%). The migration timing of sub-yearling Chinook through Big Cliff Dam is similar to observations from previous years (Romer et al. 2016). The average length of BY 2022 Chinook was 51.8 mm (min: 29 mm, max: 130 mm, median: 37 mm). A total of 125 BY 2021 Chinook (38.7% of total Chinook catch) were captured from January through June with peak capture occurring from April through June ($n=111$, 88.8%). The average fork length of BY 2021 Chinook was 155.8 mm (min: 72 mm, max: 199, median: 160 mm) with an average weight of 43.6 g (min: 3.8 g, max: 84.4 g, median: 44.0 g). In total, 42 BY 2020 Chinook were captured at the site during the reporting period. The peak capture for this group occurred in January ($n=23$, 54.8%). The average length of BY 2020 fish was 202.8 mm (min: 157 mm, max: 340 mm, median: 195 mm) with an average weight of 85.3 g (min: 38.1 g, max: 328.5 g, median: 70.5 g).

Peak capture of Chinook at Big Cliff Dam coincided with spill operations at Detroit and Big Cliff Dams that occurred in January and late April/May. We observed modest catch for a period of time after each spill event which suggests that fish were still present in the forebay and passed through the Powerhouse at a slower rate once spill had ceased (Figure 4). Downstream movement of tagged fish in Big Cliff Reservoir suggests that fish typically take between 11 and 23 days to navigate from the Detroit Dam Tailrace to the forebay of Big Cliff Dam (Beeman et al. 2015). Assuming these migration rates for fish to reach the forebay of Big Cliff Dam from the Detroit Tailrace, it is reasonable to assume that the two periods of highest catch at Big Cliff are associated with Detroit Spill operations. 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 Cramer Fish Sciences (2022) also observed increased catch associated with spill operations.

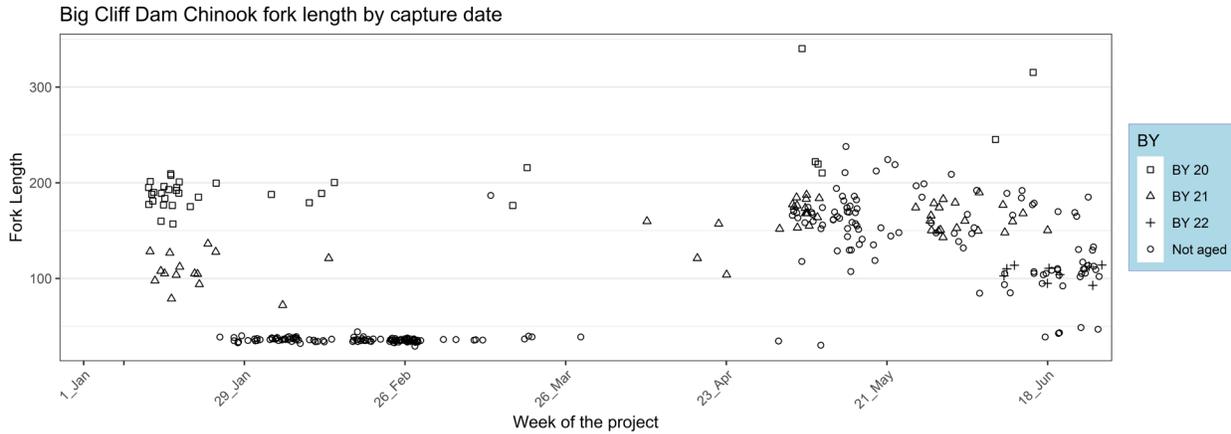


Figure 3. Length-frequency of juvenile Chinook salmon at the Big Cliff Dam Tailrace site from January 1, 2023, to June 30, 2023.

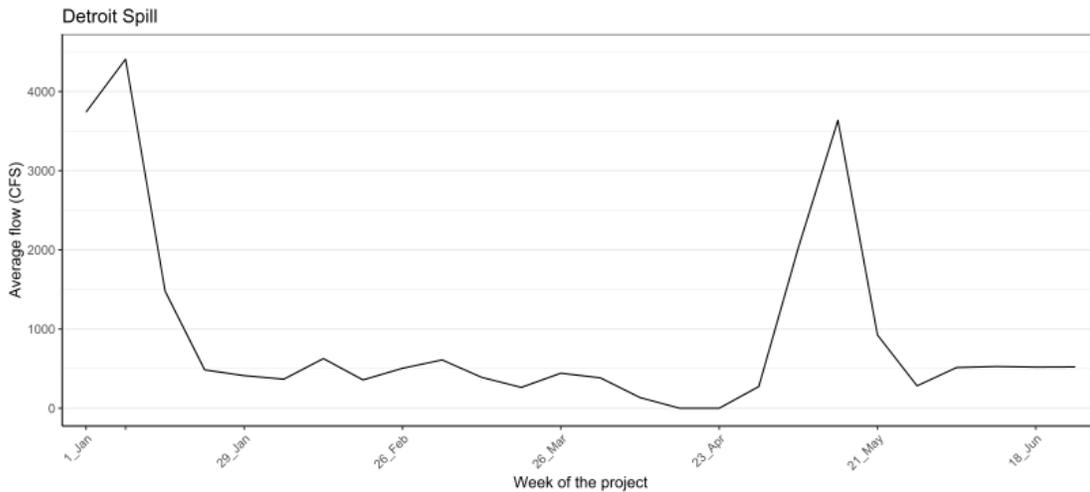


Figure 4. Detroit spill operations from January 1, 2023, through June 30, 2023.

Trapping Efficiency Trials

A total of seven trapping efficiency trials occurred using hatchery reared Chinook salmon in the Big Cliff Dam Tailrace during the spring of 2023. A total of 20 trials have been performed at this site since 2021. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 4. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled. Trapping efficiencies ranged from 1.2% to 20.7%. Using trapping efficiencies by flow category, we estimate that 6,317 (95% CI: 4,938 to 9,079) juvenile Chinook passed the trapping site during the reporting period (Figure 5). Plots displaying trap efficiency and flow for all trials are displayed in Appendix E.

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

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Big Cliff Dam Tailrace	12/22/2021	3,010	997	39	3.9%
Big Cliff Dam Tailrace	5/25/2022	3,055	995	21	2.1%
Big Cliff Dam Tailrace	8/9/2022	1,060	1000	92	9.2%
Big Cliff Dam Tailrace	9/30/2022	1,580	995	48	4.8%
Big Cliff Dam Tailrace	10/13/2022	2,820	500	15	3.0%
Big Cliff Dam Tailrace	10/24/2022	5,520	535	25	4.7%
Big Cliff Dam Tailrace	11/2/2022	5,450	949	40	4.2%
Big Cliff Dam Tailrace	11/16/2022	2,650	509	15	2.9%
Big Cliff Dam Tailrace	12/14/2022	1,380	502	60	12.0%
Big Cliff Dam Tailrace	12/19/2022	1,330	1010	92	9.1%
Big Cliff Dam Tailrace	12/21/2022	1,350	1014	33	3.3%
Big Cliff Dam Tailrace	12/27/2022	1,520	704	47	6.7%
Big Cliff Dam Tailrace	12/29/2022	1,470	452	22	4.9%
Big Cliff Dam Tailrace	1/25/2023	1,320	500	56	11.2%
Big Cliff Dam Tailrace	2/17/2023	1,470	499	37	7.4%
Big Cliff Dam Tailrace	3/7/2023	1,320	2,968	61	2.1%
Big Cliff Dam Tailrace	3/10/2023	1,260	541	112	20.7%
Big Cliff Dam Tailrace	4/28/2023	1,320	498	34	6.8%
Big Cliff Dam Tailrace	5/23/2023	2,440	500	6	1.2%
Big Cliff Dam Tailrace	6/21/2023	1,270	500	8	1.6%

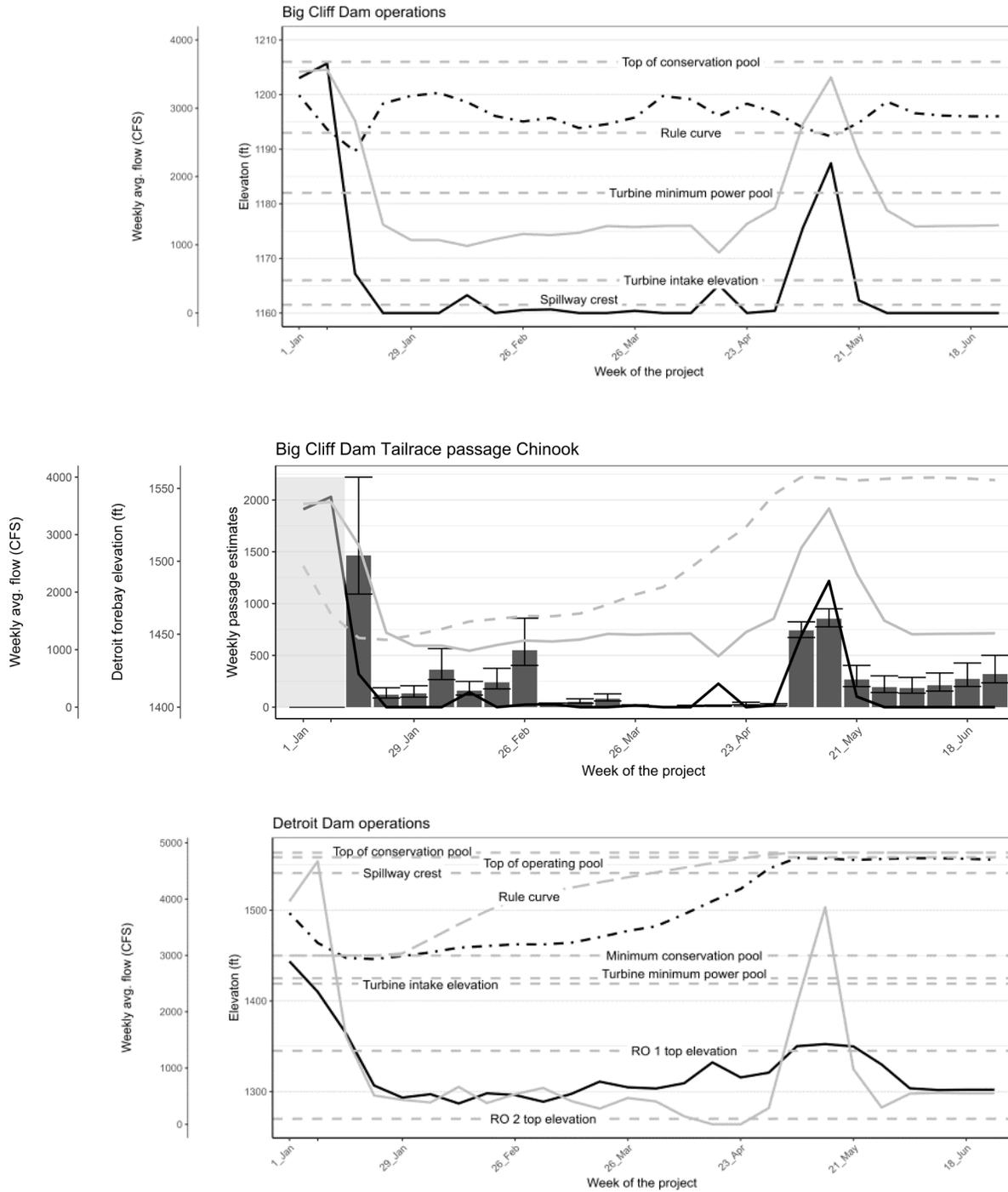


Figure 5. Big Cliff Dam (top panel) and Detroit Dam (bottom panel) operations with rule curve (gray long dash line), forebay elevation (black dot dash line), spill/RO outflow (black line) and powerhouse outflow (gray line). Passage estimates with 95% confidence for juvenile Chinook salmon at Big Cliff Dam (middle panel) with spill at Big Cliff Dam (black line), Powerhouse outflow from Big Cliff Dam (gray line), Detroit forebay elevation (gray dash line), and non-sampling weeks shaded out (gray) for January 1, 2023, through the end of June 2023.

Injury Data

A total of 213 juvenile Chinook (65.9% of total Chinook catch) and 35 juvenile *O. mykiss* (45.5% of total *O. mykiss* catch) displayed at least one of the injury code conditions, other than copepods (COP), listed in Table 2. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. This was then applied as a correction factor to provide more clarity to injury resulting from passage. The most common injuries associated with trap capture include descaling less than 20% and fin damage while the most common injuries associated with passage include descaling less than 20%, descaling greater than 20%, operculum damage and fin damage (Table 5). We also observed 39 Chinook (12.1% of total Chinook 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 (Figure 6). A total of 165 juvenile Chinook salmon and 23 juvenile *O. mykiss* were infected with copepods at time of capture (Figure 7). Copepod presence on captured Chinook salmon shows a positive correlation with the size of fish similar to observations made by previous studies (Cramer Fish Sciences 2022; Monzyk et al. 2015). This is likely a correlation between time spent rearing in the reservoir rather than the size of the fish. Monzyk et al. also noted that *O. mykiss* were infected with copepods at a much lower rate than Chinook, a trend we also observed in *O. mykiss* captured at the Big Cliff Dam site. 18 Chinook (5.6 %) and 8 *O. mykiss* (10.4%) were dead at the time the trap was checked. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

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

Injury Code	TE Release Injuries (~50 per trial, proportion of total)	TE Recapture Injuries (proportion of total)	Proportional Percent Change	Observed Chinook Injuries	Corrected Chinook Injuries for Passage
NXI	52.0%	29.1%	-22.9%	110	135
MUNK	0.0%	0.0%	0.0%	1	1
DS<2	16.9%	66.5%	49.6%	145	73
DS>2	2.0%	1.9%	-0.1%	57	57
BLO	0.0%	0.0%	0.0%	2	2
EYB	0.0%	0.0%	0.0%	28	28
BVT	0.0%	0.0%	0.0%	8	8
FVB	0.0%	0.0%	0.0%	17	17
GBD	0.0%	3.5%	3.5%	39	38
POP	0.0%	0.0%	0.0%	9	9
HIN	0.0%	0.0%	0.0%	20	20
OPD	0.9%	3.2%	2.3%	42	41
TEA	0.0%	0.9%	0.9%	11	11
BRU	0.0%	0.3%	0.3%	23	23
HBP	0.0%	0.0%	0.0%	3	3
HO	0.0%	0.0%	0.0%	0	0
BO	0.0%	0.3%	0.3%	1	1
HBO	0.0%	0.0%	0.0%	1	1
FID	38.9%	68.7%	29.8%	163	114
PRD	0.0%	0.3%	0.3%	0	0
COP	0.0%	0.3%	0.3%	165	164
BKD	0.0%	0.0%	0.0%	0	0
FUN	0.3%	0.9%	0.7%	7	7

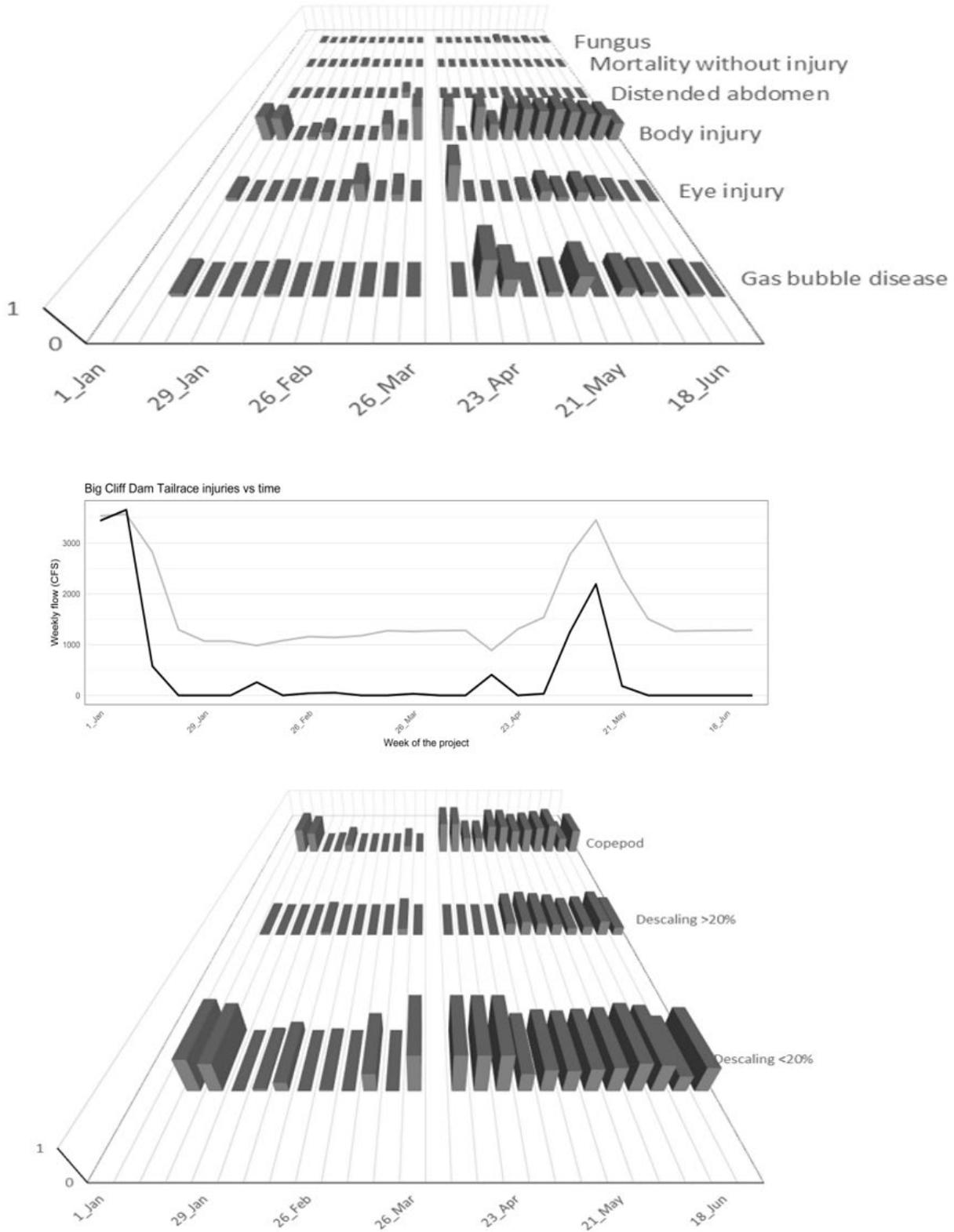


Figure 6. Injury rate of captured Chinook below Big Cliff Dam displaying proportion of fish with injuries by type (top panel) and descaling injuries and copepod presence (bottom panel). The middle panel shows spill (black line) and Powerhouse flow (gray line) at Big Cliff Dam.

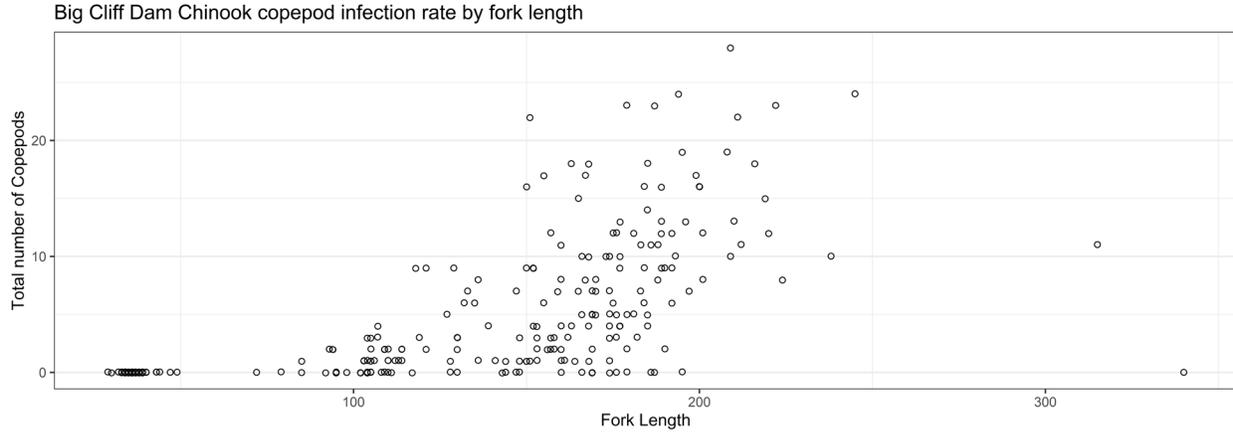


Figure 7. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon below Big Cliff Dam.

24-Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook and *O. mykiss* captured in the Big Cliff Dam Tailrace to assess delayed mortality potentially from dam passage, collection, or holding. A total of 351 fish, 291 Chinook and 60 *O. mykiss*, were held in 2023 (Table 6). A total of 22 fish died during hold (6.3%), 19 of the 291 Chinook (6.5%) and 3 of the 60 *O. mykiss* (5.0%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 18.2%.

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

Hold Period	Species	Number of Fish Held	Mortalities	% Survived
1/16/2023–1/31/2023	Chinook	39	4	89.7%
1/16/2023–1/31/2023	<i>O. mykiss</i>	2	0	100%
2/1/2023–2/15/2023	Chinook	43	1	97.7%
2/1/2023–2/15/2023	<i>O. mykiss</i>	3	0	100%
2/16/2023–2/28/2023	Chinook	43	0	100%
2/16/2023–2/28/2023	<i>O. mykiss</i>	1	0	100%
3/1/2023–3/15/2023	Chinook	22	0	100%
3/1/2023–3/15/2023	<i>O. mykiss</i>	1	1	0%
3/16/2023–3/31/2023	Chinook	7	0	100%
3/16/2023–3/31/2023	<i>O. mykiss</i>	1	1	0%
4/1/2023–4/15/2023	Chinook	1	0	100%
4/1/2023–4/15/2023	<i>O. mykiss</i>	2	0	100%
4/16/2023–4/30/2023	Chinook	3	0	100%
4/16/2023–4/30/2023	<i>O. mykiss</i>	1	0	100%
5/1/2023–5/15/2023	Chinook	38	7	81.6%
5/1/2023–5/15/2023	<i>O. mykiss</i>	7	0	100%
5/16/2023–5/31/2023	Chinook	19	3	84.2%
5/16/2023–5/31/2023	<i>O. mykiss</i>	3	1	66.7%
6/1/2023–6/15/2023	Chinook	27	3	88.9%
6/1/2023–6/15/2023	<i>O. mykiss</i>	2	0	100%
6/16/2023–6/30/2023	Chinook	49	1	98.0%
6/16/2023–6/30/2023	<i>O. mykiss</i>	37	0	100%

PIT Tagged fish and Downstream Detections

A total of 17 fish were PIT tagged at the Big Cliff Dam site in 2023, 14 juvenile Chinook and 3 juvenile *O. mykiss*. No PIT tagged fish were detected downstream and no VIE marked fish were detected at the site. A summary of all tagged fish can be found in Appendix C.

Willamette Valley Project Marked Fish Release Recaptures

In March of 2023, ODFW released 100,000 Bismarck dyed 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. Additionally, ODFW released 2,968 Bismarck dyed 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.

Non-Target Capture Data

We captured 250 non-target fish in addition to natural origin juvenile Chinook and *O. mykiss* (Table 7). The most common non-targets captured were kokanee and pumpkinseed.

Table 7. Summary of non-target species captured at the Big Cliff Dam RST site.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	24	3
Brown Bullhead	4	1
Chinook (Adult)	2	0
Kokanee	154	18
Kokanee (clipped)	11	3
<i>O. mykiss</i> (clipped)	4	1
Pumpkinseed	49	6
Unknown	1	1
Mountain Whitefish	1	0
Totals	250	33

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. The trap sampled 99 days in 2023. The initiation of sampling was delayed while a new highline anchor was being designed. The highline was reinstalled on a temporary anchor and the trap began sampling on March 14, 2023. The trap was raised to the non-sampling position from March 23 to March 31 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 install. Spill was initiated once the reservoir reached the spillway crest, after the new highline was installed and the RST was actively sampling. Further details regarding trap sampling outages can be found in Appendix B. In calendar year 2022, 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.

Target Catch and Passage Timing

The trap captured 100 naturally produced juvenile Chinook salmon and 11 juvenile *O. mykiss* at this site. *O. mykiss* captured at this location are likely progeny of resident trout. However, all juvenile *O. mykiss* at this site were treated as target fish. Peak capture of juvenile Chinook in the spring occurred in the latter half of May (n=86, 86% of total Chinook catch) (Figure 8). Peak capture of juvenile *O. mykiss* also occurred in May (n=8, 72.7% of total *O. mykiss* catch) (Figure 9). Chinook catch was composed entirely of BY 2022 sub-yearlings (Figure 10). The average fork length of BY 2022 Chinook was 66.8 mm (min: 33 mm. max: 98 mm, median: 66 mm) with an average weight of 3.7 g (min: 1.0 g, max 10.8 g, median: 3.4 g). The *O. mykiss* captured consisted of two-year olds (n=5, 45.5%), one-year olds (n=5, 45.5%), and a sub-yearling

(n=1, 9.1%) fish (Figure 11). The average fork length of the two-year old fish was 271.4 mm (min: 240 mm, max: 318 mm, median: 268 mm) and the average weight was 183.8 g (min: 114.0 g, max: 340.0 g, median: 143.9 g). The one-year-old fish had an average fork length of 185.8 mm (min: 174 mm, max: 195 mm, median: 185 mm) and average weight of 62.4 g (min: 54.4 g, max: 71.6 g, median: 59.0 g). The one sub-yearling fish captured had a fork length of 29 mm and was too small to gather an accurate weight.

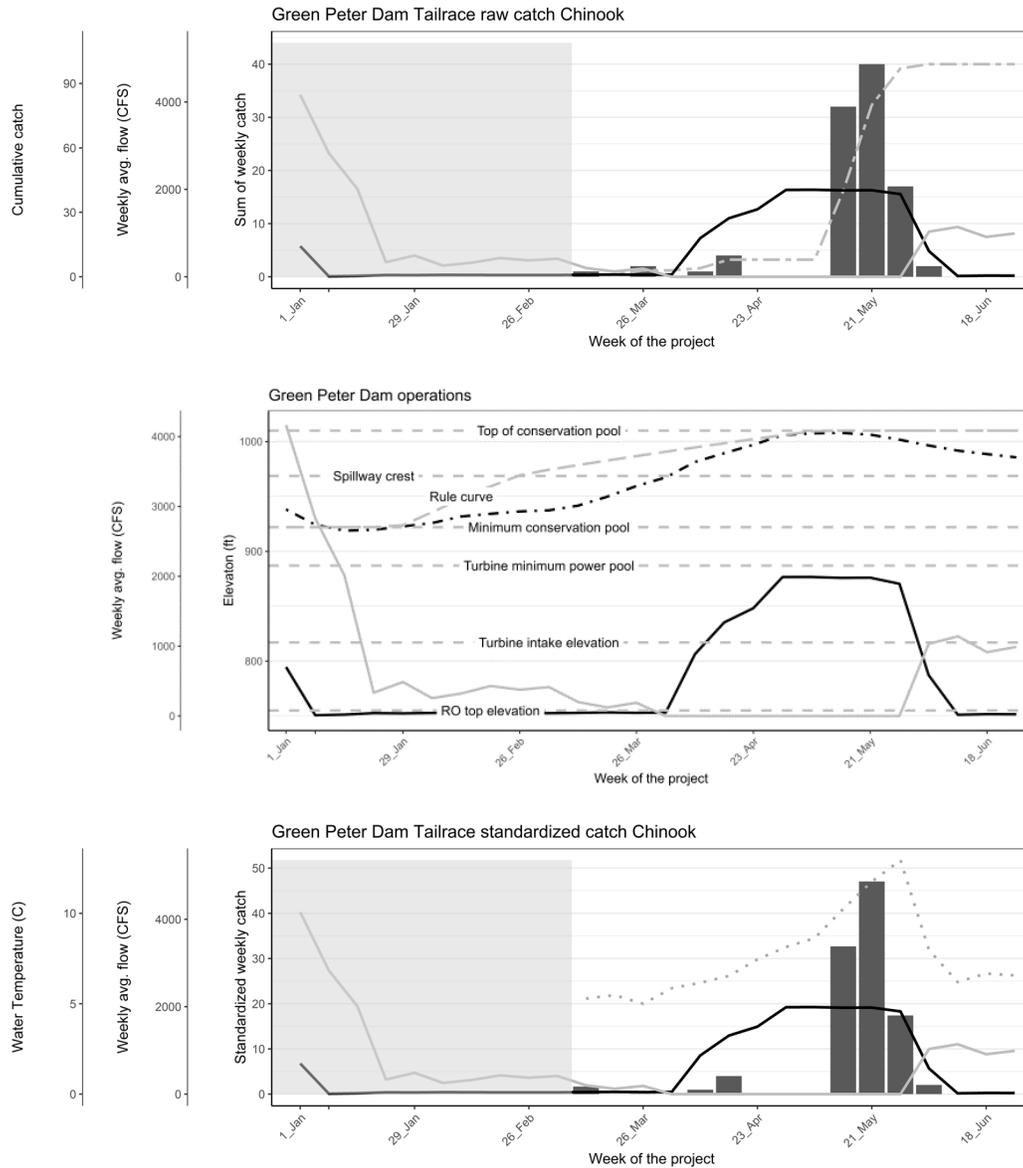


Figure 8. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Green Peter Dam Tailrace with spill (black line), Powerhouse (gray line), cumulative catch (grey two dash line) stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for 2023. Middle panel displays Green Peter Dam operations and features of interest with spill/RO outflow (black line), Powerhouse outflow (gray line), and forebay elevation (black dot dash line).

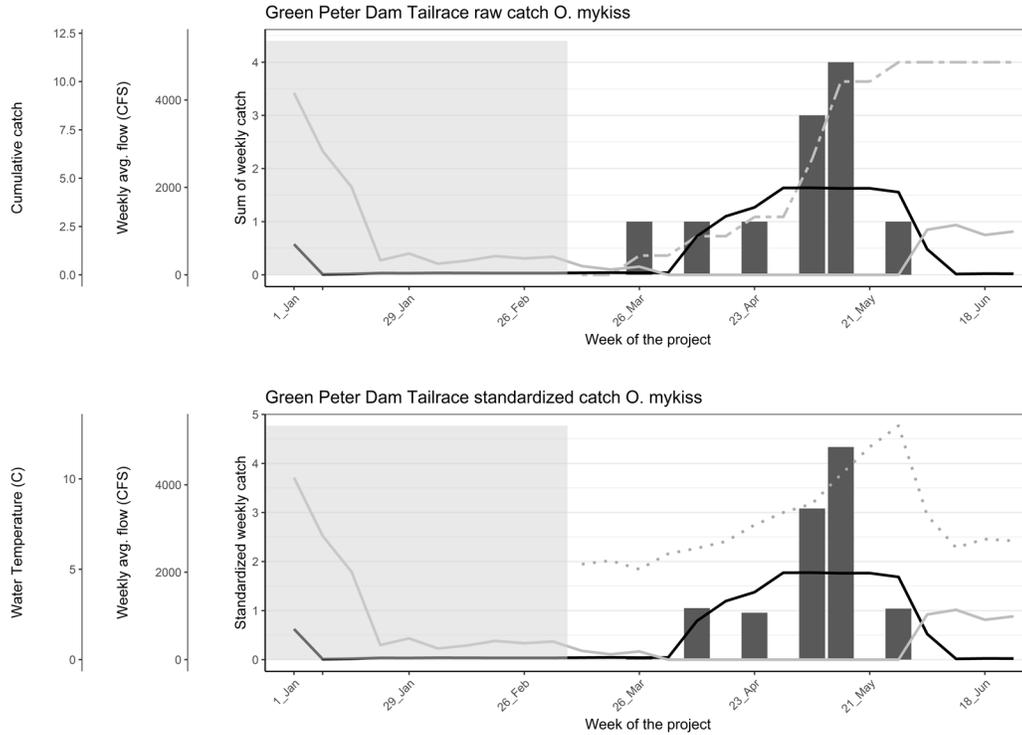


Figure 9. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile *O. mykiss* at Green Peter Dam Tailrace with spill (black line) and Powerhouse (gray line), cumulative catch (grey two dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

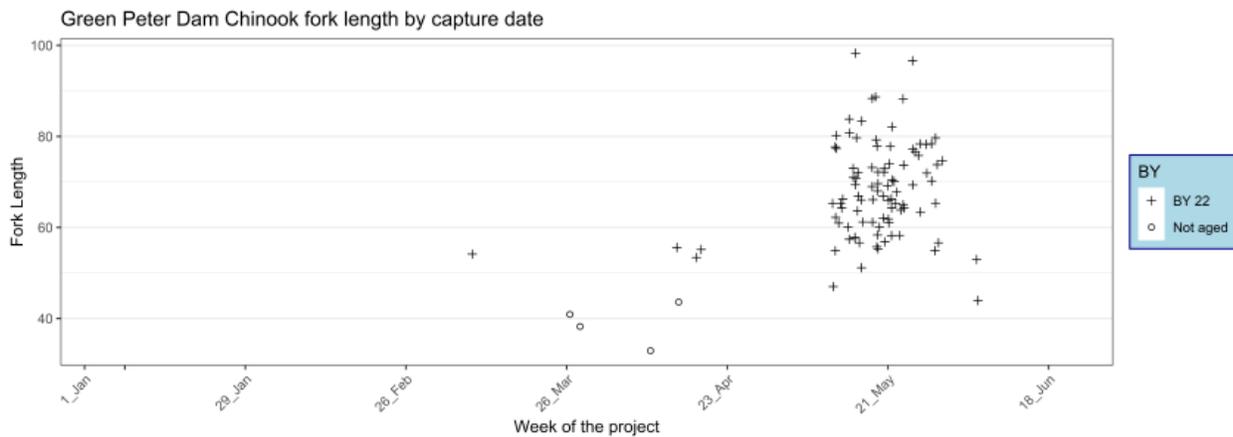


Figure 10. Age length-frequency for captured natural origin Chinook at the Green Peter Dam Tailrace site.

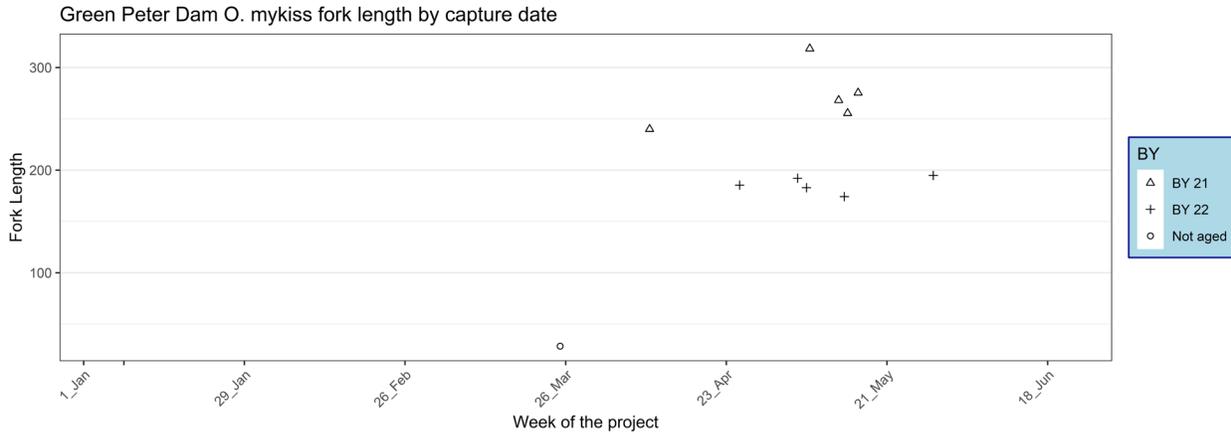


Figure 11. Age length-frequency for captured natural origin *O. mykiss* at the Green Peter Dam Tailrace site.

Trapping Efficiency Trials

A total of three trapping efficiency trials occurred using hatchery reared Chinook salmon in the Green Peter Dam Tailrace in the spring of 2023. A total of five 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 8. Trapping efficiencies for live fish releases ranged from 0.6% to 1.7%. 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. We estimate that 8,725 (95% CI: 6,116 to 15,212) juvenile Chinook passed through Green Peter Dam in the spring of 2023. 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 trap efficiency and flow for all trials are displayed in Appendix E.

Table 8. Summary table of marked hatchery Chinook releases in the Green Peter Dam Tailrace for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Green Peter Dam Tailrace-Spill	3/29/2022	970	643	4	0.6%
Green Peter Dam Tailrace-Spill	4/30/2022	1,310	518	9	1.7%
Green Peter Dam Tailrace-Spill (Dead Fish)	5/11/2023	1,987	1,001	0	0%
Green Peter Dam Tailrace-Spill	5/11/2023	1,987	999	9	0.9%
Green Peter Dam Tailrace-Powerhouse	5/25/2023	2,001	1,000	10	1.0%

Injury Data

A total of 92 juvenile Chinook (92.0%) and 10 juvenile *O. mykiss* (90.9%) displayed at least one of the injury code conditions listed in Table 2. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type both pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. Data from TE recaptures show that injuries observed on fish were not a result of RST capture at this site. The most common injuries observed on juvenile Chinook and *O. mykiss* at this site include fin damage, descaling, operculum damage, and gas bubble disease. 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. 20 Chinook (20%) and 5 *O. mykiss* (45.5%) were dead at the time of trap check. A summary of injury type by species is included in Table 9. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 9. Percentage of Chinook and *O. mykiss* displaying injury by type at Green Peter Dam Tailrace RST site.

Injury Code	Chinook Injuries	<i>O. mykiss</i> Injuries
NXI	8.0%	9.1%
MUNK	4.0%	0.0%
DS<2	49.0%	36.4%
DS>2	28.0%	54.5%
BLO	1.0%	0.0%
EYB	14.0%	18.2%
BVT	8.0%	9.1%
FVB	11.0%	9.1%
GBD	30.0%	54.5%
POP	2.0%	36.4%
HIN	14.0%	18.2%
OPD	13.0%	36.4%
TEA	5.0%	0.0%
BRU	9.0%	18.2%
HBP	0.0%	0.0%
HO	0.0%	0.0%
BO	0.0%	0.0%
HBO	0.0%	0.0%
FID	66.0%	81.8%
PRD	0.0%	0.0%
COP	7.0%	27.3%
BKD	0.0%	0.0%
FUN	2.0%	0.0%

24 Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook and *O. mykiss* captured in the Green Peter Dam Tailrace to assess delayed mortality resulting from dam passage. A total of 86 fish, 80 Chinook and 6 *O. mykiss*, were held in 2023 (Table 10). A total of 46 fish died during hold (53.5%), 44 of the 80 Chinook (55.0%) 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 75.0%.

Table 10. Summary of 24-hour hold trials for fish captured in the RST at the Green Peter Dam Tailrace site.

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

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. The trap did capture one PIT tagged fish involved in another study at this site on May 28, 2023. A summary including tag numbers, observation date, and site can be found in Appendix C.

Non-Target Capture Data

A total of 2,708 non-target fish were captured in addition to natural origin juvenile *O. mykiss* in the Green Peter Dam Tailrace RST in 2023 (Table 11). The most common species captured were bluegill and kokanee.

Table 11. Summary of non-target fish capture at the Green Peter Dam Tailrace RST.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	121	66
Crappie	28	17
Dace	1	1
Kokanee	2,514	1,398
Kokanee (clipped)	10	2
Largemouth Bass	1	0
<i>O. mykiss</i> (clipped)	25	6
Sculpin	2	1
Smallmouth Bass	5	3
Unknown	1	1
Totals	2,708	1,495

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. The trap sampled a total of 145 days in 2023. Sampling outages that resulted from high flows and debris are listed in Appendix B.

Target Catch and Passage Timing

A total of 576 juvenile Chinook salmon and 38 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, 82.1% of total Chinook catch) (Figure 12). Brood year BY 2021 yearling (n=21, 3.6% of total Chinook catch) and BY 2022 sub-yearling (n=555, 96.4% of total Chinook catch) Chinook were captured at

the trap during the spring monitoring period (Figure 13). Spring passage timing of yearling Chinook 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 sub-yearling was captured on February 2, 2023. Previous study by Romer (2015) captured the most sub-yearling Chinook in January and February. They also noted that fry emergence in the South Santiam above Foster Reservoir in 2015 was earlier than other basins and that the fish they captured late in the spring were significantly larger than their counterparts in other areas. Past observations combined with our fry capture on the first day of sampling suggest that we missed Chinook fry passing through the trap site prior to the initiation of sampling. The average length of BY 2021 Chinook caught during the spring period was 108.6 mm (n=21, min: 93 mm, max: 134 mm, median: 109 mm) and the average weight was 14.9 g (min: 8.0 g, max: 24.3 g, median: 15.0 g). The average length of BY 2022 Chinook captured in the spring was 37.8 mm (n=555, min: 30 mm, max: 95 mm, median: 36 mm).

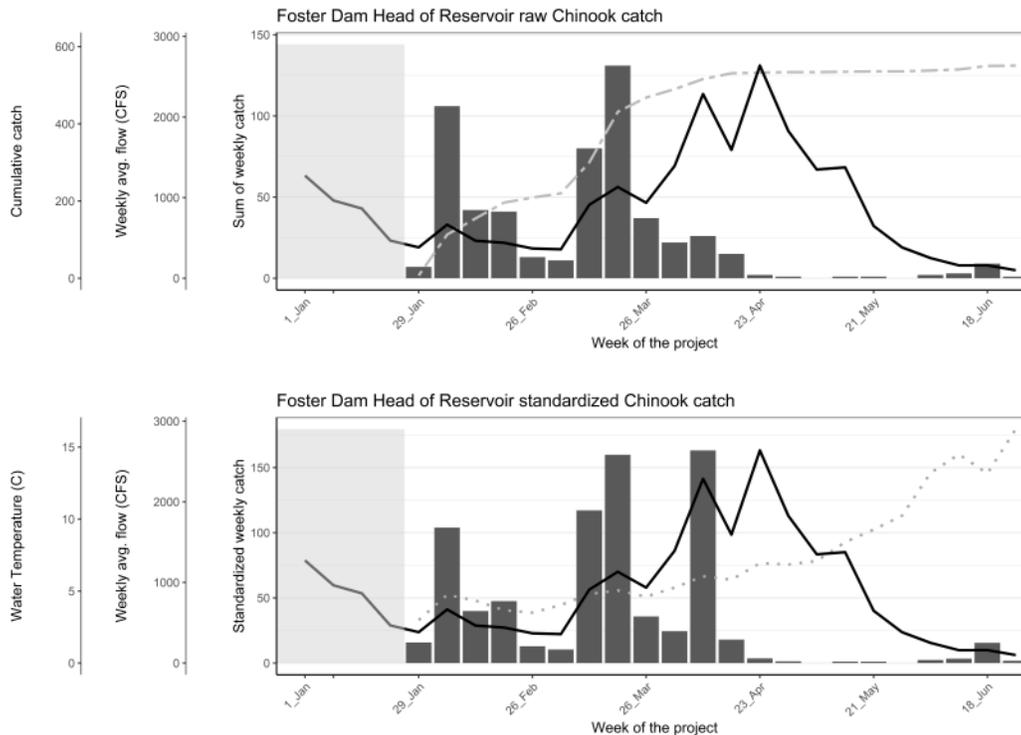


Figure 12. Raw catch (top panel) and standardized catch (bottom panel) overlaid with flow (black line), cumulative catch (gray dot dash line), stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for juvenile Chinook at the Foster Dam Head of Reservoir site for January 1, 2023, to June 30, 2023.

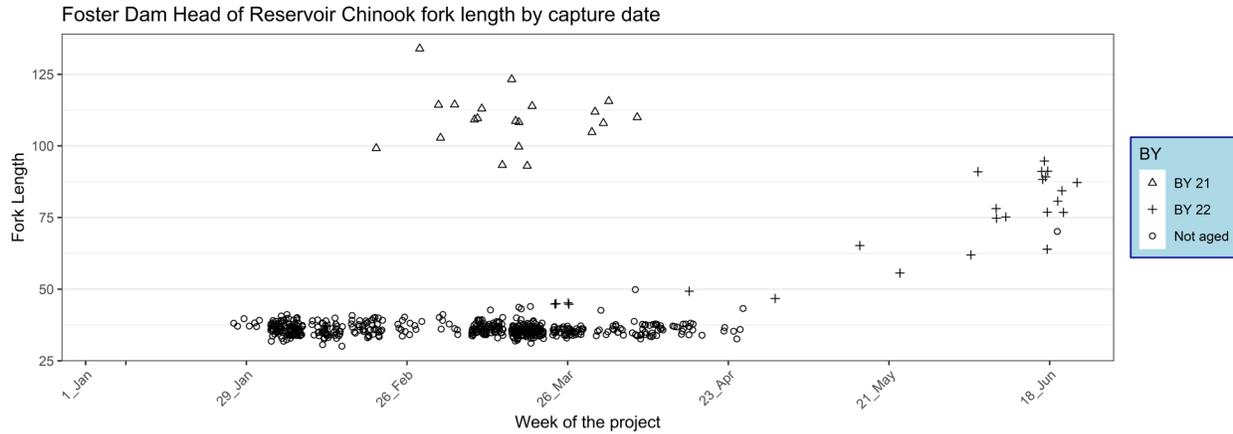


Figure 13. Length-frequency analysis for juvenile Chinook at the Foster Dam Head of Reservoir site for 2023.

Peak capture of juvenile *O. mykiss* in the spring monitoring period occurred in May (n=17, 44.7% of total *O. mykiss* catch) (Figure 14). *O. mykiss* catch comprised three brood years, BY 2021 (n=10, 26.3% of total *O. mykiss* catch), BY 2022 (n=21, 55.3%), and BY 2023 (n=7, 18.4%) (Figure 15). BY 2021 fish were captured March through June and had an average length of 172.6 mm (min: 139 mm, max: 199 mm, median: 176.5 mm) and an average weight of 49.6 g (min: 29.2 g, max: 91.0 g, median: 44.5 g). BY 2022 fish were captured April through June and had an average length of 107.8 mm (min: 84 mm, max: 138 mm, median: 104 mm) and an average weight of 16.9 g (min: 8.5 g, max: 33.1 g, median: 13.8 g). BY 2023 *O. mykiss* were captured February through May and had an average length of 35.4 mm (min: 29 mm, max: 51 mm, median: 35 mm). 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).

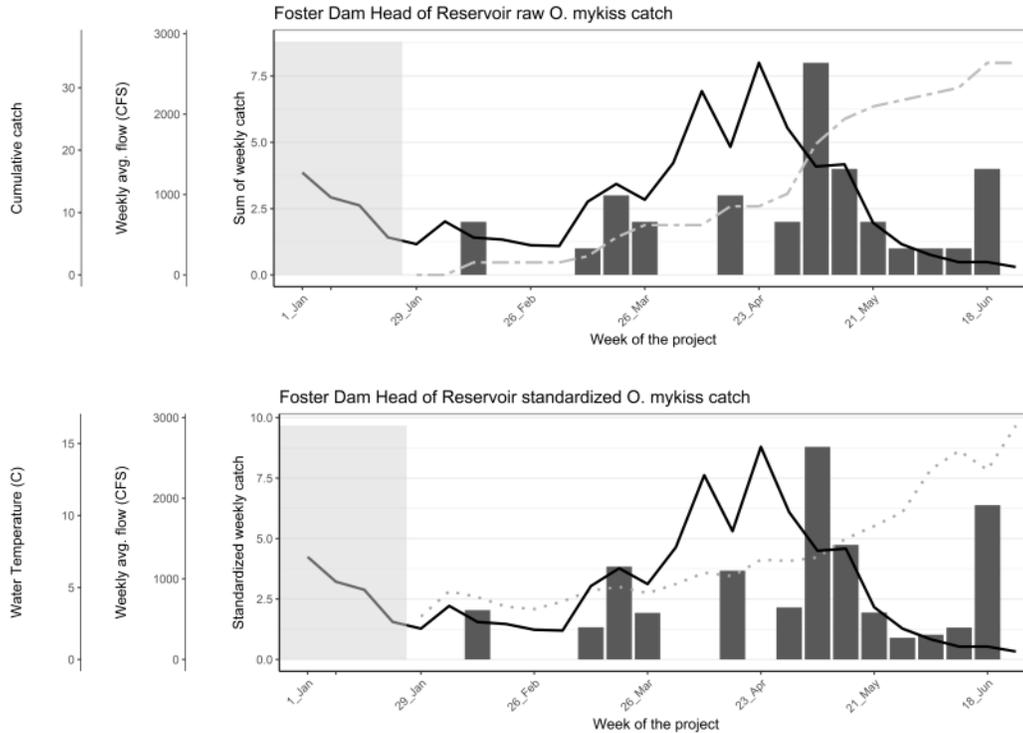


Figure 14. Shows raw (top panel) and weekly standardized (bottom panel) catch of juvenile *O. mykiss* overlaid with stream flow (black line), cumulative catch (grey two dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

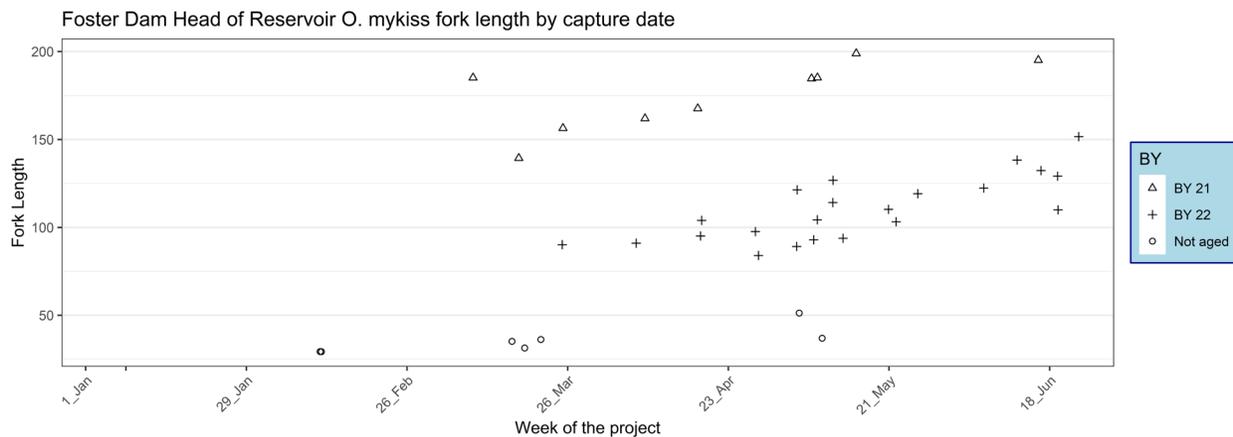


Figure 15. Shows length-frequency analysis by brood year for juvenile *O. mykiss* at the Foster Dam Head of Reservoir site for 2023.

Trapping Efficiency Trials

A total of six trapping efficiency trials occurred using hatchery reared Chinook salmon in the South Santiam River above Foster Reservoir in the spring of 2023. A total of 12 trapping efficiencies have occurred with hatchery fish 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 12. Trapping efficiencies ranged from 0% to 26.1%. 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 1 week of release. In low flow conditions, fish may hold in deep pools instead of actively migrating, resulting in failed trapping efficiency trials. Using trapping efficiencies by flow category, we estimate that 7,758 (95% CI: 4,891 to 18,752) juvenile Chinook passed the trapping site in 2023 (Figure 16). However, given the small sample size of successful trap efficiency 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 trap efficiency and flow for all successful trials (5 or more returns) are displayed in Appendix E.

Table 12. Summary table of marked hatchery Chinook releases at the Foster Dam Head of Reservoir site for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Foster Dam Head of Reservoir	9/29/2022	51	1,063	0	0%
Foster Dam Head of Reservoir	10/25/2022	211	821	116	14.1%
Foster Dam Head of Reservoir	11/1/2022	261	1006	263	26.1%
Foster Dam Head of Reservoir	11/9/2022	560	1007	68	6.8%
Foster Dam Head of Reservoir	11/15/2022	240	1009	55	5.5%
Foster Dam Head of Reservoir	11/22/2022	165	933	163	17.5%
Foster Dam Head of Reservoir	2/27/2023	376	1,002	21	2.1%
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	16	1.6%

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

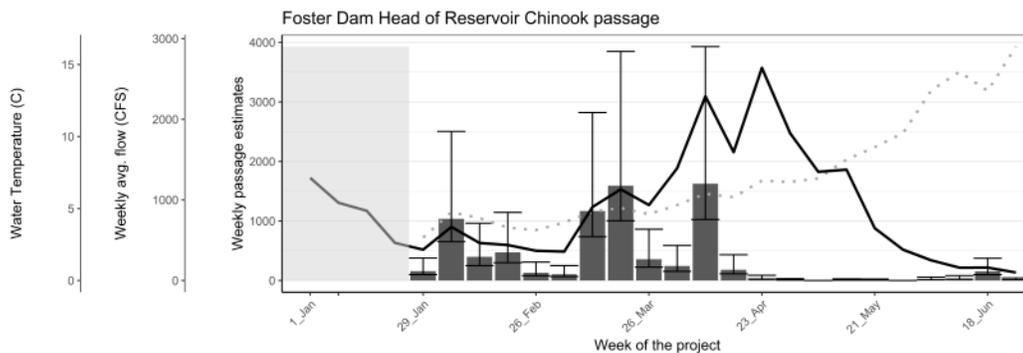


Figure 16. Weekly passage estimates of juvenile Chinook with 95% confidence intervals overlaid with flow (black line), stream temperature (gray dot dash line), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

Injury Data

A total of 58 juvenile Chinook (10.1% of total Chinook catch) and 28 juvenile *O. mykiss* (73.7% 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. Table 13 provides a summary of injuries observed on Chinook and *O. mykiss* at the Foster Dam Head of Reservoir site.

Table 13. Summary of injuries observed on juvenile Chinook and *O. mykiss* at the Foster Dam Head of Reservoir RST site.

Injury Code	Chinook Injuries	<i>O. mykiss</i> Injuries
NXI	89.9%	26.3%
MUNK	0.5%	0.0%
DS<2	4.5%	55.3%
DS>2	1.0%	0.0%
BLO	0.0%	0.0%
EYB	0.3%	2.6%
BVT	0.7%	0.0%
FVB	0.3%	0.0%
GBD	0.0%	0.0%
POP	1.0%	0.0%
HIN	2.6%	7.9%
OPD	0.9%	2.6%
TEA	2.1%	2.6%
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	6.3%	42.1%
PRD	0.0%	0.0%
COP	0.2%	10.5%
BKD	0.0%	0.0%
FUN	0.0%	7.9%

PIT Tagged Fish and Downstream Detections

A total of 24 juvenile Chinook and 27 Juvenile *O. mykiss* were PIT tagged and released at the Foster Dam Head of Reservoir site in 2023. Of these, 1 *O. mykiss* was recaptured at the tagging site. This was a fish transported and released upstream for the purpose of conducting run of river trapping efficiency trials. 1 tagged Chinook was redetected downstream on the TWX-Estuary Towed Array (Exp.), 61 days after release at the RST site. Table 14 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 14. 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	Foster Dam Head of Reservoir– South Santiam River	5/19/2023	TWX – Estuary Towed Array (Exp.)

Non-Target Capture Data

We captured 219 non-target fish in addition to natural origin juvenile Chinook and *O. mykiss* at the Foster Dam Head of Reservoir site (Table 15). Dace and Largescale Sucker were the most encountered non-target species.

Table 15. 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	202	0
Largescale Sucker	10	0
Sculpin	4	0
Unknown	1	0
Totals	219	0

Cougar Dam Tailrace

EAS began monitoring the three traps (two 8-foot RSTs in the Powerhouse channel and one 5-foot RST in the RO channel) below Cougar Dam on December 1, 2021. The Powerhouse traps sampled 160 days during the period from January 1, 2023, through June 30, 2023. There were two short periods of time when the Powerhouse traps did not sample due to low flows out of the Powerhouse that prevented them from being lowered into the sampling position. The RO channel trap sampled 158 days during the period from January 1, 2023, through June 30, 2023. The RO at Cougar Dam went offline in June for scheduled construction on the RO chute that is slated for completion in August. The RO RST was removed for maintenance on June 8, 2023, while the RO is offline. It will be returned to service in September when the RO is back online. Additional information regarding sampling outages at this site can be found in Appendix B.

Target Catch and Passage Timing

A total of 864 juvenile Chinook were captured at the Cougar Dam Tailrace during the reporting period. 73 Chinook were captured in the Powerhouse traps (8.4% of total catch) (Figure 17) and 791 in the RO trap (91.6% of total catch) (Figure 18). Peak capture in the Powerhouse traps occurred in June (n= 45, 61.6% of total Powerhouse catch). Peak capture in the RO channel in the spring occurred in May (n= 675, 85.3% 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. Chinook catch comprised two brood years, BY 2021 yearlings (n= 802, 92.8%) and BY 2022 sub-yearlings (n= 62, 7.2%) (Figure 19). Of note, catch of yearling Chinook below Cougar Dam was significantly higher this year than had been observed in the past by previous monitoring efforts (Romer et al. 2016; Cramer Fish Sciences 2022). Passage of BY 2021 Chinook occurred throughout the monitoring period and peaked in April when 673 fish were captured (83.9% of BY 2021 capture). The average fork length of BY 2021 Chinook was 144.1 mm (min: 76 mm, max: 196 mm, median: 149 mm) with an average weight of 33.7 g (min: 4.2 g, max: 80.0 g, median: 35.2 g). The first BY 2022 sub-yearling was captured on March 16th and catch of sub-yearlings continued through the end of June. Peak capture of BY 2022 Chinook occurred in June (n=39, 62.9%). BY 2022 fish had an average fork length of 57.3 mm (min: 33 mm, max: 102 mm, median: 54.5 mm) and an average weight of 3.8 g (min: 1.0 g, max: 15.0 g, median: 2.9 g).

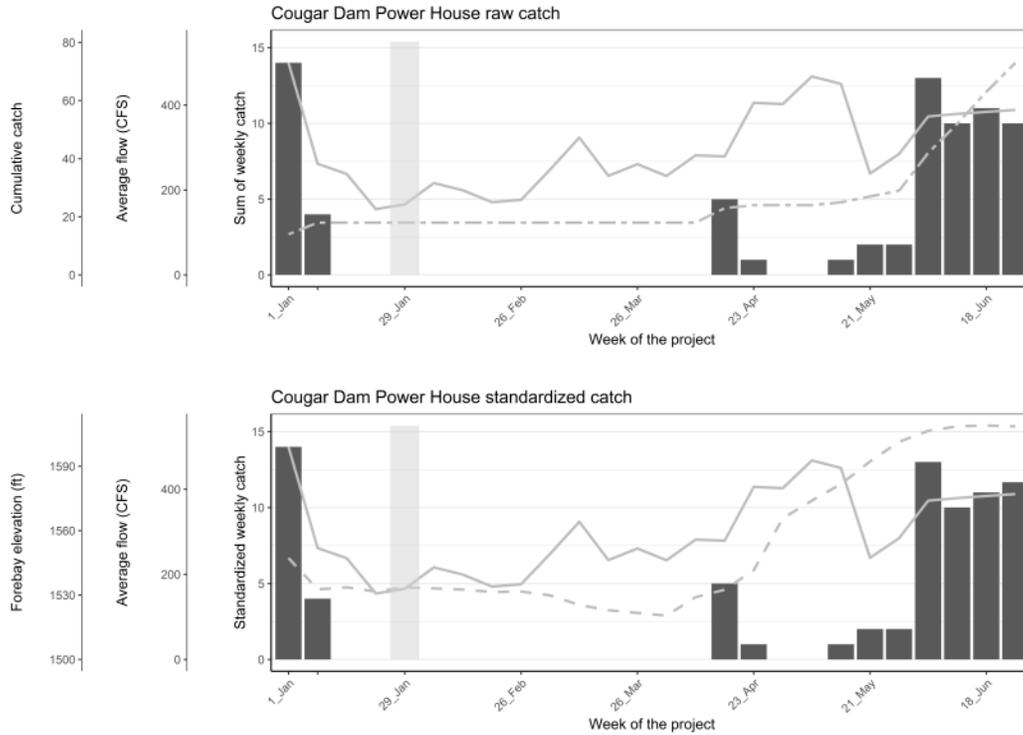


Figure 17. Raw catch (top panel) and weekly standardized catch (bottom panel) overlaid with Powerhouse outflow (gray line), cumulative catch (gray dash dot line), forebay elevation (gray dashed line), and non-sampling weeks shaded out (gray) for the Powerhouse traps at Cougar Dam from January 1, 2023, through June 30, 2023.

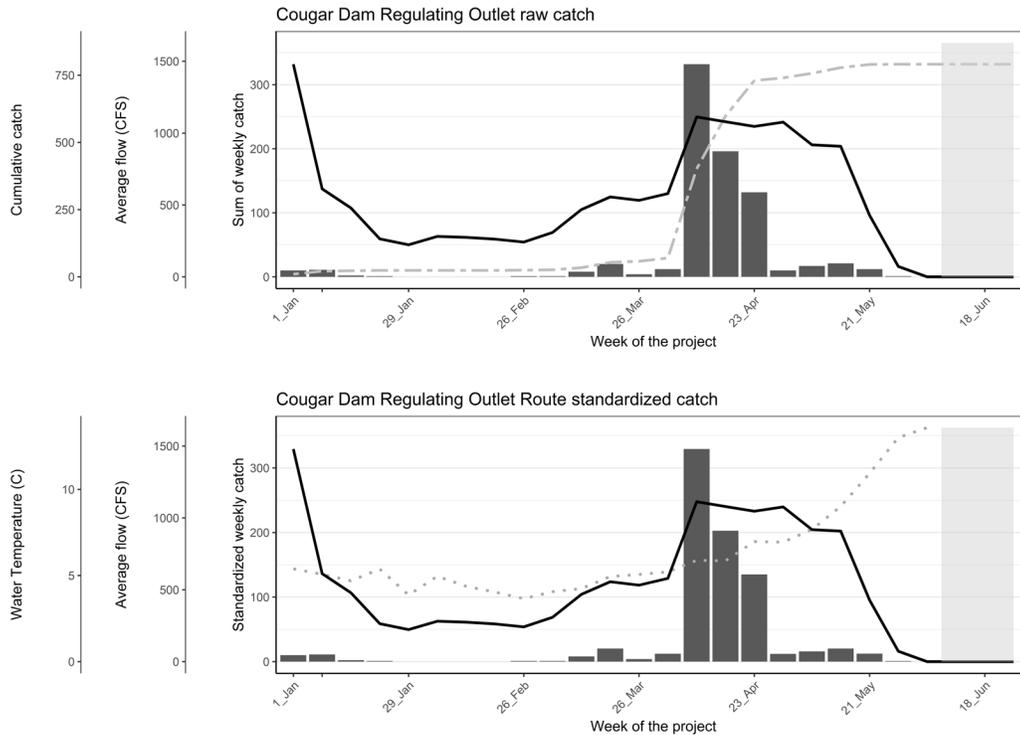


Figure 18. Raw catch (top panel) and weekly standardized catch (bottom panel) overlaid with regulating outlet outflow (black line), cumulative catch (gray dash dot line), water temperature (gray dot line), and non-sampling weeks shaded out (gray) for the RO trap at Cougar Dam.

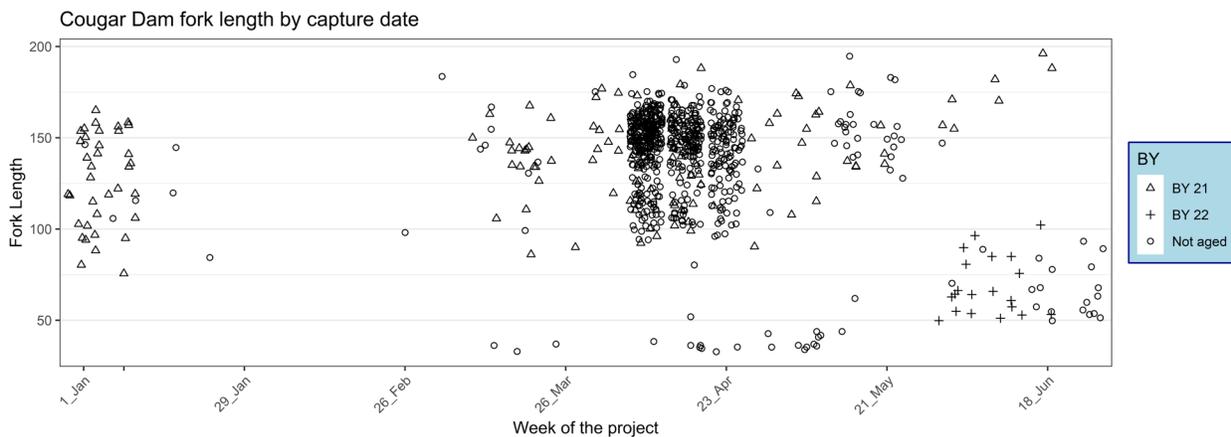


Figure 19. Length-frequency age analysis for juvenile Chinook captured below Cougar Dam in 2023.

Trapping Efficiency Trials

A total of 11 trapping efficiency trials occurred using hatchery reared Chinook salmon below Cougar Dam in 2023, 5 in the RO channel, and 6 in the Powerhouse channel. A total of 23 trials have occurred since sampling started in December of 2021. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 16. Trials were averaged for the purpose of creating passage estimates and standard deviation used to calculate 95% C.I.s. At this time there appears to be no relationship with flow rate, as linear models fit were non-significant (see Appendix E-4). However, samples are lacking at higher flows (see Appendix E-4). Trapping efficiencies ranged from 0% to 12.8% in the RO channel and from 1.0%

to 27.7% in the Powerhouse channel. We estimate that 12,329 (95% CI: 9,322 to 18,199) Chinook passed through the RO and 660 (95% CI: 442 to 1,298) passed through the Powerhouse from January 1, 2023, through June 30, 2023 (Figure 20). Total passage for this period at Cougar Dam is estimated to be 12,989 (95% CI: 9,764 to 19,497) juvenile Chinook. Plots displaying trap efficiency and flow for all trials are displayed in Appendix E.

Table 16. Summary table of marked hatchery Chinook releases at Cougar Dam for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Cougar Dam Powerhouse Channel	1/19/2022	405	997	37	3.7%
Cougar Dam Regulating Outlet Channel	1/19/2022	410	995	26	2.6%
Cougar Dam Powerhouse Channel	4/20/2022	357	1000	67	6.7%
Cougar Dam Regulating Outlet Channel	4/20/2022	378	995	16	1.6%
Cougar Dam Regulating Outlet Channel	5/15/2022	987	500	64	12.8%
Cougar Dam Powerhouse Channel	7/19/2022	495	535	148	27.7%
Cougar Dam Powerhouse Channel	8/11/2022	501	949	29	3.1%
Cougar Dam Regulating Outlet Channel	10/14/2022	442	509	49	9.6%
Cougar Dam Regulating Outlet Channel	12/13/2022	506	502	42	8.4%
Cougar Dam Regulating Outlet Channel	12/15/2022	1015	1010	56	5.5%
Cougar Dam Regulating Outlet Channel	12/20/2022	500	1014	61	6.0%
Cougar Dam Regulating Outlet Channel	12/28/2022	443	704	14	2.0%
Cougar Dam Powerhouse Channel	1/12/2023	500	843	159	18.9%
Cougar Dam Regulating Outlet Channel	1/30/2023	350	509	6	1.2%
Cougar Dam Powerhouse Channel	3/23/2023	500	500	49	9.8%
Cougar Dam Regulating Outlet Channel	3/23/2023	556	511	4	0.8%
Cougar Dam Powerhouse Channel	3/30/2023	490	497	12	2.4%
Cougar Dam Regulating Outlet Channel	3/30/2023	500	491	31	6.3%
Cougar Dam Powerhouse Channel	4/18/2023	580	297	14	4.7%
Cougar Dam Regulating Outlet Channel	4/18/2023	590	501	2	0.4%
Cougar Dam Powerhouse Channel	5/10/2023	710	499	5	1.0%
Cougar Dam Regulating Outlet Channel	5/10/2023	710	499	0	0%
Cougar Dam Powerhouse Channel	6/6/2023	370	507	65	12.8%

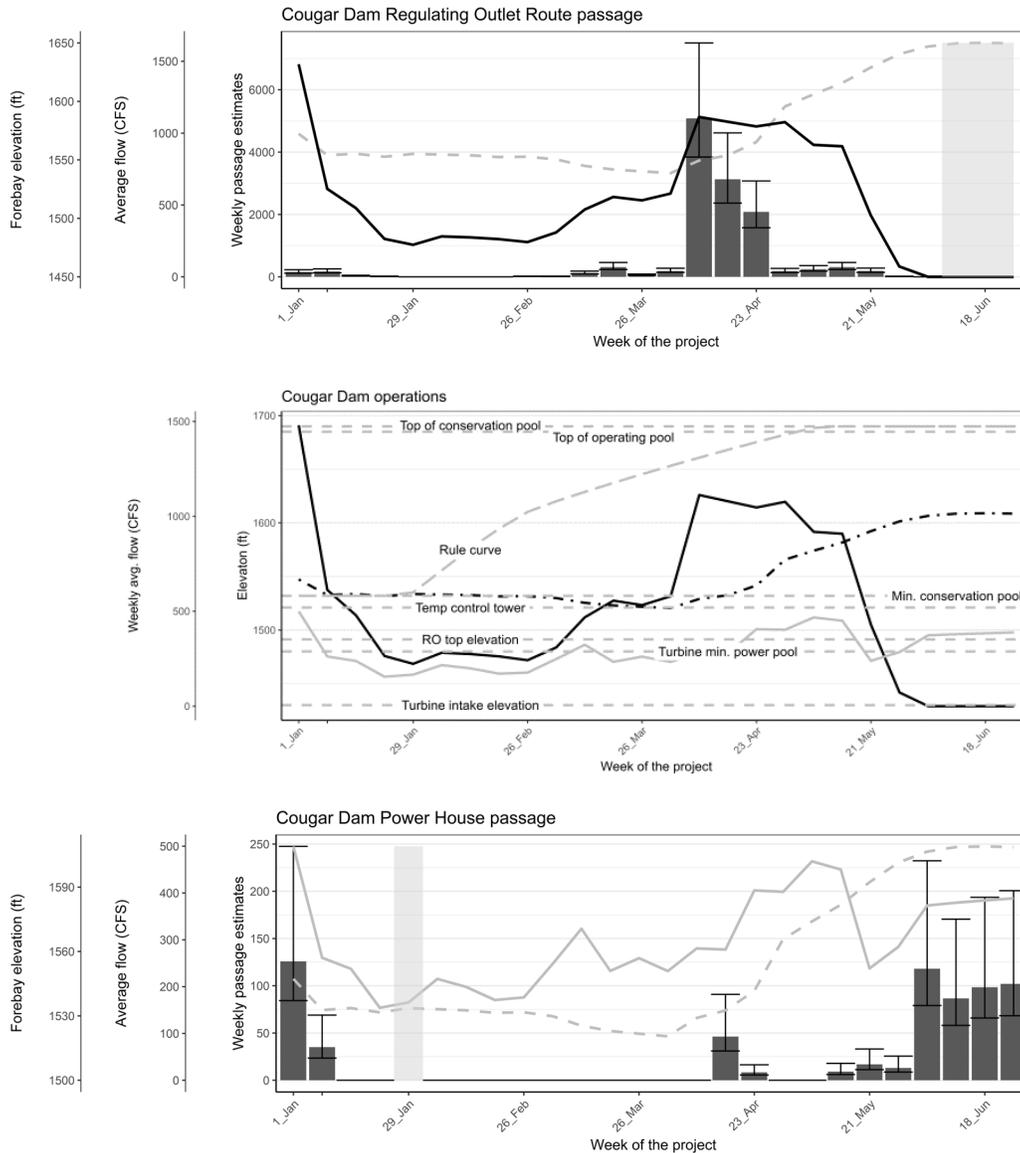


Figure 20. Shows estimated passage for the RO (top panel) and the Powerhouse (bottom panel) at Cougar Dam overlaid with Powerhouse outflow (gray line), RO outflow (black line), forebay elevation (gray dashed line), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023. The middle panel shows Cougar Dam operations and features of interest with RO outflow (black line), Powerhouse outflow (gray line), and forebay elevation (black dot dash line).

Injury Data

A total of 832 juvenile Chinook (96.3% of total Chinook catch), 774 captured in the RO trap (97.9% of total RO catch) and 58 captured in the Powerhouse traps (79.5% of total Powerhouse catch), displayed at least one of the injury code conditions listed in Table 2. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. This was then applied as a correction factor to provide more clarity on injury resulting from passage. The most common injuries associated with trap capture include descaling less than 20% and fin damage while the most common injuries associated with passage include descaling less than 20%, descaling greater than 20%, operculum damage, and fin damage. For fish captured in the Powerhouse 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 correlation 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 17 and 18 show injuries observed on Chinook by route of passage. The proportion of fish displaying injuries by type over the sample period is shown in Figure 21. 680 juvenile Chinook salmon (78.7% of total Chinook catch) were infected with copepods at time of capture (Figure 22). Copepod presence on captured Chinook salmon shows a positive correlation with the size of fish similar to observations made by previous studies (Cramer Fish Sciences 2022; Monzyk et al. 2015). This is likely an association between time spent rearing in the reservoir rather than the size of the fish. Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 17. Summary of injuries for trapping efficiency fish, observed injuries on natural origin Chinook, and corrected injuries for Chinook at the Cougar Dam Powerhouse RSTs.

Injury Code	TE Release Injuries (~50 per trial, proportion of total)	TE Recapture Injuries (proportion of total)	Proportional Percent Change	Observed Chinook Injuries	Corrected Chinook Injuries for Passage
NXI	49.2%	5.7%	-43.5%	15	22
MUNK	0.0%	0.7%	0.7%	0	0
DS<2	42.9%	70.3%	27.4%	33	24
DS>2	4.0%	7.9%	3.9%	8	8
BLO	0.7%	0.0%	-0.7%	2	2
EYB	0.0%	1.0%	1.0%	5	5
BVT	0.0%	0.0%	0.0%	6	6
FVB	0.0%	0.0%	0.0%	7	7
GBD	0.0%	0.2%	0.2%	2	2
POP	0.0%	0.0%	0.0%	0	0
HIN	1.0%	0.7%	-0.3%	2	2
OPD	0.0%	4.7%	4.7%	5	5
TEA	0.0%	1.2%	1.2%	5	5
BRU	0.3%	0.5%	0.2%	8	8
HBP	0.0%	0.0%	0.0%	2	2
HO	0.0%	0.0%	0.0%	0	0
BO	0.0%	0.0%	0.0%	0	0
HBO	0.0%	0.0%	0.0%	0	0
FID	41.9%	86.9%	45.0%	25	14
PRD	0.0%	0.0%	0.0%	0	0
COP	0.0%	2.0%	2.0%	29	28
BKD	0.0%	0.0%	0.0%	0	0
FUN	0.0%	0.0%	0.0%	1	113

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

Injury Code	TE Release Injuries (~50 per trial, proportion of total)	TE Recapture Injuries (proportion of total)	Proportional Percent Change	Observed Chinook Injuries	Corrected Chinook Injuries for Passage
NXI	50.2%	4.8%	-45.5%	17	25
MUNK	0.0%	0.0%	0.0%	1	1
DS<2	42.8%	76.2%	33.4%	500	333
DS>2	1.0%	11.9%	10.9%	215	192
BLO	1.0%	0.0%	-1.0%	7	7
EYB	0.0%	3.6%	3.6%	89	86
BVT	0.0%	0.0%	0.0%	36	36
FVB	0.0%	3.6%	3.6%	104	100
GBD	0.0%	19.0%	19.0%	376	304
POP	0.0%	3.6%	3.6%	14	14
HIN	0.0%	0.0%	0.0%	26	26
OPD	0.0%	8.3%	8.3%	119	109
TEA	0.5%	6.0%	5.5%	56	53
BRU	0.5%	1.2%	0.7%	46	46
HBP	0.0%	0.0%	0.0%	8	8
HO	0.0%	0.0%	0.0%	0	0
BO	0.0%	0.0%	0.0%	1	1
HBO	0.0%	0.0%	0.0%	0	0
FID	33.8%	88.1%	54.3%	649	297
PRD	0.0%	0.0%	0.0%	2	2
COP	0.0%	21.4%	21.4%	651	512
BKD	0.0%	2.4%	2.4%	0	0
FUN	0.0%	2.4%	2.4%	27	26

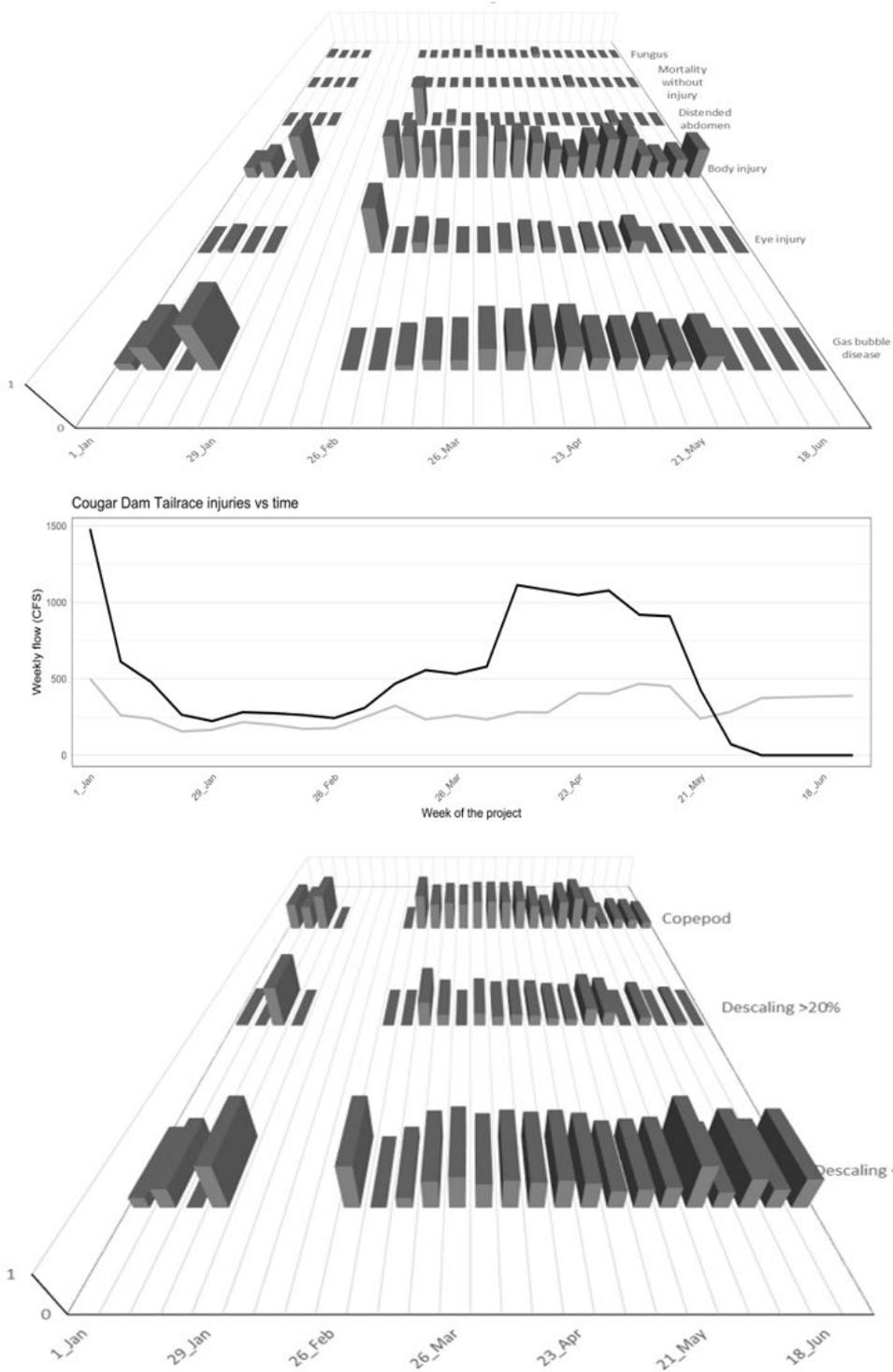


Figure 21. Proportion of captured juvenile Chinook displaying injuries by type (top panel), operations data from Cougar Dam showing cfs of spill (black line) and Powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook displaying descaling and copepod injuries (bottom panel).

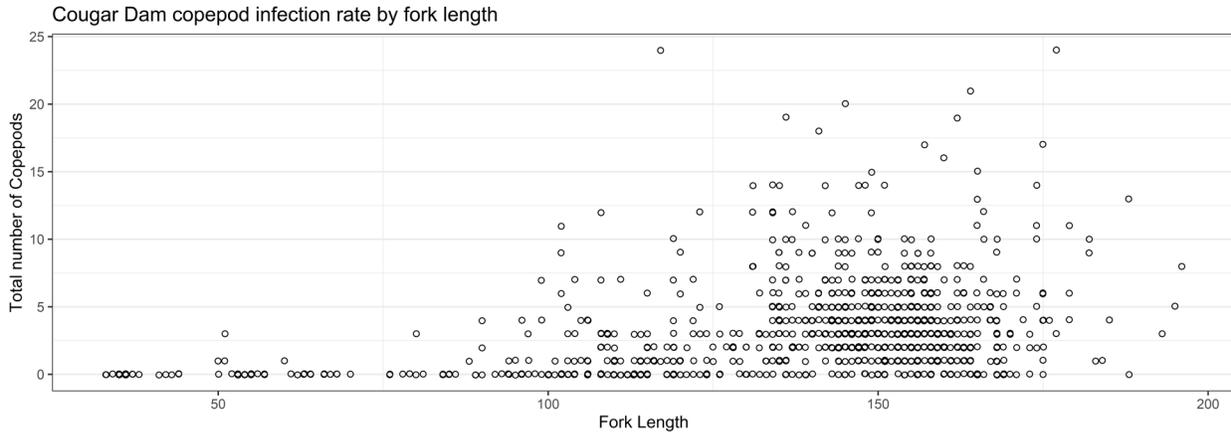


Figure 22. Copepod presence vs fork length on juvenile Chinook captured at Cougar Dam.

24 Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook captured at Cougar Dam to assess delayed mortality resulting from dam passage. A total of 366 fish, 302 from the RO and 64 from the Powerhouse, were held (Table 19). A total of 18 fish died during hold (4.9%), 14 of the RO Chinook (4.6%) and 4 of the Powerhouse Chinook (6.3%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 22.2%.

Table 19. Summary of 24-hour hold trials for Chinook captured in the RSTs at the Cougar Dam site.

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	RO	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%

PIT Tagged/VIE Marked Fish and Downstream Detections

A total of 356 juvenile Chinook were PIT tagged and released at the Cougar Dam sites in 2023. None of these fish were redetected at downstream sites. In addition to the tagged run of river fish, 843 PIT tagged and adipose clipped Chinook were released at Cougar Dam for a trapping efficiency trial. Of these, 149 fish were recaptured at the Powerhouse RSTs. 6 tags were redetected downstream in the Columbia River Estuary. As of July 20, 2023, data from the ODFW PIT array at Cougar Dam has not been uploaded to PTAGIS. Table 20 shows summary statistics of the fish redetected at downstream sites. Information regarding the redetections at the RST site can be found in Appendix C.

Table 20. Summary of redetections of fish PIT tagged at the Cougar Dam sites.

Number of Chinook Redetected	Redetection Site	Minimum Travel Time	Maximum Travel Time	Mean Travel Time
2	PD6 - Columbia River Estuary rkm 68	93 days	108 days	100.5 days
2	PD5 - Columbia River Estuary rkm 62	96 days	112 days	104 days
2	TWX – Estuary Towed Array (Exp.)	92 days	108 days	100 days

Non-Target Capture Data

A total of 849 non-target fish were captured at the Cougar Dam sites in the spring of 2023. A summary of species and catch is provided below in Table 21. The most commonly captured non-target species were dace, *O. mykiss*, and sculpin. Information regarding captured Bull Trout is provided in Appendix C.

Table 21. Summary of non-target fish capture for the Cougar Dam RSTs from January 1, 2023, through June 30, 2023.

Species	Season Total	Season Total Mortality (subset of total)
Bull Trout	2	0
Chinook (clipped)	29	1
Cutthroat Trout	5	0
Dace	637	1
Largescale Sucker	6	0
Mountain Whitefish	10	2
<i>O. mykiss</i>	75	0
Sculpin	85	2
Totals	849	6

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. The trap sampled 127 days in 2023. The trap was not sampled from February 20, 2023, to 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.

Target Catch and Passage Timing

The trap captured 4,624 juvenile Chinook salmon during this reporting period. Peak catch of juvenile Chinook salmon above Cougar Reservoir in the spring occurred April through June (n= 4556, 98.5% of total Chinook catch). This timing is consistent with data from previous studies (Romer et al. 2016). Figure 23 shows raw and standardized catch overlaid with flow at the Cougar Dam Head of Reservoir site. Chinook catch consisted of two BY classes, BY 2021 (n= 32, 0.7%) and BY 2022 (n= 4,592, 99.3%). BY 2022 sub-yearling Chinook were the dominant age class captured at this site from March through the end of the period (Figure 24). The first BY 2022 Chinook captured at the trap occurred on February 16. Peak capture of BY 2022 sub-yearlings occurred in May when 2,950 Chinook were captured (64.2% of total BY 22 catch). BY 2022 Chinook had an average fork length of 36.2 mm (min: 25 mm, max: 64 mm, median: 36 mm). The first BY 2021 yearling was captured on February 7, 2023, and yearling catch continued into early April. BY 2021 Chinook had an average fork length of 88.2 mm (min: 73 mm, max: 106 mm, median: 89 mm) and an average weight of 7.0 g (min: 3.2 g, max: 13.7 g, median: 6.8 g). 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.

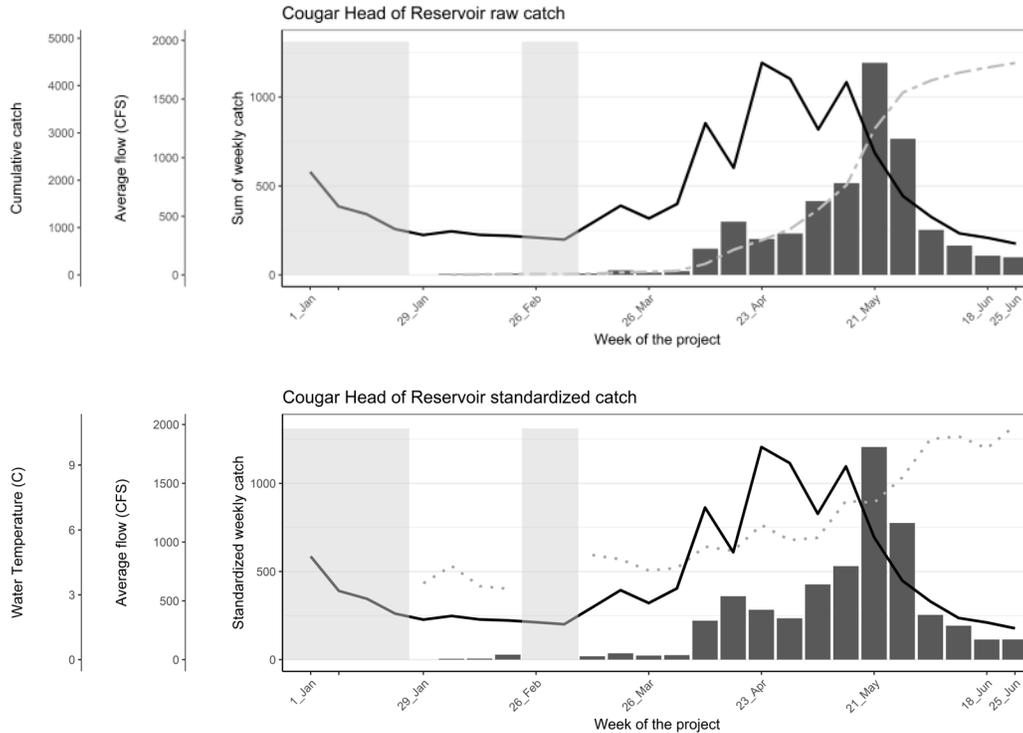


Figure 23. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Cougar Dam Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), water temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

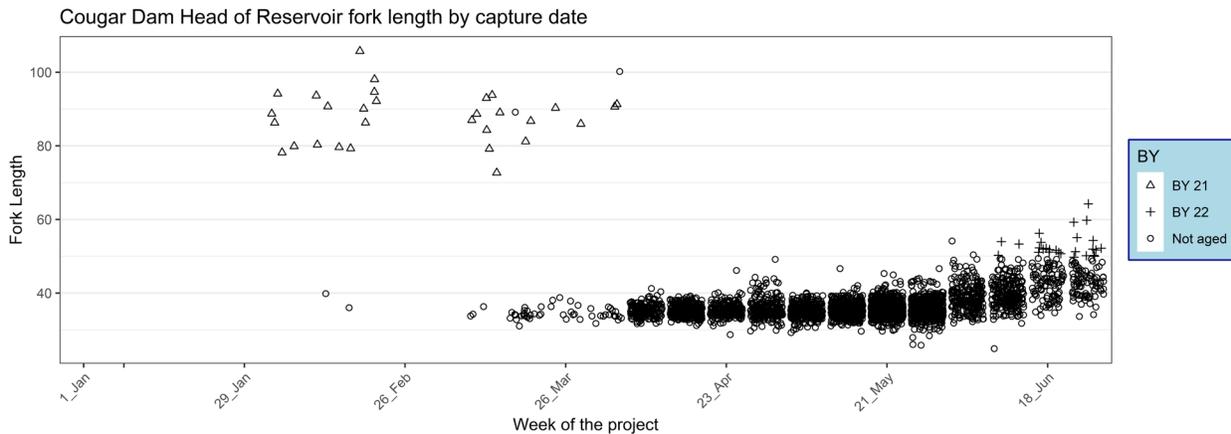


Figure 24. Length-frequency of juvenile Chinook salmon by brood year at the Cougar Dam Head of Reservoir site.

Trapping Efficiency Trials

A total of four trapping efficiency trials occurred using hatchery reared Chinook salmon at the Cougar Dam Head of Reservoir site in 2023. We were unable to perform trials with yearlings in the spring due to limited availability of hatchery fish. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 22. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled. A linear model which showed decreasing TE with increasing flow was fit to the TE

trials ($Rsq=0.30$ and $Pvalue=0.05$) (see appendix E). However, the sample size is small making it difficult to detect assumption violations, and results could change with more data. Trapping efficiencies ranged from 1.4% to 10.2%. We estimate that 29,525 (95% CI: 16,650 to 139,177) juvenile Chinook migrated past our trap into Cougar Reservoir between February 1, 2023, and April 8, 2023, and May 28, 2023, to June 30, 2023 (Figure 25). Estimates do not include fish passing through the site from April 9, 2023, to May 27, 2023, as confidence intervals for this period are not possible because the TE value is low and the 95% CI drop below 0 resulting in a null upper 95% CIs. (weekly catch/lower 95% CI). Plots displaying trap efficiency and flow for all successful trials are displayed in Appendix E.

Table 22. Summary table of marked hatchery Chinook releases at the Cougar Dam Head of Reservoir site for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Cougar Dam Head of Reservoir	3/18/2022	774	806	40	5.0%
Cougar Dam Head of Reservoir	5/19/2022	1,385	498	23	4.6%
Cougar Dam Head of Reservoir	6/23/2022	711	486	7	1.4%
Cougar Dam Head of Reservoir	9/22/2022	225	551	56	10.2%
Cougar Dam Head of Reservoir	10/5/2022	207	608	47	7.7%
Cougar Dam Head of Reservoir	11/10/2022	340	704	33	4.7%
Cougar Dam Head of Reservoir	11/16/2022	259	719	28	3.9%
Cougar Dam Head of Reservoir	11/23/2022	292	752	48	6.4%
Cougar Dam Head of Reservoir	11/29/2022	295	620	48	7.7%
Cougar Dam Head of Reservoir	4/14/2023	964	506	10	2.0%
Cougar Dam Head of Reservoir	5/10/2023	1142	508	7	1.4%
Cougar Dam Head of Reservoir	5/16/2023	1728	497	23	4.6%
Cougar Dam Head of Reservoir	6/8/2023	484	510	23	4.5%

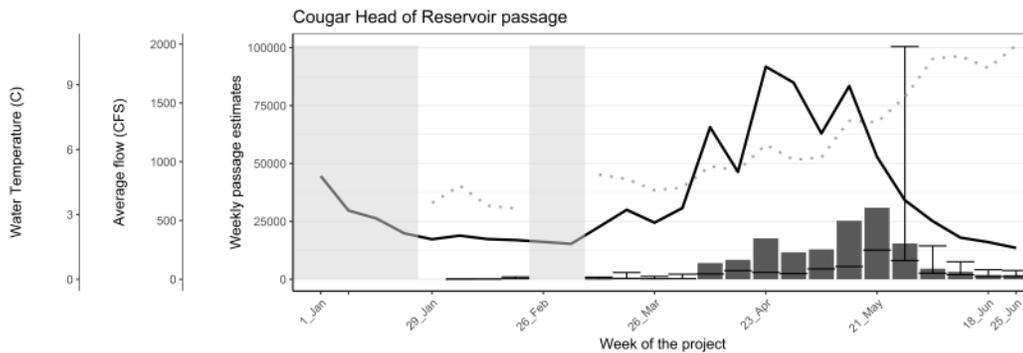


Figure 25. Passage estimates with 95% confidence for juvenile Chinook salmon at the Cougar Dam Head of Reservoir site with streamflow (black line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

Injury Data

A total of 321 juvenile Chinook (6.9% of total Chinook catch) displayed at least one of the injury code conditions listed in Table 23. The most common injuries observed at this site include descaling less than 20% and fin damage. These injuries were likely incurred upon capture in the RST due to debris or contact with various surfaces in the trap. There were 13 mortalities (0.3% of total Chinook catch) likely resulting from high debris in the trap.

Table 23. Percentage of juvenile Chinook displaying injury by type at the Cougar Head of Reservoir RST site.

Injury Code	Chinook Injuries
NXI	93.1%
MUNK	0.1%
DS<2	0.9%
DS>2	0.4%
BLO	0.0%
EYB	0.2%
BVT	0.1%
FVB	0.2%
GBD	0.0%
POP	0.4%
HIN	0.7%
OPD	1.0%
TEA	0.5%
BRU	0.7%
HBP	0.0%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	1.3%
PRD	0.2%
COP	0.1%
BKD	0.0%
FUN	0.0%

PIT Tagged/VIE Marked fish and Downstream Detections

A total of 24 fish were PIT tagged and 2,998 were VIE marked at Cougar Dam Head of Reservoir site in 2023. The rest of the captured fish were either sac-fry or did not meet minimum length requirements for tagging. One of the PIT tagged fish was recaptured at the RST site the day after tagging as it was released upstream of the trap for run of river trapping efficiency trials. None of the VIE marked fish have been detected at downstream sites to date. As of July 20, 2023, data from the ODFW PIT arrays at Cougar Dam has not been available on PTAGIS. Additionally, a group of PIT tagged Chinook that were originally slated for use above Cougar Reservoir were released from Leaburg due to extenuating circumstances. A total of 1 fish from this group was redetected at the PD6- Columbia River Estuary Array 93 days after release. See Appendix C for information regarding tags redetected at the Cougar Dam Head of Reservoir site and VIE marked fish.

Non-Target Capture Data

We captured 153 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught are provided in Table 24. The most commonly captured non-target species was rainbow trout. Additionally, our trap captured 3 Bull Trout. All Bull Trout were measured and scanned for PIT tags. All information gathered was provided to ODFW. Additional information on captured Bull Trout is provided in Appendix C.

Table 24. Summary of non-target species capture at the Cougar Dam Head of Reservoir RST site for 2023.

Species	Season Total	Season Total Mortality (subset of total)
Northern Pikeminnow	0	0
Bull Trout	3	0
Cutthroat Trout	3	0
Dace	1	0
Mountain Whitefish	2	1
<i>O. mykiss</i>	139	0
Sculpin	4	0
Unknown	1	1
Totals	153	2

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 is reported in the respective Corps bi-annual reports. The trap sampled 134 days in 2023. The trap did not sample from January 1st to January 11th and from January 25th to March 2nd when river bed movement from reservoir drawdown filled the RO channel with sediment to the point that the cone could not be lowered to the sampling position. Additional details regarding sampling dates and trap outages can be found in Appendix B.

Target Catch and Passage Timing

The trap in the Regulating Outlet Channel below Fall Creek Dam captured 61 juvenile Chinook salmon during sampling in 2023. Capture of juvenile Chinook salmon occurred in March and April (Figure 26). Peak capture occurred in March (n=44, 72.1%). This timing is later than previous monitoring efforts observed as in previous efforts, Chinook sub-yearlings and yearlings often migrated out of Fall Creek Dam in January and February (Keefer et al. 2012). Recent observations of juvenile Chinook in the Fall Creek Adult Fish Facility (D. Garletts, personal communication, July 13, 2023) suggest that juvenile Chinook continue passing through Fall Creek Dam later in the spring than RST capture indicates as the RST is very inefficient in low flows. Only BY 2022 sub-yearlings were captured at this site during the reporting period (Figure 27). Sampling in 2022 above Fall Creek Dam in the spring and below Fall Creek Dam in the spring and fall captured no BY 2021 fish (EAS 2023). This corroborates data from last year that suggested that BY 2021 juveniles experienced a year-class failure. The average fork length of capture Chinook was 36.8 mm (min: 33 mm, max: 60 mm, median: 37 mm).

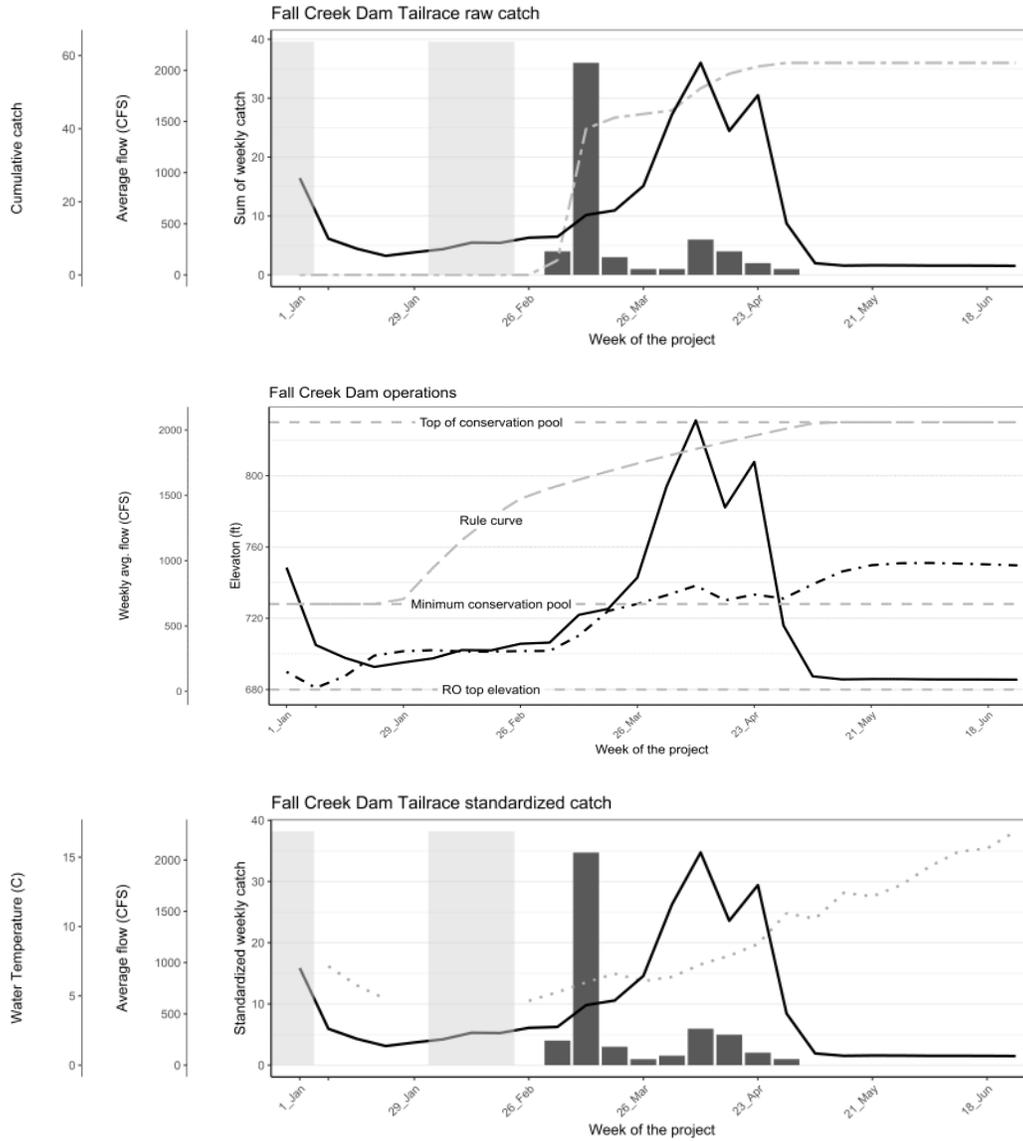


Figure 26. Raw catch (top panel), Fall Creek Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Fall Creek Dam Tailrace site with RO outflow (black line), forebay elevation (black dot dash line), intake elevations (gray dash line), cumulative catch (gray dot dash line), stream temperature (gray dot line), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

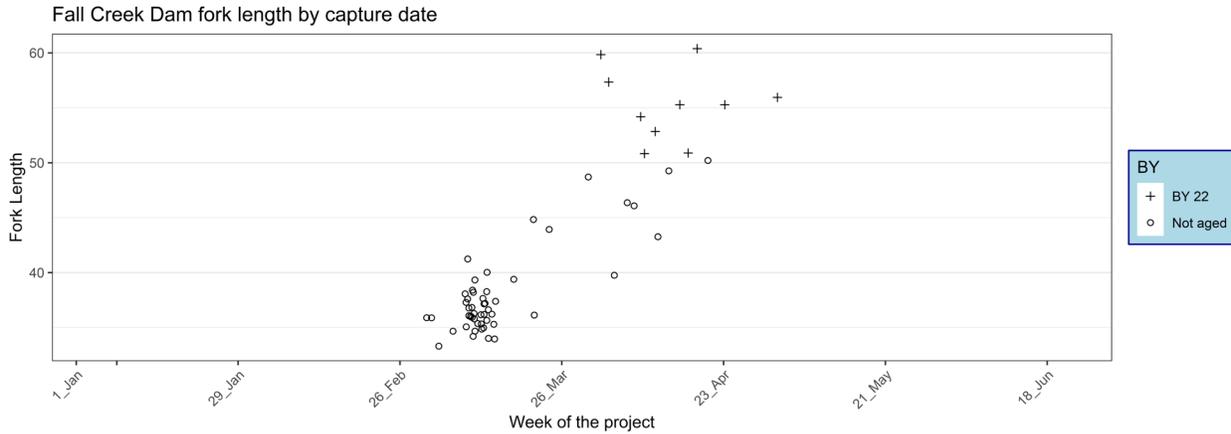


Figure 27. Length-frequency of juvenile Chinook salmon at the Fall Creek Dam Tailrace site.

Trapping Efficiency Trials

A total of two trapping efficiency trials occurred using hatchery reared Chinook salmon in the RO channel of Fall Creek Dam in 2023. A total of five 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 25. Trapping efficiencies ranged from 0% to 2.1%. Due to strict limitations on the availability of hatchery Chinook from Middle Fork Willamette brood stocks and low catch rate of natural origin fish at this site, we were unable to perform enough trap efficiency trials in the early spring when flows were sufficient to spin the cone of the trap. Efficiency trials performed during low flow did not yield any recaptures. This is likely due to the slow rotation speed of the trap at these flow levels allowing fish to easily avoid the trap. Plots displaying trap efficiency and flow for all successful trials are displayed in Appendix E.

Table 25. Summary table of marked hatchery Chinook releases at Fall Creek Dam Tailrace for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Fall Creek Dam Regulating Outlet	06/08/2022	957	517	11	2.1%
Fall Creek Dam Regulating Outlet	06/30/2022	231	513	0	0%
Fall Creek Dam Regulating Outlet	07/13/2022	228	498	0	0%
Fall Creek Dam Regulating Outlet	5/11/2023	114	998	0	0%
Fall Creek Dam Regulating Outlet	6/28/2023	89	992	0	0%

Injury Data

In total, 11 juvenile Chinook (18.0% of total Chinook capture) captured at the Fall Creek Dam Tailrace site displayed injuries upon capture. A total of 2 Chinook were dead at the time of trap check (3.2% of total Chinook capture). A summary of injuries by type is shown in Table 26.

Table 26. Percentage of juvenile Chinook displaying injury by type at the Fall Creek Tailrace site.

Injury Code	Chinook Injuries
NXI	82.0%
MUNK	0.0%
DS<2	6.6%
DS>2	0.0%
BLO	1.6%
EYB	3.3%
BVT	1.6%
FVB	0.0%
GBD	3.3%
POP	0.0%
HIN	3.3%
OPD	1.6%
TEA	1.6%
BRU	1.6%
HBP	1.6%
HO	0.0%
BO	0.0%
HBO	0.0%
FID	6.6%
PRD	0.0%
COP	0.0%
BKD	0.0%
FUN	0.0%

24 Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook captured in the Fall Creek Dam Tailrace to assess delayed mortality potentially from dam passage, collection, or holding. A total of 58 Chinook were held in 2023 (Table 27). A total of 1 Chinook died during hold (1.7%).

Table 27. Summary of 24-hour hold trials for fish captured in the RST at the Fall Creek Dam Tailrace site.

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 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 313 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught is provided in Table 28. The most commonly captured non-target species were Dace and *O. mykiss*.

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

Species	Season Total	Season Total Mortality (subset of total)
Mosquitofish	0	0
Brook Lamprey	15	0
Brown Bullhead	33	11
Cutthroat Trout	26	0
Dace	138	5
Largescale Sucker	11	3
Northern Pikeminnow	1	0
<i>O. mykiss</i>	66	3
<i>O. mykiss</i> (clipped)	16	3
Pacific Lamprey	1	0
Sculpin	6	0
Totals	313	25

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. The trap sampled 125 days in 2023. Additional information regarding trap sample dates and outages can be found in Appendix B.

Target Catch and Passage Timing

The trap at Fall Creek Head of Reservoir captured 148 juvenile Chinook salmon (Figure 28). Peak passage of Chinook 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 29). Captured Chinook had an average fork length of 36.7 mm (min: 31 mm, max: 86 mm, median: 34 mm). 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.

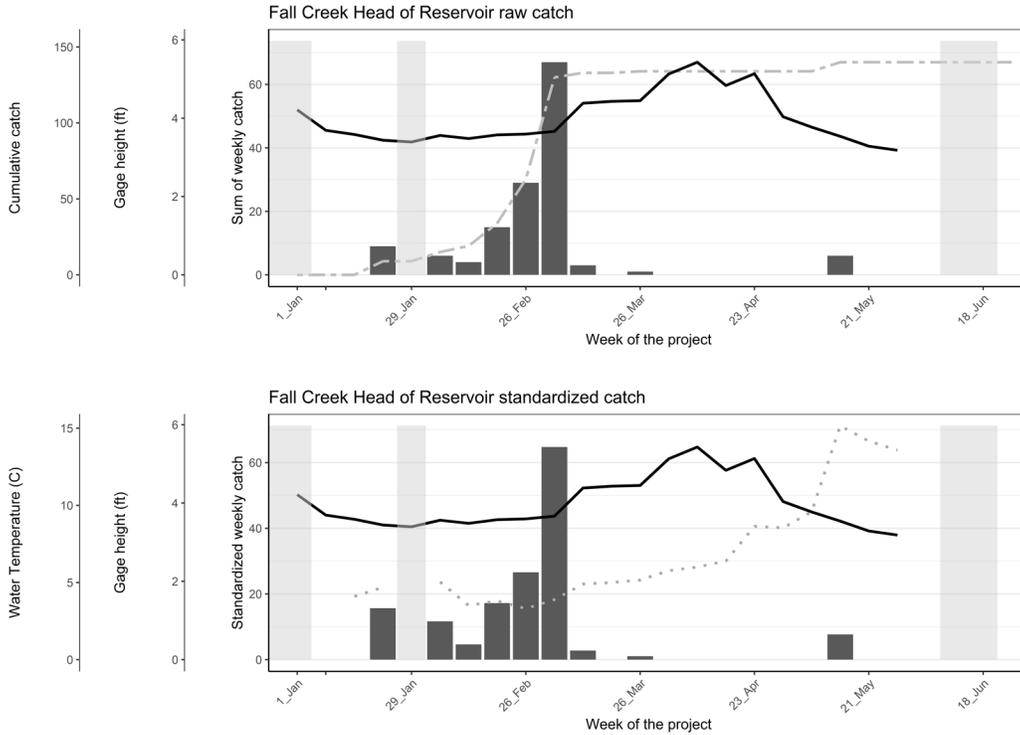


Figure 28. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Fall Creek Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), stream temperature (gray dots), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

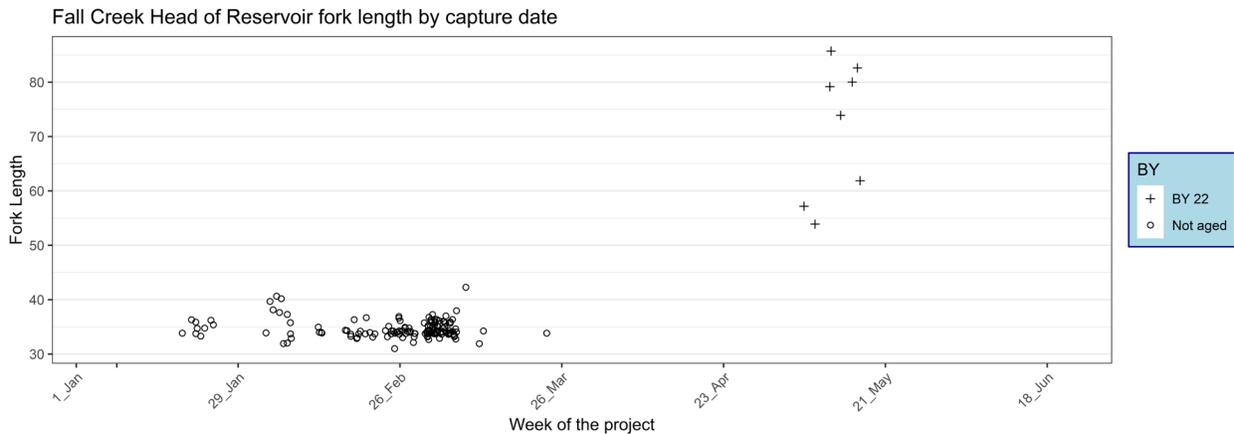


Figure 29. Length-frequency of juvenile Chinook salmon at the Fall Creek Head of Reservoir site.

Trapping Efficiency Trials

A total of four trapping efficiency trials occurred using hatchery reared Chinook salmon at the Fall Creek Head of Reservoir site in 2023. Due to limited availability of BY 2021 hatchery Chinook and BY 2022 hatchery fish being too small to safely mark until May, we were unable to test the efficiency of the RST to the extent we had planned. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 29. Trapping efficiencies ranged from 0.5% to 3.1%. Passage estimates are based on the average of successful trials (n=3) and 95% C.I.s are estimated from the standard deviations. We estimate that 7,100 (95% CI: 4,883 to 13,010) Chinook migrated past the sample site into Fall Creek Reservoir during the sampling period (Figure 30). However, given the small sample size of successful trap efficiency 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 trap efficiency and flow for all successful trials are displayed in Appendix E.

Table 29. Summary table of marked hatchery Chinook 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%

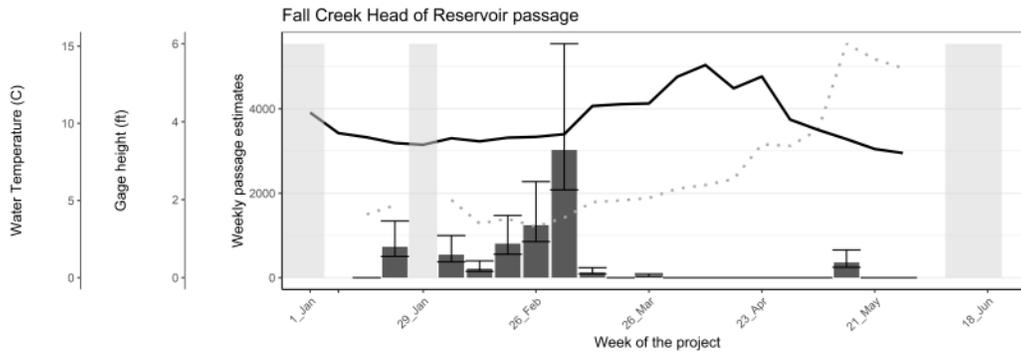


Figure 30. Passage estimates with 95% confidence for juvenile Chinook salmon at the Fall Creek Head of Reservoir site with streamflow (black line) and stream temperature (gray dots) for the 2022 sampling period.

Injury Data

A total of 8 juvenile Chinook (5.4% of total Chinook 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. A total of 5 Chinook (3.4%) were dead at the time of trap check and were associated with periods of high debris. A summary of injuries at this site can be found in Table 30.

Table 30. Percentage of juvenile Chinook displaying injury by type at the Fall Creek Head of Reservoir RST site.

Injury Code	Chinook Injuries
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 4 fish were PIT tagged at the Fall Creek Head of Reservoir site in 2023. As of July 20, 2023, none of the tagged fish were redetected at downstream sites. A total of 46 Chinook were captured and VIE marked at the Fall Creek Head of Reservoir site in 2023. All other fish captured were either sac-fry or too small to mark. One VIE tagged fish was recaptured at the Fall Creek Head of Reservoir site, no VIE marked fish were redetected downstream at the Fall Creek Dam site. Further information on tagged and VIE marked fish at this site is available in Appendix C.

Non-Target Capture Data

The Fall Creek Head of Reservoir trap captured 788 non-target fish in addition to natural origin juvenile Chinook. 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 31.

Table 31. 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	44	1
Brown Bullhead	0	0
Cutthroat Trout	67	0
Dace	116	1
Largescale Sucker	9	0
O. mykiss	436	0
O. mykiss (clipped)	47	0
Pacific Lamprey	11	0
Redside Shiner	0	0
Sculpin	1	1
Unknown Lamprey	57	0
Totals	788	3

Dexter Dam Tailrace

Monitoring of a single 5-foot RST in the Dexter Dam Tailrace began on March 7, 2022. The trap sampled 180 days in 2023. Information on monitoring periods and sampling outages that resulted from high flows and high debris are listed in Appendix B.

Target Catch and Passage Timing

The trap captured 20 juvenile Chinook salmon in 2023 (Figure 31). Chinook catch below Dexter Dam was composed of BY 2021 yearlings (n=15, 75%) and BY 2022 sub-yearlings (n=5, 25%) (Figure 32). The average length of BY 2021 Chinook was 158.2 mm (min:103 mm, max: 190 mm, median: 162 mm) with an average weight of 46.3 g (min: 12.9 g, max: 65.5 g, median 49.0 g). The average fork length of BY 2022 sub-yearlings was 85.4 mm (min: 54 mm, max: 109 mm, median: 100 mm) with an average weight of 8.1 g (min: 1.5 g, max: 13.0 g, median: 11.0 g). Peak capture of juvenile Chinook salmon leaving Dexter Reservoir 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 capture at Dexter Dam shows an association with the concurrent surface spill events at Lookout and Dexter Dams.

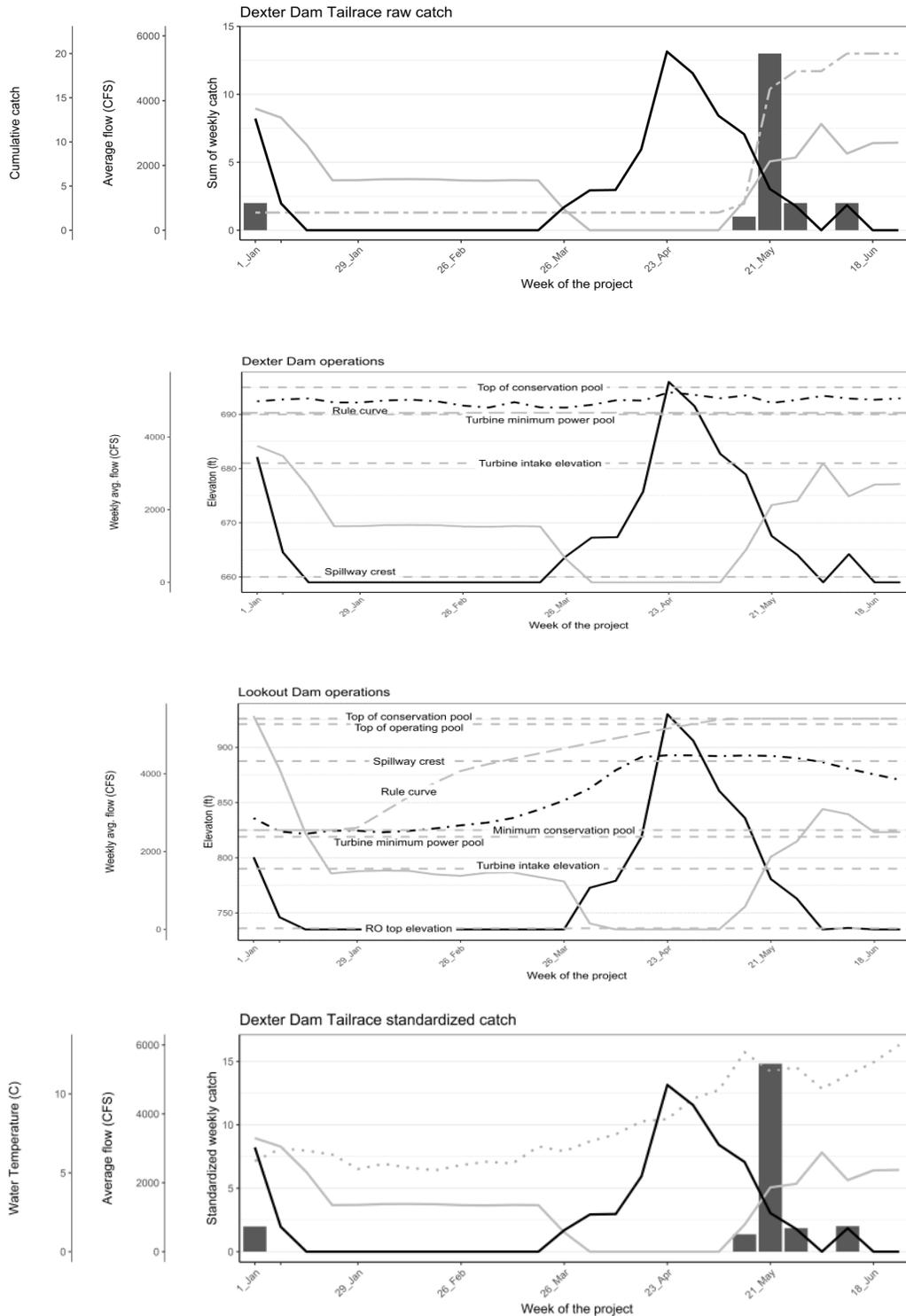


Figure 31. Raw catch Dexter Dam (top panel), Dexter Dam operations and features of interest (second panel), Lookout Dam operations and features of interest (third panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Dexter Dam Tailrace site with spill (black line), Powerhouse outflow (gray line), cumulative catch (gray dot dash line), forebay elevations (black dot dash line), and water temperature (gray dots) for 2023.

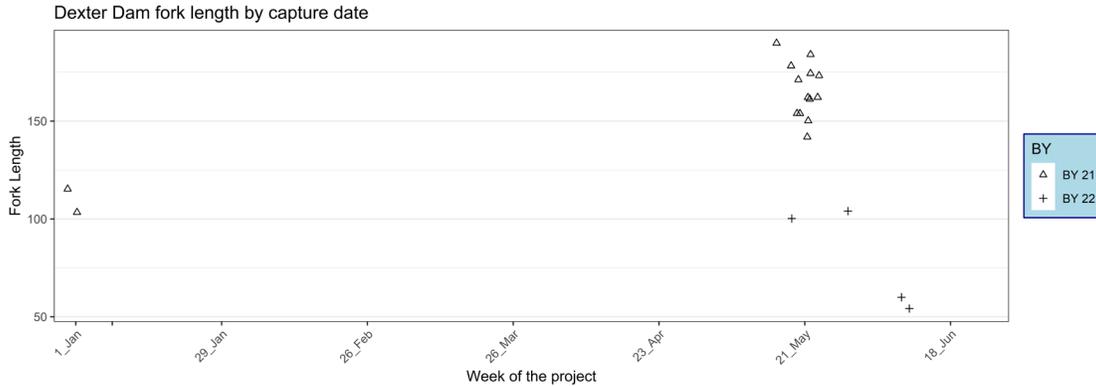


Figure 32. Length-frequency of juvenile Chinook salmon by brood year at the Dexter Dam Tailrace site.

Trapping Efficiency Trials

A total of five trapping efficiency trials occurred using hatchery reared Chinook salmon at the Dexter Dam Tailrace site in 2023, one in the spillway outflow and four in Powerhouse outflow. We were unable to perform efficiency 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 were too small to safely mark until early May. During one of the Powerhouse releases, spill was also occurring. A total of 14 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 32. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled. Trapping efficiencies in the spillway release ranged from 0.2% to 6.6% and those in Powerhouse ranged from 0.1% to 1.0%. Only three spill trials and three Powerhouse trials yielded the minimum number of five recaptures in a week needed to calculate efficiencies. Efficiencies at this site have varied widely and we are unable to make an estimate of Chinook passage at this time. The location of the trap in the Dexter Dam Tailrace remains in the same location across all flows as a highline was not approved to be installed at this site. Thus, the trap cannot be adjusted to improve sampling as flows change and result in a wide array of capture efficiencies at this site. More successful trials across multiple flow ranges are necessary to perform estimates in the future. Plots displaying trap efficiency and flow for all successful trials are displayed in Appendix E.

Table 32. Summary table of marked hatchery Chinook releases at Dexter Dam Tailrace for trapping efficiency.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Dexter Dam Spillway	3/23/2022	1,240	988	2	0.2%
Dexter Dam Spillway	5/4/2022	5,040	995	43	4.3%
Dexter Dam Spillway	5/24/2022	2,620	1018	67	6.6%
Dexter Dam Powerhouse	7/21/2022	1,560	976	2	0.2%
Dexter Dam Powerhouse	10/26/2022	2,950	1007	1	0.1%
Dexter Dam Powerhouse	11/1/2022	3,670	755	1	0.1%
Dexter Dam Powerhouse	11/17/2022	3,450	991	4	0.4%
Dexter Dam Powerhouse	12/6/2022	1,610	1010	10	1.0%
Dexter Dam Powerhouse	12/15/2022	1,540	1025	1	0.1%
Dexter Dam Powerhouse	3/16/2023	1,591	1,200	2	0.2%
Dexter Dam Spillway	3/29/2023	1,279	1,199	5	0.4%
Dexter Dam Powerhouse	5/25/2023	3,092	4,003	14	0.3%
Dexter Dam Powerhouse	6/7/2023	3,228	4,010	4	0.1%
Dexter Dam Powerhouse	6/21/2023	2,758	4,028	15	0.4%

Injury Data

A total of 18 juvenile Chinook (90% of total Chinook catch) displayed at least one of the injury code conditions listed in Table 2. No mortalities were observed during the spring monitoring period. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type both pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. This was then applied as a correction factor to provide more clarity to injury resulting from passage. The most common injuries observed at this site include descaling less and greater than 20% and fin damage (Table 33). 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.

Table 33. Summary of observed injuries on trapping efficiency and natural origin juvenile Chinook captured in the Dexter Dam Tailrace

Injury Code	TE Release Injuries (~50 per trial)	TE Recapture Injuries	Proportional Percent change	Observed Target Injuries	Corrected Target Injuries for Passage
NXI	39.0%	7.8%	-31.2%	2	3
MUNK	0.0%	0.0%	0.0%	0	0
DS<2	41.7%	88.0%	46.3%	7	4
DS>2	4.3%	2.1%	-2.2%	9	9
BLO	0.0%	0.4%	0.4%	0	0
EYB	0.0%	0.0%	0.0%	1	1
BVT	0.0%	0.0%	0.0%	0	0
FVB	0.0%	0.7%	0.7%	1	1
GBD	0.0%	14.1%	14.1%	0	0
POP	0.0%	0.7%	0.7%	1	1
HIN	0.0%	0.0%	0.0%	0	0
OPD	0.7%	4.2%	3.6%	1	1
TEA	0.0%	0.4%	0.4%	0	0
BRU	2.3%	0.7%	-1.6%	1	1
HBP	0.0%	0.0%	0.0%	0	0
HO	0.0%	0.0%	0.0%	0	0
BO	0.0%	0.0%	0.0%	0	0
HBO	0.0%	0.0%	0.0%	0	0
FID	42.3%	83.0%	40.7%	12	7
PRD	0.0%	0.0%	0.0%	0	0
COP	0.0%	1.1%	1.1%	7	7
BKD	0.0%	0.0%	0.0%	0	0
FUN	0.0%	0.0%	0.0%	0	0

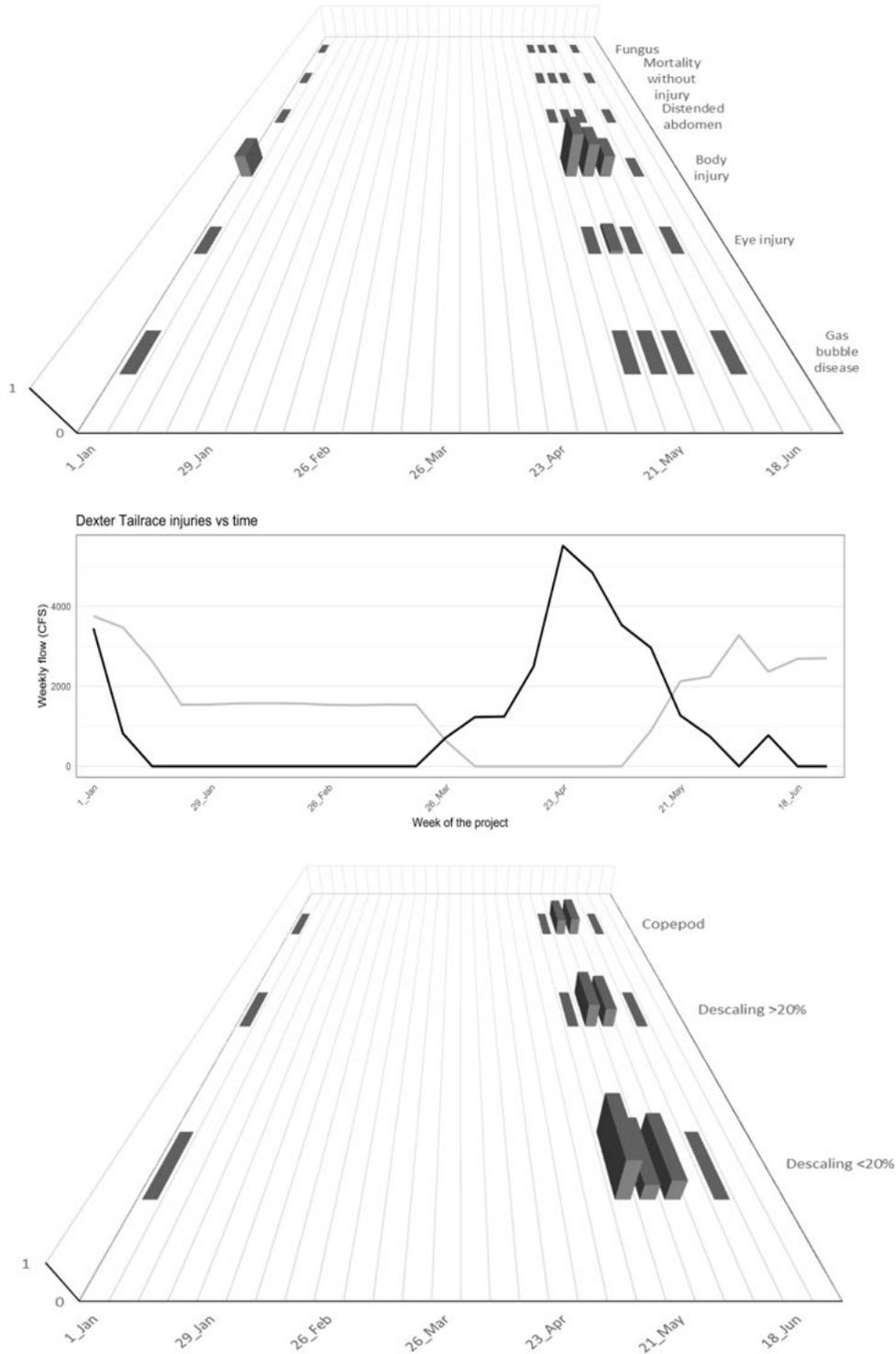


Figure 33. Proportion of captured juvenile Chinook displaying descaling less or greater than 20% descaling (top panel), operations data from Dexter Dam Tailrace showing cfs of spill (black line) and Powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook displaying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

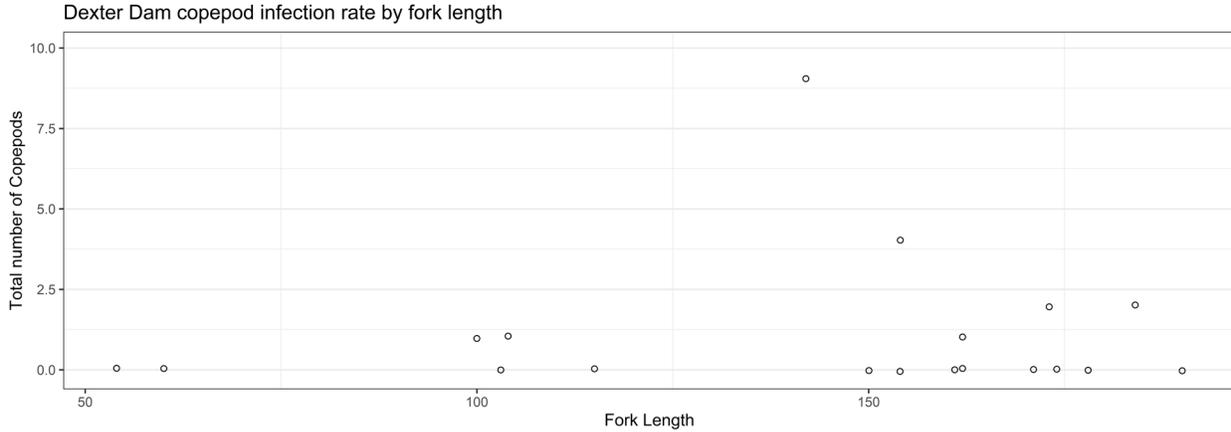


Figure 34. Fork length versus number of observed copepods on fins and in the branchial cavity of RST captured juvenile Chinook salmon at Dexter Dam Tailrace.

24 Hour Hold Trials

24-hour hold trials were performed on natural origin juvenile Chinook captured in the Dexter Dam Tailrace to assess delayed mortality from dam passage. 20 Chinook were held in 2023 (Table 34). A total of 0 Chinook died during hold (0.0%).

Table 34. Summary of 24-hour hold trials for Chinook captured in the RST at the Dexter Dam Tailrace site.

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%

PIT Tagged/VIE Marked fish and Downstream Detections

No Chinook 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.

Non-Target Capture Data

We captured 982 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught are provided in Table 35. The most commonly captured non-target species were crappie, sculpin, and clipped Chinook (escapes from the Dexter Fish Facility).

Table 35. Summary of non-target fish captured in the RST at the Dexter Dam Tailrace site.

Species	Season Total	Season Total Mortality (subset of total)
Bluegill	2	0
Chinook (clipped)	418	0
Crappie	313	22
Cutthroat Throat	1	0
Dace	10	2
Largescale Sucker	3	1
<i>O. mykiss</i>	3	0
<i>O. mykiss</i> (clipped)	1	0
Redside Shiner	1	0
Sculpin	229	7
Smallmouth Bass	1	1
Totals	982	33

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, three in the channel downstream of the Powerhouse outlet that are referred to as Powerhouse 1 (PH 1) and Powerhouse 2 (PH 2), and one in the channel on the south side of the island that is referred to as the Spill trap. These traps can capture fish that pass either the Powerhouse, 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. The Powerhouse channel traps and the Spill channel trap fished 180 days in 2023. A summary of sampling outages at this site can be found in Appendix B.

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 Powerhouse traps (55.1% of total catch, 15 in PH 1, 12 in PH 2) and 22 in the Spill trap (44.9% of total catch). Date of capture for 33 of the 49 Chinook occurred between April 21, 2023, and May 31, 2023 (Figures 35, 36, and 37). In January, Chinook capture comprised individuals from BY 2020 and 2021, while catch for the rest of the period comprised BY 2020, 2021, and 2022 fish (Figure 38). A total of 5 BY 2020 Chinook (10.2% of total catch) were captured and had an average fork length of 246 mm (min: 227 mm, max: 275 mm, median: 247 mm) with an average weight of 158.7 g (min: 37.9 g, max: 269.0 g, median: 161.4 g). BY 2021 yearlings comprised a majority of the total Chinook catch (n=32, 65.3%). They had an average fork length of 155.9 mm (min: 96 mm, max: 199 mm, median: 116.25) and an average weight of 47.3 g (min: 9.4 g, max: 81.9 g, median: 47.5 g). The first BY 2022 sub-yearling was captured on March 28, 2023. A total of 12 sub-yearlings were captured and had an average fork length of 57.3 mm (min: 33 mm, max: 113 mm, median: 53.5 mm).

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 (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.

Observations from sampling in 2012 and 2013 found that fish passed in the summer when spill occurred at the Lookout Dam Tailrace. On years when no spring/summer spill occurred and water primarily passed through the turbines, Chinook passage occurred predominantly in the fall months (Romer et al. 2013). Catch below Lookout Point Dam in 2023 coincided with surface spill events in the late spring and early summer, in concurrence with previous study's conclusions.

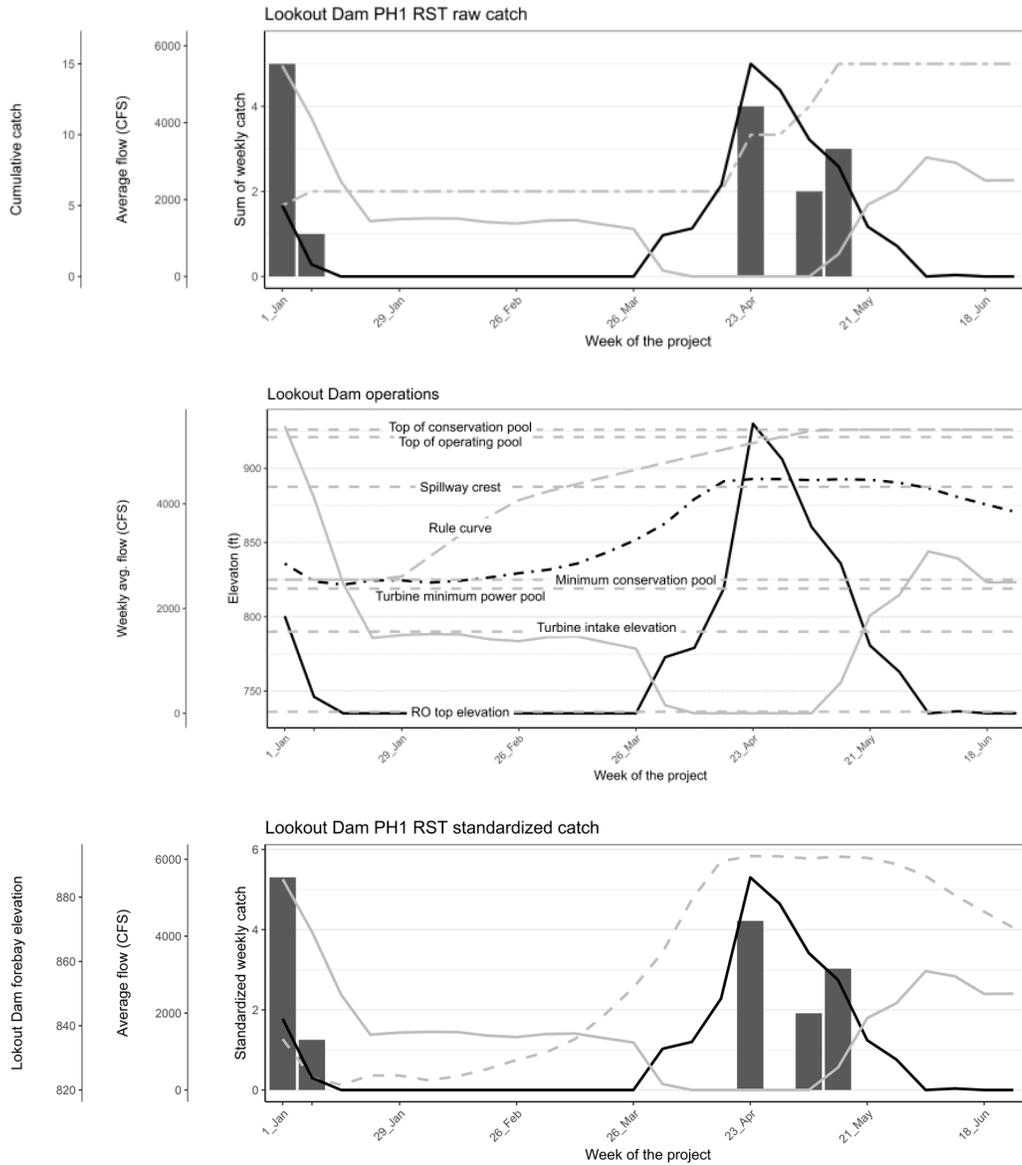


Figure 35. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Lookout Point Dam Tailrace PH 1 trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot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

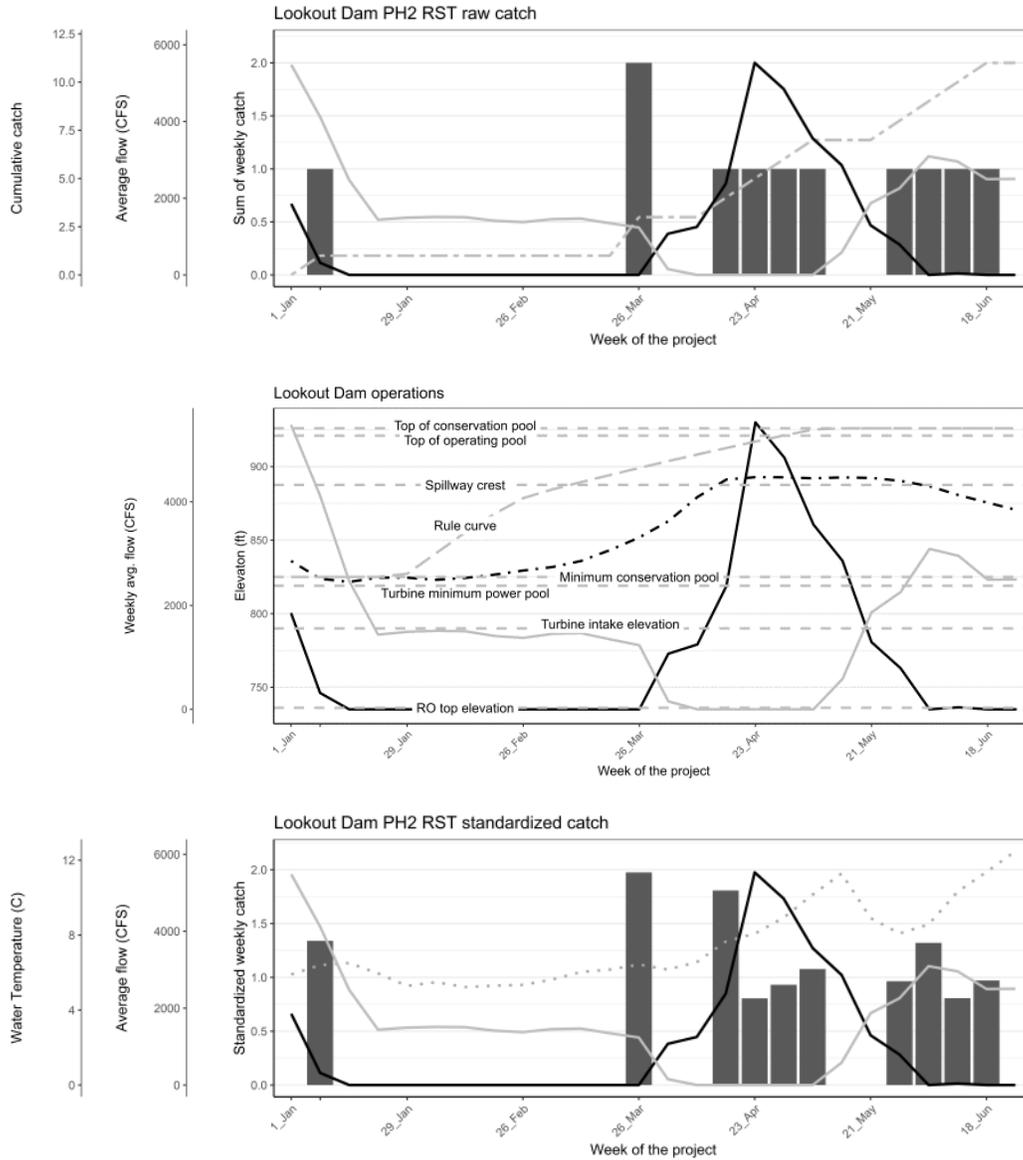


Figure 36. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Lookout Dam Tailrace PH 2 trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash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

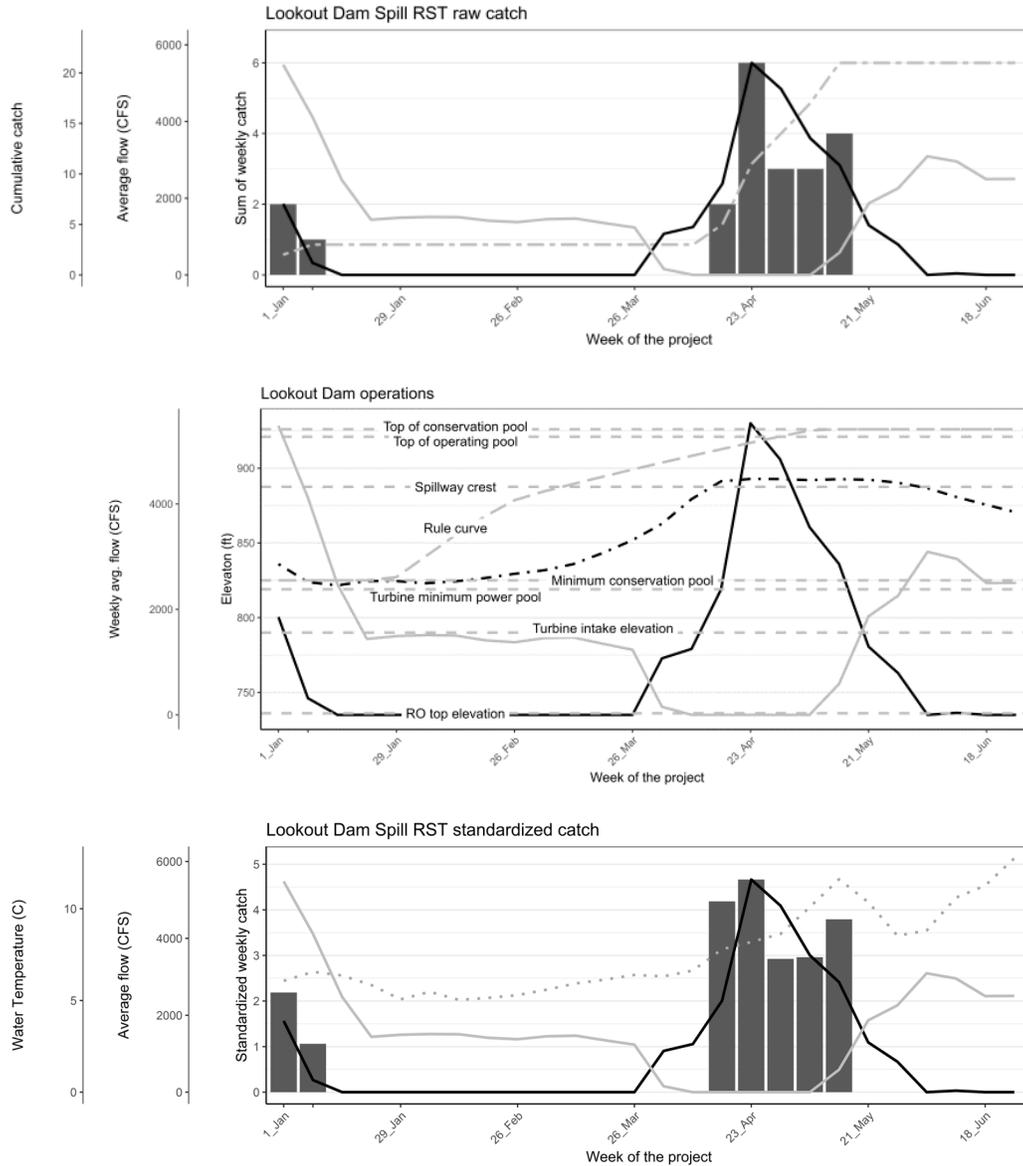


Figure 37. Raw catch (top panel), Lookout Point Dam forebay and intake elevations (middle panel), and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at Lookout Dam Tailrace Spill trap with spill (black line), Powerhouse outflow (gray line), forebay elevation (black dot dash line), intake elevations (gray dash line), stream temperature (gray dots), and cumulative catch (gray dot dash line) for 2023.

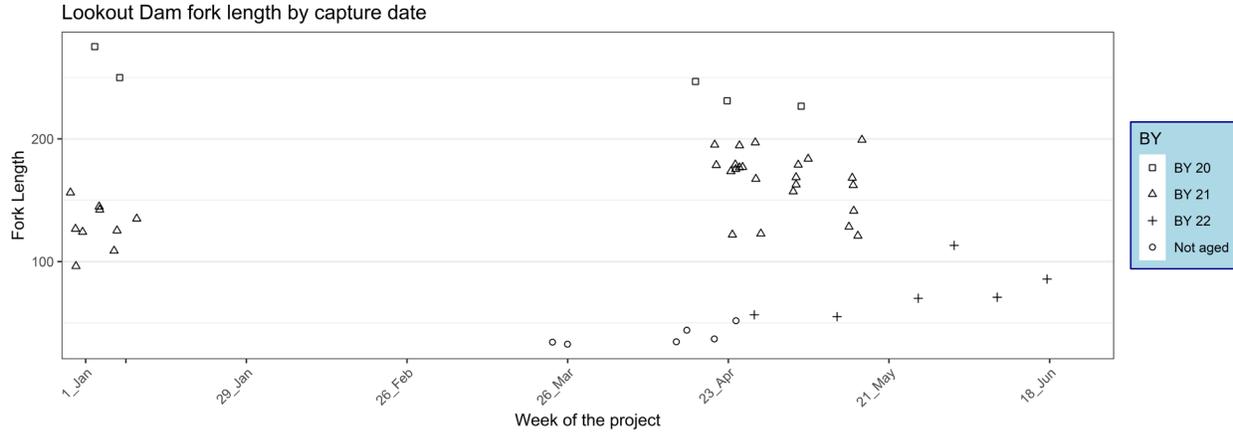


Figure 38. Length-frequency analysis for age of juvenile Chinook captured below Lookout Point Dam.

Trapping Efficiency Trials

A total of four trapping efficiency trials occurred using hatchery reared Chinook salmon at the Lookout Dam Tailrace site in 2023. Due to the large volume of fish required to perform a trapping efficiency trial and limited availability of BY 2021 hatchery fish, we were unable to test the RSTs to the extent we had planned. A total of five trials have occurred here since 2022. 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. Currently, it is estimated that 17,000 fish would need to be released to guarantee 5 returns. However, it is not practical to release that many fish, and the current capacity is 4,000 fish. Therefore, several trials likely failed to capture 5 return fish and it may be necessary to pool similar flows together to accurately represent the TE. A summary of fish release numbers, recaptures, and flow level for the trial is provided in Table 36. Plots displaying trap efficiency and flow for all successful trials are displayed in Appendix E.

Table 36. Summary of trapping efficiency trials below Lookout Point Dam in 2022 and 2023.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Lookout Dam Powerhouse	4/13/2022	2,925	998	0	0%
Lookout Dam Powerhouse	5/23/2023	2,900	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	3,100	4,010	3	0.1%

Injury Data

A total of 30 juvenile Chinook (61.2% of total Chinook 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 6 juvenile Chinook (12.2% of total Chinook catch) were dead at the time of trap check (2 in PH1, 1 in PH2, and 3 in Spill). The most common injuries observed at this site include descaling less than 20%, descaling greater than 20%, and fin damage (Table 37). Figure 39 shows the proportion of captured Chinook 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 (Cramer Fish Sciences 2022; Monzyk et al. 2015). However, this correlation is not as strong as those seen in other basins (Figure 40). Additional information regarding injuries by size and average injuries per fish is available in Appendix D.

Table 37. Summary of observed injuries on natural origin juvenile Chinook captured in the Lookout Dam Tailrace

Injury Code	Observed Chinook Injuries PWR RSTs	Observed Chinook Injuries PWR RSTs (%)	Observed Chinook Injuries Spillway RST	Observed Chinook Injuries Spillway RST (%)
NXI	3	11.1%	1	4.5%
MUNK	0	0.0%	0	0.0%
DS<2	10	37.0%	10	45.5%
DS>2	10	37.0%	10	45.5%
BLO	0	0.0%	0	0.0%
EYB	4	14.8%	2	9.1%
BVT	3	11.1%	0	0.0%
FVB	5	18.5%	10	45.5%
GBD	5	18.5%	8	36.4%
POP	0	0.0%	0	0.0%
HIN	4	14.8%	5	22.7%
OPD	1	3.7%	4	18.2%
TEA	5	18.5%	2	9.1%
BRU	5	18.5%	3	13.6%
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	18	66.7%	20	90.9%
PRD	0	0.0%	0	0.0%
COP	8	29.6%	10	45.5%
BKD	0	0.0%	0	0.0%
FUN	1	3.7%	0	0.0%

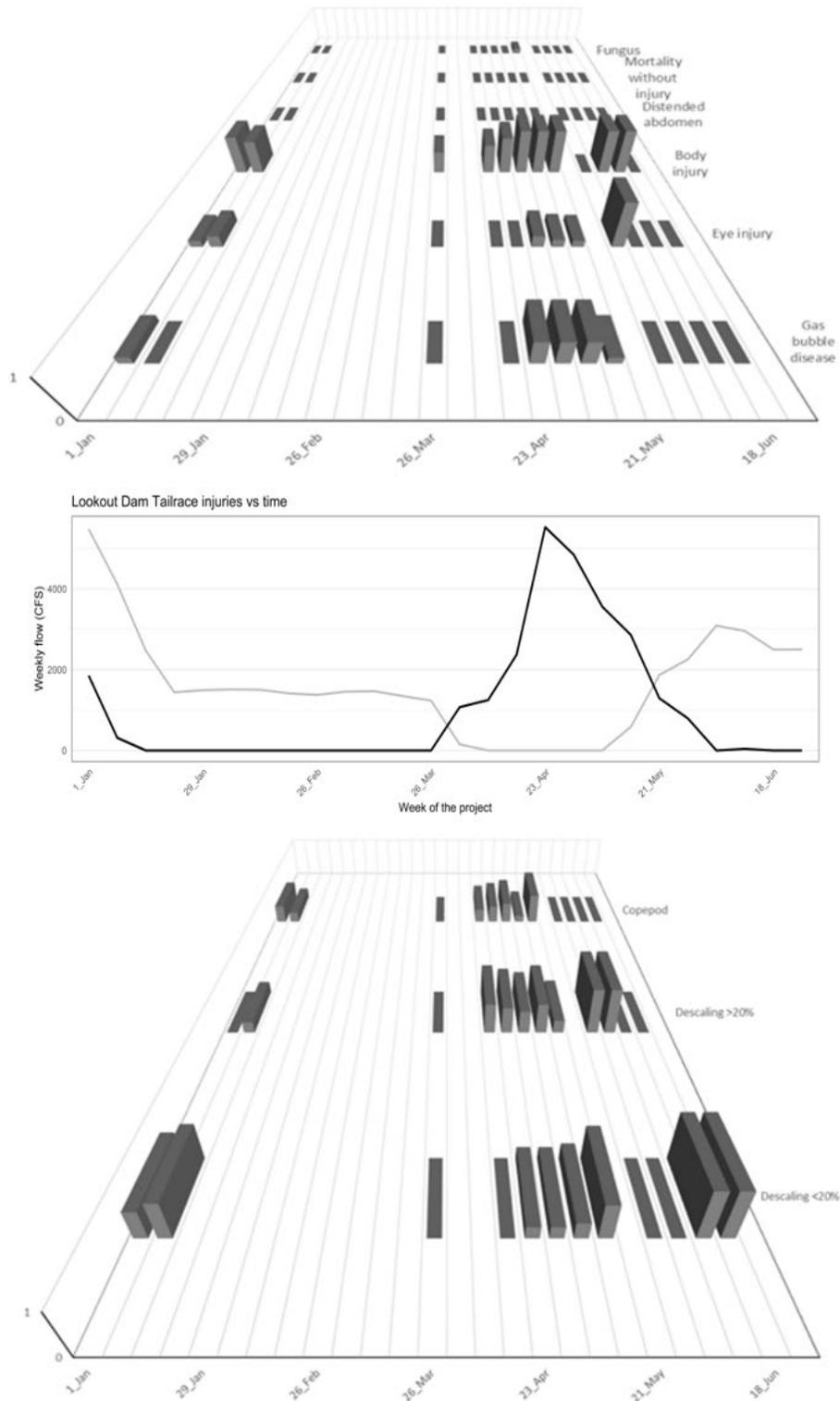


Figure 39. Proportion of captured juvenile Chinook displaying injuries by type (top panel), operations data from the Lookout Dam Tailrace showing cfs of spill (black line) and Powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook displaying descaling injuries and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

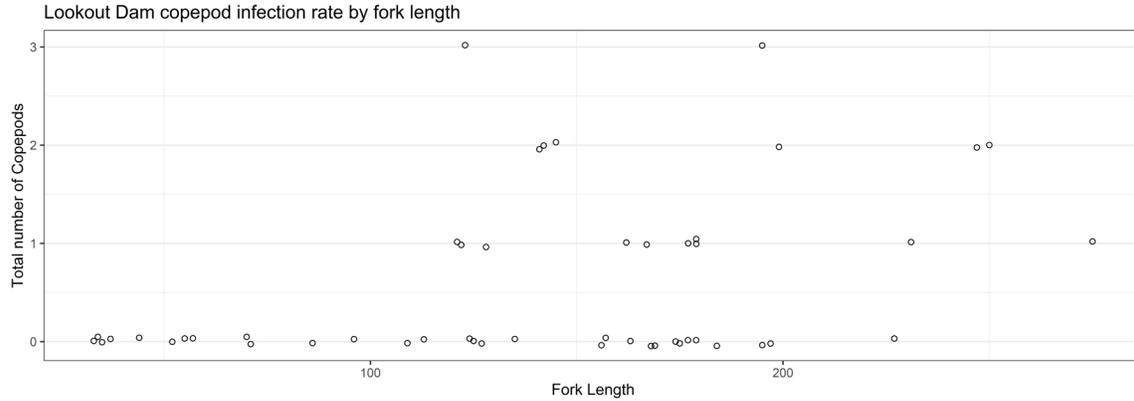


Figure 40. Copepod prevalence vs fork length on juvenile Chinook captured below Lookout Point Dam.

24 Hour Hold Trials

24-hour hold trials were performed at the Lookout Dam Tailrace site to 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 38). A total of 10 fish died during hold (24.4%), 5 of the Spill Chinook (26.3%) and 5 of the Powerhouse Chinook (22.7%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 100%.

Table 38. Summary of 24-hour hold trials for Chinook captured in the RSTs at the Lookout Dam Tailrace sites.

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 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.

Non-Target Species

A total of 154,240 non-target fish were captured in the RSTs below Lookout Point Dam in 2023 (Table 39). The most common non-target species encountered were crappie and bass.

Table 39. Summary of non-target fish capture below Lookout Point Dam.

Species	Season Total	Season Total Mortality (subset of total)
Cutthroat Trout	0	0
Dace	0	0
Largemouth Bass	0	0
Bass Unknown	293	275
Bluegill	59	11
Brown Bullhead	2	1
Chinook (clipped)	14	2
Crappie	153,641	109,225
Largescale Sucker	6	4
Northern Pikeminnow	3	2
<i>O. mykiss</i>	6	0
<i>O. mykiss</i> (clipped)	1	1
Pumpkinseed	1	0
Redside Shiner	1	0
Sculpin	100	6
Smallmouth Bass	77	70
Spotted Bass	1	0
Unknown	7	0
Walleye	28	6
Totals	154,240	109,603

Lookout Point Head of Reservoir- Middle Fork Willamette River

Monitoring of a single 5-foot RST in the Middle Fork Willamette River above Lookout Point Reservoir began on March 10, 2022. The trap sampled 118 days in 2023. The trap did not sample from March 16, 2023, to May 17, 2023, due to safety concerns at the site. Additional information regarding sampling outages is listed in Appendix B.

Target Catch and Passage Timing

The trap captured 128 juvenile Chinook salmon. Peak capture of juvenile Chinook salmon entering Lookout Point Reservoir occurred in May (n= 46, 35.9%). 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 41 shows raw and standardized catch overlaid with flow at the Lookout Point Head of Reservoir site. Chinook catch consisted of two BY classes, BY 2021 yearlings (n= 5, 3.9%) and BY 2022 sub-yearlings (n= 123, 96.1%). BY 2022 Chinook were the dominant age class captured at this site throughout the sampling period (Figure 42.). The first BY 2022 sub-yearling captured at the trap occurred on January 12, 2023. BY 2022 Chinook had an average fork length of 46.4 mm (min: 30 mm, max: 93 mm, median: 42 mm). BY 2021 Chinook had an average fork length of 99.8 mm (min: 94 mm, max: 113 mm, median: 97 mm) and an average weight of 10.5 g (min: 7.7 g, max: 14.5 g, median: 8.5 g).

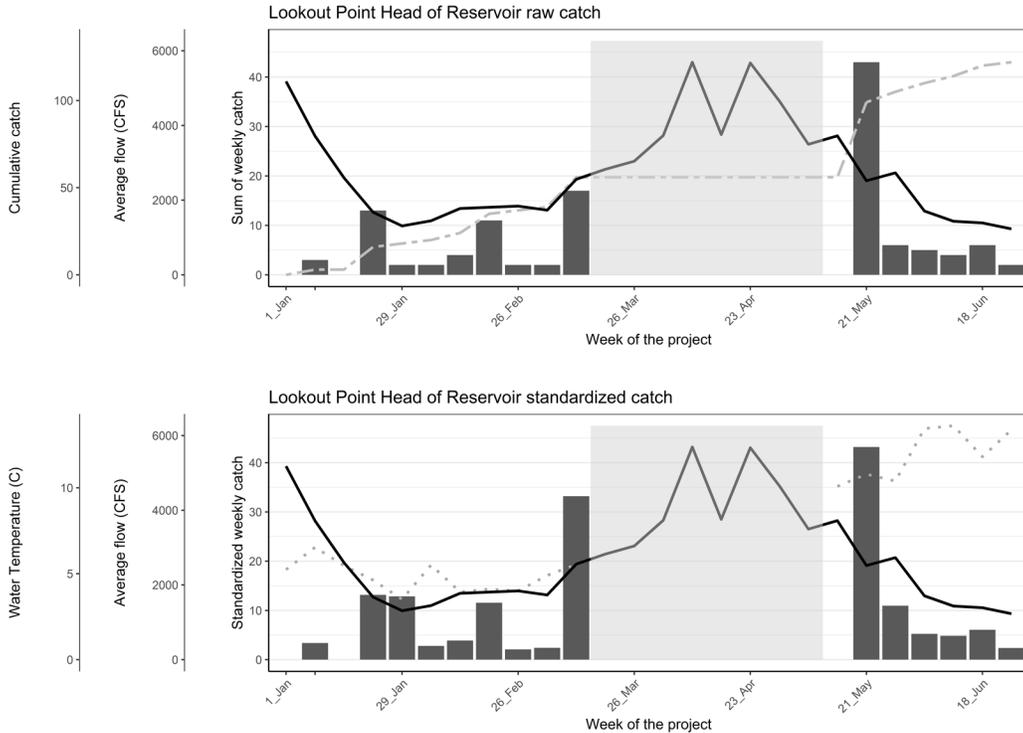


Figure 41. Raw catch (top panel) and weekly standardized catch (bottom panel) of natural origin juvenile Chinook at the Lookout Point Head of Reservoir site with stream flow (black line), cumulative catch (gray dot dash line), stream temperature (gray dotted line), and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

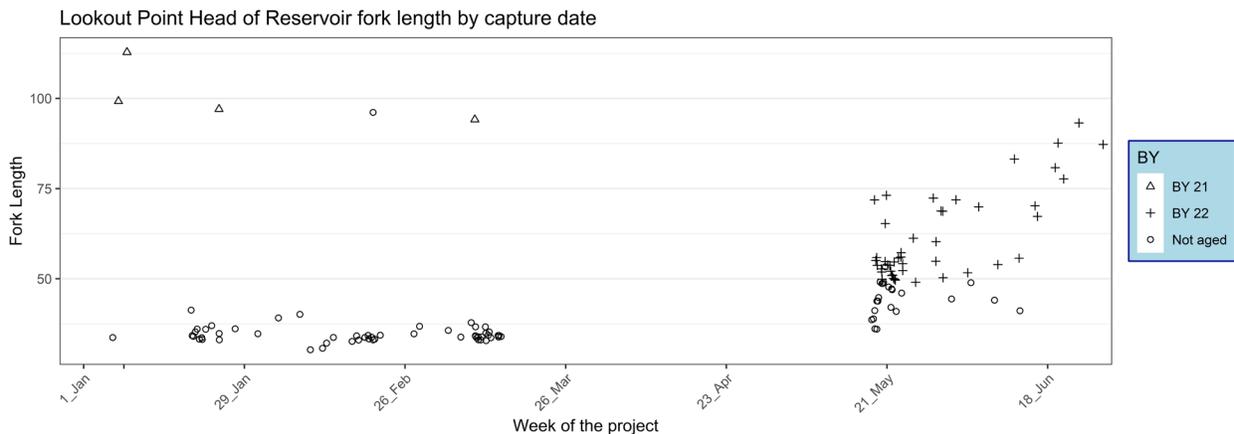


Figure 42. Length-frequency of juvenile Chinook salmon at the Lookout Point Head of Reservoir site.

Trapping Efficiency Trials

A total of four trapping efficiency trials occurred using hatchery reared Chinook salmon at the Lookout Point Head of Reservoir site in 2023. We were unable to perform trials to the extent we had planned due to limited availability of BY 2021 juvenile hatchery Chinook and sampling outages due to safety concerns. A total of 11 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 34. 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. Trapping efficiencies ranged from 0 to 12.5%. A linear model which showed increasing TE with increasing flow was fit to the TE trials (Rsq=0.71 and Pvalue=0.005) (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. We estimate that 5,348 (95% CI: 3,528 to 11,046) juvenile Chinook salmon passed the sampling site during monitoring in 2023 (Figure 43). 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 trap efficiency and flow for all trials are displayed in Appendix E.

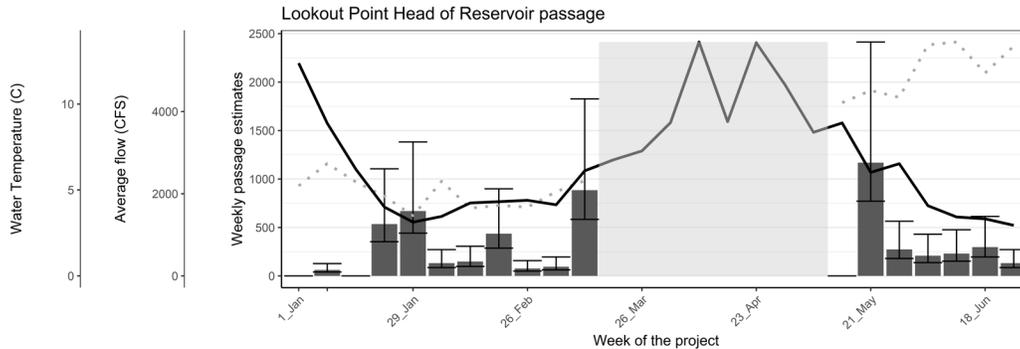


Figure 43. Passage estimates with 95% confidence intervals for juvenile Chinook salmon at the Lookout Point Head of Reservoir site with streamflow (black line) and stream temperature (gray dotted line) and non-sampling weeks shaded out (gray) for January 1, 2023, to June 30, 2023.

Table 40. 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	4/5/2022	3,620	993	53	5.3%
Lookout Point Head of Reservoir	4/14/2022	3,821	987	19	1.9%
Lookout Point Head of Reservoir	5/18/2022	4,538	1004	125	12.5%
Lookout Point Head of Reservoir	7/20/2022	915	1005	9	0.9%
Lookout Point Head of Reservoir	10/27/2022	1,522	506	9	1.8%
Lookout Point Head of Reservoir	11/17/2022	1,403	510	0	0%
Lookout Point Head of Reservoir	12/12/2022	1,580	510	0	0%
Lookout Point Head of Reservoir	1/13/2023	3,041	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	1,248	765	6	0.7%
Lookout Point Head of Reservoir	6/29/2023	938	769	2	0.3%

Injury Data

A total of 36 juvenile Chinook (28.1% of total Chinook 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 41). There were 3 mortalities (2.3% of total Chinook 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.

Table 41. Summary of observed injuries on natural origin juvenile Chinook captured in the Lookout Point Head of Reservoir RST

Injury Code	Target Injury percentage	Raw Target injuries
NXI	72.0%	90
MUNK	0.8%	1
DS<2	14.4%	18
DS>2	2.4%	3
BLO	0.0%	0
EYB	1.6%	2
BVT	0.0%	0
FVB	0.8%	1
GBD	0.0%	0
POP	0.0%	0
HIN	0.0%	0
OPD	3.2%	4
TEA	2.4%	3
BRU	2.4%	3
HBP	0.0%	0
HO	0.0%	0
BO	0.0%	0
HBO	0.0%	0
FID	12.0%	15
PRD	0.0%	0
COP	0.8%	1
BKD	0.0%	0
FUN	0.0%	0

PIT Tagged/VIE Marked fish and Downstream Detections

A total of 20 juvenile Chinook 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 July 20, 2023, no PIT tagged or VIE marked fish have been redetected at downstream sites. Table 42 shows a summary of VIE marked fish with the tagging period and mark details.

Table 42. Summary of VIE tagged Chinook 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

Non-Target Capture Data

We captured 125 non-target fish in addition to natural origin juvenile Chinook. A summary of species and numbers of fish caught are provided in Table 43. The most commonly captured non-target species were Dace and Rainbow Trout.

Table 43. Summary of non-target fish capture at the Lookout Point Head of Reservoir site.

Species	Season Total	Season Total Mortality (subset of total)
Chinook (clipped)	7	0
Crappie	2	2
Cutthroat Trout	5	0
Dace	50	0
Largescale Sucker	7	0
Mountain Whitefish	1	0
Northern Pikeminnow	6	0
<i>O. mykiss</i>	41	1
Redside Shiner	2	0
Sculpin	4	0
Totals	125	3

Hills Creek Dam Tailrace

Monitoring in the Middle Fork Willamette River in the Hills Creek Dam Tailrace began on October 15, 2021. The Powerhouse and RO traps sampled a total of 180 days in 2023. A summary of sampling outings 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 Powerhouse outlet channels and is referred to as the RO trap. This trap captures fish from both outlets and thus juvenile Chinook 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 Powerhouse and is referred to as the Powerhouse trap. For interpretation of results, it is important to note that no BY 2020 juvenile hatchery Chinook (i.e., yearlings typically released in June 2021) or adult Chinook in 2021 were out planted above Hills Creek Dam due to low adult returns (i.e., no production of BY 2021 juvenile Chinook above Hills Creek Dam).¹ In calendar year 2022, a total of 462 adult spring Chinook were out planted above Hills Creek Dam. This consisted of 198 females, 250 males, and 14 jack Chinook (USACE 2022).

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 Powerhouse trap (62.9% of total catch) and 135 in the RO trap (37.1% of total catch) (Figures 44 and 45). Peak capture of juvenile Chinook occurred between March 8, 2023, and April 28, 2023, when 340 fish were captured (98.3% of total Chinook catch). 124 Chinook were captured in the RO trap (36.5% of catch for this period) and 216 were captured in the Powerhouse trap (63.5% of catch for this period). Scale age analysis showed that Chinook were captured from four brood years during this sampling period, BY 2019, 2020, 2021, and 2022 (Figure 46). One BY 2019 fish was captured on June 27, 2023, that had a fork length of 314 mm and weighed 290.2 g. A total of 12 BY 2020 Chinook (3.3% of total Chinook catch) were caught and had an average fork length of 255.1 mm (min: 234 mm, max: 285 mm, median: 251.5 mm) with an average weight of 171.6g (min: 124.8 g, max: 218.5 g, median: 177.8 g). A single BY 2021 yearling was captured on April 4, 2023, that had a fork length of 122 mm and weight of 19.6 g. BY 2022 sub-yearlings comprised a majority of the catch (n= 346, 95.1% of total Chinook catch). The average fork length of sub-yearlings was 36.0 mm (min: 31 mm, max: 61 mm, median: 35 mm).

Previously, a majority of observed Chinook passage at Hills Creek Dam occurred during our sampling from October 2021 to the end of January 2022. Prior monitoring found that peak passage at Hills Creek Dam occurred November through January (Keefer et al 2012). Previous studies also captured no small sub-

¹ For additional information, see the W-FPOM MFR, Title – 21DEX02 MFR Middle Fork Willamette Adult Chinook Outplanting, Subject – W9127N19C0030, Middle Fork Willamette Adult Chinook Outplanting and Juvenile Fingerling Release(s) (http://pweb.crohms.org/tmt/documents/FPOM/2010/Willamette_Coordination/2021_WFPOM/2021_SEP/).

yearling Chinook 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 brood years suggesting that some Chinook rear in the reservoir for multiple years or remain as adfluvial Chinook in Hills Creek Reservoir.

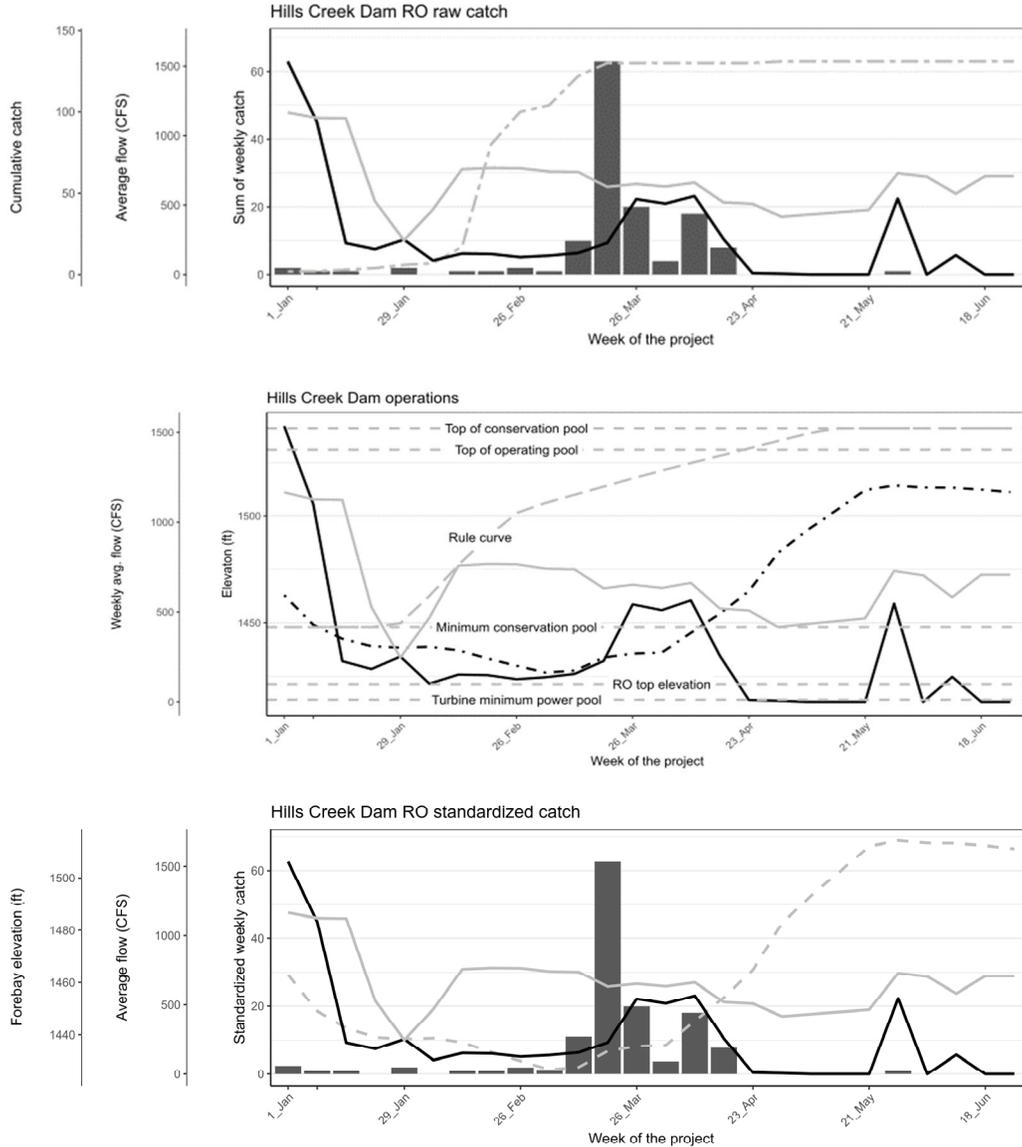


Figure 44. Raw catch (top panel) and weekly standardized catch (bottom panel) overlaid with RO outflow (black line), Powerhouse outflow (gray line), cumulative catch (gray dash dot line), and forebay elevation (gray dash line) for the RO trap below Hills Creek Dam for sampling from January 1, 2023, through 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).

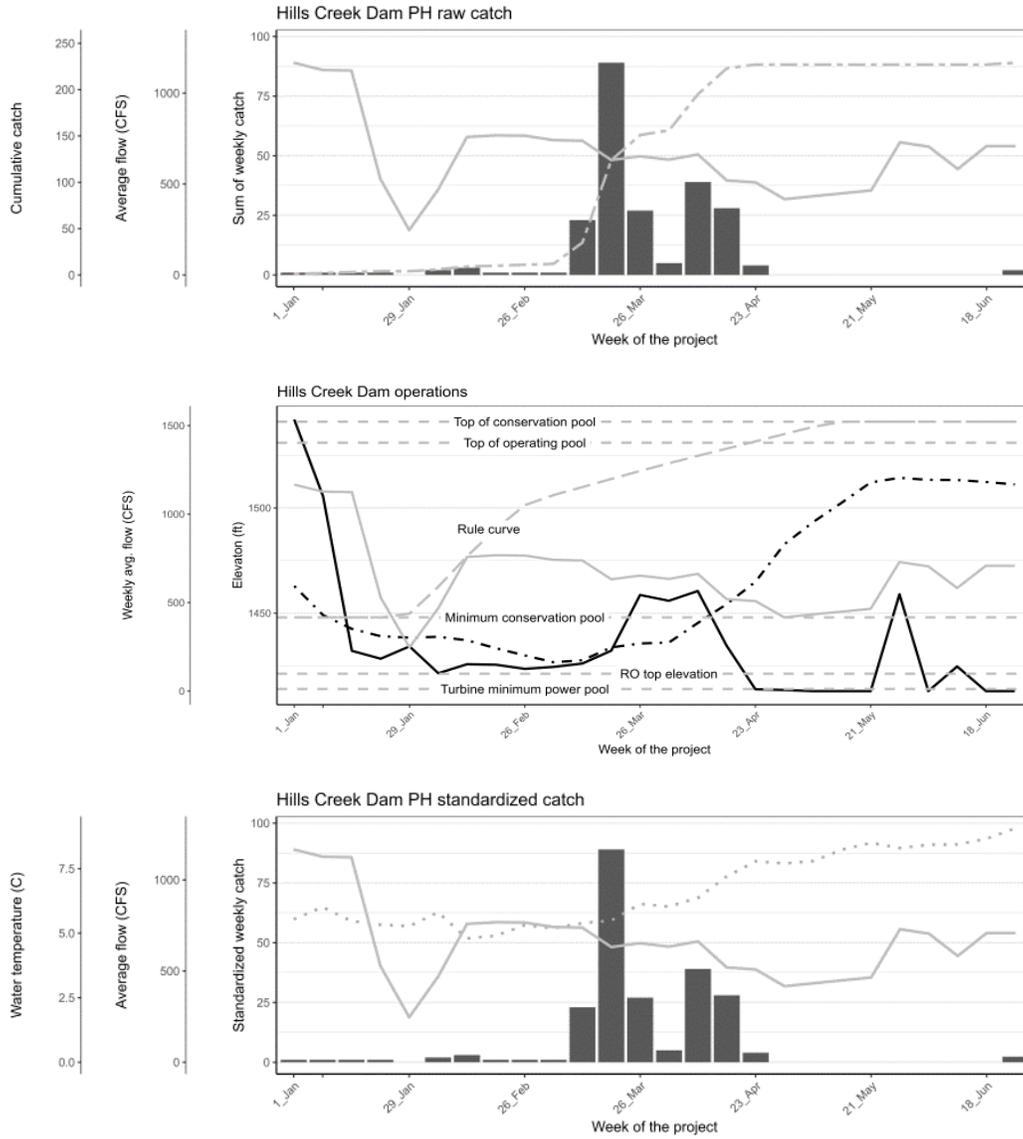


Figure 45. Raw catch (top panel), Hills Creek Dam operations and features of interest (middle panel), and weekly standardized catch (bottom panel) overlaid with Powerhouse outflow (gray line), RO outflow (black line), cumulative catch (gray dash dot line), forebay elevation (black dot dash line) and stream temperature (gray dots) for the PH trap below Hills Creek Dam for sampling from January 1, 2023, through June 30, 2023.

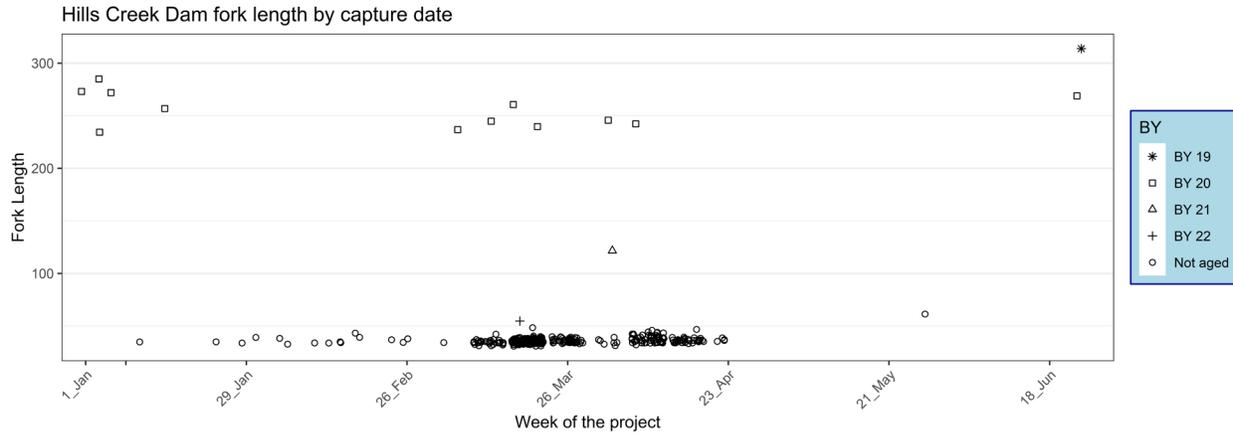


Figure 46. Length-frequency of juvenile Chinook salmon by brood year at the Hills Creek Dam site.

Trapping Efficiency Trials

A total of seven trapping efficiency trials occurred using hatchery reared Chinook salmon in the Hills Creek Dam sites in 2023. A total of 19 trials have occurred here since monitoring began in 2021. We 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 Powerhouse channel can be captured in the RO trap. Thus, each Powerhouse release is treated as a trial for both the Powerhouse and RO trap. A summary of fish release numbers, recaptures, and flow level for each trial is provided in Table 44. Trials were grouped by flow for the purpose of creating passage estimates across the range of flows sampled (Figure 47). Trapping efficiencies ranged from 0 to 12.5%. A linear model for the Powerhouse trap showed decreasing TE with increasing flow was fit to the TE trials (Rsq=0.65 and Pvalue=0.005) (see appendix E). However, the sample size is small, and 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 passed through the Powerhouse 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 trap efficiency and flow for all successful trials are available in Appendix E.

Table 44. Summary of trapping efficiency trials below Hills Creek Dam in 2022 and 2023.

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
Hills Creek Dam Powerhouse	1/6/2022	810	596	20	3.4%
Hills Creek Dam Regulating Outlet	1/6/2022	820	605	13	2.1%
Hills Creek Dam Powerhouse	2/16/2022	410	600	12	2.0%
Hills Creek Dam Regulating Outlet	2/16/2022	410	593	19	3.2%
Hills Creek Dam Powerhouse	2/25/2022	410	604	6	1.0%
Hills Creek Dam Regulating Outlet	2/25/2022	420	625	6	1.0%
Hills Creek Dam Powerhouse	12/7/2022	890	514	29	5.6%
Hills Creek Dam Regulating Outlet	12/13/2022	630	516	1	0.2%
Hills Creek Dam Powerhouse- RO Trial	1/6/2022	810	596	5	0.8%
Hills Creek Dam Powerhouse- RO Trial	2/16/2022	410	600	0	0%
Hills Creek Dam Powerhouse- RO Trial	2/25/2022	410	604	1	0.2%
Hills Creek Dam Powerhouse- RO Trial	12/7/2022	890	514	3	0.6%
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	907	478	0	0%

Release Location	Date of Release	CFS at Release	Number of Fish Released	Number of Fish Recaptured	Percent Efficiency
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	728	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%

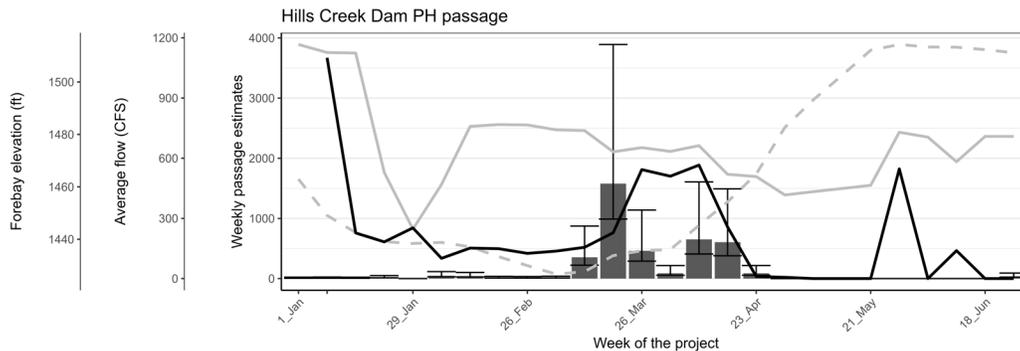


Figure 47. Estimated passage at Hills Creek Dam through the Powerhouse with 95% confidence intervals overlaid with RO outflow (black line), Powerhouse outflow (gray line), and forebay elevation (gray dash line) for January 1, 2023, through June 30, 2023.

Injury Data

A total of 54 juvenile Chinook (14.8% of total Chinook catch) displayed at least one of the injury code conditions listed in Table 2. To account for injuries associated with capture in a RST, injury data was collected from hatchery fish utilized for trapping efficiency trials at time of release and upon recapture. Injury rates by type both pre and post capture were then compared to determine a rate of injury occurrence attributable to trap capture. At this location, it appears that capture in the trap had little to no association with observed injuries. Due to this, we are only reporting observed injuries and not a corrected injury rate. The most common injuries observed at this site include descaling less and greater than 20%, bleeding from vent, fin damage, and copepods (Table 45). It is likely that observations of gas bubble disease are higher for RST captured fish than those that are not captured in an RST as these fish are often captured and held in areas of higher dissolved gas. The proportion of fish displaying injuries overtime is displayed in Figure 48. Copepod presence on captured Chinook salmon showed a positive correlation with the size of fish (Figure 49). There were two mortalities (0.5% of total Chinook capture) at the time of trap check for this site: one in Powerhouse 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 45. Summary of observed injuries on natural origin juvenile Chinook captured in the RO and PWR RST at Hills Creek Dam.

Injury Code	Observed Chinook Injuries (RO)	Observed Chinook Injuries (PWR)
NXI	85.8%	86.3%
MUNK	0.7%	0.9%
DS<2	3.7%	2.2%
DS>2	3.0%	2.2%
BLO	0.0%	0.4%
EYB	0.7%	2.2%
BVT	2.2%	3.1%
FVB	2.2%	0.4%
GBD	2.2%	0.4%
POP	1.5%	1.8%
HIN	2.2%	1.3%
OPD	3.0%	1.8%
TEA	0.0%	2.7%
BRU	3.7%	4.0%
HBP	0.0%	0.4%
HO	0.0%	0.0%
BO	0.7%	0.0%
HBO	0.0%	0.0%
FID	6.0%	4.0%
PRD	0.0%	0.4%
COP	4.5%	2.7%
BKD	0.0%	0.0%
FUN	0.0%	0.0%

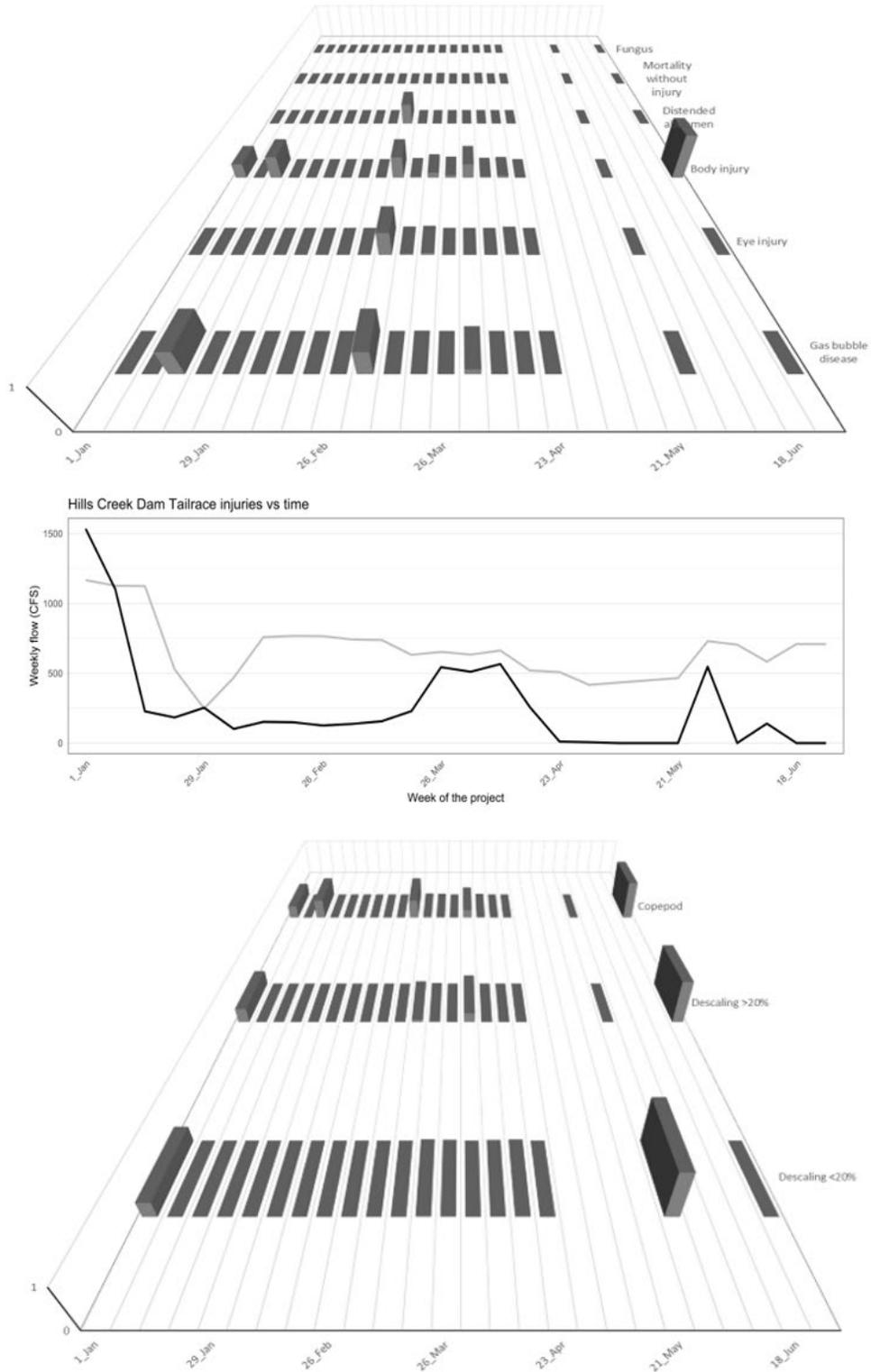


Figure 48. Proportion of captured juvenile Chinook displaying injuries by type (top panel), operations data from the Hills Creek Dam showing cfs of spill (black line) and Powerhouse (gray line) outflows (middle panel), and proportion of captured juvenile Chinook displaying descaling injuries and copepods (bottom panel).

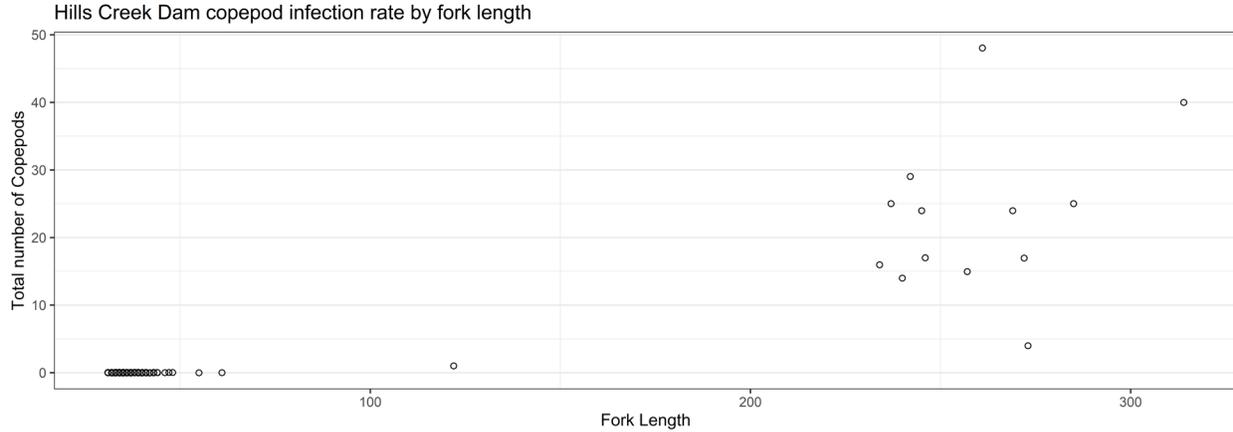


Figure 49. Copepod presence vs fork length on juvenile Chinook captured below Hills Creek Dam.

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 Powerhouse traps, were held (Table 46). A total of 2 fish died during hold (0.8%), 1 of the RO Chinook (1.1%) and 1 of the Powerhouse Chinook (0.6%). Mortality rates across the two-week periods in which fish were held ranged from 0 to 25.0%.

Table 46. Summary of 24-hour hold trials for Chinook captured in the RST at the Hills Creek Dam site.

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, 1 Chinook 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 were detected at this site. All other captured Chinook were not tagged as they were prioritized for the 24-hour hold study. The tagged fish were not redetected downstream as of July 20, 2023 (Table 47).

Table 47. Summary of VIE tagged Chinook at the Hills Creek Dam site.

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

Non-Target Species

In addition to natural origin juvenile Chinook, a total of 1,058 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 48.

Table 48. Summary of non-target catch for the RSTs in the Hills Creek Dam.

Species	Season Total	Season Total Mortality (subset of total)
Brook Lamprey	0	0
Bass Unknown	5	1
Bluegill	142	58
Brown Bullhead	6	0
Crappie	375	215
Dace	42	2
Largemouth Bass	7	23
Largescale Sucker	35	4
Northern Pikeminnow	1	0
<i>O. mykiss</i>	58	20
<i>O. mykiss (clipped)</i>	12	45
Redside Shiner	1	1
Sculpin	279	0
Smallmouth Bass	2	2
Spotted Bass	92	46
Unknown	1	1
Totals	1,058	418

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Appendix A – Locations of Rotary Screw Traps

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Appendix A: Locations of Rotary Screw Traps

Figures

Figure A-1. Big Cliff Dam Tailrace

Figure A-2. Green Peter Tailrace- Middle Santiam River

Figure A-3. Foster Dam Head of Reservoir- South Santiam River

Figure A-4. Cougar Dam Tailrace

Figure A-5. Cougar Dam Head of Reservoir

Figure A-6. Fall Creek Dam Tailrace

Figure A-7. Fall Creek Head of Reservoir

Figure A-8. Dexter Dam Tailrace

Figure A-9. Lookout Dam Tailrace

Figure A-10. Lookout Point Head of Reservoir- Middle Fork Willamette

Figure A-11. Hills Creek Dam Tailrace

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FIGURE A-1
Big Cliff Dam

● RST Locations

500 Feet





Imagery Source: 2021, ESRI.



FIGURE A-2 Green Peter Tailrace - Middle Santiam River

● RST Locations

500 Feet



EAS ENVIRONMENTAL ASSESSMENT SERVICES
 Wholly Owned Subsidiary of Natives of Kodiak



Imagery Source: 2021, ESRI.



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

● RST Locations

———— 500 Feet



EAS ENVIRONMENTAL ASSESSMENT SERVICES
 Wholly Owned Subsidiary of Natives of Kodiak



FIGURE A-4
Cougar Dam

● RST Locations

500 Feet





FIGURE A-5
Cougar Dam Head of Reservoir

● RST Locations

500 Feet





Imagery Source: 2021, ESRI.



FIGURE A-6
Fall Creek Dam Tailrace

● RST Locations

500 Feet





FIGURE A-7
Fall Creek Head of Reservoir

● RST Locations

500 Feet





Imagery Source: 2021, ESRI.



FIGURE A-8
Dexter Dam Tailrace

● RST Locations

500 Feet





FIGURE A-9
Lookout Dam Tailrace

● RST Locations

500 Feet





FIGURE A-10
Lookout Point Head of Reservoir

● RST Locations

500 Feet





FIGURE A-11
Hills Creek Dam

● RST Locations

500 Feet



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Appendix B – Sampling Outages by Site

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Appendix B: Sampling Outages by Site

Site	Date(s) of Trap Outage	Reason for Outage
Big Cliff Dam Tailrace	1/1/2023–1/16/2023	Flow surpassed safe sampling levels. Trap temporarily removed due to safety concerns associated with high flows.
Big Cliff Dam Tailrace	5/15/2023–5/16/2023	Cone raised due to high flows resulting in unsafe sampling conditions.
Big Cliff Dam Tailrace	6/8/2023–6/9/2023	Trap raised overnight until repairs could be made the following day.
Green Peter Dam Tailrace- Middle Santiam River	2/1/2023–3/14/2023	Trap operation delayed until a new highline anchor was constructed.
Green Peter Dam Tailrace- Middle Santiam River	3/23/2023–3/31/2023	Trap operation suspended for personnel safety until construction of a new highline anchor was finished.
Foster Dam Head of Reservoir- South Santiam	4/10/2023–4/13/2023	Cone raised due to high flows and debris creating unsafe conditions for crews and captured fish.
Cougar Dam Tailrace	1/16/2023–1/20/2023	Low flows prevented traps from being able to operate.
Cougar Dam Tailrace	1/24/2023–2/9/2023	Low flows prevented traps from being able to operate.
Cougar Dam RO	6/8/2023–7/1/2023	Trap removed for repairs and prioritization to other sites while Cougar RO is down for resurfacing.
Cougar Head of Reservoir	2/20/2023–3/14/2023	Snow blocked access to the trapping site. Cone was raised until access to site was restored.
Fall Creek Dam Tailrace	1/1/2023–1/10/2023	Sediment filled channel to the point where the cone could not be lowered into the sampling position.
Fall Creek Dam Tailrace	1/25/2023–3/2/2023	Sediment filled channel to the point where the cone grounded out when in the sampling position during low flow.
Fall Creek Head of Reservoir	1/26/2023–2/6/2023	Low flows resulted in the trap grounding out frequently.
Fall Creek Head of Reservoir	2/21/2023–2/22/2023	Winter storm resulted in high flow and debris creating unsafe sampling conditions.
Fall Creek Head of Reservoir	3/20/2023–3/21/2023	Winter storm resulted in high flow and debris creating unsafe sampling conditions.
Fall Creek Head of Reservoir	4/7/2023–4/13/2023	Storm resulted in high flow and debris creating unsafe sampling conditions.
Fall Creek Head of Reservoir	4/23/2023–4/25/2023	Storm resulted in high flow and debris creating unsafe sampling conditions.
Lookout Point Head of Reservoir- Middle Fork Willamette River	3/16/2023–5/17/2023	An incident near the trapping site created a security issue. Sampling and access to the site was suspended until safety concerns could be adequately addressed.

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Appendix C – PIT Tags and VIE Tagging

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Appendix C: PIT Tags and VIE Tagging

Sections

VIE Mark C-5
PIT Tags C-5

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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.

Tagging Site	Total Number of Run of River Fish PIT Tagged
Big Cliff Dam Tailrace	17
Foster Head of Reservoir- South Santiam	64
Cougar Dam Tailrace	356
Cougar Dam Head of Reservoir	31
Fall Creek Head of Reservoir	4
Lookout Point Head of Reservoir- Middle Fork Willamette River	20
Hills Creek Dam Tailrace	1

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

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

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

Site	Date Tagged	VIE Color	# Tagged	# Recaptured to Date
Cougar Dam Head of Reservoir	2/1/2023-2/28/2023	Yellow	1	0
Cougar Dam Head of Reservoir	3/1/2023-3/31/2023	Red	10	0
Cougar Dam Head of Reservoir	4/1/2023-4/30/2023	Blue	365	0
Cougar Dam Head of Reservoir	5/1/2023-5/31/2023	Orange	1893	0
Cougar Dam Head of Reservoir	6/1/2023-6/30/2023	Pink	721	0
Fall Creek Head of Reservoir	1/1/2023-1/31/2023	Blue	6	0
Fall Creek Head of Reservoir	2/1/2023-2/28/2023	Yellow	4	0
Fall Creek Head of Reservoir	3/1/2023-3/31/2023	Red	33	0
Fall Creek Head of Reservoir	5/1/2023-5/31/2023	Orange	3	0
Hills Creek Dam Tailrace	3/1/2023-3/31/2023	Red	39	0
Lookout Point Head of Reservoir	1/1/2023-1/31/2023	Blue	9	0
Lookout Point Head of Reservoir	2/1/2023-2/28/2023	Yellow	3	0
Lookout Point Head of Reservoir	3/1/2023-3/31/2023	Red	3	0
Lookout Point Head of Reservoir	5/1/2023-5/31/2023	Orange	42	0
Lookout Point Head of Reservoir	6/1/2023-6/30/2023	Pink	11	0

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

Site	Date	Length (est. mm)	Tag(s)	Condition
Cougar Dam Tailrace	5/29/2023	242	N/A	Unharmmed
Cougar Dam Tailrace	6/5/2023	166	N/A	Unharmmed
Cougar Dam Head of Reservoir	4/12/2023	125	N/A	Injured
Cougar Dam Head of Reservoir	4/12/2023	125	N/A	Injured
Cougar Dam Head of Reservoir	4/28/2023	160	N/A	Unharmmed
Cougar Dam Head of Reservoir	6/4/2023	140	N/A	Unharmmed
Hills Creek Head of Reservoir	5/31/2023	245	N/A	Unharmmed

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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

Table D-1. Big Cliff Dam Tailrace injuries for Chinook by size. D-5

Table D-2. Green Peter Dam Tailrace injuries for Chinook by size. D-6

Table D-3. Cougar Dam Powerhouse route injuries for Chinook by size. D-7

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Table D-9. Hills Creek Dam Regulatory Outlet route injuries for Chinook by size..... D-13

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

Total Chinook (n=323)	>60mm (n=121)	>60mm and <110mm (n=37)	>110mm (n=165)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
NXI	90.9%	0.0%	0.0%
MUNK	0.8%	0.0%	0.0%
DS<2	4.1%	78.4%	67.3%
DS>2	0.0%	16.2%	30.9%
BLO	0.0%	0.0%	1.2%
EYB	0.8%	8.1%	14.8%
BVT	0.8%	0.0%	4.3%
FVB	0.0%	2.7%	9.9%
GBD	1.7%	2.7%	22.2%
POP	1.7%	2.7%	3.7%
HIN	0.8%	2.7%	11.1%
OPD	0.0%	5.4%	24.1%
TEA	2.5%	0.0%	4.9%
BRU	1.7%	5.4%	11.7%
HBP	0.8%	0.0%	1.2%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.6%
HBO	0.0%	0.0%	0.6%
FID	1.7%	67.6%	82.1%
PRD	0.0%	0.0%	0.0%
COP	0.0%	54.1%	87.7%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	2.7%	3.7%
Totals	9.9%	100%	100%
Average number of injuries per fish (non NXI)	0.2	2.5	3.8

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

Total Chinook (n=100)	<60 (n=25)	>60 and <110 mm (n=75)	>110 mm (n=0)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
NXI	20.0%	4.0%	--
MUNK	8.0%	2.7%	--
DS<2	40.0%	52.0%	--
DS>2	16.0%	32.0%	--
BLO	4.0%	0.0%	--
EYB	20.0%	12.0%	--
BVT	4.0%	9.3%	--
FVB	0.0%	14.7%	--
GBD	16.0%	34.7%	--
POP	4.0%	1.3%	--
HIN	12.0%	14.7%	--
OPD	24.0%	9.3%	--
TEA	8.0%	4.0%	--
BRU	8.0%	9.3%	--
HBP	0.0%	0.0%	--
HO	0.0%	0.0%	--
BO	0.0%	0.0%	--
HBO	0.0%	0.0%	--
FID	52.0%	70.7%	--
PRD	0.0%	0.0%	--
COP	4.0%	8.0%	--
BKD	0.0%	0.0%	--
FUN	0.0%	2.7%	--
Totals	80.0%	96.0%	--
Average number of injuries per fish (non NXI)	2.2	2.4	--

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

Total Chinook (n=74)	>60mm (n=18)	>60mm and <110mm (n=28)	>110mm (n=33)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
NXI	50.0%	18.8%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	33.3%	50.0%	47.8%
DS>2	5.6%	9.4%	17.4%
BLO	0.0%	3.1%	4.3%
EYB	11.1%	0.0%	13.0%
BVT	0.0%	6.3%	17.4%
FVB	0.0%	9.4%	17.4%
GBD	0.0%	0.0%	8.7%
POP	0.0%	0.0%	0.0%
HIN	0.0%	0.0%	8.7%
OPD	5.6%	3.1%	13.0%
TEA	0.0%	15.6%	0.0%
BRU	11.1%	0.0%	26.1%
HBP	0.0%	3.1%	4.3%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	22.2%	37.5%	39.1%
PRD	0.0%	0.0%	0.0%
COP	16.7%	18.8%	87.0%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	4.3%
Totals	50.0%	81.3%	100.0%
Average number of injuries per fish (non NXI)	1.1	1.5	3.1

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

Total Chinook (n=863)	>60mm (n=18)	>60mm and <110mm (n=69)	>110mm (n=702)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
NXI	83.3%	3.3%	0.0%
MUNK	0.0%	0.0%	0.1%
DS<2	5.6%	68.9%	64.2%
DS>2	0.0%	24.6%	28.2%
BLO	0.0%	1.6%	0.9%
EYB	0.0%	9.8%	11.5%
BVT	0.0%	4.9%	4.7%
FVB	5.6%	4.9%	14.1%
GBD	0.0%	23.0%	51.0%
POP	0.0%	4.9%	1.4%
HIN	0.0%	8.2%	3.0%
OPD	0.0%	8.2%	16.2%
TEA	0.0%	9.8%	7.0%
BRU	0.0%	6.6%	5.8%
HBP	0.0%	1.6%	1.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.1%
HBO	0.0%	0.0%	0.0%
FID	5.6%	78.7%	84.5%
PRD	0.0%	0.0%	0.3%
COP	0.0%	59.0%	87.5%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	3.3%	3.6%
Totals	16.7%	96.7%	100.0%
Average number of injuries per fish (non NXI)	0.2	2.8	3.9

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

Total Chinook (n=61)	>60mm (n=59)	>60mm and <110mm (n=2)	>110mm (n=0)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
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%	--	--
Average number of injuries per fish (non NXI)	0.3	--	--

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

Total Chinook (n=19)	>60mm (n=1)	>60mm and <110mm (n=5)	>110mm (n=13)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
NXI	100.0%	20.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	0.0%	40.0%	38.5%
DS>2	0.0%	20.0%	61.5%
BLO	0.0%	0.0%	0.0%
EYB	0.0%	0.0%	7.7%
BVT	0.0%	0.0%	0.0%
FVB	0.0%	0.0%	7.7%
GBD	0.0%	0.0%	0.0%
POP	0.0%	0.0%	7.7%
HIN	0.0%	0.0%	0.0%
OPD	0.0%	20.0%	0.0%
TEA	0.0%	0.0%	0.0%
BRU	0.0%	0.0%	7.7%
HBP	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	0.0%	20.0%	84.6%
PRD	0.0%	0.0%	0.0%
COP	0.0%	40.0%	38.5%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%
Totals	100.0%	80.0%	100.0%
Average number of injuries per fish (non NXI)	0	1.6	2.5

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

Total Chinook (n=49)	>60mm (n=8)	>60mm and <110mm (n=5)	>110mm (n=36)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
NXI	50.0%	80.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	12.5%	20.0%	37.5%
DS>2	12.5%	20.0%	56.3%
BLO	0.0%	0.0%	0.0%
EYB	12.5%	20.0%	9.4%
BVT	0.0%	0.0%	6.3%
FVB	12.5%	20.0%	40.6%
GBD	0.0%	0.0%	37.5%
POP	0.0%	0.0%	0.0%
HIN	12.5%	20.0%	21.9%
OPD	0.0%	0.0%	15.6%
TEA	25.0%	40.0%	12.5%
BRU	0.0%	0.0%	25.0%
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	25.0%	40.0%	96.9%
PRD	0.0%	0.0%	0.0%
COP	0.0%	0.0%	53.1%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	3.1%
Totals	50.0%	20.0%	100.0%
Average number of injuries per fish (non NXI)	1.1	2.6	3.7

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

Total Chinook (n=225)	>60mm (n=219)	>60mm and <110mm (n=0)	>110mm (n=6)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
NXI	89.0%	--	0.0%
MUNK	0.9%	--	0.0%
DS<2	2.3%	--	0.0%
DS>2	0.0%	--	83.3%
BLO	0.0%	--	16.7%
EYB	1.4%	--	33.3%
BVT	2.3%	--	33.3%
FVB	0.0%	--	16.7%
GBD	0.0%	--	16.7%
POP	1.4%	--	16.7%
HIN	0.9%	--	16.7%
OPD	1.4%	--	16.7%
TEA	2.3%	--	16.7%
BRU	2.3%	--	66.7%
HBP	0.0%	--	16.7%
HO	0.0%	--	0.0%
BO	0.0%	--	0.0%
HBO	0.0%	--	0.0%
FID	1.4%	--	100.0%
PRD	0.0%	--	0.0%
COP	0.0%	--	100.0%
BKD	0.0%	--	0.0%
FUN	0.0%	--	0.0%
Totals	11.0%	--	100.0%
Average number of injuries per fish (non NXI)	0.2	--	5.5

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

Total Chinook (n=132)	>60mm (n=125)	>60mm and <110mm (n=1)	>110mm (n=6)
Injury Code	Injuries for (%) >60mm	Injuries (%) >60mm and <110mm	Injuries (%) >110mm
NXI	92.0%	0.0%	0.0%
MUNK	0.0%	0.0%	0.0%
DS<2	0.8%	100.0%	50.0%
DS>2	0.8%	0.0%	33.3%
BLO	0.0%	0.0%	0.0%
EYB	0.8%	0.0%	0.0%
BVT	0.0%	0.0%	33.3%
FVB	0.8%	0.0%	33.3%
GBD	0.0%	0.0%	33.3%
POP	1.6%	0.0%	0.0%
HIN	2.4%	0.0%	0.0%
OPD	1.6%	0.0%	33.3%
TEA	0.0%	0.0%	0.0%
BRU	2.4%	0.0%	33.3%
HBP	0.0%	0.0%	0.0%
HO	0.0%	0.0%	0.0%
BO	0.0%	0.0%	0.0%
HBO	0.0%	0.0%	0.0%
FID	1.6%	0.0%	83.3%
PRD	0.0%	0.0%	0.0%
COP	0.0%	0.0%	83.3%
BKD	0.0%	0.0%	0.0%
FUN	0.0%	0.0%	0.0%
Totals	8.0%	100.0%	100.0%
Average number of injuries per fish (non NXI)	0.1	1.0	4.2

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Appendix E – Trap Efficiency Plots

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Appendix E: Trap Efficiency Plots

Figures

- Figure E-1. Big Cliff Dam Tailrace successful (n = 5 recaptures) trap efficiency trial plots. Linear regression fit is non-significant. Trap efficiency appears to be discrete at low, medium, and high flows. E-5
- Figure E-2. Green Peter Dam Tailrace successful (n = 5 recaptures) trap efficiency trial plots. E-5
- Figure E-3. Foster Dam Head of Reservoir successful (n = 5 recaptures) trap efficiency trial plots. Linear regression fit is negative with increasing flow, but non-significant. E-6
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- Figure E-10. Hills Creek Dam successful (n = 5 recaptures) trap efficiency trial plots. Lookout Head of Reservoir linear regression fit is slightly positive with increasing flow and significant ($p=0.002$) and intercept set to 0 to prevent negative flow TE values. E-12

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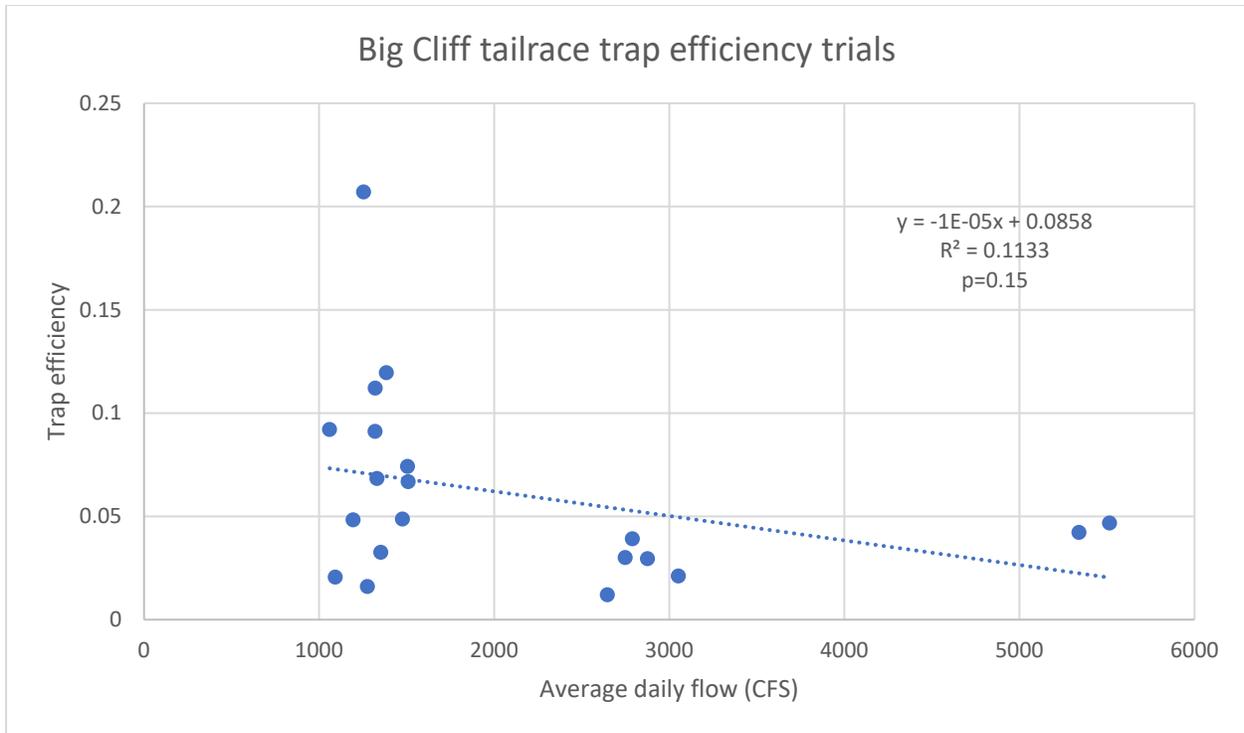


Figure E-1. Big Cliff Dam Tailrace successful (n ≥ 5 recaptures) trap efficiency trial plots. Linear regression fit is non-significant. Trap efficiency appears to be discrete at low, medium, and high flows.

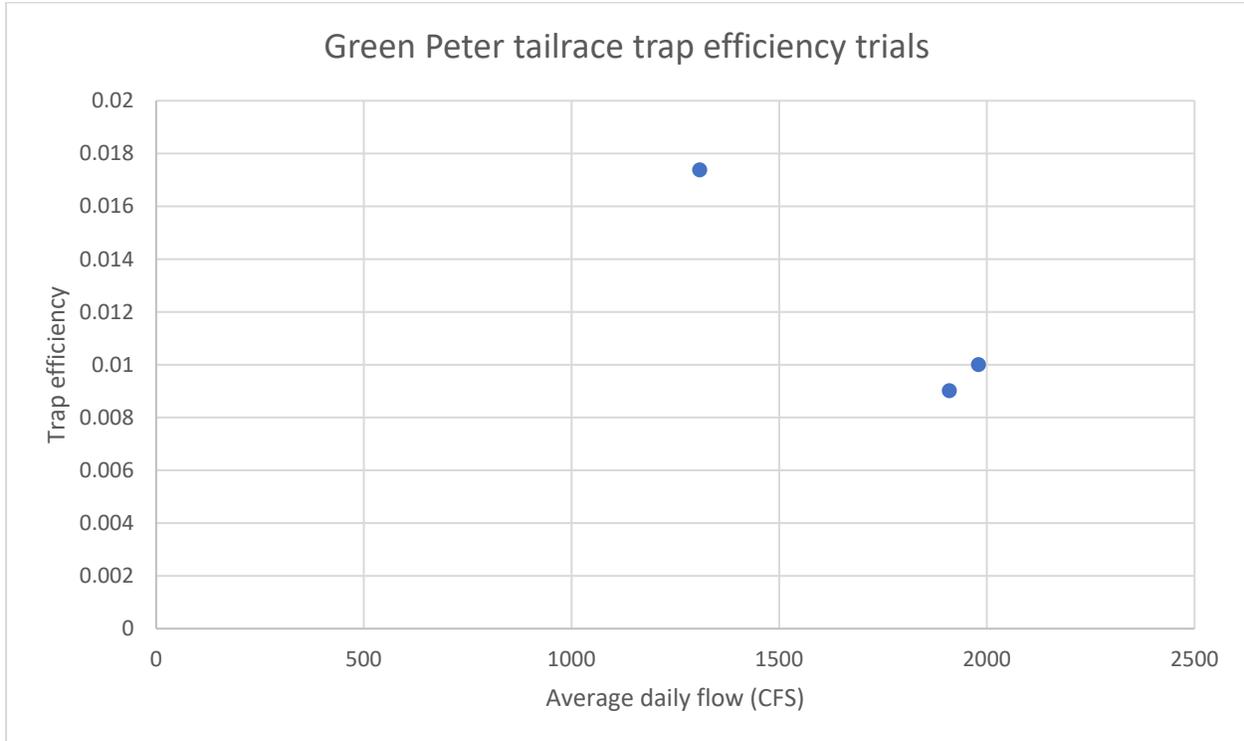


Figure E-2. Green Peter Dam Tailrace successful (n ≥ 5 recaptures) trap efficiency trial plots.

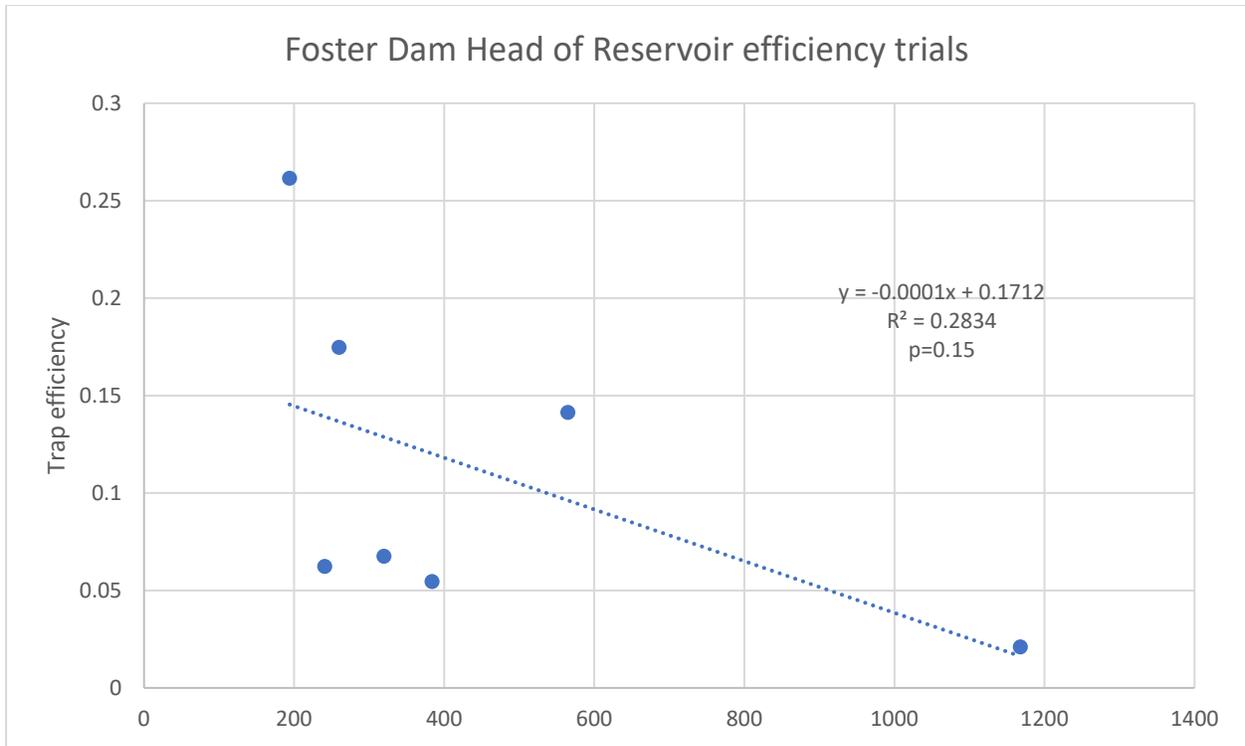


Figure E-3. Foster Dam Head of Reservoir successful ($n \geq 5$ recaptures) trap efficiency trial plots. Linear regression fit is negative with increasing flow, but non-significant.

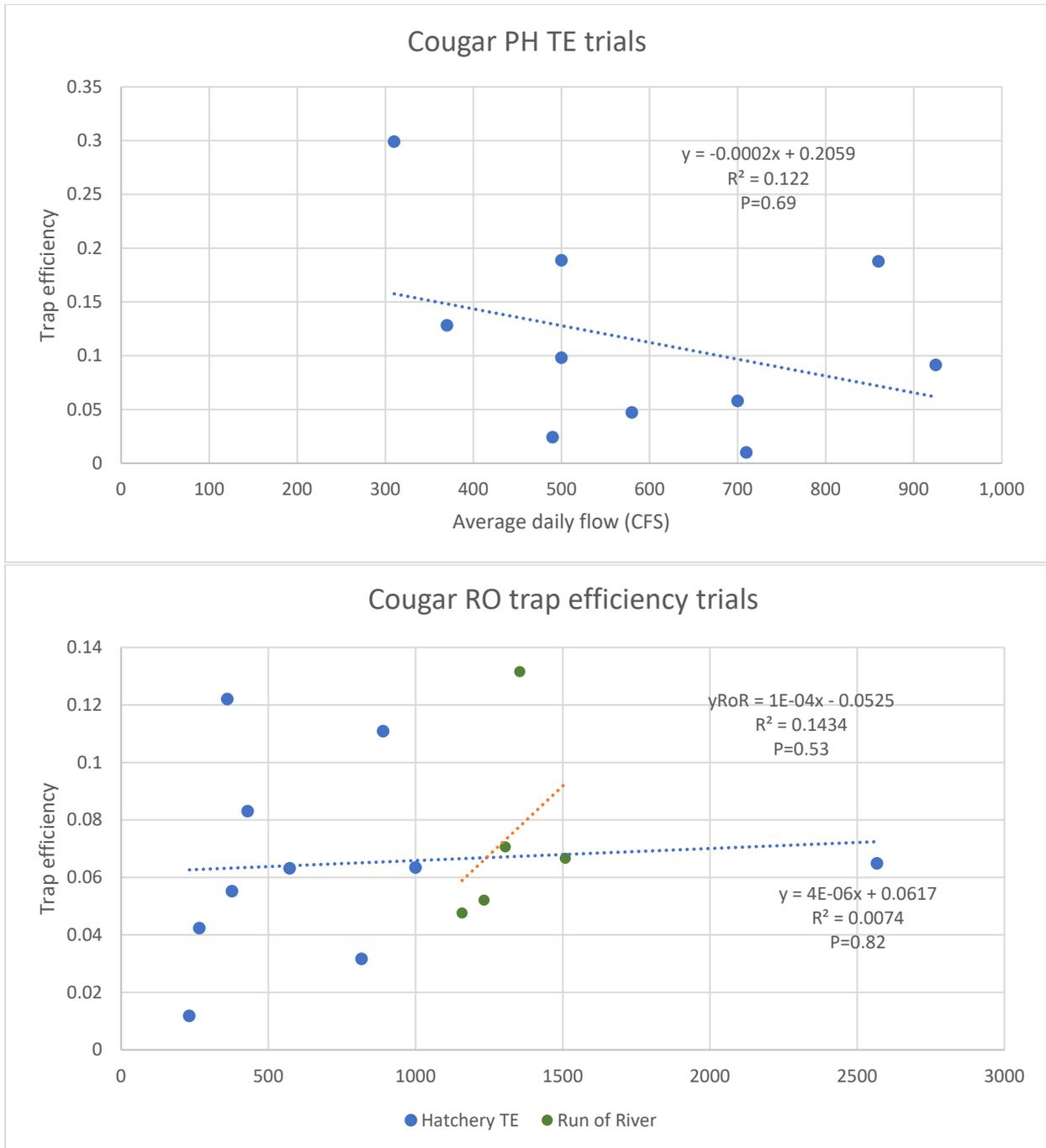


Figure E-4. Cougar Dam successful (n ≥ 5 recaptures) trap efficiency trial plots. Cougar PH linear regression fit is slightly negative with increasing flow, but non-significant. Cougar RO hatchery and Run of River fish models were both non-significant.

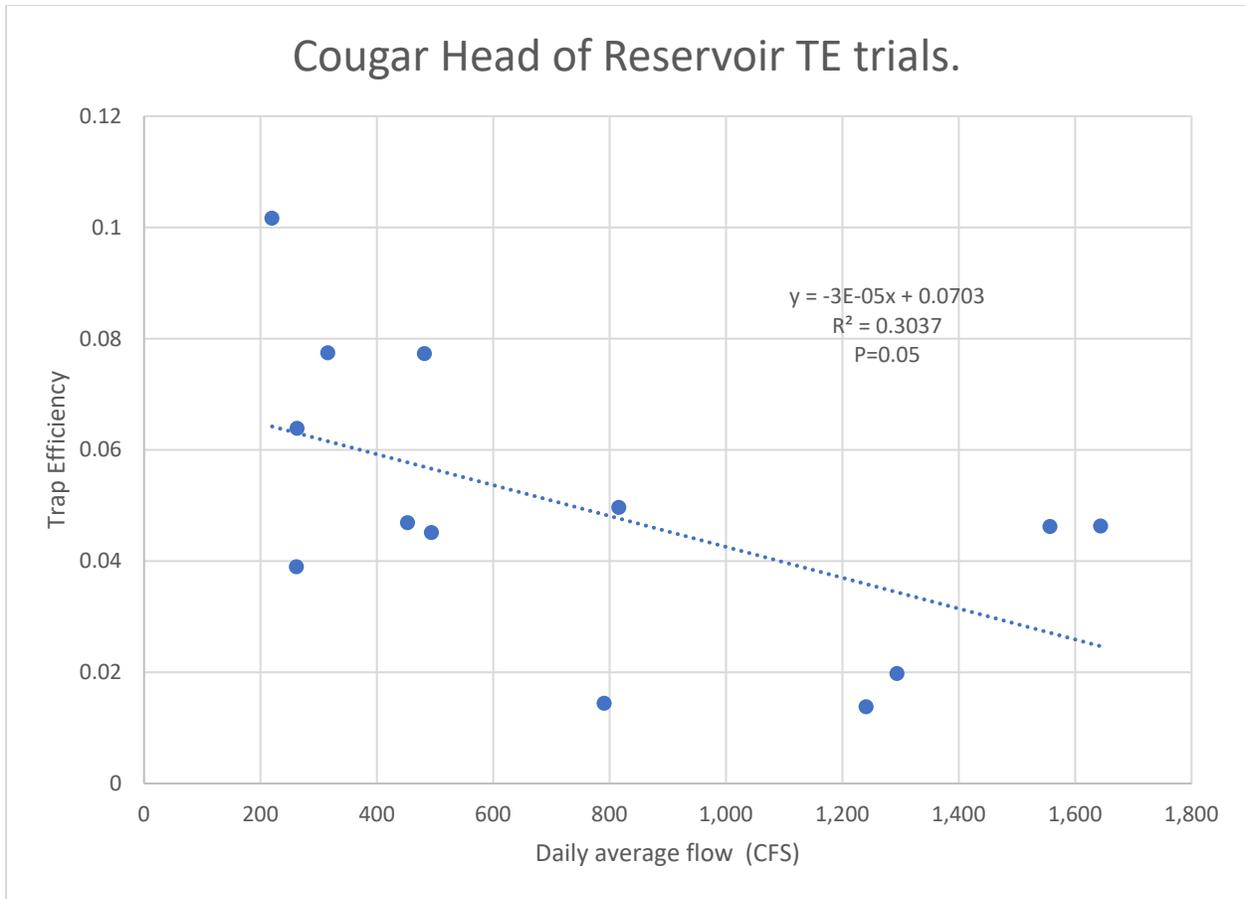


Figure E-5. Cougar Dam Head of Reservoir successful (n ≥ 5 recaptures) trap efficiency trial plots. Cougar PH linear regression fit is slightly negative with increasing flow and significant (p=0.05).

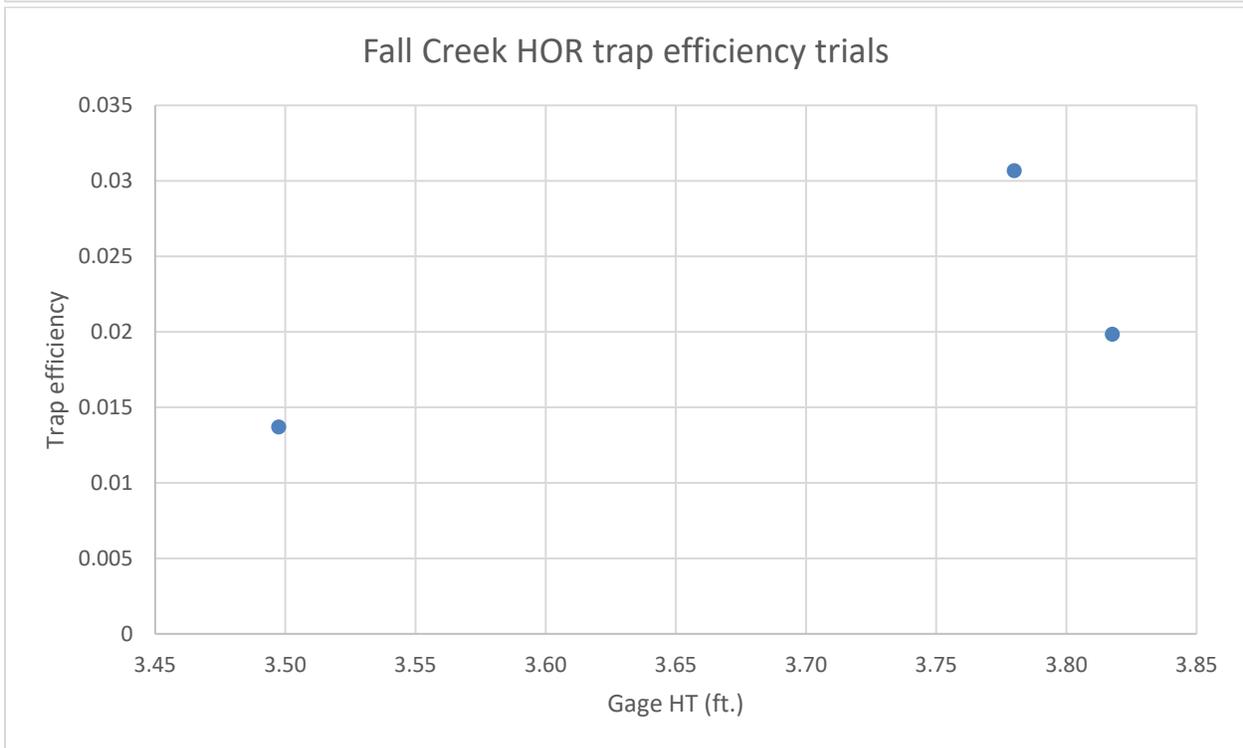
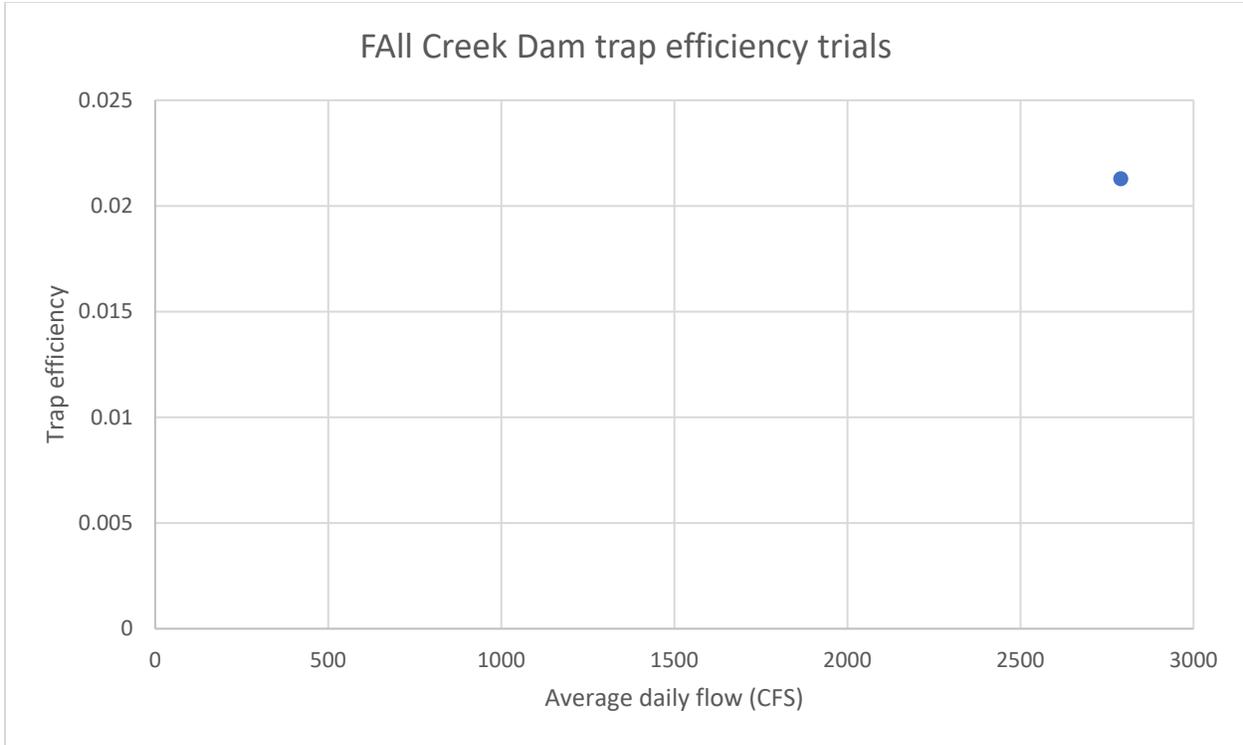


Figure E-6. Fall Creek Dam Tailrace and Fall Creek head of Reservoir successful (n ≥ 5 recaptures) trap efficiency trial plots. Too few trials to model data.

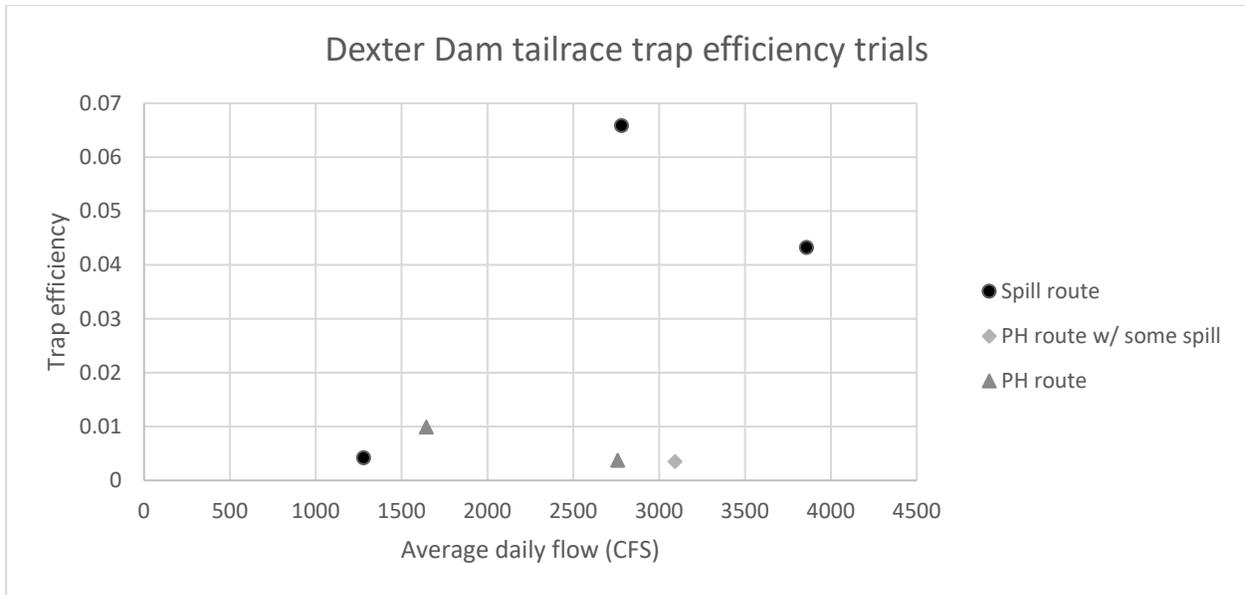


Figure E-7. Dexter Dam Tailrace successful (n ≥ 5 recaptures) trap efficiency trial plots.

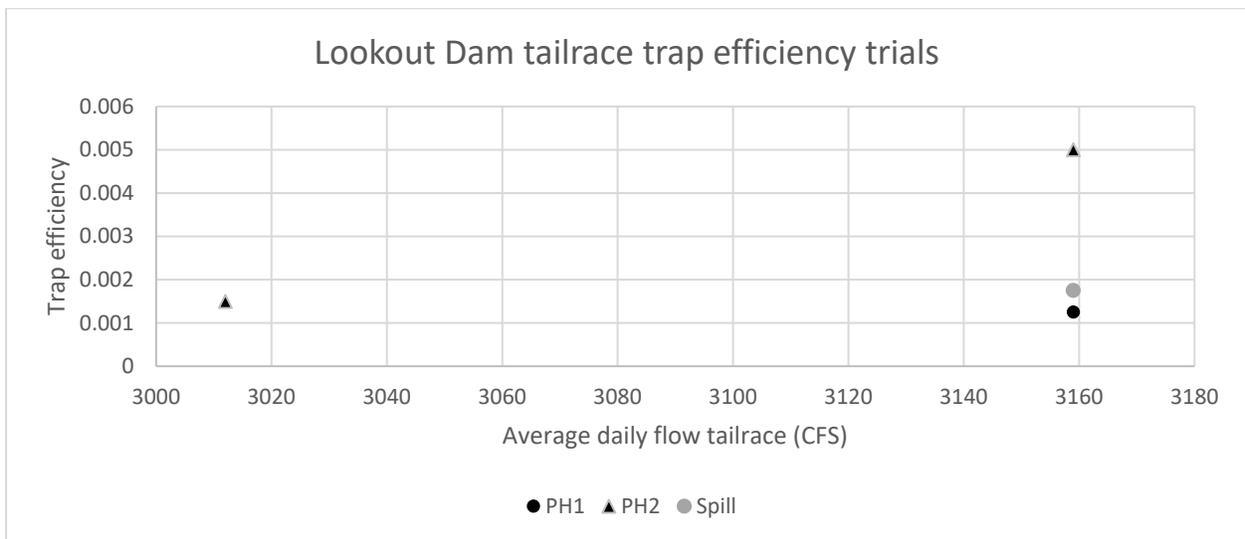


Figure E-8. Lookout Dam Tailrace successful (n ≥ 5 recaptures) trap efficiency trial plots.

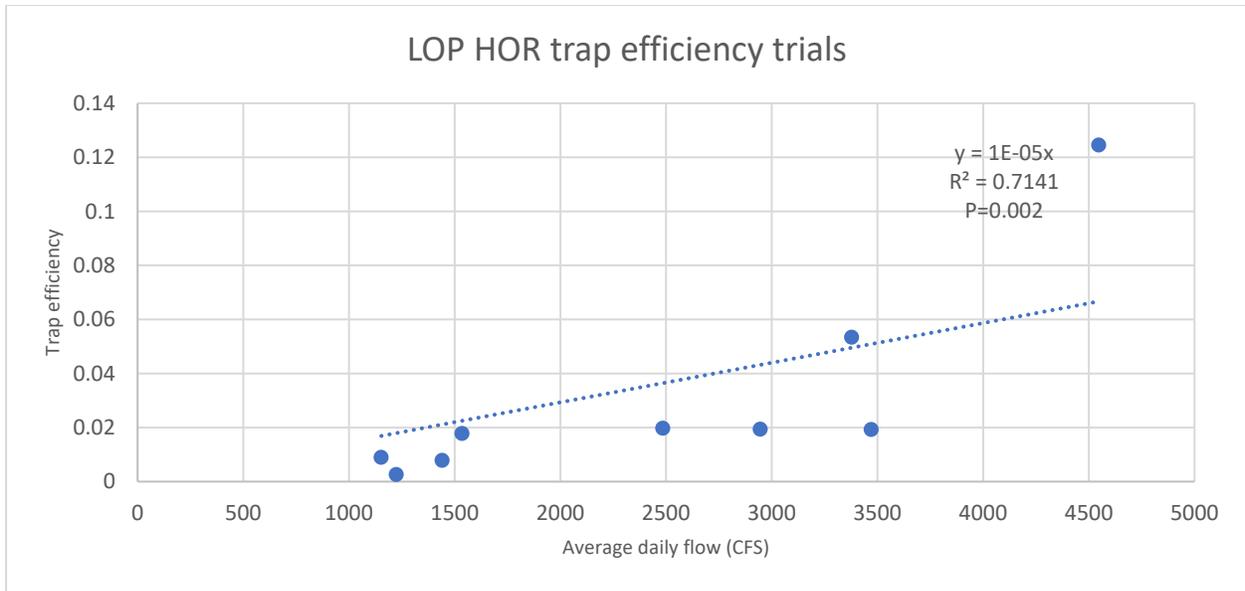


Figure E-9. Lookout Head of Reservoir successful (n ≥ 5 recaptures) trap efficiency trial plots. Lookout Head of Reservoir linear regression fit is slightly positive with increasing flow and significant (p=0.002). Intercept set to 0 to prevent negative TE values.

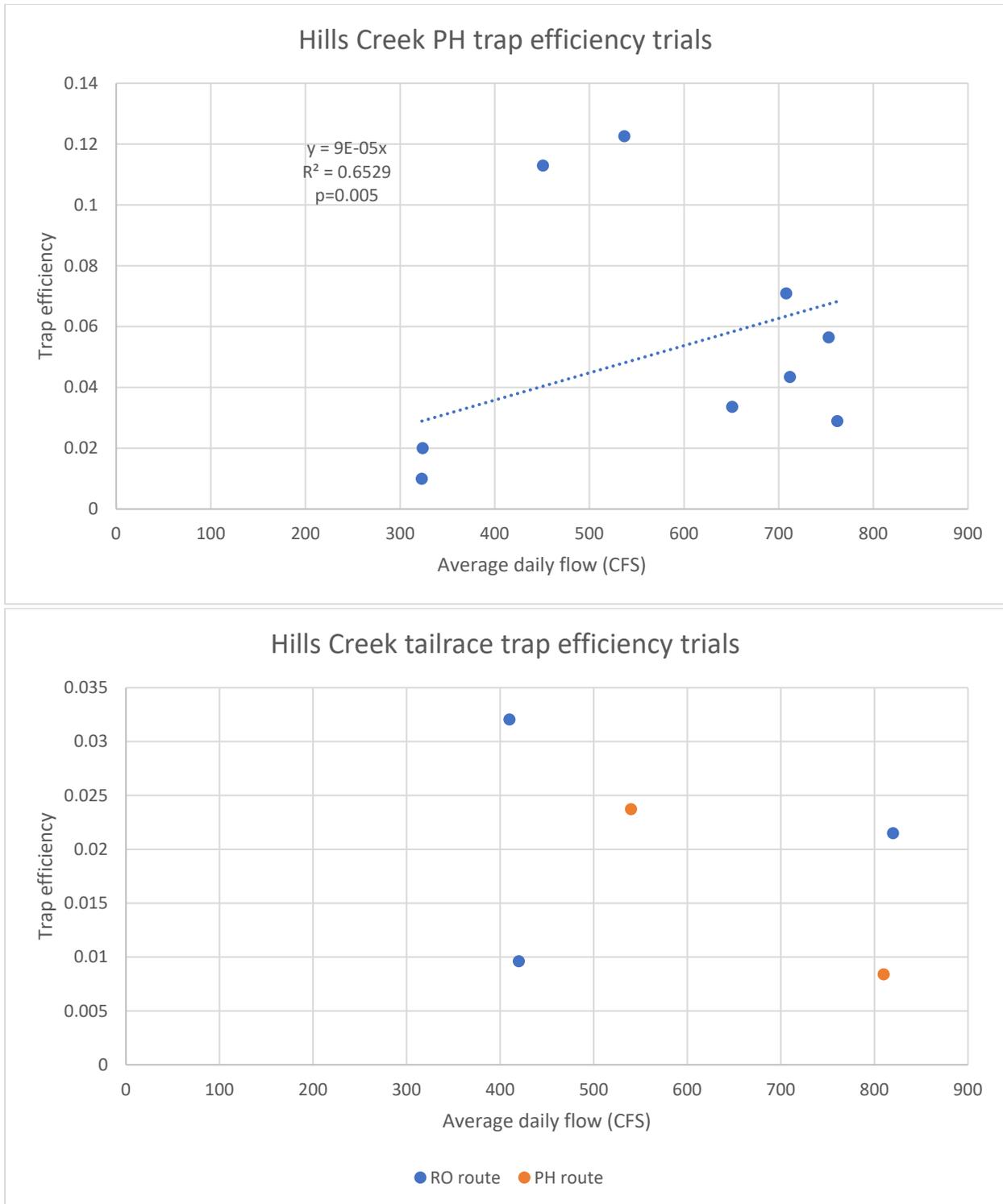


Figure E-10. Hills Creek Dam successful (n ≥ 5 recaptures) trap efficiency trial plots. Lookout Head of Reservoir linear regression fit is slightly positive with increasing flow and significant (p=0.002) and intercept set to 0 to prevent negative flow TE values.

Appendix F – Example of Injury Photos

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Appendix F: Example of Injury Photos

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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).

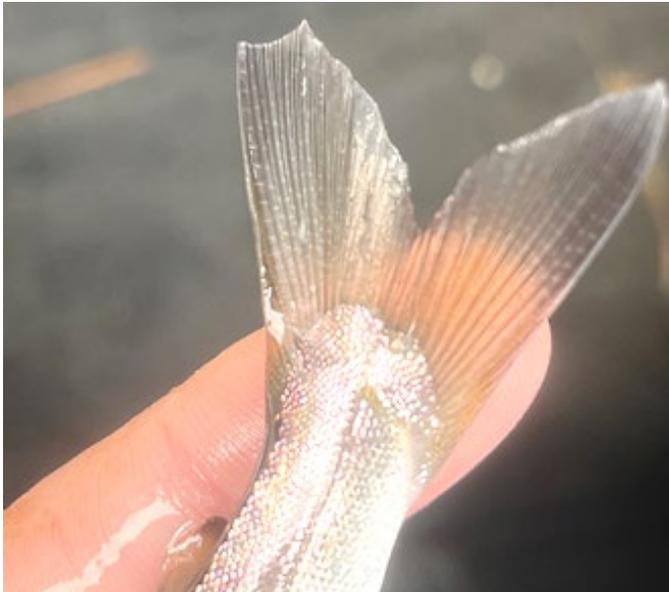


Figure F-6. Gas bubble disease (fin ray/eye inclusions) (GBD).



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

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Figure G-1. Bluegill



Figure G-2. Brook 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

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

Images of traps at various flow levels



Figure H-2. Big Cliff Dam

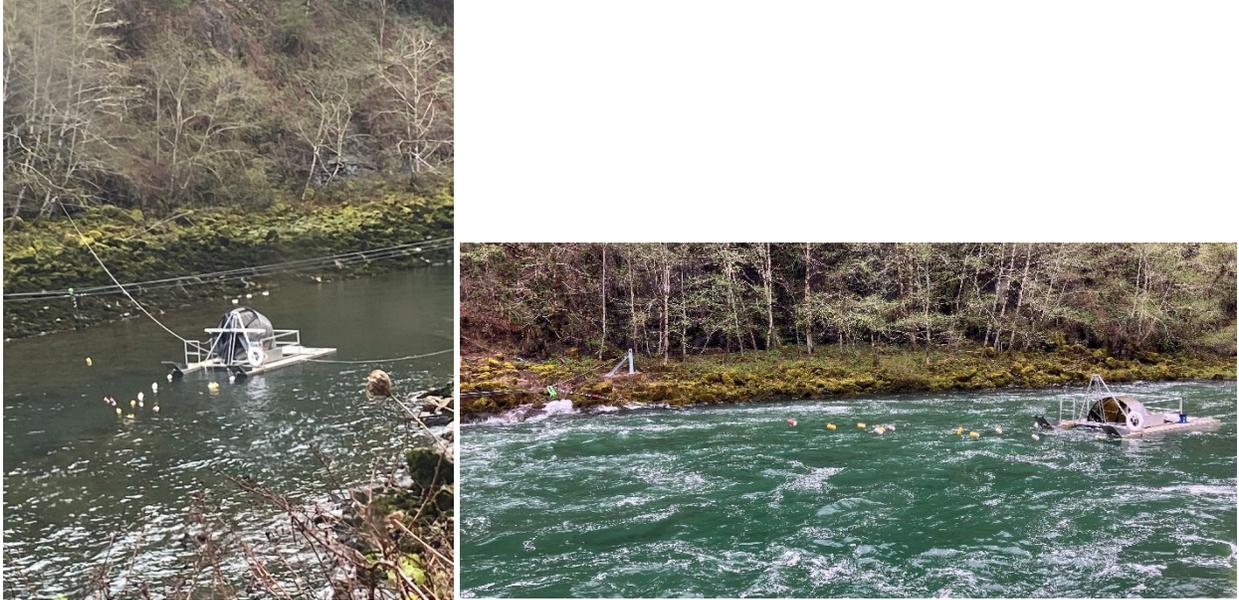


Figure H-3. Green Peter Dam Tailrace – Middle Santiam River

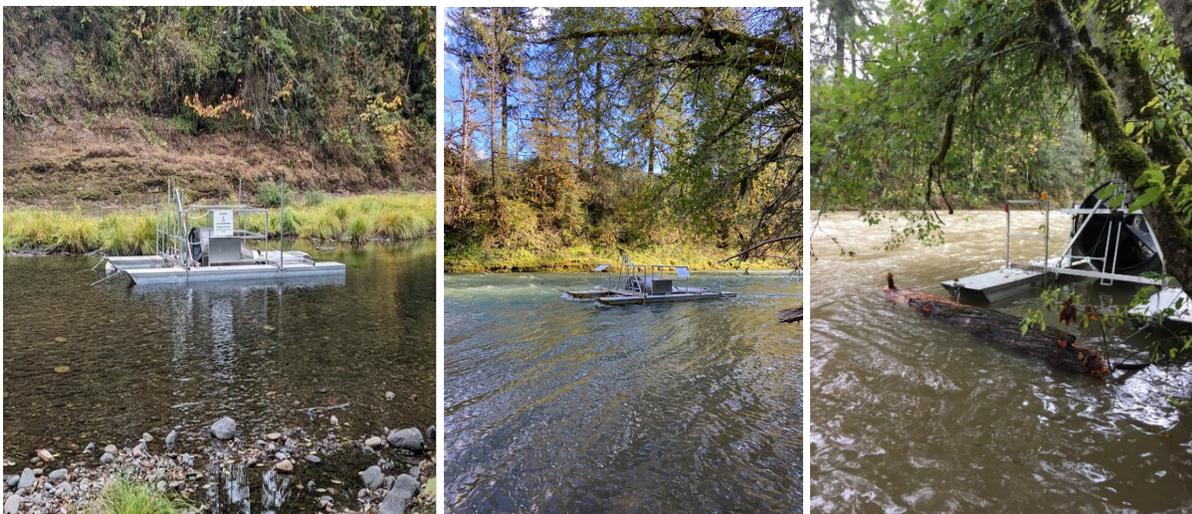


Figure H-4. Foster Dam Head of Reservoir – South Santiam River



Figure H-5. Cougar Dam – Regulating Outlet



Figure H-6. Cougar Dam – Powerhouse Channel



Figure H-7. Cougar Dam Head of Reservoir



Figure H-8. Fall Creek Dam Tailrace



Figure H-9. Fall Creek Head of Reservoir



Figure H-10. Dexter Dam Tailrace



Figure H-11. Lookout Dam Tailrace – Spillway



Figure H-12. Lookout Dam Tailrace – Powerhouse Channel



Figure H-13. Lookout Point Head of Reservoir



Figure H-14. Hills Creek Dam – Regulating Outlet



Figure H-15. Hills Creek Dam – Powerhouse Channel