WILLAMETTE VALLEY DOWNSTREAM FISH PASSAGE MONITORING

Biannual Report Summary

July through December 2023

Prepared for:

U.S. Army Corps of Engineers

Contract No. W9127N19D0009

Prepared by:

Cramer Fish Sciences

February 2024

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

For over 50 years, the U.S. Army Corps of Engineers (USACE) has managed and operated 13 dams in the Willamette River basin as part of the Willamette Valley Project (WVP). Each of these dams contributes to a system that provides flood control, power generation, and recreation. Management of the WVP is a complex process and presents challenges in meeting competing demands such as instream flows, fish passage, flood control, and recreation. Adding to the complexities are the listings of three fish species under the Endangered Species Act (ESA), spring Chinook salmon, *Oncorhynchus tshawytscha*, steelhead, *Oncorhynchus mykiss*, and bull trout *Salvelinus confluentus* (NMFS 2008; USFWS 2008). In 2008, the USACE, the U.S. Bureau of Reclamation, and the Bonneville Power Administration (BPA) (jointly known as the Action Agencies) consulted with the National Marine Fisheries Service (NMFS) to evaluate the impact of the WVP on the ESA-listed salmon and trout, which resulted in NMFS issuing the 2008 Willamette River Biological Opinion (BiOp; NMFS, 2008). In the BiOp, NMFS identified a Reasonable and Prudent Alternative (RPA) that set forth specific actions the Action Agencies could implement to satisfy their legal obligations under the ESA to "…avoid the likelihood of jeopardizing the continued existence of the ESA listed species or the destruction or adverse modification of their designated critical habitat (NMFS, 2008)."

On September 2021, the U.S. District Court for the District of Oregon issued an Interim Injunction Order directing the USACE to implement certain interim injunctive measures to improve fish passage and water quality at several WVP dam sites to benefit UWR spring Chinook salmon and winter steelhead while a reinitiated ESA consultation was completed. In the interim, the Court approved an Expert Panel to define the implementation plans of specific measures, which were required to "provide meaningful research, monitoring, and evaluation ("RM&E") of the interim injunctive measures." On February 28, 2022, the Expert Panel submitted its proposed "long term" plan for the RM&E to accompany the interim injunction measures for the remainder of the duration of the injunction. This study is a component of the RM&E measures identified by the Expert Panel.

The purpose of this project is to contribute to the understanding of downstream passage of juvenile Chinook salmon and winter steelhead in the Willamette Valley Project. Monitoring includes the North Santiam, South/Middle Santiam, South Fork McKenzie, and Middle Fork Willamette River subbasins, including Fall Creek (Figure 1). This project consists of bulk marking juvenile Chinook salmon with PIT (Passive Integrated Transponder) tags to understand migration timing and survival within the WVP and interim management measures hypothesized to contribute to greater survival of juvenile and adult salmonids. To aid in the recapture of tagged fish, rotary screw traps (RSTs) are used at multiple locations across the WVP, and sampling within Green Peter and Lookout Point Reservoirs to understand how water management strategies may influence migration patterns and survival.

This report summarizes the work conducted through 31 December 2023 under contract with the U.S. Army Corps of Engineers for bulk marking and reservoir sampling. The summary of rotary screw trap results has been submitted separately.

Figure 1. Location of Willamette River Basin in Northwestern Oregon

PROJECT SCHEDULE

The contract for this project was awarded in early March 2023, and it was anticipated that it would take approximately two months to initiate activities associated with the bulk marking and reservoir distribution studies. The anticipated schedule for 2023 was to begin bulk marking in early April and reservoir studies in the first week in May. Due to the permitting process, availability of equipment due to continued supply chain issues, coordination with hatcheries and training of field staff, a significant amount of advance work was necessary resulting in field activities ultimately beginning later than envisioned. Bulk marking of Chinook salmon fry began in mid-May and reservoir sampling started in mid-June. Bulk marking activities continued through the end of December. Reservoir field work continued through the first week of December in Lookout Point Reservoir and through the end of September in Green Peter Reservoir. Rotary screw trap (RST) sampling during 2023 was conducted both under a separate contract with Environmental Assessment Services (EAS) and as part of this contract. RST sampling under these contracts occurred year-round between January 1, 2023 and December 31, 2023, with specific dates of operation dependent on trap location (EAS 2024a, EAS 2024b).

Project reporting occurs bi-weekly and bi-annually. Bi-annual reporting periods cover January-June and July-December, with each report summarizing results during the reporting period as well as findings to date. This report is the second bi-annual report of the project, covering results of the bulk marking and reservoir distribution studies from July-December 2023 and to date since the project commenced in March 2023. RST sampling methods and results are presented separately (EAS 2024b). Future reports will expand on these results as more data is collected (e.g., PIT tagged fish released as part of this project are still potentially outmigrating, and future reports will update the analyses for efforts conducted during this reporting period).

Table 1. Summary of field sampling effort, schedule and life stage targeted as part of this project.

Activity	Timing	Target Life stage (Chinook salmon)
Bulk Marking (PIT tagging)	Winter/Spring and Fall	Fry, parr, and yearlings
Rotary Screw Trapping*	Year-round	Fry, parr, and yearlings
Reservoir Sampling (littoral and limnetic)	February through November	Fry, parr, and yearlings

*Results from rotary screw trap sampling is contained in a separate report.

BULK MARKING

Bulk marking of juvenile Chinook salmon with PIT tags offers the opportunity to evaluate how an individual behaves, survives, grows, and out-migrates to saltwater as long as the individual is recaptured and survives. The purpose of bulk marking juvenile Chinook salmon for this project is to determine how water management actions (e.g., drawdowns) influence the survival of juvenile Chinook salmon. All of the Chinook salmon used in the bulk marking portion of the project originated from hatcheries operated by the Oregon Department of Fish and Wildlife in the Willamette Valley.

Methods

The following protocol provides detailed procedures for work done to mark, hold, transport, and release juvenile Chinook salmon in the Willamette River basin during 2023.

Government Supplied Hatchery Fish

- Juvenile Chinook salmon used for bulk/batch marking in 2023 were raised and held at Willamette Valley ODFW hatchery facilities.

- Fish were reared as follows:
  - Fish to be released in the North Santiam basin were reared at the ODFW Marion Forks hatchery in Idanha, OR.
  - Fish to be released in the South/Middle Santiam and Middle Fork Willamette basins were reared at the ODFW Willamette Hatchery in Oakridge, OR.
  - Fish to be released in the South Fork McKenzie Basin were reared at the ODFW Leaburg and McKenzie Hatcheries in Leaburg, OR,

Holding and Tagging Sites

All Chinook salmon bulk/batch marked during 2023 were held and marked at the ODFW hatchery facility where they were raised. CFS coordinated with hatchery managers to ensure adequate space and water supplies for holding fish pre and post tagging at each site were available.

North Santiam Basin – Marion Forks Hatchery

Chinook salmon released in the North Santiam Basin were held pre and post tagging in indoor flow through ("Canadian") troughs (21 ft x 1.67 ft x 1.75 ft). After observation, they were moved to outdoor raceways (80 ft x 20 ft x 2.5 ft) at ODFW's Marion Forks Hatchery. Hatchery management set aside 16 troughs and two raceways for CFS use for tagging operations.

South/Middle Santiam & Middle Fork Willamette Basins – Willamette Hatchery

Fish to be released in the South/Middle Santiam and Middle Fork Willamette basins were held pre and post tagging at the ODFW Willamette Hatchery. Fry were held pre and post tagging in indoor troughs (20 ft x 4 ft x 4 ft). Yearlings and subyearlings were held pre- and post-tagging in large raceways (75 ft x 20.5 ft x 4 ft).

South Fork McKenzie – McKenzie and Leaburg Hatcheries

Fry to be released in the South Fork McKenzie basin were held pre and post tagging at ODFW's McKenzie Hatchery indoors in flow through troughs (20 ft x 2.67 ft x 1.67 ft). Yearlings and subyearlings tagged in fall were held at Leaburg Hatchery in net pens placed within the hatchery's large outdoor ponds. Hatchery management made six outdoor ponds/cement circulars at Leaburg or McKenzie hatchery available for use by this project (20ft diameter x 3.66ft deep). Net pens were constructed (6 ft x 6 ft x 3 ft) to enable separation and containment of hatchery release groups within the large outdoor ponds. Pens were made of 1/8-inch mesh and will solid bottoms to collect any shed tags.

Fish Holding Conditions and Husbandry following delivery to CFS

Fish holding conditions were consistent with ODFW hatchery management practices and each hatchery's existing protocols were followed. ODFW hatchery staff supported the project by conducting daily feedings, water quality monitoring, observation of abnormalities, and removal of mortalities at hatchery sites. Fish were under daily observation for abnormalities including poor swimming performance, fungus, unusual feeding behavior, direct mortalities, or any unusual marks.

Bulk/Batch Marking

To date, all release groups were uniquely marked with a passive integrated transponder (PIT) tag (Biomark, Inc.). An additional 3% of fish were marked for each release group to account for tagging mortality and ensure sufficient tag numbers of fish are achieved for each release group (Table 3). Fish have been tagged within the Cramer Fish Sciences fish marking trailer, which is disinfected then moved to each basin's holding site for bulk marking events. The marking trailer is equipped with 110V electricity and flow-through fish holding tanks. Additionally, it is equipped with a system to recirculate, aerate, and chill anesthetic water. During tagging, temperature, dissolved oxygen, and water chemistry were monitored for fish tagging tanks, and the recirculated anesthetization water was aerated and cooled with ice packs when necessary. Tagging ceased when the temperature of tanks exceeded 17 degrees Celsius or deviated more than 2 deg C from source/return water (Table 3). In an instance of a delay, tagging activities resumed once water temperatures returned to within thresholds safe for fish handling and tagging activities.

Working in small batches (30-50 fish), fish were anesthetized using 50 mg/L tricaine methanesulfonate (MS-222) buffered with sodium bicarbonate. To minimize fish stress, fish anesthetic exposure did not exceed five minutes (PIT Tag Steering Committee 2014). Fish were then tagged based on fish fork length (FL). Fry greater than 45 mm but less than 65 mm were marked with 8 mm PIT tags and fry greater than 65 mm were marked with a 12 mm PIT tag. All fish >45 mm were adipose fin clipped, either by ODFW or by CFS staff with surgical scissors. All subyearlings have been and yearlings will be marked with 12 mm PIT tags. Fork length to the nearest millimeter and weight to the nearest 0.01 g were recorded for the first 3% of fish tagged for each release group. For each fish, the tag code was recorded before fish were transferred to a flow-through tank for a 30-minute recovery and observation period. Any mortalities during this period were documented. After fish had recovered, the bulk of each release group (95%) were held for a minimum of 48 hours prior to release with each uniquely tagged release group held in a separate tank or holding pen where feeding commenced. The remaining 5% were held separately to be used for tag retention/mortality holding trials, as described below under "Tag Retention and Mortality Holding Trials."

VIE Batch Marking

Prior to the initiation of the spring tagging season in 2023, we had planned to use VIE (Visual Implant Elastomer) tags for fry. However, due to the timing of marking activities following contract award and setup (i.e., 'fry' were >45mm at time of marking) and after consulting experienced elastomer taggers, and reviewing how marks change ontogenetically, we worked with the Corps to find a solution utilizing 8 mm PIT tags instead of VIE tags on fish down to 43 mm to increase survival and maximize the value of data by having individually marked fish available for subsequent recapture. First, handling fry smaller than 43 mm is difficult. Second, the VIE tags on small fry are very difficult to read after a fish has grown, and if the VIE tag cannot be visually identified (i.e., read) upon recapture such as in a rotary screw trap after extended rearing, provide no information for fish that rear for an extended period in reservoirs or streams. While published literature suggests that VIE marking may be suitable for this type of project (e.g., Leblanc and Noakes 2012), it is recommended that more discussion is needed before tagging of fry occurs in 2024.

PIT Tag Bulk Marking

PIT tagging procedures followed the methods detailed in the PIT Tag Marking Procedures Manual (PIT Tag Steering Committee 2014). Prior to tagging, feeding was ceased 24-48 hours in advance of tagging and resumed 24-28 hours post tagging, in order to reduce the risk of shed tags and lower the chance of hitting vital organs when injecting the PIT tags into the peritoneal cavity (PIT Tag Steering Committee 2014). Bulk mark group fish were tagged using single-use pre-loaded injector needles, pulled from trays holding sequentially numbered PIT tags. Tags were inserted using a MK25 PIT tag implanter (Biomark, Inc.). A new needle was loaded on the implanter for each fish. Fish were held in the hand with the belly of the fish facing up with the tail oriented toward the thumb, and the insertion point lined up with the middle finger. The middle finger was used to exert a slight pressure on the side of the fish's belly to ease needle penetration. The injector was laid in the hand so that the needle bevel faced toward the body of the fish. Tags were injected into the peritoneal cavity between the posterior tip of the pectoral fin and the anterior point of the pelvic girdle 1 to 2 mm from the mid-ventral line. Care was taken to keep the needle as parallel to the body axis as possible to keep the tag against the body wall, with minimal needle penetration (approximately 1-2 mm of the needle tip for small fish). Once the needle penetrated the abdominal wall, the tag was injected by pressing the trigger. After insertion, the used needle tip was ejected, and the fish scanned to read the tag code before transfer to the recovery tank.

A tag record includes information about the tagging session (i.e., date and location of tagging event, date and location of release) and tagged fish (i.e., species, run, rearing type, PIT tag code, fork length, and weight for the 3% subsample). Data during tagging were recorded using P4 software put out by PTAGIS[1]. Prior to release, holding tanks and the fish transport truck were examined to remove mortalities and scanned with a magnet to collect any shed PIT tags. PIT tag codes from sheds and mortalities were removed from the tag record. The PIT tag data were inspected for data quality before being uploaded to PTAGIS at the time of release.

Fish Transport

Fish were transported in a 400-gallon insulated fish transport tank (Reiff Manufacturing). The tank was placed and secured in the bed of a Ford F350 truck. The tank is equipped with a water pump to circulate oxygenated water within the tank, and an oxygen tank was secured vertically in the bed of the truck and used to supply oxygen to the tank. Transport fish densities were between 20 – 50 g/L (equivalent to 0.17 – 0.42 lbs/gallon) and dissolved oxygen was monitored and maintained between 80-120%, following the juvenile Chinook salmon transport methods applied by the USGS (Kock et al. 2019). Temperature and dissolved oxygen are monitored during transport by using a water quality meter with a cable that extends to the truck cab. Prior to transport, the temperature of the release location was measured and if necessary, the temperature of tank water was manipulated during transport so that fish experience at most a 1.0 ºC change in temperature at release. Water temperature manipulations during transport were made by adding either ice or warm water to the tank at a rate that ensures fish experience a targeted less than 0.5 ºC change in temperature per 15 minutes (Kock et al. 2019) to stay in compliance with NMFS criteria.

The fish transport tank was disinfected when switching between basins to prevent disease transmission. The inside of the tank was disinfected through exposure to 200 ppm chlorine for 30 minutes, after which it was thoroughly flushed with clean water (IHOT 1994).

[1] https://www.ptagis.org/Software/P4/P4

Release

The following represents the bulk marking and release locations for the remainder of the study. In 2023 (Table 2) the opportunity to mark fry was missed due to a variety of factors as discussed above (i.e., permitting process, availability of equipment due to continued supply chain issues, coordination with hatcheries and training of field staff, and a significant amount of advance work).

Table 2. Tentative (target) release schedule for brood year 2022. Bold rows highlight the release groups that have been tagged and released during this reporting period. Italicized and underlined rows highlight release groups that have been tagged during this reporting period, but will be released at a later date. Release dates are approximate and depend upon operations and conditions such as reservoir elevation, road closures, etc.

Release Date	Release Basin	Release Area	Release Location	Lifestage	N
2/1/2023	**North Santiam**	**Detroit Reservoir**	**Breitenbush River**	**fry**	**3750**
2/1/2023	**North Santiam**	**Detroit Reservoir**	**North Santiam River**	**fry**	**3750**
3/1/2023	**MF Willamette**	**Fall Creek Dam**	**Fall Creek Head of Reservoir**	**fry**	**5000**
3/1/2023	**MF Willamette**	**Lookout Point and Dexter**	**Lookout Point Head of Reservoir**	**fry**	**5000**
3/1/2023	**MF Willamette**	**Hills Creek Dam**	**Hills Creek Head of Reservoir**	**fry**	**5000**
3/1/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Head of Reservoir**	**fry**	**5000**
3/15/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Head of Reservoir**	**fry**	**5000**
3/31/2023	**MF Willamette**	**Fall Creek Dam**	**Fall Creek Head of Reservoir**	**fry**	**5000**
4/1/2023	**MF Willamette**	**Lookout Point and Dexter**	**Lookout Point Head of Reservoir**	**fry**	**5000**
4/1/2023	**North Santiam**	**Detroit Reservoir**	**Breitenbush River**	**fry**	**3750**
4/1/2023	**North Santiam**	**Detroit Reservoir**	**North Santiam River**	**fry**	**3750**
4/1/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Head of Reservoir - Middle Santiam Arm**	**fry**	**2500**
4/1/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Head of Reservoir - Quartzville Creek Arm**	**fry**	**2500**
4/15/2023	**MF Willamette**	**Hills Creek Dam**	**Hills Creek Head of Reservoir**	**fry**	**5000**
4/15/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Head of Reservoir - Middle Santiam Arm**	**fry**	**2500**
4/15/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Head of Reservoir - Quartzville Creek Arm**	**fry**	**2500**
8/30/2023	**South Santiam**	**Foster Reservoir**	**Foster Dam Tailrace**	**subyearling**	**1000**
8/30/2023	**South Santiam**	**Foster Reservoir**	**Foster Head of Reservoir**	**subyearling**	**2000**
9/15/2023	**MF Willamette**	**Lookout Point and Dexter**	**Dexter Dam Tailrace**	**subyearling**	**2000**
9/15/2023	**MF Willamette**	**Lookout Point and Dexter**	**Lookout Point Head of Reservoir**	**subyearling**	**5000**
9/15/2023	**MF Willamette**	**Lookout Point and Dexter**	**Lookout Point Dam Forebay**	**subyearling**	**5000**
9/15/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Head of Reservoir**	**subyearling**	**3000**

Release Date	Release Basin	Release Area	Release Location	Lifestage	N
9/15/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Head of Reservoir - Middle Santiam Arm**	**subyearling**	**2500**
9/15/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Head of Reservoir - Quartzville Creek Arm**	**subyearling**	**2500**
10/1/2023	**North Santiam**	**Big Cliff Dam**	**Big Cliff Dam Tailrace**	**subyearling**	**8000**
10/1/2023	**North Santiam**	**Detroit Reservoir**	**Breitenbush River**	**subyearling**	**5000**
10/1/2023	**North Santiam**	**Detroit Reservoir**	**North Santiam River**	**subyearling**	**5000**
10/15/2023	**MF Willamette**	**Fall Creek Dam**	**Fall Creek Head of Reservoir**	**subyearling**	**5000**
10/15/2023	**MF Willamette**	**Fall Creek Dam**	**Fall Creek Dam tailrace**	**subyearling**	**1000**
10/15/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Dam Forebay**	**subyearling**	**5000**
10/15/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Dam Tailrace**	**subyearling**	**4000**
10/15/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Head of Reservoir**	**subyearling**	**4000**
10/15/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Dam Tailrace**	**subyearling**	**4000**
10/15/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Head of Reservoir - Middle Santiam Arm**	**subyearling**	**2500**
10/15/2023	**South Santiam**	**Green Peter Reservoir**	**Green Peter Head of Reservoir - Quartzville Creek Arm**	**subyearling**	**2500**
10/15/2023	**South Santiam**	**Foster Reservoir**	**Foster Dam Tailrace**	**subyearling**	**4000**
10/15/2023	**South Santiam**	**Foster Reservoir**	**Foster Head of Reservoir**	**subyearling**	**5000**
11/15/2023	**MF Willamette**	**Fall Creek Dam**	**Fall Creek Head of Reservoir**	**subyearling**	**5000**
11/15/2023	**MF Willamette**	**Fall Creek Dam**	**Fall Creek Dam tailrace**	**subyearling**	**1000**
11/15/2023	**North Santiam**	**Big Cliff Dam**	**Big Cliff Dam Tailrace**	**subyearling**	**6000**
11/15/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Dam Forebay**	**subyearling**	**5000**
11/15/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Dam Tailrace**	**subyearling**	**4000**
11/15/2023	**SF McKenzie**	**Cougar Dam**	**Cougar Head of Reservoir**	**subyearling**	**4000**
11/16/2023	**MF Willamette**	**Hills Creek Dam**	**Hills Creek Dam Head of Reservoir**	**subyearling**	**5000**
11/16/2023	**MF Willamette**	**Hills Creek Dam**	**Hills Creek Dam tailrace**	**subyearling**	**3000**
11/16/2023	**MF Willamette**	**Hills Creek Dam**	**Hills Creek forebay or mid-reservoir**	**subyearling**	**5000**
2/1/2024	*MF Willamette*	*Hills Creek Dam*	*Hills Creek Dam Head of Reservoir*	*yearling*	*5000*
2/1/2024	*MF Willamette*	*Hills Creek Dam*	*Hills Creek Dam tailrace*	*yearling*	*3000*

Release Date	Release Basin	Release Area	Release Location	Lifestage	N
2/1/2024	MF Willamette	Hills Creek Dam	Hills Creek forebay or mid-reservoir	yearling	5000
2/28/2024	MF Willamette	Fall Creek Dam	Fall Creek Dam Head of Reservoir	yearling	5000
2/28/2024	MF Willamette	Fall Creek Dam	Fall Creek Dam Tailrace	yearling	1000
2/28/2024	MF Willamette	Lookout Point & Dexter Dams	Head of Lookout Point Dam reservoir	yearling	5000
2/28/2024	MF Willamette	Lookout Point & Dexter Dams	Dexter Dam Tailrace	yearling	2000
2/28/2024	MF Willamette	Lookout Point & Dexter Dams	Lookout Point Dam Forebay	yearling	5000
2/28/2024	SF McKenzie	Cougar Dam	Cougar Dam Forebay	yearling	2000
2/28/2024	SF McKenzie	Cougar Dam	Cougar Dam Tailrace	yearling	1000
2/28/2024	SF McKenzie	Cougar Dam	Cougar Head of Reservoir	yearling	2000
3/30/2024	SF McKenzie	Cougar Dam	Cougar Dam Forebay	yearling	2000
3/30/2024	SF McKenzie	Cougar Dam	Cougar Dam Tailrace	yearling	1000
3/30/2024	SF McKenzie	Cougar Dam	Cougar Head of Reservoir	yearling	2000
3/31/2024	MF Willamette	Fall Creek Dam	Fall Creek Dam Head of Reservoir	yearling	5000
3/31/2024	MF Willamette	Fall Creek Dam	Fall Creek Dam Tailrace	yearling	1000
4/1/2024	MF Willamette	Lookout Point & Dexter Dams	Head of Lookout Point Dam reservoir	yearling	5000
4/1/2024	MF Willamette	Lookout Point & Dexter Dams	Dexter Dam Tailrace	yearling	2000
4/1/2024	MF Willamette	Lookout Point & Dexter Dams	Lookout Point Dam Forebay	yearling	5000
4/1/2024	North Santiam	Big Cliff Dam	Big Cliff Dam Tailrace	yearling	2000
4/1/2024	North Santiam	Detroit Dam	Breitenbush River	yearling	2000
4/1/2024	North Santiam	Detroit Dam	North Santiam River	yearling	2000
4/1/2024	South Santiam	Green Peter Reservoir	Green Peter Dam Tailrace	yearling	1000
4/1/2024	South Santiam	Green Peter Reservoir	Green Peter Forebay	yearling	2000
4/1/2024	South Santiam	Green Peter Reservoir	Green Peter Head of Reservoir – Middle Santiam Arm	yearling	1000
4/1/2024	South Santiam	Green Peter Reservoir	Green Peter Head of Reservoir – Quartzville Creek Arm	yearling	1000
4/1/2024	South Santiam	Green Peter Reservoir	Green Peter – Mid Reservoir	yearling	2000
4/1/2024	South Santiam	Foster Reservoir	Foster Tailrace	yearling	4000

Release Date	Release Basin	Release Area	Release Location	Lifestage	N
4/1/2024	South Santiam	Foster Reservoir	Head of Foster Reservoir	yearling	5000
4/1/2024	South Santiam	Foster Reservoir	Foster Tailrace	yearling	2000
4/1/2024	South Santiam	Foster Reservoir	Head of Foster Reservoir	yearling	1000

Release Methods

Maps of release locations are provided in Figure 2-Figure 6. The method of release from the transport truck depended on the release location and reservoir elevation. When release locations were at boat ramps, the truck was backed down to the water's edge, where fish were then volitionally released from the tank by attaching 6" collapsible tube, 6" semi-rigid tube, or 3" semi-rigid tube to the sluice gate at the bottom of the tank. Prior to fish release, the tubes were filled with water to prevent fish injury. To ensure fish were fully flushed from the tube at the end of the release, buckets of release location water were used to flush the tube after the tank emptied. A generator and trash pump were also used occasionally to pump river water into the tank to assist in flushing fish from the tank. At roadside release locations, the same methods were used, however the truck was parked at the nearest road shoulder.

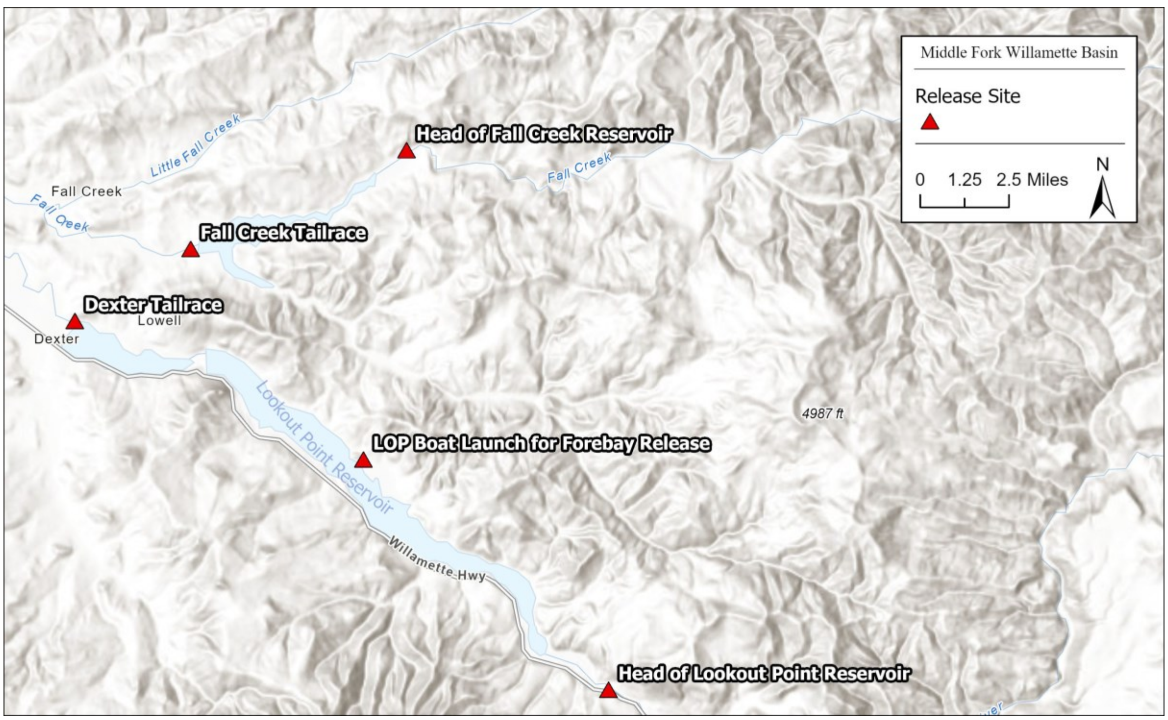


Figure 2. Map of Lookout Point, Dexter tailrace and Fall Creek release locations within the Middle Fork Willamette Basin. Head of Lookout Pt reservoir at Hampton Boat Launch (Black Canyon Campground as backup). Head of Fall Creek reservoir is at the location of the decommissioned boatramp approximately 800 meters below Dolly Varden Campground.

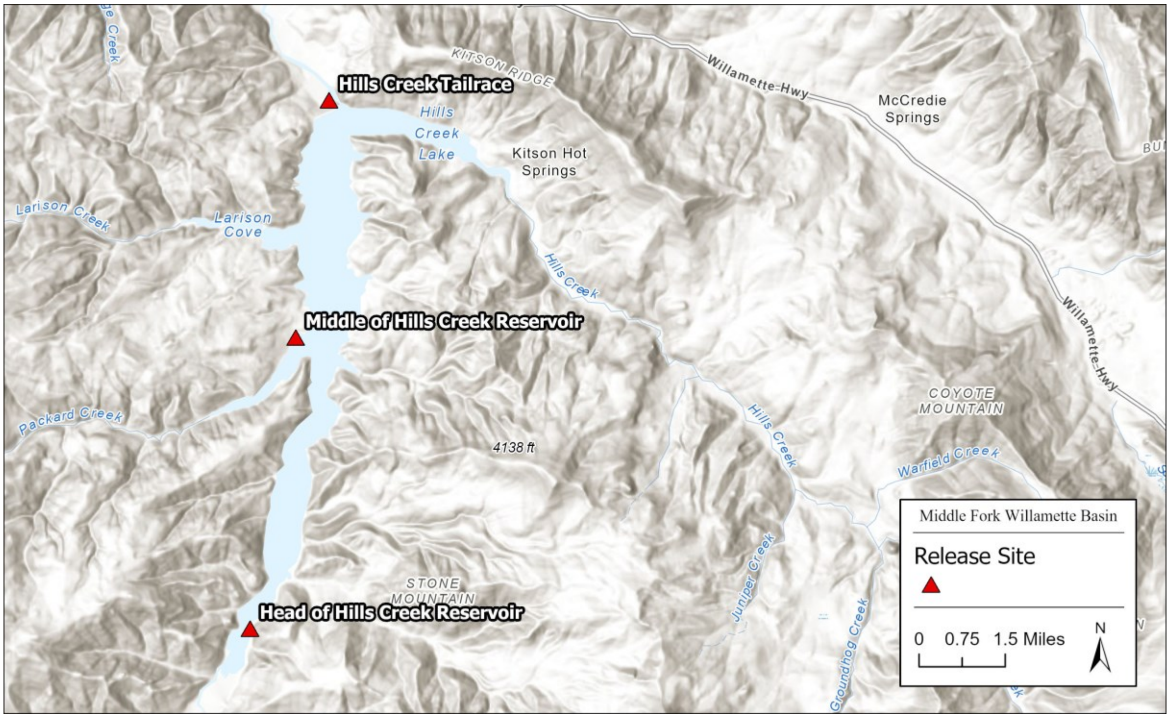


Figure 3. Map of Hills Creek Reservoir release locations within the Middle Fork Willamette Basin. The mid-reservoir release location occurs at Packard boat ramp. The head of reservoir release location occurs at the upper reservoir bridge crossing.

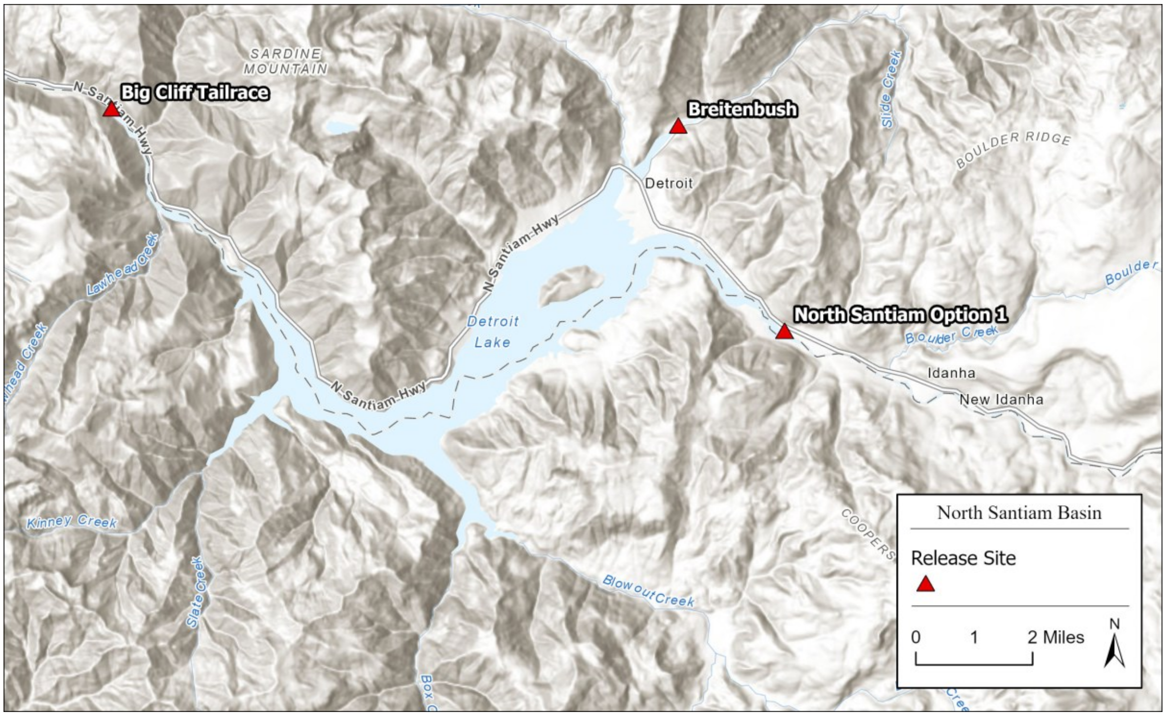


Figure 4. Map of release locations within the North Santiam Basin. The North Santiam head of reservoir release site is the Santiam Falls Campground or Hoover Campground. The Breitenbush release site is at the USGS gaging station.

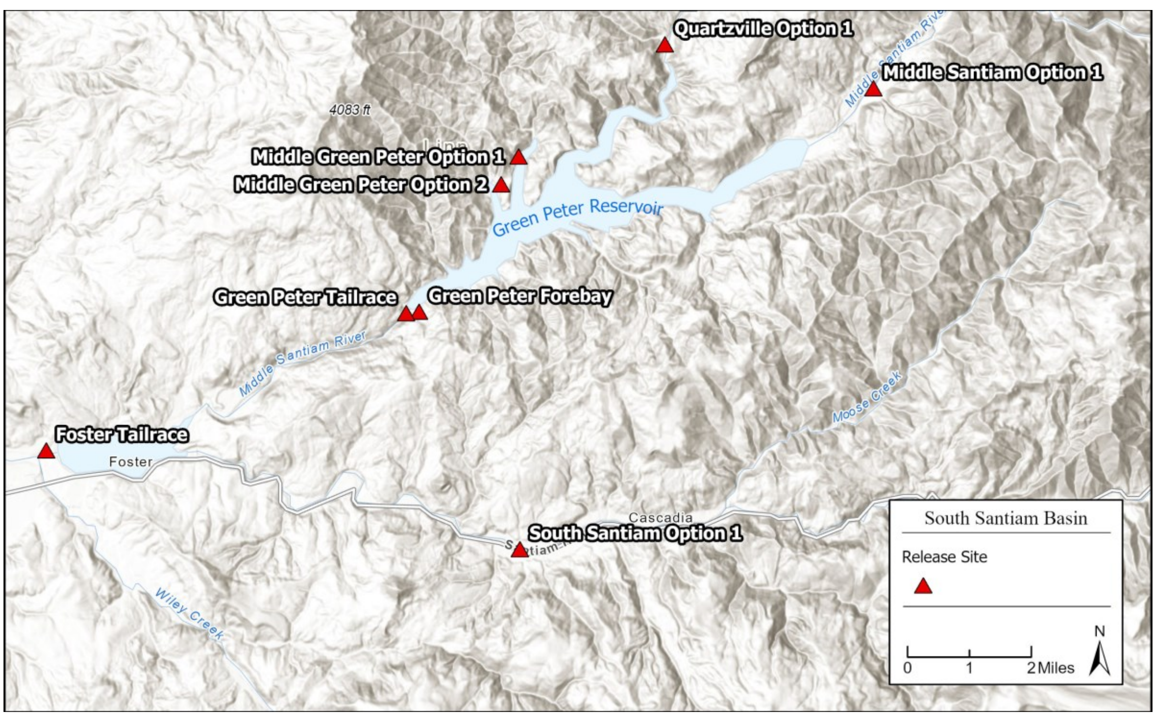


Figure 5. Map of release locations in the Middle/South Santiam basin including Green Peter Reservoir. Green Peter forebay releases are at Billings Park. Middle Santiam head of reservoir releases occur at the bridge crossing at the top of the reservoir. Quartzville head of reservoir

releases occur at one of the multiple river access sites along the Quartzville Dr depending on conditions at the time of release. Whitcomb County Park and Thistle Creek boat ramp are alternate release locations.

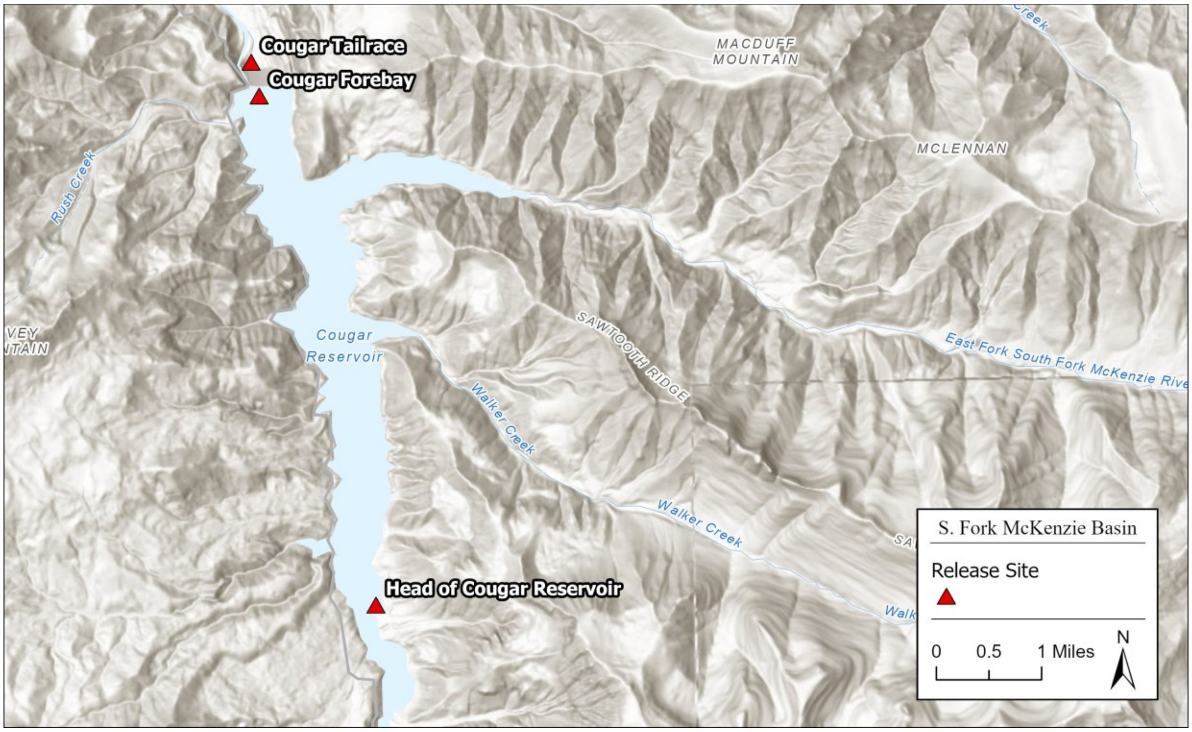


Figure 6. Map of release locations in Cougar Reservoir within the South Fork McKenzie basin. Cougar forebay releases occurred at the face of Cougar dam during drawdown periods as distances were too far for effective forebay releases elsewhere. Cougar head of reservoir releases were at Cougar Crossing or Slide Creek Day Use area.

Results: Bulk Marking Summary through 31 December 2023

South Fork McKenzie

The objective in the South Fork McKenzie River basin was to PIT tag and release a total of 39,000 brood year 2022 McKenzie River stock (23H) sub-yearling juvenile Chinook salmon during 2023 (Table 2). We released 37,604 PIT tagged sub-yearling Chinook salmon in 2023, representing 96.4 percent of the objective target (Table 4, Figure 6). In addition to the fish that were tagged and released, we began tagging the group of brood year 2022 juveniles that are slated to be released as yearlings in the spring of 2024 (4,023 of 10,000). We observed an estimated mortality rate of 3.5 percent and an estimated tag shed rate of 0.25 percent across all fish tagged for the South Fork McKenzie River basin in 2023 (Table 3).

The juvenile Chinook salmon that were reared at Leaburg Hatchery were subject to various pathogen outbreaks during the summer and fall of 2023. We started PIT tagging juvenile Chinook salmon at Leaburg Hatchery on June 20, 2023, aiming to tag 10,000 fish. However, on the first day, we noted high mortality rates among both tagged fish and those waiting in the staging trough. Of the 3,553 salmon tagged that day, 93 died by day’s end, a rate of 2.3%. This rate was alarming to our crew, as we had been averaging a tagging mortality rate of less than 1 percent up to that point in the project. Also surprising was the discovery of several dead fish in the staging trough (i.e., fish that had not been tagged or handled yet), a situation we had not observed to this extent in the staging area earlier in the year. By this date, our crews were highly experienced, water temperatures were averaging 10.4 degrees Celsius, and we had been using the same stock solution of anesthesia that had resulted in low mortality rates in the weeks prior. The hatchery manager informed us that pathogen outbreaks, particularly Proliferative Kidney Disease (PKD), had been common at Leaburg in recent years. Consequently, we halted our tagging activities and contacted the state pathologist, Dr. Aimee Reed. Throughout the summer and into the fall, the juvenile Chinook salmon at Leaburg underwent various treatments by ODFW staff under the guidance of the state pathologist. Pathogens continued to be an issue at Leaburg well into the fall and are the likely cause of the relatively high mortality rates of our tagged fish in this basin.

Cougar Dam

The first release of PIT tagged juvenile Chinook salmon into the Cougar Dam project area occurred on August 29, 2023 with the release of 5,200 fish at the head of Cougar Reservoir. The original intended release target for these fish was prior to the start of the spring drawdown of Cougar Reservoir which commenced in early March and the intended release number was 10,000 fish. The release window was missed because the project was not awarded in time and the release number was not met due to adverse fish health conditions. Our intent was to release these fish two weeks after marking them, in late-June or early-July. Once again, we were unable to release these fish when we had hoped because of the pathogen outbreaks at Leaburg Hatchery. This group of fish had an average fork length of 67.9 millimeters and an average weight of 4 grams at the time of marking but a subset was not handled and measured prior to release and therefore lengths and weights for this release group are not presented. This group of fish was released upstream of the rotary screw trap that is operated by Environmental Assessment Services. All subsequent releases at the head of Cougar Reservoir took place below the Cougar Crossing Bridge. The water temperature at time of release was 10.1 degree Celsius.

The next release in the Cougar Dam project area took place October 2, 2023 when a total of 8,012 fish were released at the head of Cougar Reservoir. The size of this release group was impacted by the pathogen outbreaks. The original intent was to release a group of 3,000, however, to compensate for the 5,000 fish shortfall in the previous release, the decision was made to increase the release size to approximately 8,000. This release group was designed to target the fall drawdown of Cougar Reservoir which commenced on October 1, 2023. The fish in this release group had a mean fork length of 117 millimeters and a mean weight of 19 grams. The water temperature at the release site was 8.5 degrees Celsius.

The subsequent release took place on October 18 and October 19, 2023 with the release of 3,979 at the head of Cougar Reservoir (mean FL = 118 mm; mean weight = 20 g), 5,010 into the Cougar Dam forebay (mean FL = 121 mm; mean weight = 21 g), and 3,997 into the tailrace of Cougar Dam (mean FL = 113; mean weight = 17 g). The objective was to release this group of fish prior to the Cougar Dam forebay reaching an elevation of 1505 feet. The forebay elevation averaged 1563 feet above mean sea level during the releases. Cougar’s forebay would eventually reach 1505 feet on November 3, 2023. Release site temperatures were 8 degrees at the head of reservoir, 15.4 degrees at the forebay, and 10.5 degrees Celsius in the tailrace.

The final group of fish was released over three days between November 13 and November 15, 2023. This release group was designed to target regulating outlet operations at Cougar Dam. We released 3,999 fish at head of Cougar Reservoir (mean FL = 121.3 mm; mean weight = 23 g), 4,995 fish into the Cougar forebay (mean FL = 124.6 mm; mean weight = 24 g), and 2,412 into the Cougar Dam tailrace (mean FL = 120.1 mm; mean weight = 21.5 g). The tailrace release was scheduled for 4,000 fish, however the disease outbreaks and subsequent mortality among the tagged fish left us short of our target. The water temperature at the release sites ranged from 8.0 to 8.4 degrees Celsius.

Table 3. Bulk marking summary statistics. Total number of fish marked (N), mean fork length (FL), mean weight, start date of marking, end date of marking, total mortalities, mortality percentage, total shed tags, and shed tag percentage. For the "Bulk Groups", mortalities and tag shed statistics were calculated as the total number mortalities and sheds observed from Date Start through the end of 2023. For all other groups, mortalities and tag shed statistics were calculated as the total number of mortalities and shed observed from Date Start through when the fish were released. HOR denotes head of reservoir.

Basin	Mark Group	N	Mean FL (mm)	Mean Weight (g)	Date Start	Date End	Mort	Mort. %	Sheds	Shed %
McKenzie	Cougar HOR fry	5,626	67.7	3.5	6/20/2023	6/20/2023	475	8.4	44	0.78
	Fall 23 & Spring 24 Bulk Group	36,001	NA	NA	8/30/2023	9/8/2023	987	2.74	60	0.17
Middle Fork Willamette	Lookout Point HOR fry	10,041	63.1	2.9	5/22/2023	5/24/2023	39	0.39	53	0.53
	Hills Creek HOR fry	10,117	64.7	2.9	5/30/2023	6/1/2023	22	0.22	9	0.09
	Fall Creek HOR fry	10,040	67.4	3.2	6/1/2023	6/7/2023	68	0.68	30	0.3
	Fall 23 & Spring 24 Bulk Group	85,233	NA	NA	7/26/2023	12/7/2023	380	0.45	340	0.4
South Santiam	Green Peter HOR - Middle Santiam Arm fry	5,071	56.2	NA	5/15/2023	5/16/2023	74	1.46	32	0.63
	Green Peter HOR - Quartzville Creek Arm fry	5,203	58.5	NA	5/17/2023	5/18/2023	18	0.35	19	0.37
	Fall 23 &Spring 2024 Bulk Group	43,407	NA	NA	8/14/2023	12/20/2023	128	0.29	101	0.23
North Santiam	Detroit HOR Breitenbush Arm fry	7,530	66.9	3.6	6/13/2023	6/14/2023	82	1.09	24	0.32
	Detroit HOR - North Santiam Arm fry	7,528	66.9	3.6	6/14/2023	6/15/2023	83	1.1	25	0.32
	Fall 23 & Spring 24 Bulk Group	30,680	67.3	3.5	6/26/2023	7/20/2023	3,437	10.6	99	0.32

Table 4. Releases of PIT-tagged juvenile Chinook salmon arranged by basin and release date.

Basin	Release Location	Release Date	Fish	Mean FL (mm)	Mean Weight (g)	Release Temp (C)
McKenzie	Cougar Head of Reservoir - Cougar Crossing Bridge	8/29/2023	5200	NA	NA	10.1
	Cougar Head of Reservoir - Cougar Crossing Bridge	10/2/2023	5006	117.2	18.9	8.3
	Cougar Head of Reservoir - Cougar Crossing Bridge	10/2/2023	3006	116.7	19	8.7
	Cougar Head of Reservoir - Cougar Crossing Bridge	10/18/2023	3979	118.4	19.8	8
	Cougar Forebay	10/18/2023	5010	120.8	21	15.4
	Cougar Tailrace - USGS	10/19/2023	3997	112.5	16.8	10.5
	Cougar Head of Reservoir - Cougar Crossing Bridge	11/13/2023	3999	121.3	23	8
	Cougar Forebay	11/14/2023	4995	124.6	23.8	8.1

Basin	Release Location	Release Date	Fish	Mean FL (mm)	Mean Weight (g)	Release Temp (C)
	Cougar Tailrace - USGS	11/15/2023	2412	120.1	21.5	8.4
Middle Fork Willamette	LOP Head of Reservoir - Black Canyon	5/30/2023	9647	63.1	2.9	13.2
	Hills Creek Head of Reservoir	6/5/2023	9784	64.7	2.8	11.4
	Fall Creek Head of Reservoir - Old Boat Ramp	6/12/2023	9649	67.4	3.2	19
	LOP Head of Reservoir - Black Canyon	9/18/2023	4998	122.9	23.8	20.9
	LOP Forebay - Signal Point	9/18/2023	5002	128.3	25.1	13.6
	LOP Tailrace - Pengra	9/19/2023	2011	128.4	25.2	19.3
	Fall Creek Head of Reservoir - Old Boat Ramp	9/28/2023	5006	133.5	29.1	13.8
	Fall Creek Tailrace	9/28/2023	1001	134.8	29.8	18.3
	Fall Creek Head of Reservoir - Old Boat Ramp	11/6/2023	5000	139.4	32.2	10.8
	Fall Creek Tailrace	11/6/2023	1000	134.9	30.2	11.3
	Hills Creek Head of Reservoir	11/7/2023	5000	135.2	28.6	8.7
	Hills Creek Mid Reservoir - Packard Creek Boat Ramp	11/8/2023	4999	145.3	36.9	14.3
	Hills Creek Dam Tailrace	11/9/2023	2999	129.4	26.9	12.5
South Santiam	Green Peter Head of Reservoir - Quartzville Creek Arm	5/22/2023	5171	58.5	NA	18.3
	Green Peter Head of Reservoir - Middle Santiam Arm	5/22/2023	4961	56.2	NA	18
	Foster Tailrace - South Santiam Hatchery	8/23/2023	1030	115.7	18.2	10
	Foster Reservoir Head of Reservoir - Cascadia Covered Bridge	8/24/2023	2059	105.6	14.5	15.3
	Green Peter Head of Reservoir - Quartzville Creek Arm	9/20/2023	2518	113.5	19.5	14.8
	Green Peter Head of Reservoir - Middle Santiam Arm	9/21/2023	2508	117.1	20.7	12.5
	Green Peter Head of Reservoir - Quartzville Creek Arm	10/3/2023	2502	122.8	25.1	12.5
	Green Peter Head of Reservoir - Middle Santiam Arm	10/4/2023	2516	119.6	23.8	13.3
	Green Peter Tailrace - Sunnyside Boat Ramp	10/9/2023	4002	125.9	26.4	18.1
	Foster Reservoir Head of Reservoir - Cascadia Covered Bridge	10/10/2023	5000	125.8	24.5	13.2
	Foster Tailrace - South Santiam Hatchery	10/11/2023	4000	135.2	31.8	12
North Santiam	Marion Forks Hatchery Escape	6/16/2023	1247	NA	NA	NA
	Detroit Head of Reservoir - Breitenbush River	7/13/2023	7000	66.9	3.6	12.5
	Detroit Head of Reservoir - North Santiam River	7/13/2023	6638	66.9	3.6	13
	Detroit Head of Reservoir - Breitenbush River	9/26/2023	5002	106.5	11.8	10.5
	Detroit Head of Reservoir - North Santiam River	9/26/2023	4997	102.6	10.4	10.3
	Big Cliff Tailrace - Packsaddle Boat Ramp	9/27/2023	8009	106.5	11.9	12.7

Basin	Release Location	Release Date	Fish	Mean FL (mm)	Mean Weight (g)	Release Temp (C)
	Big Cliff Tailrace - Packsaddle Boat Ramp	11/20/2023	5998	112.4	16.6	10.5

Middle Fork Willamette

The objective in the Middle Fork Willamette basin was to PIT tag and release a total of 67,000 brood year 2022 Middle Fork Willamette stock (22H) sub-yearling juvenile Chinook salmon during 2023 (Table 2). We released 66,096 tagged sub-yearling Chinook salmon in 2023, representing 98.6% of the objective total (Table 4). In addition to the fish that were tagged and released, we also tagged the vast majority brood year 2022 fish that are slated to be released as yearlings during the spring of 2023 (48,826 out of 49,000). We observed an estimated mortality rate of 0.44 percent and an estimated tag shed rate of 0.37 percent across all fish tagged in the Middle Fork Willamette in 2023 (Table 3). An overview of the specific releases that occurred in the Middle Fork Willamette basin are detailed below.

Hills Creek Dam

The first release of PIT tagged juvenile Chinook salmon into the Hills Creek Dam project area occurred on May 30, 2023 with the release of 9,784 fish at the head of reservoir (Table 4; Figure 3). This release was intended coincide with the run-or-river fry migration and to help inform how regulating outlet operations at Hills Creek Dam affect downstream movement patterns. The fish had a mean fork length of 67 millimeters, a mean weight of three grams, and were released into water that was approximately 11.4 degrees Celsius.

The next set of PIT tagged juvenile Chinook salmon releases were intended to target fall and winter regulating outlet operations at Hills Creek Dam. These releases took place over three days between November 7, 2023 and November 9, 2023. We released 5,000 fish at the head of reservoir (mean FL = 133 mm), 4,999 at mid-reservoir (mean FL = 145 mm), and 2,999 into the Hills Creek Dam tailrace (mean FL = 129 mm). The water temperature into which the fish were released was measured to be 8.7, 14.3, and 12.5 degrees Celsius at the head of reservoir, mid-reservoir, and tailrace, respectively.

Lookout Point and Dexter Dams

The first release of PIT tagged juvenile Chinook salmon into the Lookout Point Dam project area occurred on May 30, 2023 with the release of 9,647 fish at the head of reservoir (Table 4; Figure 2). This release was intended to target spring spill operations at Lookout Point Dam. These fish had a mean fork length of 63 millimeters, a mean weight of three grams, and were released into water that was 13.2 degrees Celsius.

The next set of PIT tagged juvenile Chinook salmon releases were intended to target the fall deep drawdown of Lookout Point Reservoir. These releases took place on September 18th and September 19th, 2023. We released a total of 4,998 fish into the head of reservoir, 5,002 fish into the forebay, and 2,011 fish into Dexter Dam's tailrace. The mean fork length of fish released at head of reservoir (123 mm) was slightly smaller than that the fork length of the fish released into the forebay (128 mm) and the tailrace of Dexter (128 mm). Similarly, fish released at the head of reservoir were on average two grams lighter than those released at the forebay and tailrace. Release location temperatures were 20.9, 13.6, and 19.3 degrees Celsius at the head of reservoir, forebay, and tailrace, respectively.

Fall Creek Dam

The first release of PIT tagged juvenile Chinook salmon into the Fall Creek Dam project area took place on June 12, 2023 with the release of 9,649 fish at the head of reservoir (Table 4; Figure 2). Our objective was to release these fish prior to the forebay water elevation reaching 728 feet above mean sea level. Forebay elevation was approximately 750 feet above mean sea level on the day of release. Fish had a mean length of 67 millimeters and a mean weight of three grams. The fish were released at the site of the decommissioned boat ramp that is approximately 800 meters downstream of Dolly Varden Campground (location of the historic rotary screw trap), where water temperatures were approximately 19 degrees Celsius.

The next PIT tag releases into the Fall Creek occurred in the fall and were intended to target the fall deep drawdown of Fall Creek Reservoir. The first of the fall releases took place on September 28, 2023, consisting of 5,006 fish released at the head of Fall Creek Reservoir and 1,001 fish released into the Fall Creek Dam tailrace. Those groups of fish had a mean length of 134 millimeters and a mean weight of 29.4 grams. Water temperature at the head of reservoir was 13.8 degrees C while the temperature in the tailrace was nearly five degrees warmer at 18.3 degrees C. The final fall releases designed to evaluate the fall deep drawdown took place on November 6th, 2023. Once again, 5,000 fish were released at the head of Fall Creek reservoir and 1000 fish were released into the Fall Creek Dam tailrace. These fish had average fork lengths of 137 millimeters and average weights of 31.1 grams. Release temperatures were cooler than in September with measurements of 10.8 degrees C at the head of reservoir and 11.3 degrees C in the tailrace.

South Santiam

The objective in the South Santiam River basin was to PIT tag and release a total of 36,000 brood year 2022 South Santiam stock (24H) sub-yearling juvenile Chinook salmon during 2023 (Table 2). We released 36,267 PIT tagged sub-yearling Chinook salmon in 2023, slightly exceeding the objective total (Table 4). In addition to the fish that were tagged and released, we also tagged the vast majority brood year 2022 fish that are slated to be released as yearlings during the spring of 2023 (17,414 out of 19,000). We observed an estimated mortality rate of 0.41 percent and an estimated tag shed rate of 0.28 percent across all fish tagged for the South Santiam basin in 2023. An overview of the specific releases that occurred in the South Santiam basin are detailed below.

Green Peter Dam

The first release of PIT tagged juvenile Chinook salmon into the Green Peter Dam project area took place on May 22, 2023 with the release of a total of 10,132 fish into the head of reservoir. This release was split between the Quartzville Creek arm (n = 5,171) and the Middle Santiam arm (n = 4,961) of Green Peter Reservoir (Table 4; Figure 5). This release was intended to target surface spill operations at Green Peter Dam. Both groups of fish had a mean fork length of 58 millimeters. Weights are not presented for these release groups because the small size of the fish resulted in unreliable weight estimates. Water temperature at the release sites averaged 18 degrees Celsius.

The next release of PIT tagged juvenile Chinook salmon took place on September 20 and September 21, 2023. We once again released at the head of reservoir, this time a group of 5,026 split between the Quartzville and Middle Santiam arms. This release group was intended to target the beginning of the fall deep drawdown of Green Peter Reservoir. Fish released into the Quartzville Creek arm (n = 2,518) had a mean fork length of 114 millimeters and a mean weight of 20 grams while the group of fish released into the Middle Santiam (n = 2,508) had a mean fork length of 117 millimeters and mean weight of 21 grams. Release temperature was slightly warmer in Quartzville Creek arm at 14.8 degrees Celsius versus 12.5 degrees in the Middle Santiam arm.

The final release of PIT tagged juveniles targeting the Green Peter Dam project occurred on October 3, October 4, and October 9, 2023. The first two releases were once again at the head of reservoir, while the last release was into the Green Peter tailrace. These groups were intended to target conditions experienced by fish midway through the fall deep drawdown of Green Peter Reservoir. Once again, we split the head of reservoir release between the Quartzville Creek arm (n = 2,502) and the Middle Santiam arm (n = 2,516). The Quartzville Creek group had a mean fork length of 123 millimeters, a mean weight of 25 grams, and were released into water that was 12.5 degrees Celsius. The Middle Santiam group had a mean fork length of 120 millimeters, a mean weight of 24 grams, and were released into water that was 13.3 degrees Celsius. A total of 4,002 PIT tagged fish with a mean fork length of 126 millimeters and a mean weight of 26 grams were released into the Green Peter Tailrace where water temperatures 18.1 degree Celsius.

Foster Dam

The first release of PIT tagged juvenile Chinook salmon into the Foster Dam project area took place on August 23, and August 24, 2023 with the release of 1,030 fish into the Foster Dam tailrace and 2,059 fish into the head of Foster Reservoir (Table 4; Figure 5). These releases aimed to assess fish response to the initiation of fall drafting of the reservoir. The fish that were released into the tailrace had an average fork length and weight of 116 millimeters and 18 grams, while the fish released at head of reservoir had an average fork length of 106 millimeters and 15 grams. Release water temperatures were measured to be 10 degrees and 15.3 degrees Celsius in the tailrace and at the head of reservoir, respectively.

The final release of PIT tagged fish into the Foster Dam project occurred on October 10 and October 11, 2023. This release was designed to target fall dam operations (nighttime spillway operations) at the Foster project. Once again, we released at the head of reservoir (n = 5,000) and into the tailrace (n = 4,000). The average fork length of fish released at the head of reservoir was 126 millimeters and the average weight was 26 grams. The group of fish released into the tailrace had an average length of 135 millimeters and an average weight of 32 grams.

North Santiam River

The objective in the North Santiam River basin was to PIT tag and release a total of 39,000 brood year 2022 North Santiam stock (21H) sub-yearling juvenile Chinook salmon during 2023 (Table 2). We released 38,891 PIT tagged sub-yearling Chinook salmon in 2023, representing 99.7 percent of the objective target (Table 4). In addition to the fish that were tagged and released, we also tagged all of the brood year 2022 juveniles that are slated to be released as yearlings in the spring of 2024. We observed an estimated mortality rate of 7.5 percent and an estimated tag shed rate of 0.32 percent across all fish tagged for the North Santiam basin in 2023.

The alarming mortality rate was due to an outbreak of furunculosis at Marion Forks Hatchery. We began tagging fish for fall releases in late June of 2023. During the week of June 26, 2023, a total of 15,195 Chinook salmon were PIT tagged and adipose clipped by Cramer Fish Sciences staff. The tagged fish were held for recovery in indoor troughs for 2 days without feeding. On the 3rd day, they were transferred to an outdoor pond, C-10, where they were to rear until their release in the fall of 2023 or spring of 2024. Feeding resumed once they were ponded. Water temperatures were closely monitored during tagging and recorded hourly, with a maximum observed temperature of 15.2 degrees Celsius. Of the 15,195 Chinook salmon tagged, there were a total of 2,809 mortalities (approximately 18 percent) when hatchery staff arrived at work on July 3, 2023. Fearing that we might have inadvertently brought a pathogen from Leaburg, we immediately halted operations, contacted state pathology (Dr. Sarah Bjork), and disinfected all our equipment. On July 5, 2023, Dr. Sarah Bjork, ODFW Fish Health Specialist, visited Marion Forks Hatchery to examine the mortalities and take samples for culturing. Her initial suspicion was confirmed on July 7, 2023, when bacteria cultures revealed the presence of furunculosis, a pathogen previously found at Marion Forks Hatchery that typically emerges at around 12-14 degrees Celsius. Dr. Bjork recommended medicated feed for the fish. Once treated, mortality rates returned to normal and we were able to resume tagging. We estimate that the furunculosis outbreak led to well over 3,000 mortalities.

Detroit and Big Cliff Dams

The first release of PIT tagged juvenile Chinook salmon into the Detroit-Big Cliff project area took place on July 13, 2023 with the release of a total of 13,638 fish at the head of Detroit Reservoir (Table 4; Figure 4). The original size of the release group was intended to be approximately 15,000 fish; however, we estimate that 1,247 escaped their indoor holding troughs, presumably into the effluent. The effluent from the holding troughs drains to Horn Creek approximately 100 meters upstream of the confluence with the North Santiam River around river kilometer 121. We cannot be certain of when these fish escaped into the North Santiam but we know that it had to be between June 15th (completion of tagging) and July 13th. This group of fish had an intended release target of any time prior to the start of Detroit Reservoir refill in the spring, however, due to the project's late start, that release window was missed. Furthermore, we had intended to release this group of fish on July 3, 2023 but had to hold them under observation due to the outbreak of furunculosis. The eventual release of 13,638 fish on July 13th was split between the Breitenbush River (n = 7,000) and the North Santiam River (n = 6,638). These fish all had average fork lengths of 67 millimeters and average weights of 3.6 grams.

The next release of PIT tagged juvenile Chinook salmon took place between September 26th and September 27th, 2023. The intended release target was prior to Detroit Reservoir reaching a forebay elevation of 1520 feet, we missed this target by six days for the head of reservoir releases (1515 feet) and by seven days for tailrace release (1514.5 feet). We released 5,002 tagged fish into the Breitenbush River (mean FL = 107 mm; mean weight = 12 g), 4,997 into the North Santiam River (mean FL = 103 mm; mean weight = 10 g), and 8,009 into the tailrace of Big Cliff Dam (mean FL = 107 mm; mean weight = 12 g). Water temperatures at the release point were 10.5, 10.3, and 12.7 degrees Celsius at the Breitenbush, North Santiam, and Big Cliff tailrace, respectively.

The final release of PIT tagged fish into the greater Detroit-Big Cliff project area occurred on November 20, 2023 with the release of 5,998 fish into Big Cliff Dam's tailrace. The intended release target for this group was when Detroit Reservoir forebay elevation reached 1465 feet above mean sea level. Detroit's forebay was at approximately 1478 feet on the day of release and would be at 1465 feet by November 26th, 2023. This group of fish had a mean fork length of 112 millimeters and a mean weight of 17 grams. Water temperature at the release point was 10.5 degrees Celsius.

Recaptures

A total of 2,777 PIT tagged fish were recaptured or redetected during 2023 (Table 5). The most significant number of detections, 1,629 occurred at CGR - Cougar Dam and were recaptured via rotary screw trap. Other notable detection counts include 434 at FAL - Fall Creek Dam, and 227 at HCR - Hills Creek Dam, and 24 at NSANTR – North Santiam River via a screw trap operated in the Stayton Power Canal by the Oregon Department of Fish and Wildlife. The PIT tag antennas at Lebanon Dam (LD1, LD2, LD3, and LD4), on the South Santiam River, collectively accounted for 203 detections. A total of 19 PIT tagged fish were observed passing the pile dike array PD7 in the Columbia River Estuary at river kilometer 70. There were no detections at any of the other pile dike arrays, or from the PIT trawl, reported to PTAGIS in 2023. Pile dike arrays PD5, PD6, and PD8 were operational from late March through early October of 2023, whereas PD7 operations continued through the end of the year. All detections on pile dike array PD7 took place after PD5, PD6, and PD8 were offline. Table 5 presents a comprehensive analysis of PIT tag redetections across various observation locations and capture methods. Figure 7 illustrates the location of each observation location.

Table 5. PIT tag recoveries by release basin, observation location, and detection method.

Basin	Observation Location	Detection Method	Detections
MCK	CGR - Cougar Dam	Screw Trap	1,629
MCK	MCKESF - South Fork McKenzie River	Screw Trap	133
MCK	PD7 - Columbia River Estuary rkm 70	Passive	2
MFW	HCR - Hills Creek Dam, Middle Fork Willamette River	Screw Trap	227
MFW	LOP - Lookout Point Dam (USACE), MF Willamette River	Fyke Net	1
MFW	LOP - Lookout Point Dam (USACE), MF Willamette River	Gillnet Fishery or Research	6
MFW	LOP - Lookout Point Dam (USACE), MF Willamette River	Screw Trap	38
MFW	DEX - Dexter Dam (USACE), Middle Fork Willamette River	Screw Trap	20
MFW	FAL - Fall Creek Dam (USACE), MF Willamette River	Screw Trap	434
MFW	WILRMF - Middle Fork Willamette River	Screw Trap	1

MFW	PD7 - Columbia River Estuary rkm 70	Passive	5
SST	GPD - Green Peter Dam	Screw Trap	33
SST	LD1 - Lebanon Dam South Ladder	Passive	48
SST	LD2 - Lebanon Dam North Ladder	Passive	47
SST	LD3 - Lebanon Dam Diversion Bypass	Passive	85
SST	LD4 - Lebanon Dam Spillway	Passive	23
SST	PD7 - Columbia River Estuary rkm 70	Passive	6
NST	BCL - Big Cliff Dam - North Santiam River	Screw Trap	6
NST	NSANTR - North Santiam River, Oregon	Bypass Sub-Sample	24
NST	NSANTR - North Santiam River, Oregon	Screw Trap	3
NST	PD7 - Columbia River Estuary rkm 70	Passive	6

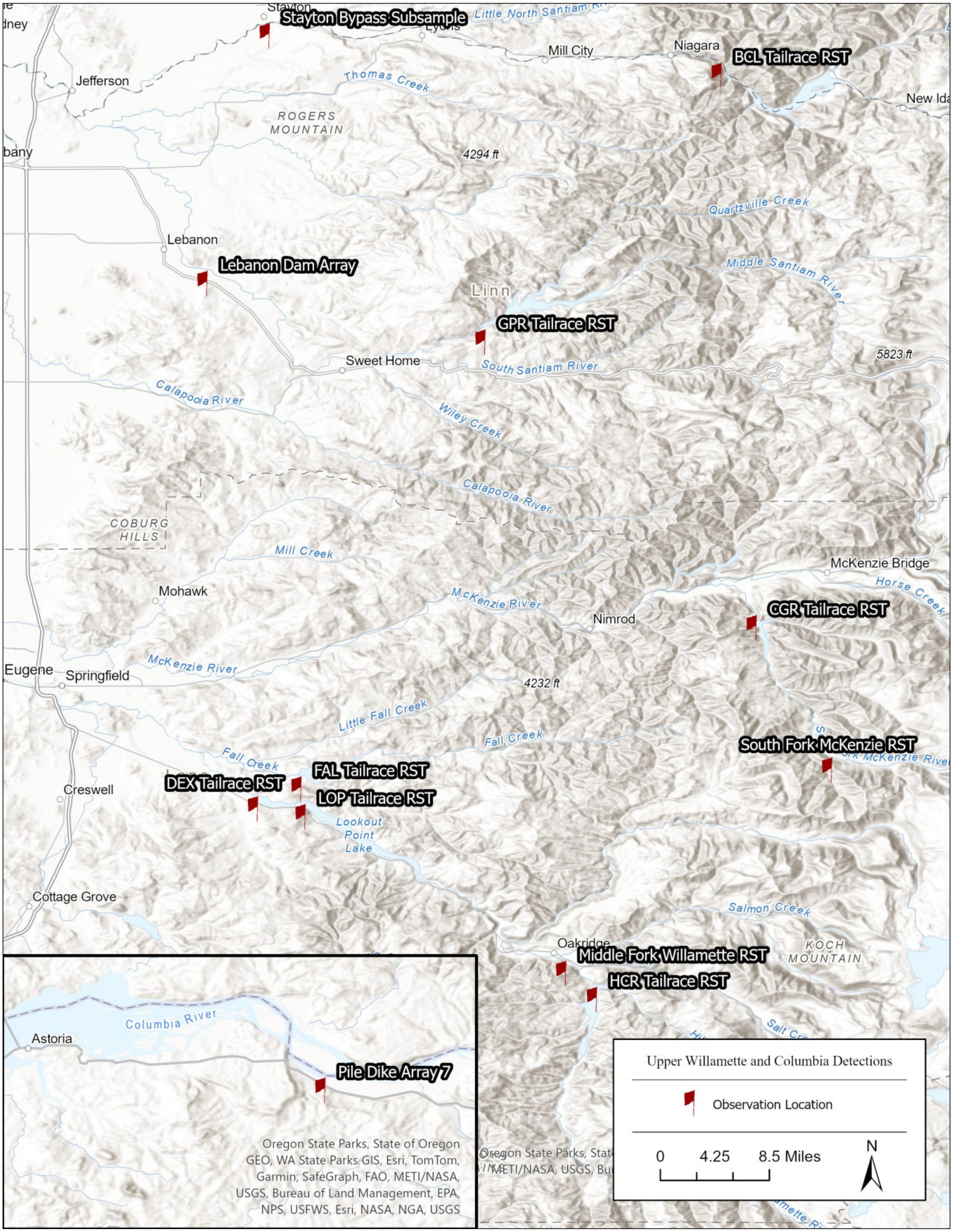


Figure 7. PIT tag redetection locations.

We calculated travel time and travel rate for all migration pathways (e.g., release at Cougar Forebay and recapture at Cougar tailrace) that were observed during 2023. All recapture travel times and travel rates are presented in Table 6 and Table 7, respectively. The following section presents data from all release groups that had subsequent recaptures or observations downstream of the release location. Specific details pertaining to fish captured in Lookout Point Reservoir can be found in the Reservoir Distribution Studies section of this report. Specific details pertaining to fish captured in the various screw trap locations can be found in the reports titled: Willamette Valley Fish Passage Monitoring via Rotary Screw Traps (EAS 2024a) and Downstream Juvenile Fish Passage Monitoring via Rotary Screw Traps (EAS 2024b).

South Fork McKenzie - Cougar

In the South Fork McKenzie basin, the travel time and rate data reveal distinct differences between migration pathways. All releases of PIT tagged fish in this basin were subyearlings. The first release in this basin took place at the head of Cougar reservoir on August 29, 2023 (n = 5,200; Table 4). At time of release, the reservoir was slowly drafting and all flow was being directed through the powerhouse (Figure 8). A total of 26 fish from that release group were recaptured in the rotary screw traps that operate in the Cougar Dam tailrace. These fish had mean and median travel times from release to recapture of 69 and 66 days, respectively (Table 6). Additionally, the 25th percentile of travel times for those fish was 61.5 days indicating that only 25 percent of the fish passed the dam within 61.5 days or less. These travel times suggest that the majority of the release group did not pass Cougar Dam until late October when spill operations were well underway and the forebay elevation was near the drawdown target.

The next release in the South Fork McKenzie basin occurred on October 2, 2023 at the head of reservoir (n = 8,012; Table 4). This release coincided with the beginning of the fall drawdown, which began on October 1, 2023 and reached the target forebay elevation of approximately 1505 feet November 3, 2023. Cougar reservoir would remain at that elevation until December 4, 2023 when it began to refill. All flow was directed through the regulating outlet during the fall drawdown (Figure 8). A total of 446 fish from this release group were recaptured in Cougar Dam tailrace. These fish exhibited mean and median travel times from release to the tailrace of 28.5 and 28.9 days, respectively. These travel times are roughly 30 days shorter than what was experienced by first group of fish that was released on August 29th, suggesting that while the two groups were released one month apart, the majority of them passed Cougar Dam during the drawdown. In addition to the fish recaptured in the tailrace, a single fish from this release group was observed in the Columbia River at pile dike array PD7 (travel time: 47.8 days).

The subsequent releases took place on October 18, 2023, during the drafting of the reservoir to its drawdown elevation target, as illustrated in Figure 7. Two distinct groups were released: one at the head of the reservoir (n = 3,979) and another at the forebay of Cougar Dam (n = 5,010; refer to Table 3). The travel times for both of these groups exhibited similarities. For fish released at the Cougar Head of Reservoir and recaptured at the Tailrace (n = 185), the mean and median travel times were 15.2 days and 14.0 days, respectively. Correspondingly, for the fish released at Cougar Forebay and recaptured at the Tailrace (n = 400), the mean and median travel times were 13.2 days and 12.8 days. These findings indicate that, on average, the fish released at the head of the reservoir experienced a delay of only a couple of days relative to those released at the forebay. This trend further reinforces the observation that the bulk of these fish passed Cougar Dam when the forebay elevation was nearing its targeted drawdown level. Of note, a single fish from the Forebay release group was later observed at the Columbia River pile dike array PD7 (travel time: 32.1 days).

The final releases occurred on November 13, 2023, at the head of the reservoir (n = 3,999), and on November 14, 2023, at the forebay (n = 4,995; refer to Table 4). These releases happened while the reservoir was maintained at the full fall drawdown level, as depicted in Figure 8. During this period, the travel times for each migration pathway diverged drastically. The fish released at the Cougar Head of Reservoir and recaptured at the Tailrace had mean and median travel times of 16.1 and 11.0 days, respectively. In contrast, the fish released at the Cougar Forebay and recaptured in the Tailrace recorded much shorter mean and median travel times of 4.6 and 0.9 days, respectively. This discrepancy is further highlighted by the 75th percentile of travel times, where 75 percent of the fish from the Forebay group passed through within just 2.9 days, whereas the Head of Reservoir group took nearly six times longer, with a 75th percentile travel time of 18.1 days. These data points underscore a substantial acceleration in passage times for the group released closer to the dam, at the forebay, compared to those released further upstream, at the head of the reservoir.

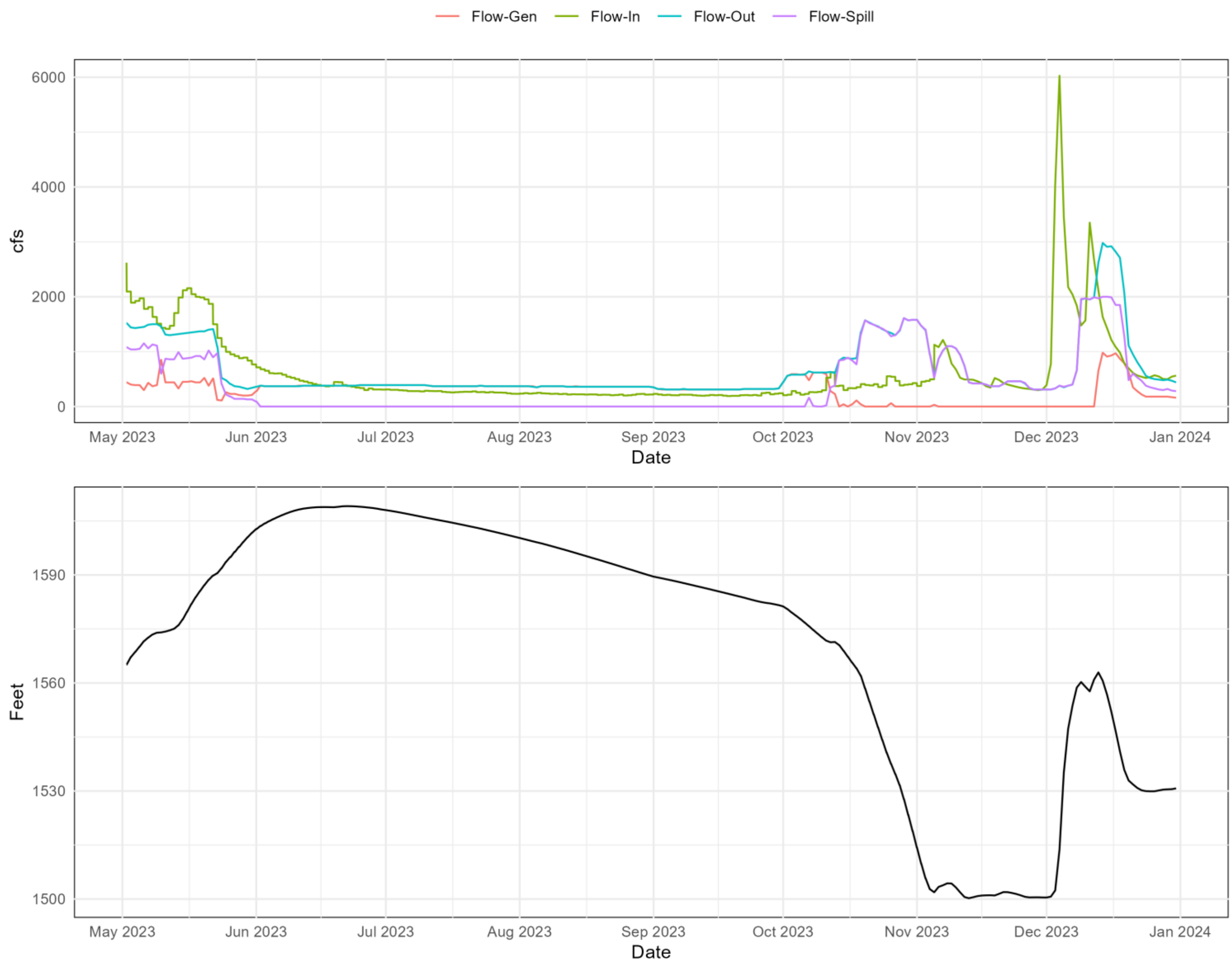


Figure 8. Dam operations at Cougar Dam. Top panel presents flow through the powerhouse (Flow-Gen), flow into the reservoir (Flow-In), flow out of the reservoir (Flow-Out), and flow through the regulating outlet (Flow-Spill). The bottom panel presents the forebay elevation.

Middle Fork Willamette

Hills Creek

The first release at the Hills Creek project area took place on June 5, 2023, with 9,784 PIT-tagged Chinook salmon fry being released at the Head of Reservoir. At this time, the forebay elevation was around 1513 feet, nearing its annual peak. Over the following months, the elevation gradually decreased, entering a period of fall drawdown starting mid-November and lasting into early December, a phase punctuated by a significant rain event that led to reservoir refilling, as outlined in Figure 9. The dam's operations primarily involved consistent flows through the powerhouse, occasionally supplemented by discharges through the regulating outlet. From this cohort, 61 fish were later recaptured via the Hills Creek Tailrace screw traps. The travel times for these fish were extensive, with a mean of 167.8 days and a median even higher at 184.1 days, suggesting a considerable delay in migration. The earliest detection in the tailrace occurred on September 16, 2023, translating to a minimum travel time of 103.1 days from release. This initial detection aligned with an active regulating outlet and a forebay elevation of about 1475 feet. A significant portion of detections—nearly 50%—were clustered between November 9 and December 9, 2023. These dates match the 25th and 75th percentiles for travel times (157.1 and 187.1 days, respectively) and correspond to the timeframe of the fall drawdown operations. In addition to the fish detected at the Hills Creek Tailrace, six fish were detected at the Lookout Point Tailrace screw traps (mean travel time: 188.9 days) and three fish were detected at the Dexter Tailrace screw trap (mean travel time: 184.8 days).

The final releases of fish into the Hills Creek project area were conducted in quick succession on November 7, 8, and 9 of 2023, with 5,000, 4,999, and 2,999 subyearlings released at the Head of Reservoir, Mid-Reservoir, and Tailrace, respectively. Recaptures at the Hills Creek Tailrace included 46 fish from the Head of Reservoir with mean and median travel times of 26.7 and 28.3 days, and 76 fish from the Mid-Reservoir with travel times closely aligning at 25.4 and 27.9 days for mean and median, respectively. For both groups, about 75% were detected within a month's window—between November 11 and December 11—aligning with fall drawdown operations, regulatory outlet flows, and early December's significant rainfall.

A handful of fish from these release groups were also detected at the Lookout Point Tailrace including six fish from the Head of Reservoir group with mean and median travel times of 38.3 and 36.8 days, 15 from the Mid-Reservoir group with slightly swifter mean and median travel times of 35.3 and 35.9 days, and nine from the Tailrace group, which predictably showcased much quicker travel times with a mean of 17.5 and a median of 6.9 days. Further detections were noted at the Dexter Tailrace, with two fish from the Head of Reservoir group averaging 27.3 days, one fish from the Mid-Reservoir group taking 30.9 days, and six from the Tailrace group averaging 15.4 days in travel time. Moreover, a single detection from the Mid-Reservoir release was recorded at the Middle Fork Willamette screw trap, taking 16.9 days, and single detection was recorded at the Columbia River pile dike PD7 array, with a travel time of 53.1 days.

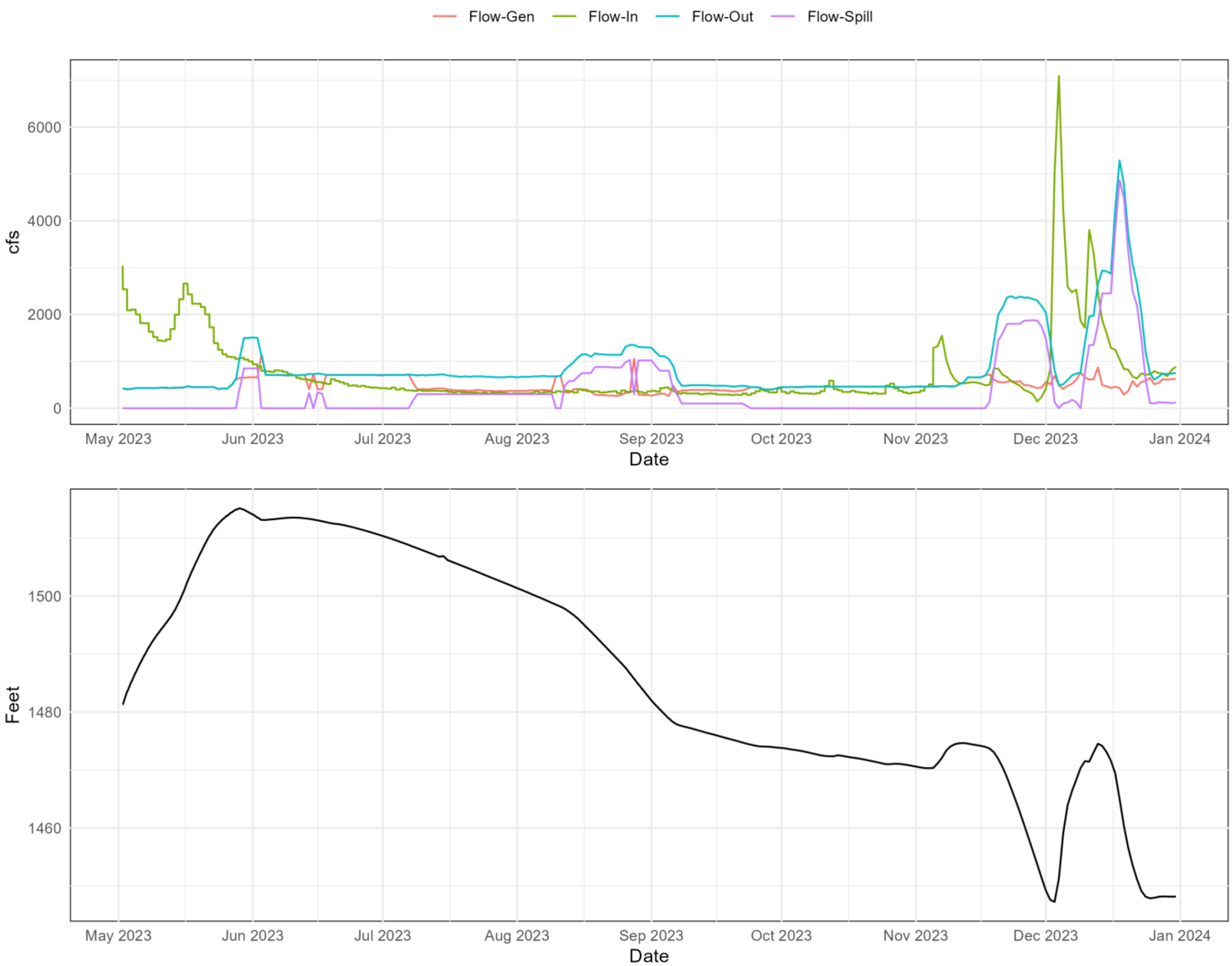


Figure 9. Dam operations at Hills Creek Dam. Top panel presents flow through the powerhouse (Flow-Gen), flow into the reservoir (Flow-In), flow out of the reservoir (Flow-Out), and flow through the regulating outlet (Flow-Spill). The bottom panel presents the forebay elevation.

Lookout Point

The Lookout Point project had its first release of PIT-tagged juvenile Chinook salmon on May 30, 2023, when 9,647 fry were liberated at the Head of Reservoir. The release coincided with a forebay elevation of around 890 feet, just before the commencement of deep drawdown operations in early June. The reservoir level was continuously drafted until early November to achieve the target deep drawdown elevation of approximately 750 feet, a process depicted in Figure 10. The reservoir remained at deep drawdown until early December when heavy rains induced a rapid increase of inflow, elevating the reservoir levels. Dam flows during the study period were initially powerhouse-driven, transitioning to spill gate passage by mid-September and continuing until December 20, when the flows reverted to the powerhouse. Redetections of all fish released in the Lookout Point project area were exceedingly rare. Two out of the 9,647 released fry were redetected. One individual was caught in an Oneida net within Lookout Point Reservoir 82.1 days post-release, and another was captured in the Dexter Tailrace screw trap after 36 days.

The final releases of the year at the Lookout Point project area took place on September 18, 2023, with 4,998 subyearlings at the Head of Reservoir and an additional 5,002 at the Forebay. A single fish from each release site was subsequently found in the Lookout Point Tailrace, with travel times of 88.2 and 86.8 days respectively. In-reservoir research gillnets caught three fish from the Head of Reservoir release and one from the Forebay group, displaying mean travel times of 13.1 and 30.7 days. At Dexter Tailrace, one fish from the Head of Reservoir group was recaptured after 43.2 days, while five from the Forebay group had a mean travel time of 36.0 days. Additionally, the PD7 array in the Columbia River reported a single observation from the Head of Reservoir release at 35.4 days post-release.

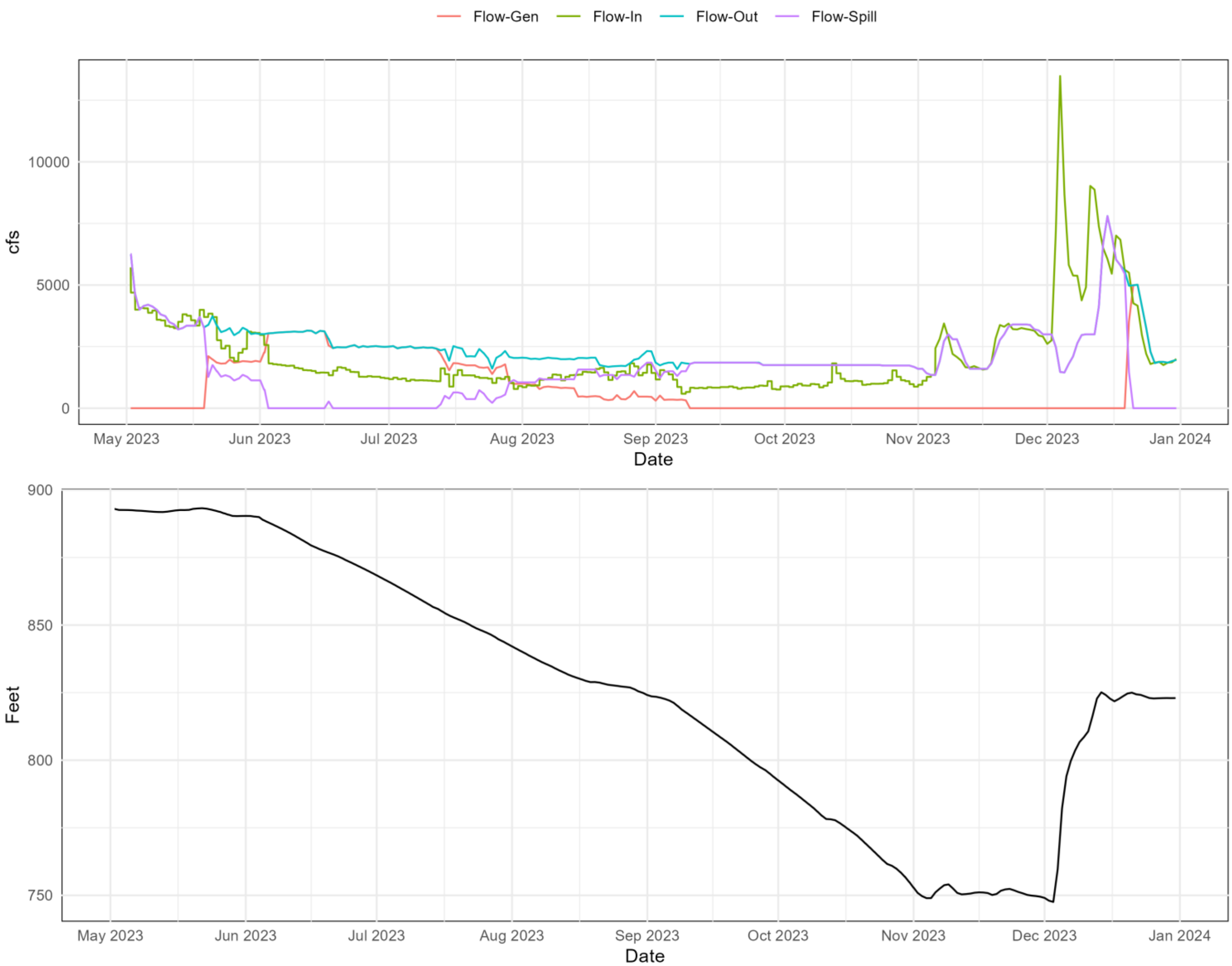


Figure 10. Dam operations at Lookout Point Dam. Top panel presents flow through the powerhouse (Flow-Gen), flow into the reservoir (Flow-In), flow out of the reservoir (Flow-Out), and flow through the spill gates (Flow-Spill). The bottom panel presents the forebay elevation.

Fall Creek

The first release in the Fall Creek sub-basin took place on June 12, 2023, when 9,649 PIT tagged Chinook salmon fry were introduced at the head of Fall Creek Reservoir. During this time, the forebay elevation at Fall Creek Dam had reached approximately 750 feet, marking the peak for the year, as illustrated in Figure 8. Subsequent recapture data indicated that 13 of these released fish were later found in the Fall Creek Tailrace. The travel times for these fish were notably prolonged, with a mean of 130.5 days and a median of 128.9 days to recapture, as recorded in Table 6. The earliest recorded recapture took place on October 18, 2023, which corresponds to a minimum travel time of 127.9 days post-release. The commencement of the first fall drawdown began on October 16, when the outflow from the dam increased sharply, from about 61 cubic feet per second (cfs) to in excess of 2,400 cfs by October 18. This transition initiated a rapid descent of the reservoir's level from approximately 741 feet to approximately 691 feet, which concluded by October 22. It is noteworthy that during this swift drawdown phase, 12 out of the 13 recaptured fish were detected between October 18 and October 21, implying a correlation between the drawdown operations and the passage of fish through Fall Creek Dam.

The subsequent release in the Fall Creek sub-basin was conducted on September 18, 2023, when 5,006 PIT-tagged subyearling Chinook salmon were introduced at the head of Fall Creek Reservoir. Of this cohort, 142 individuals were later recaptured in the Fall Creek Tailrace, demonstrating notably quicker travel times in comparison to the earlier release. The recaptured fish had a mean travel time of 24.4 days and a median of 20.9 days, as reported in Table 6. The initial recapture occurred on October 18th, corresponding to the shortest travel time of 19.9 days. Similar to the previous release group, a significant portion of the recaptures, numbering 113 fish, coincided with the rapid drawdown of the reservoir, which spanned from October 18th to 20th, providing more evidence of fish exiting the reservoir during drawdown operations. In addition to the fish that were recaptured in the tailrace, two fish from this release group were observed at the Columbia River pile dike PD7 array (mean travel time: 28.9 days).

The final release in the Fall Creek sub-basin occurred on November 6, 2023, with the introduction of 5,000 PIT-tagged subyearling Chinook salmon into the head of Fall Creek Reservoir. A large number of recaptures (n = 279) indicated much shorter travel times than the previous release groups, with a mean of 1.8 days and a median identical to the mean, suggesting a rapid movement from release, through the reservoir, and through Fall Creek Dam. All recaptured fish had navigated through Fall Creek Dam within six days of their release. There are a couple of factors that may have driven the rapid movement of these fish through the Fall Creek project area. First, the reservoir elevation was at fall deep drawdown levels providing a more direct route for the fish to follow and easier access to passage routes once at the face of the dam. Second, a large increase in inflow to the reservoir coincided with this release, which would have provided a stronger current to expedite their way downstream.

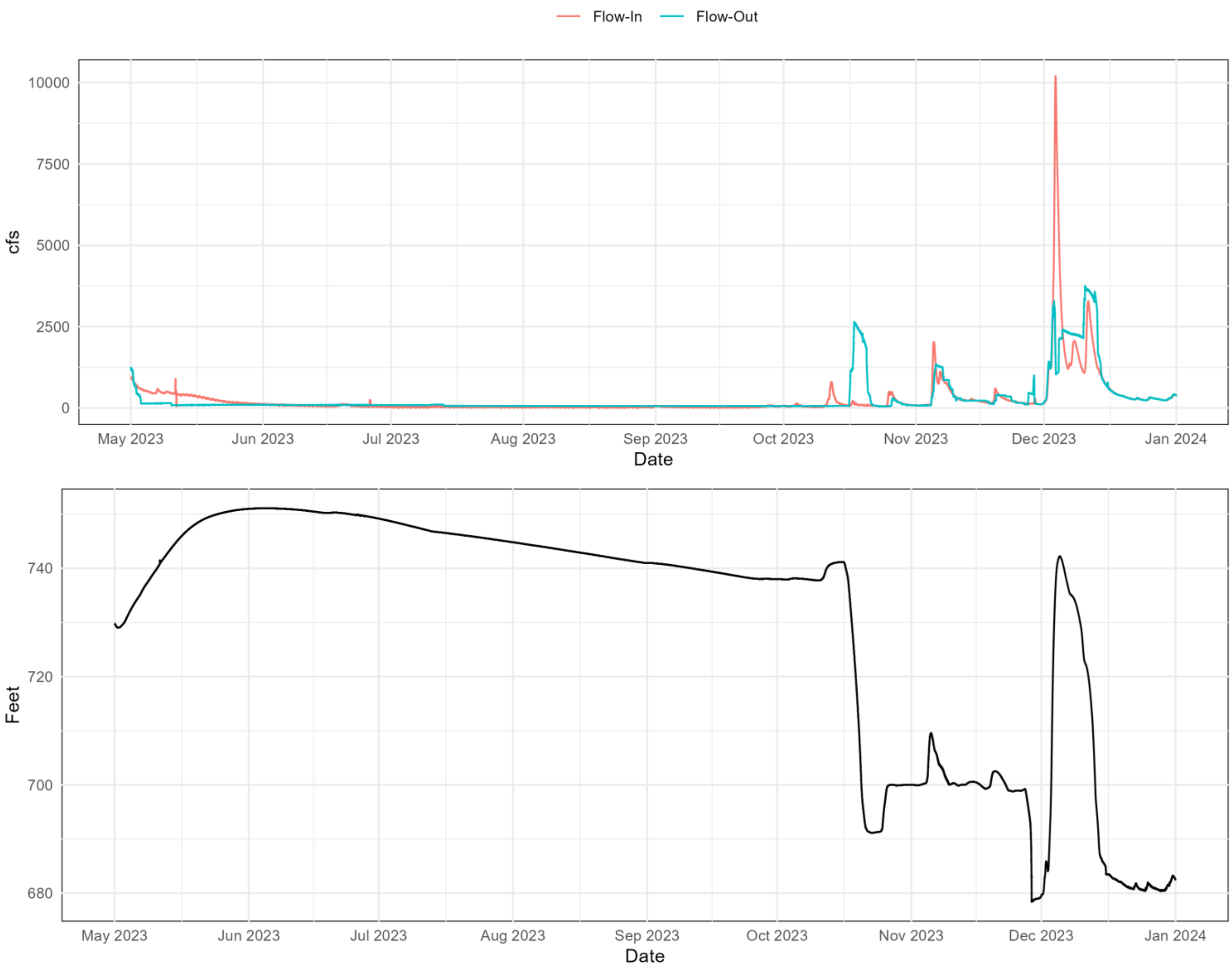


Figure 11. Dam operations at Fall Creek Dam. Top panel presents flow into the reservoir (Flow-In) and flow out of the reservoir (Flow-Out). The bottom panel presents the forebay elevation.

South Santiam

Green Peter

The initial release in the Green Peter project area was on May 22, 2023, with 10,132 fry distributed between the Quartzville Creek (n = 5,171) and Middle Santiam (n = 4,961) arms at the Head of Reservoir. The forebay elevation at release was approximately 1,008 feet, the highest it would be for the remainder of the year. The reservoir underwent steady drafting until late September when fall deep drawdown operations aiming for a target forebay elevation of 780 feet began. The reservoir was quickly drafted from that point and the target forebay elevation was achieved by early November. Dam operations during the study period included a spring spill block from April 10 to June 6, transitioning to powerhouse flow until October 6, when flow shifted back to the spill gates for the deep drawdown, as shown in Figure 12. Of the released fry, only one was detected downstream in the Green Peter Dam Tailrace screw trap 5.7 days after release.

Further releases occurred on September 20 and 21, 2023, with 5,026 subyearlings released at the Head of Reservoir, just before the fall deep drawdown operations. Sixteen of these fish were later detected downstream, with 11 from the Middle Santiam release group recaptured in the Green Peter tailrace screw trap with mean and median travel times of 20.6 and 12.9 days, respectively. Five were observed at the Lebanon Dam PIT tag array, with mean and median travel times of 63.0 and 59.3 days.

The final releases at the Head of Green Peter Reservoir on October 3 and 4, 2023, introduced 5,018 subyearlings. These fish were released just prior to the beginning of spill operations at Green Peter Dam. Twenty-one were recaptured in the Green Peter Tailrace, with 11 from Quartzville Creek showing mean and median travel times of 22.6 and 27.0 days, and ten from Middle Santiam having slightly shorter times of 20.5 and 22.4 days. Additionally, 12 detections at the Lebanon Dam PIT tag array included eight from Quartzville Creek (mean and median travel times of 34 and 32.6 days) and four from Middle Santiam (28.5 and 29.1 days). One fish from the Middle Santiam group was detected at the Columbia River pile dike array PD7 33.0 days after release.

On October 9, 2023, an additional 4,002 subyearlings were released into the Green Peter Dam Tailrace. This release coincided with spill operations at Foster Dam (see Figure 13). Forty-eight were observed passing the Lebanon Dam PIT tag array, with mean and median travel times of 35.0 and 32.2 days. Two fish from this group were detected passing the PD7 array in the Columbia River 15 days post-release. This surprisingly fast travel time is equivalent to 24 kilometers per day from release to detection.

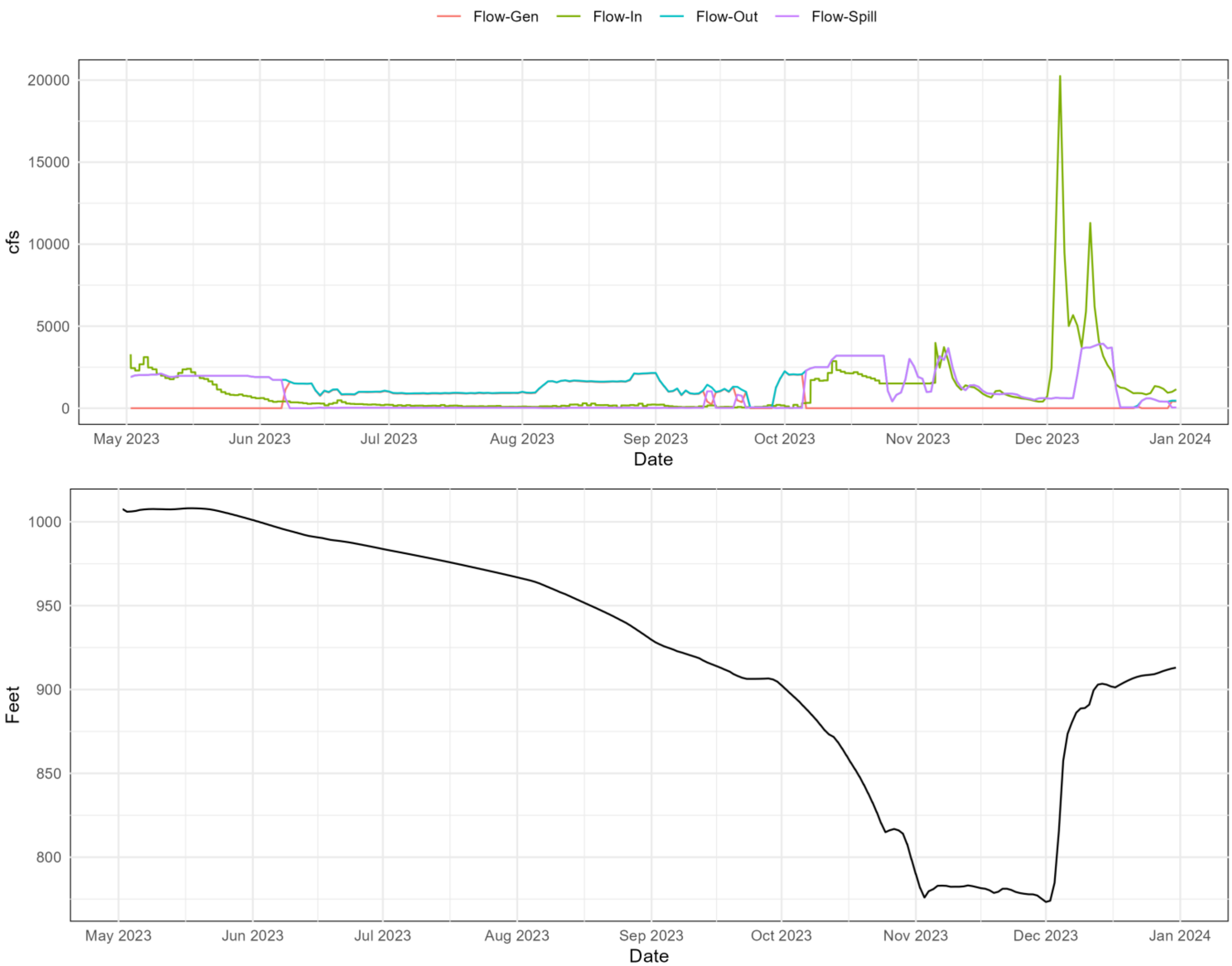


Figure 12. Dam operations at Green Peter Dam. Top panel presents flow through the powerhouse (Flow-Gen), flow into the reservoir (Flow-In), flow out of the reservoir (Flow-Out), and flow through the spill gates (Flow-Spill). The bottom panel presents the forebay elevation.

Foster

The first group of fish released in the Foster Dam project area took place on August 22, 2023 and August 23, 2023 with introduction of 1,030 subyearling Chinook salmon into Foster Dam Tailrace and 2,059 into the Head of Reservoir. At this time, the forebay elevation was approximately 636 feet and all flow was being directed through the powerhouse as detailed in Figure 13. Forebay elevation would remain fairly stable throughout the summer and into the fall until fall drawdown operations commenced on October 1, 2023. Those operations included directing a significant proportion of the flow through the spill gates. Spill gate operations would continue until mid-December when all flow was transitioned back to the powerhouse.

Of this initial release, 21 subyearlings were observed passing the Lebanon Dam PIT tag array with mean and median travel times of 22.0 and 1.3 days, respectively. This discrepancy between mean and median indicates a swift downstream movement by a large number of fish shortly after release, with 15 subyearling passing the Lebanon Dam array within the first five days. The remaining six fish observations at Lebanon Dam occurred between October 10 and November 28, a period marked by increased Foster Dam outflows.

The next release in the Foster project area occurred on October 10 and October 11, 2023 with 5,000 subyearlings released at Head of Reservoir and 4,000 subyearlings released at the Foster Dam Tailrace, coinciding with the reservoir's drawdown and ongoing spill operations. The subyearlings from the Head of Reservoir were detected passing Lebanon Dam with a mean travel time of 42.2 days and a median of 37.2 days. The 25^{th} percentile of travel times (29.9 days) indicates that the majority of these fish were observed passing Lebanon Dam after November 9, 2023 which coincided with a large increase of inflow into Foster Reservoir. Of the fish that were released into the Tailrace, a total of 68 were observed passing Lebanon Dam with mean and median travel times of 26.3 days and 21.6 days. Additionally, three fish from the Tailrace release were observed passing the Columbia River PD7 array with a mean travel time of 26.3 days.

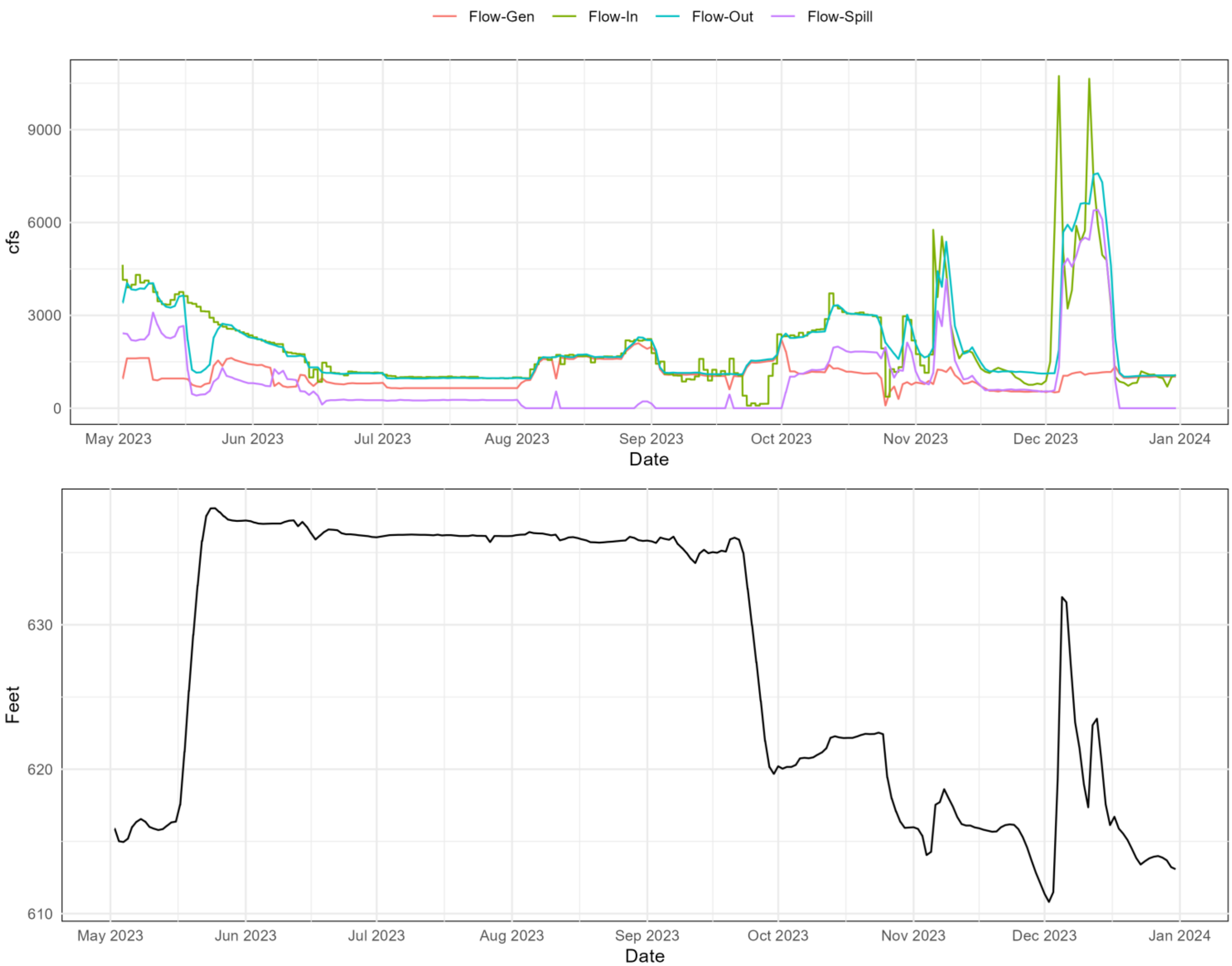


Figure 13. Dam operations at Foster Dam. Top panel presents flow through the powerhouse (Flow-Gen), flow into the reservoir (Flow-In), flow out of the reservoir (Flow-Out), and flow through the spill gates (Flow-Spill). The bottom panel presents the forebay elevation.

North Santiam – Detroit-Big Cliff

The first release of PIT tagged juvenile Chinook salmon into the head of the Detroit - Big Cliff project area occurred on July 13, 2023 with the release of 7,000 fry into the Breitenbush River and 6,638 fry into the North Santiam River. At the time of release, dam operations at Detroit were directing flow through both the powerhouse and the spill gates and the reservoir was being drafted (Figure 14). These operations continued until early August when all discharge through Detroit Dam was transitioned to the powerhouse. All discharge through Detroit was directed through the powerhouse until late September when discharge began to be transitioned to the spill gates and by late October all flow through Detroit Dam was via spill. Spill operations continued until early December when dam operations switched to a mix of both spill and powerhouse flow. At Big Cliff, flow predominantly passed through the powerhouse, except for a 10-day spill from July 18 to 28 and a brief two-day spill on September 26-27, with a shift to regular spill gate operations starting in November, as shown in Figure 15.

Of the 13,638 fry released at the head of Detroit Reservoir five were recaptured in the Big Cliff Tailrace screw trap and three were recaptured in the Stayton Power Canal Bypass screw trap. Those recaptured in the Tailrace exhibited mean and median travel times of 93.6 and 91.0 days, respectively. The minimum and maximum travel times, 85.0 and 111.0 days, indicate that all of those fish were recaptured between October 6 and November 1, 2023, a period of time that coincided with a lower forebay elevation and spill operations at Detroit Dam. The minimum travel time of 89.9 days for three fish that were recaptured in the Power Canal Bypass also indicates that those fish were detected after spill operations had begun at Detroit Dam.

The next release group consisted of 9,999 subyearlings released at the head of Detroit Reservoir (split evenly between the Breitenbush and North Santiam Rivers) on September 26, 2023 and 8,009 subyearlings released into the Big Cliff Dam Tailrace on September 27, 2023. A single fish from the Head of Reservoir release was recaptured at the Big Cliff Dam screw trap 32.8 days later. A total of 18 fish from the Tailrace release were recaptured in the Stayton Power Canal Bypass screw trap. Those fish exhibited mean and median travel times of 15.8 days and 7.8 days. In addition, six fish from the Tailrace group were observed passing the Columbia River PD7 array (mean travel time: 26.8 days).

There was one final release of 5,998 subyearlings at the Big Cliff Tailrace on November 20, 2023. Three of those fish were later recaptured at the Stayton Bypass (mean travel time 7.8 days).

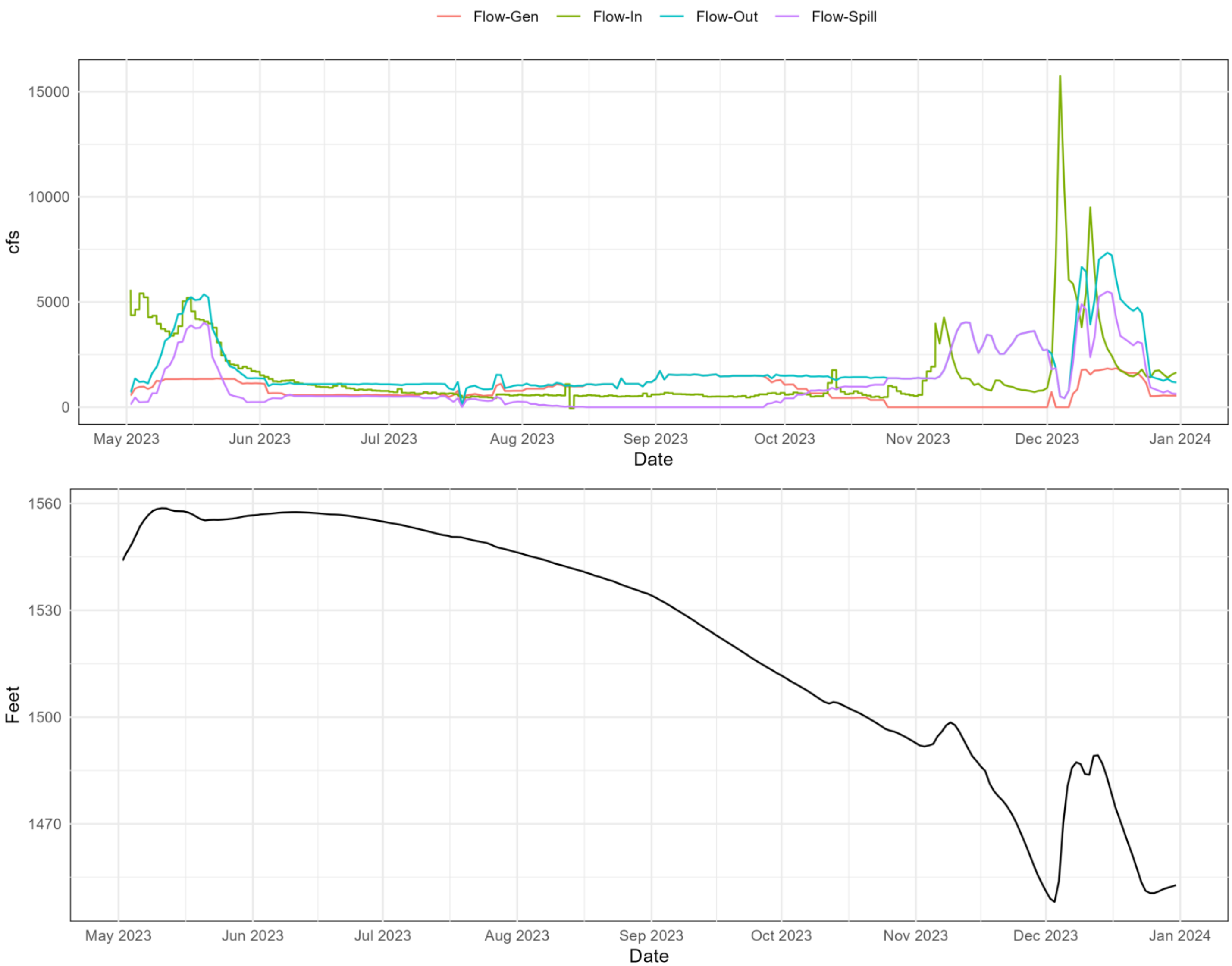


Figure 14. Dam operations at Detroit Dam. Top panel presents flow through the powerhouse (Flow-Gen), flow into the reservoir (Flow-In), flow out of the reservoir (Flow-Out), and flow through the spill gates (Flow-Spill). The bottom panel presents the forebay elevation.

Figure 15. Dam operations at Big Cliff Dam. Top panel presents flow through the powerhouse (Flow-Gen), flow into the reservoir (Flow-In), flow out of the reservoir (Flow-Out), and flow through the spill gates (Flow-Spill). The bottom panel presents the forebay elevation.

Table 6. Travel time metrics from release to observation or redetection. Travel time is presented in days. Observation Location definitions: CGR – Cougar Tailrace, DEX – Dexter Tailrace, FAL – Fall Creek Tailrace, GPD – Green Peter Tailrace, HCR – Hills Creek Tailrace, LOP – Lookout Point Tailrace, NSANTR – North Santiam Stayton Power Canal Bypass, PD7 - Columbia River Pile Dike Array 7, WILRMF – Middle Fork Willamette.

							Travel Time (days)					
Basin	Project	Release Location	Release Date	Observation Location	Method	Count	Mean	Min	25%	Median	75%	Max
MCK	Cougar	Head of Reservoir	8/29/2023	CGR	Screw Trap	26	69.2	45.0	61.5	66.0	72.1	108.1
MCK	Cougar	Head of Reservoir	10/2/2023	CGR	Screw Trap	446	28.5	5.7	19.7	28.9	33.8	79.9
MCK	Cougar	Head of Reservoir	10/2/2023	PD7	Passive	1	47.8	47.8	47.8	47.8	47.8	47.8
MCK	Cougar	Forebay	10/18/2023	CGR	Screw Trap	328	13.2	0.8	9.8	12.8	17.8	62.8
MCK	Cougar	Forebay	10/18/2023	PD7	Passive	1	32.1	32.1	32.1	32.1	32.1	32.1
MCK	Cougar	Head of Reservoir	10/18/2023	CGR	Screw Trap	243	15.2	2.0	12.0	14.0	18.1	61.1
MCK	Cougar	Head of Reservoir	11/13/2023	CGR	Screw Trap	185	16.1	1.0	4.0	11.0	30.0	42.0
MCK	Cougar	Forebay	11/14/2023	CGR	Screw Trap	400	4.6	0.9	0.9	0.9	2.9	43.9
MFW	Hills Creek	Head of Reservoir	5/18/2023	HCR	Screw Trap	44	11.3	0.8	0.8	0.8	0.8	200.9
MFW	Hills Creek	Head of Reservoir	6/5/2023	DEX	Screw Trap	3	184.8	181.1	181.6	182.1	186.6	191.1
MFW	Hills Creek	Head of Reservoir	6/5/2023	HCR	Screw Trap	61	167.8	103.1	157.1	184.1	187.1	204.1
MFW	Hills Creek	Head of Reservoir	6/5/2023	LOP	Screw Trap	6	188.9	171.1	192.1	192.1	192.9	193.1
MFW	Hills Creek	Head of Reservoir	11/7/2023	DEX	Screw Trap	2	27.3	26.8	27.1	27.3	27.6	27.8
MFW	Hills Creek	Head of Reservoir	11/7/2023	HCR	Screw Trap	46	26.7	4.8	15.8	28.3	34.8	52.8
MFW	Hills Creek	Head of Reservoir	11/7/2023	LOP	Screw Trap	6	38.3	36.8	36.8	36.8	38.3	43.8
MFW	Hills Creek	Mid Reservoir	11/8/2023	DEX	Screw Trap	1	30.9	30.9	30.9	30.9	30.9	30.9
MFW	Hills Creek	Mid Reservoir	11/8/2023	HCR	Screw Trap	76	25.4	3.9	14.9	27.9	32.9	47.9
MFW	Hills Creek	Mid Reservoir	11/8/2023	LOP	Screw Trap	15	35.3	14.9	35.9	35.9	39.9	42.9
MFW	Hills Creek	Mid Reservoir	11/8/2023	PD7	Passive	1	53.1	53.1	53.1	53.1	53.1	53.1
MFW	Hills Creek	Mid Reservoir	11/8/2023	WILRMF	Screw Trap	1	16.9	16.9	16.9	16.9	16.9	16.9
MFW	Hills Creek	Tailrace	11/9/2023	DEX	Screw Trap	6	15.4	9.9	10.4	11.9	20.9	24.9
MFW	Hills Creek	Tailrace	11/9/2023	LOP	Gillnet	2	5.8	5.8	5.8	5.8	5.8	5.8
MFW	Hills Creek	Tailrace	11/9/2023	LOP	Screw Trap	9	17.5	3.9	3.9	6.9	31.9	35.9
MFW	LOP	Head of Reservoir	5/30/2023	DEX	Screw Trap	1	82.1	82.1	82.1	82.1	82.1	82.1
MFW	LOP	Head of Reservoir	5/30/2023	LOP	Fyke Net	1	28.0	28.0	28.0	28.0	28.0	28.0
MFW	LOP	Forebay	9/18/2023	DEX	Screw Trap	5	36.0	9.8	30.8	33.8	43.8	61.8
MFW	LOP	Forebay	9/18/2023	LOP	Gillnet	1	30.7	30.7	30.7	30.7	30.7	30.7

							Travel Time (days)					
Basin	Project	Release Location	Release Date	Observation Location	Method	Count	Mean	Min	25%	Median	75%	Max
MFW	LOP	Forebay	9/18/2023	LOP	Screw Trap	1	86.8	86.8	86.8	86.8	86.8	86.8
MFW	LOP	Head of Reservoir	9/18/2023	DEX	Screw Trap	1	43.2	43.2	43.2	43.2	43.2	43.2
MFW	LOP	Head of Reservoir	9/18/2023	LOP	Gillnet	3	13.1	2.1	2.1	2.1	18.6	35.1
MFW	LOP	Head of Reservoir	9/18/2023	LOP	Screw Trap	1	88.2	88.2	88.2	88.2	88.2	88.2
MFW	LOP	Head of Reservoir	9/18/2023	PD7	Passive	1	35.4	35.4	35.4	35.4	35.4	35.4
MFW	Fall Creek	Head of Reservoir	6/12/2023	FAL	Screw Trap	13	130.5	127.9	127.9	128.9	129.9	148.9
MFW	Fall Creek	Head of Reservoir	9/28/2023	FAL	Screw Trap	142	24.4	19.9	19.9	20.9	21.9	44.9
MFW	Fall Creek	Head of Reservoir	9/28/2023	PD7	Passive	2	28.9	28.4	28.6	28.9	29.2	29.5
MFW	Fall Creek	Head of Reservoir	11/6/2023	DEX	Screw Trap	1	7.9	7.9	7.9	7.9	7.9	7.9
MFW	Fall Creek	Head of Reservoir	11/6/2023	FAL	Screw Trap	279	1.8	0.9	0.9	1.9	1.9	5.9
MFW	Fall Creek	Head of Reservoir	11/6/2023	PD7	Passive	1	33.9	33.9	33.9	33.9	33.9	33.9
SST	Green Peter	Head of Reservoir	5/22/2023	GPD	Screw Trap	1	5.7	5.7	5.7	5.7	5.7	5.7
SST	Green Peter	Head of Reservoir	9/20/2023	LBN	Passive	3	65.4	43.0	50.5	57.9	76.6	95.3
SST	Green Peter	Head of Reservoir	9/21/2023	GPD	Screw Trap	11	20.6	10.9	11.9	12.9	25.4	38.9
SST	Green Peter	Head of Reservoir	9/21/2023	LBN	Passive	2	60.6	50.0	55.3	60.6	66.0	71.3
SST	Green Peter	Head of Reservoir	10/3/2023	GPD	Screw Trap	11	22.6	13.0	17.0	27.0	28.0	30.0
SST	Green Peter	Head of Reservoir	10/3/2023	LBN	Passive	8	34.0	27.3	27.6	32.6	36.4	51.9
SST	Green Peter	Head of Reservoir	10/4/2023	GPD	Screw Trap	10	20.5	4.9	13.6	22.4	27.4	36.9
SST	Green Peter	Head of Reservoir	10/4/2023	LBN	Passive	4	28.5	23.7	25.8	29.1	31.8	32.2
SST	Green Peter	Head of Reservoir	10/4/2023	PD7	Passive	1	33.0	33.0	33.0	33.0	33.0	33.0
SST	Green Peter	Tailrace	10/9/2023	LBN	Passive	48	35.0	4.0	22.4	32.2	48.7	70.9
SST	Green Peter	Tailrace	10/9/2023	PD7	Passive	2	14.7	14.4	14.5	14.7	14.9	15.0
SST	Foster	Tailrace	8/23/2023	LBN	Passive	21	22.0	0.4	0.5	1.3	48.2	96.4
SST	Foster	Head of Reservoir	8/24/2023	LBN	Passive	2	81.0	76.9	79.0	81.0	83.1	85.1
SST	Foster	Head of Reservoir	10/10/2023	LBN	Passive	47	42.2	4.4	29.9	37.2	61.4	73.6
SST	Foster	Head of Reservoir	10/10/2023	PD7	Passive	3	33.4	18.7	20.7	22.6	40.8	58.9
SST	Foster	Tailrace	10/11/2023	LBN	Passive	68	26.3	0.2	17.6	21.6	36.4	78.8
NST	Detroit	Head of Reservoir	7/13/2023	BCL	Screw Trap	5	93.6	85.0	90.1	91.0	91.0	111.0
NST	Detroit	Head of Reservoir	7/13/2023	NSANTR	Bypass	3	111.0	89.9	97.5	105.1	121.6	138.0
NST	Detroit	Head of Reservoir	9/26/2023	BCL	Screw Trap	1	32.8	32.8	32.8	32.8	32.8	32.8

							Travel Time (days)					
Basin	Project	Release Location	Release Date	Observation Location	Method	Count	Mean	Min	25%	Median	75%	Max
NST	Big Cliff	Tailrace	9/27/2023	NSANTR	Bypass	18	15.8	0.8	6.8	7.8	13.8	62.8
NST	Big Cliff	Tailrace	9/27/2023	PD7	Passive	6	26.8	23.2	24.1	25.4	27.5	34.8
NST	Big Cliff	Tailrace	11/20/2023	NSANTR	Bypass	3	7.8	7.8	7.8	7.8	7.8	7.8

Table 7. Travel rate metrics from release to redetection or observation. Observation Location definitions: CGR – Cougar Tailrace, DEX – Dexter Tailrace, FAL – Fall Creek Tailrace, GPD – Green Peter Tailrace, HCR – Hills Creek Tailrace, LOP – Lookout Point Tailrace, NSANTR – North Santiam Stayton Power Canal Bypass, PD7 - Columbia River Pile Dike Array 7, WILRMF – Middle Fork Willamette.

							Travel Rate (km/day)					
Basin	Project	Release Location	Release Date	Observation Location	Method	Count	Mean	Min	25%	Median	75%	Max
MCK	Cougar	Head of Reservoir	8/29/2023	CGR	Screw Trap	26	0.14	0.08	0.13	0.14	0.15	0.20
MCK	Cougar	Head of Reservoir	10/2/2023	CGR	Screw Trap	446	0.37	0.11	0.27	0.31	0.46	1.58
MCK	Cougar	Head of Reservoir	10/2/2023	PD7	Passive	1	10.07	10.07	10.07	10.07	10.07	10.07
MCK	Cougar	Forebay	10/18/2023	CGR	Screw Trap	328	0.04	0.00	0.01	0.02	0.02	0.27
MCK	Cougar	Forebay	10/18/2023	PD7	Passive	1	14.71	14.71	14.71	14.71	14.71	14.71
MCK	Cougar	Head of Reservoir	10/18/2023	CGR	Screw Trap	243	0.79	0.15	0.50	0.64	0.75	4.48
MCK	Cougar	Head of Reservoir	11/13/2023	CGR	Screw Trap	185	2.00	0.22	0.30	0.82	2.28	9.50
MCK	Cougar	Forebay	11/14/2023	CGR	Screw Trap	400	0.16	0.01	0.07	0.23	0.23	0.23
MFW	Hills Creek	Head of Reservoir	5/18/2023	HCR	Screw Trap	44	17.46	0.09	20.23	20.23	20.23	20.23
MFW	Hills Creek	Head of Reservoir	6/5/2023	DEX	Screw Trap	3	0.33	0.32	0.33	0.34	0.34	0.34
MFW	Hills Creek	Head of Reservoir	6/5/2023	HCR	Screw Trap	61	0.09	0.07	0.08	0.08	0.10	0.15
MFW	Hills Creek	Head of Reservoir	6/5/2023	LOP	Screw Trap	6	0.30	0.29	0.29	0.29	0.29	0.33
MFW	Hills Creek	Head of Reservoir	11/7/2023	DEX	Screw Trap	2	2.23	2.19	2.21	2.23	2.25	2.27
MFW	Hills Creek	Head of Reservoir	11/7/2023	HCR	Screw Trap	46	0.80	0.28	0.43	0.53	0.95	3.10
MFW	Hills Creek	Head of Reservoir	11/7/2023	LOP	Screw Trap	6	1.47	1.28	1.46	1.52	1.52	1.52
MFW	Hills Creek	Mid Reservoir	11/8/2023	DEX	Screw Trap	1	1.72	1.72	1.72	1.72	1.72	1.72
MFW	Hills Creek	Mid Reservoir	11/8/2023	HCR	Screw Trap	76	0.37	0.15	0.21	0.25	0.47	1.81
MFW	Hills Creek	Mid Reservoir	11/8/2023	LOP	Screw Trap	15	1.50	1.12	1.21	1.34	1.34	3.23
MFW	Hills Creek	Mid Reservoir	11/8/2023	PD7	Passive	1	8.93	8.93	8.93	8.93	8.93	8.93
MFW	Hills Creek	Mid Reservoir	11/8/2023	WILRMF	Screw Trap	1	4.74	4.74	4.74	4.74	4.74	4.74
MFW	Hills Creek	Tailrace	11/9/2023	DEX	Screw Trap	6	3.54	1.89	2.46	3.95	4.55	4.75
MFW	Hills Creek	Tailrace	11/9/2023	LOP	Gillnet	2	7.21	7.21	7.21	7.21	7.21	7.21
MFW	Hills Creek	Tailrace	11/9/2023	LOP	Screw Trap	9	5.52	1.17	1.32	6.09	10.79	10.79
MFW	LOP	Head of Reservoir	5/30/2023	DEX	Screw Trap	1	0.34	0.34	0.34	0.34	0.34	0.34
MFW	LOP	Head of Reservoir	5/30/2023	LOP	Fyke Net	1	0.82	0.82	0.82	0.82	0.82	0.82
MFW	LOP	Forebay	9/18/2023	DEX	Screw Trap	5	0.53	0.21	0.30	0.39	0.42	1.33
MFW	LOP	Forebay	9/18/2023	LOP	Gillnet	1	0.26	0.26	0.26	0.26	0.26	0.26

							Travel Rate (km/day)					
Basin	Project	Release Location	Release Date	Observation Location	Method	Count	Mean	Min	25%	Median	75%	Max
MFW	LOP	Forebay	9/18/2023	LOP	Screw Trap	1	0.09	0.09	0.09	0.09	0.09	0.09
MFW	LOP	Head of Reservoir	9/18/2023	DEX	Screw Trap	1	0.65	0.65	0.65	0.65	0.65	0.65
MFW	LOP	Head of Reservoir	9/18/2023	LOP	Gillnet	3	7.57	0.66	5.84	11.02	11.02	11.02
MFW	LOP	Head of Reservoir	9/18/2023	LOP	Screw Trap	1	0.26	0.26	0.26	0.26	0.26	0.26
MFW	LOP	Head of Reservoir	9/18/2023	PD7	Passive	1	12.69	12.69	12.69	12.69	12.69	12.69
MFW	Fall Creek	Head of Reservoir	6/12/2023	FAL	Screw Trap	13	0.22	0.19	0.22	0.22	0.22	0.22
MFW	Fall Creek	Head of Reservoir	9/28/2023	FAL	Screw Trap	142	1.23	0.62	1.28	1.34	1.41	1.41
MFW	Fall Creek	Head of Reservoir	9/28/2023	PD7	Passive	2	15.05	14.76	14.90	15.05	15.19	15.34
MFW	Fall Creek	Head of Reservoir	11/6/2023	DEX	Screw Trap	1	1.78	1.78	1.78	1.78	1.78	1.78
MFW	Fall Creek	Head of Reservoir	11/6/2023	FAL	Screw Trap	279	19.81	4.79	15.16	15.16	33.05	33.05
MFW	Fall Creek	Head of Reservoir	11/6/2023	PD7	Passive	1	12.85	12.85	12.85	12.85	12.85	12.85
SST	Green Peter	Head of Reservoir	5/22/2023	GPD	Screw Trap	1	2.66	2.66	2.66	2.66	2.66	2.66
SST	Green Peter	Head of Reservoir	9/20/2023	LBN	Passive	3	0.90	0.56	0.74	0.92	1.07	1.23
SST	Green Peter	Head of Reservoir	9/21/2023	GPD	Screw Trap	11	0.91	0.39	0.59	1.16	1.26	1.37
SST	Green Peter	Head of Reservoir	9/21/2023	LBN	Passive	2	0.95	0.79	0.87	0.95	1.04	1.12
SST	Green Peter	Head of Reservoir	10/3/2023	GPD	Screw Trap	11	0.59	0.40	0.43	0.45	0.73	0.93
SST	Green Peter	Head of Reservoir	10/3/2023	LBN	Passive	8	1.62	1.02	1.46	1.64	1.92	1.94
SST	Green Peter	Head of Reservoir	10/4/2023	GPD	Screw Trap	10	1.16	0.41	0.55	0.69	1.15	3.07
SST	Green Peter	Head of Reservoir	10/4/2023	LBN	Passive	4	2.00	1.74	1.76	1.94	2.18	2.37
SST	Green Peter	Head of Reservoir	10/4/2023	PD7	Passive	1	11.34	11.34	11.34	11.34	11.34	11.34
SST	Green Peter	Tailrace	10/9/2023	LBN	Passive	48	1.55	0.49	0.72	1.09	1.57	8.66
SST	Green Peter	Tailrace	10/9/2023	PD7	Passive	2	24.04	23.52	23.78	24.04	24.30	24.56
SST	Foster	Tailrace	8/23/2023	LBN	Passive	21	31.85	0.29	0.58	20.83	56.44	74.63
SST	Foster	Head of Reservoir	8/24/2023	LBN	Passive	2	0.56	0.53	0.54	0.56	0.57	0.59
SST	Foster	Head of Reservoir	10/10/2023	LBN	Passive	47	1.55	0.61	0.74	1.21	1.50	10.28
SST	Foster	Head of Reservoir	10/10/2023	PD7	Passive	3	13.88	6.16	11.10	16.03	17.74	19.46
SST	Foster	Tailrace	10/11/2023	LBN	Passive	68	5.55	0.36	0.77	1.30	1.59	117.63
NST	Detroit	Head of Reservoir	7/13/2023	BCL	Screw Trap	5	16.27	1.10	5.01	8.82	10.16	89.55
NST	Detroit	Head of Reservoir	7/13/2023	NSANTR	Bypass	3	13.51	10.21	12.94	13.98	14.77	15.29

							Travel Rate (km/day)					
Basin	Project	Release Location	Release Date	Observation Location	Method	Count	Mean	Min	25%	Median	75%	Max
NST	Detroit	Head of Reservoir	9/26/2023	BCL	Screw Trap	1	8.89	8.89	8.89	8.89	8.89	8.89
NST	Big Cliff	Tailrace	9/27/2023	NSANTR	Bypass	18	0.24	0.21	0.23	0.25	0.25	0.27
NST	Big Cliff	Tailrace	9/27/2023	PD7	Passive	6	0.89	0.70	0.80	0.89	0.98	1.07
NST	Big Cliff	Tailrace	11/20/2023	NSANTR	Bypass	3	0.70	0.70	0.70	0.70	0.70	0.70

RESERVOIR DISTRIBUTION STUDIES

Methods

Reservoir distribution studies were conducted during 2023 in Green Peter and Lookout Point reservoirs to characterize the life history characteristics and body condition of juvenile Chinook salmon and *O. mykiss* utilizing the reservoir environment, including nearshore and longitudinal distribution of Chinook salmon and *O. mykiss* in relation to dam operations.

Data Collection

Juvenile Chinook Salmon Longitudinal Distribution & Body Condition

Biological Data

Past research in Willamette reservoirs indicates that Chinook salmon fry (<50 mm fork length [FL]) are closely associated with shallow nearshore habitat in spring before beginning to move offshore in June and shifting farther offshore and into deeper waters later in summer when water temperatures are at their maximum (Monzyk et al. 2015). Fish sampling methodology was selected to be consistent with past efforts (e.g. Monzyk et al. 2015) and to account for seasonal habitat use by juvenile Chinook salmon. To capture nearshore migration, floating box minnow traps and Oneida Lake traps were used to sample shallow nearshore environments. In summer and fall, juvenile Chinook salmon were sampled using gill nets, set in the pelagic zone at depths corresponding with typical Chinook salmon thermal preferences as determined by past vertical distribution evaluations in Lookout Point Reservoir (Monzyk et al. 2013, Kock et al. 2019a).

Subyearling nearshore distribution

Sampling was conducted biweekly in nearshore habitats between mid-June and mid-July in Green Peter and Lookout Point reservoirs during 2023. Initiation of sampling in 2023 was delayed from our target of early May because our net supplier was unable to meet its delivery deadline due to unanticipated supply chain issues. In 2024, nearshore sampling will begin in the first week of February to capture the entire spring outmigration period.

Each sampling event consisted of four days on each reservoir, including one day of setting traps and three days of checking and moving traps to new locations each day. Each reservoir was sampled on alternate weeks (i.e. Green Peter one week, Lookout Point the following week) for a total of two weeks of sampling effort on each reservoir per month.

Nearshore trapping was conducted following the methods of Monzyk et al. 2015. A stratified random sampling design was used for daily trap locations. Each reservoir was stratified into three longitudinal zones (lower, middle and upper) where each zone represents approximately one third of the reservoir length (Figure 16; Figure 17). In Green Peter Reservoir, an additional zone was created to capture the Quartzille Creek arm of the reservoir (labeled "Quartzville" in Figure 17). Within each reservoir zone, the maximum conservation pool shoreline[2] was split into reaches of approximately 850 m. In Lookout Point Reservoir, nearshore shoreline reaches were altered slightly to be consistent with those used by ODFW in past studies (Brandt et al. 2016).

---

[2]https://geospatialusace.opendata.arcgis.com/datasets/03e322d7e89b48a9b48e9c3f4bcaf29e_0/explore?location=34.797101%2C-97.473165%2C5.00

In Lookout Point Reservoir, three shoreline reaches within each longitudinal zone (lower, middle and upper) were randomly selected each sampling day for floating box trap placement (n = 9 total), and one location was randomly selected per zone for Oneida Lake trap placement (n = 3 total). These same trap allocations were used for Green Peter Reservoir, however, in addition, one Oneida trap and one floating box trap were placed in randomly selected shoreline reaches within the Quartzville zone, for a total of n=10 box traps and n=4 Oneida Lake traps per day in Green Peter Reservoir. Within each selected shoreline segment, trap placement was determined in the field based on suitability of site access and tie off locations. Traps were fished for approximately 24 hours, before being checked and moved to a new random location.

Collapsible floating box traps and Oneida Lake traps were constructed by Research Nets, Inc. following the specifications of Monzyk et al. 2015, with the exception that mesh sizes were decreased from 0.4 cm to 0.32 cm. Box traps were 0.61 x 0.61 x 0.91 m (W x H x L) and wrapped with 0.32 cm (1/8 inch) delta mesh, with a 51 mm throat opening to allow for entrance of small fish but sized to exclude larger predator fish. A 5 m lead net (0.91 m deep) was set perpendicular to shore to direct fish into the trap and a "tongue" fyke net (0.32 cm mesh) was attached below the trap opening to help direct fish into the trap. Small Oneida Lake traps consisted of a 1.2 x 1.2 x 1.2 m box wrapped in 0.32 cm delta mesh, with a 102 mm throat opening. A 20 m lead net (1.8 m deep, 0.32 cm delta mesh) was set perpendicular to shore to direct fish into the trap.

During each daily trap check, the trap throat was closed and the time the trap was checked was recorded. All fish were then removed from the trap using nylon mesh dip nets and transferred to buckets filled with well-oxygenated fresh reservoir water. Non-target fish (i.e., fish other than juvenile Chinook salmon*)* were identified to species and coarse size class, enumerated and the first 10 of each species and size class were measured for FL to the nearest mm and released. Non-target species were also checked for presence/absence of the ectoparasitic copepod *Salmincola californiensis* and the number of fish with copepods was recorded. Size classes were estimated in the field based on relative size differences between cohorts. When size modes were indistinct, size classes were based on 50 mm fork length bins. During 2023 sampling, *O. mykiss* were processed inadvertently in the field as a non-target species, but in 2024 they will be processed as a target species following the same protocol as Chinook salmon.

Captured Chinook salmon were examined for marks (adipose fin clips, PIT or VIE tags). All marked target species less than 300 mm were anesthetized in small batches using 50 mg/L MS-222 buffered with sodium bicarbonate. They then had their mark/tag information recorded and were measured for FL to the nearest mm, weighed to the nearest 0.01 g, and assessed for physical condition. The physical condition assessment included percent descaling, injuries, evidence of disease or pathogens, and parasite presence and intensity. Fish were examined systematically for *S. californiensis* infection intensity following methods used by Romer et al. (2017). Field crews examined the brachial cavity and fins for the presence of copepods and the number of copepods in each location were recorded. Following physical assessment, fish were transferred to a bucket filled with well-oxygenated fresh reservoir water to recover before release. Chinook salmon greater than 300 mm were to be checked for marks, measured for length and immediately released.

Unmarked Chinook salmon less than 300 mm were anesthetized and tagged in the field with a PIT tag based on fork length. Fish over 45 mm were tagged with uniquely identifiable PIT tags. Fish tagged in the field had their tag information recorded, fork length and weight measured, and were given a physical condition assessment. After being processed, fish recovered in buckets prior to release. Data on PIT tagged fish were uploaded to PTAGIS.

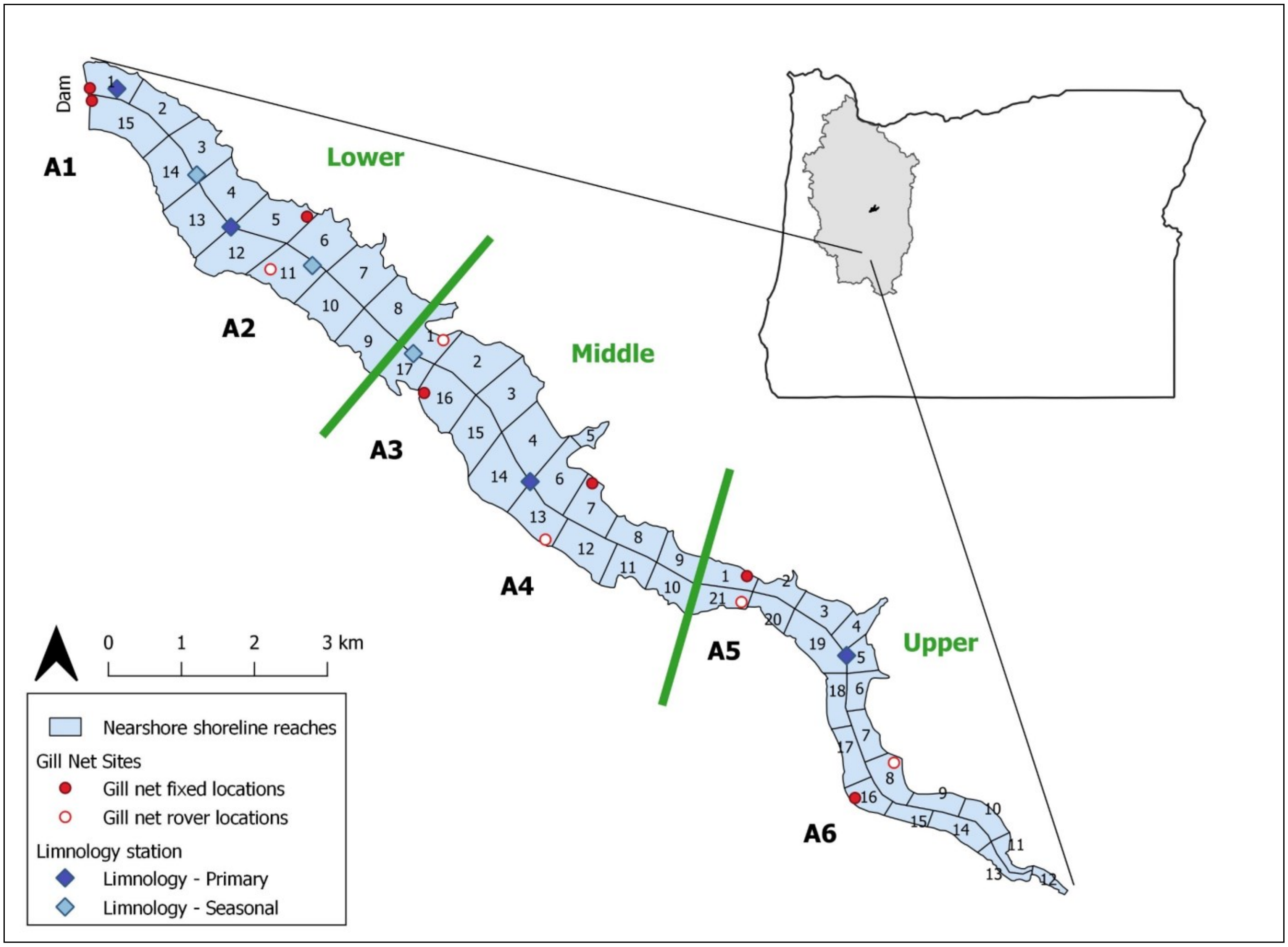


Figure 16. Map of Lookout Point Reservoir nearshore shoreline reaches, reservoir zones (lower, middle and upper), gill netting sampling areas and limnological stations.

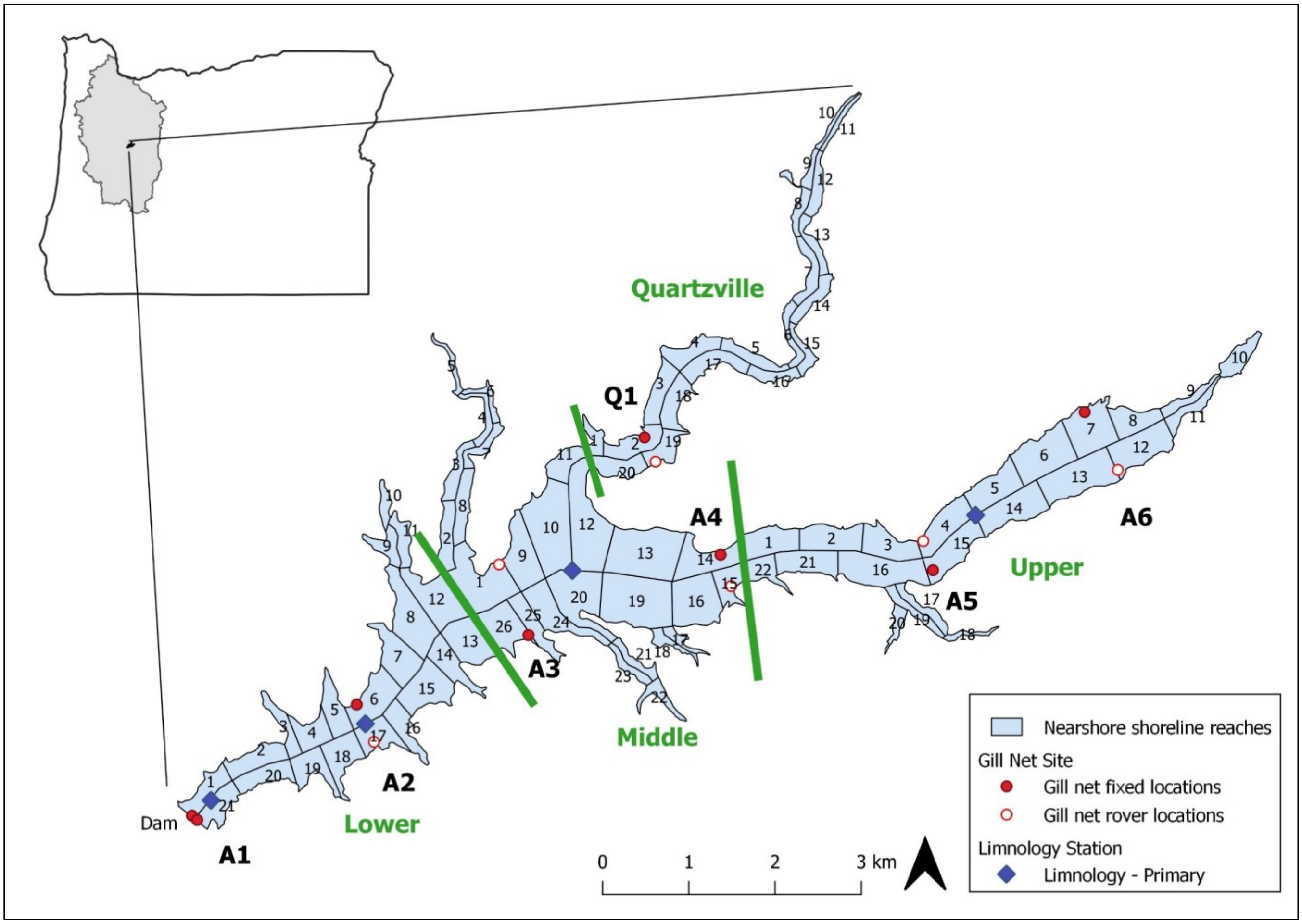


Figure 17. Map of Green Peter Reservoir nearshore shoreline reaches, reservoir zones (lower, middle and upper), gill netting sampling areas and limnological stations.

Parr longitudinal distribution

Biweekly gill netting was conducted between mid-June and the first week of December to assess the longitudinal distribution of Chinook salmon parr offshore. Consistent with nearshore sampling, each sampling event consisted of four days on each reservoir, including one day of setting gill nets and three days of checking nets. Green Peter and Lookout Point reservoirs were sampled on alternate weeks for a total of two weeks of sampling effort on each reservoir per month. During the fall drawdown period, the boat ramps on both reservoirs were no longer accessible and research boats were moored in the forebay of each reservoir. The boat on Green Peter Reservoir unexpectedly sunk on 10/2/2023. Because accessing the reservoir from the shoreline on a routine basis for purposes of this study was deemed unsafe due to steeply inclined banks and deep, sinking mud, gill netting on Green Peter Reservoir was suspended for the remainder of the year and sampling effort was reallocated to Lookout Point Reservoir, which was sampled every week from mid-October through the first week of December.

Gill netting was conducted following methods modified from Monzyk et al. 2015. In each reservoir, floating gill net sampling stations were established at six fixed locations (A1-A6) evenly spaced from the head of the reservoir to the dam (Figure 16; Figure 17). A seventh fixed sampling location was used in Green Peter Reservoir within the Quartzville arm (station Q1). Our initial sampling scheme was to set a total of 8 nets each day in Lookout Point Reservoir and 9 nets in Green Peter Reservoir. In each reservoir, two nets were set off the dam face (station A1), while one net was set at each of the remaining sites (stations A2-A6, and station Q1 in Green Peter). Lastly, each day one "rover" net was set across the reservoir from a fixed site to increase sampling effort (see Figure 16 and Figure 17 for rover locations). The rover site was selected systematically each day to ensure as close as possible to equal supplemental sampling effort among sites each month. Due to dropping reservoir elevations, upstream stations became dewatered and were not sampled when there was insufficient depth or unsafe boat access. Lost effort from upstream sites was reallocated downstream to additional rover locations and to sample additional depths. During peak drawdown, stations were also added between established stations (notated as A1.5, A2.5, and A3.5) to span the remaining reservoir footprint more evenly. Because the reservoir became very narrow during the drawdown, it also became necessary to stagger placement of nets at each station rather than having primary and rover nets directly across from each other. Lastly, after netting was suspended on Green Peter Reservoir, nets from that reservoir were taken for use on Lookout Point to try to increase both effort and catches, with up to 12 net sets per day.

Nets were set perpendicular to shore at depths corresponding to typical Chinook salmon habitat use and thermal preferences (Monzyk et al. 2015, Kock et al. 2019a, Monzyk et al. 2013). During past work in Lookout Point Reservoir, net depths used were greatest during peak thermal stratification (top of net at approximately 9.1 m July and August, 15.2 m early September), before returning to near the surface by the end of October (Monzyk et al. 2015). To capture this range, we set gill nets at 10m, 12m, 14m, 16m, 18m, and 20m at the start of the offshore season in August and early September to try to locate the depth with greatest target fish densities. It became apparent, however, that the thermocoline was deeper in 2023 and the shallow nets were fishing in waters warmer than 20ºC and unlikely to capture Chinook salmon. We changed our approach mid-season to begin selecting net depths based on the vertical temperature profile taken on the first day of each sampling week, with nets set as close as possible to 15ºC, which had the highest modal catch in past studies (Kock et al. 2019a, Monzyk et al. 2013). At shallow stations where it was not possible to reach the depth of 15ºC, nets were set as deep as possible while staying approximately 1-2 m off the bottom to minimize entanglement with stumps and other hazards visible on the depth sounder. With this depth selection method, net depth varied weekly and by station, with specific depths used reported in Appendix Table A2.

It was our intent to match our gill net dimensions and mesh sizes to those used by ODFW in previous work (e.g. Monzyk et al. 2015) to enable direct comparisons of CPUE between years. We ordered a full set of custom 24.4 m long (80 ft) by 4.9 m deep[3] gill nets, comprised of four 6.1 m panels (square mesh sizes: 9.5, 12.7, 19.1 and 25.4 mm) from Research Nets, Inc., however only 2 of these nets were delivered by our supplier in time for use during the season, with supply chain issues indefinitely delaying the rest of the order. To enable sampling to commence, we ordered replacement nets from Duluth Nets that were available immediately. These nets were the AFS Experimental Gill Net Small Fish Option which are 9.1 m (30 ft) long by 1.8 m (6 ft) deep, comprised of three 3 m panels (square mesh sizes: 9.5, 12.7 and 15.9 mm). This represents a reduction in net area and a shift to smaller mesh sizes in comparison with the ODFW nets. During the first sampling week in Green Peter Reservoir, both the 30' and 80' nets were trialed, however because only two of the larger nets were available and it wasn't possible to evenly distribute them across our stations, we elected to only use the 30' nets for the duration of the season in both reservoirs. A comparison of effort between this study and past evaluations, in terms of net area, is provided in the discussion to provide context on observed differences in CPUE.

Net suspension methods followed Ingram and Korn (1969). For each net set, we recorded site GPS, set and pull date and time, site depth, net depth, and described the weather. Nets were fished for approximately 24 hours between pulls. All fish caught were identified to species and coarse size class, the mesh size where each fish was captured was recorded, and each fish was assessed for copepod presence. The first 10 of each non-target species (non-Chinook salmon) and size class were measured for FL before disposal/release. All mortalities were sunk

[3] Note, this is slightly larger than reported by Monzyk et al. 2015, which used 4.6 m deep nets. The net depth was increased to conform with the manufacturer's material specifications.

after puncturing the swim bladder, while live non-target fish were immediately released after measurement. Chinook salmon captured were examined for marks (fin clips, PIT or VIE tags). Marks and tag codes were recorded, and mortalities were measured for FL and weight and assessed for physical condition, including copepod infestation prevalence and intensity. Any live target species less than 300 mm FL were handled following the same procedures as for nearshore sampling and if unmarked, were tagged. Consistent with nearshore sampling, *O. mykiss* were inadvertently processed as non-target fish during 2023 offshore sampling, but will be processed as target species following the protocol for Chinook salmon beginning in 2024.

Limnological Sampling

In each reservoir, three primary limnological stations were established. One was located in the upper third of the reservoir, one in the middle, and one in the lower third along the longitudinal axis (Figure 16; Figure 17). On the first day of each biweekly sampling effort, crews collected a vertical temperature and dissolved oxygen (DO) profile at each station using a YSI. From June through early September, a model ProODO (YSI, Inc.) with 30 m cable was used to collect profiles with readings taken every 1 m down to a maximum depth of 30 m. From September through December, a YSI model ProDSS (YSI, Inc.) equipped with a depth sensor and 100 m cable was used to collect temperature, DO and turbidity readings at one second intervals (approximately every 0.25 m) on the descent until the maximum station depth was reached. Profile data were downloaded from the YSI and saved to an electronic database. As the reservoir drawdown progressed in late summer and fall in Lookout Point Reservoir, upper and middle primary limnological stations became too shallow to access and the lower station was not deep enough to capture the entire thermocline. A primary station was added to the forebay of each reservoir in September to capture the deepest profile possible. To maintain at minimum three limnology sampling stations spread along the reservoir longitudinal axis each sampling week, seasonal stations were added over the course of the drawdown between the primary stations (Figure 16). Due to the greater depth of Green Peter Reservoir and suspension of sampling before peak drawdown was reached, seasonal limnology stations were not needed for that reservoir.

Data Analysis

Chinook Salmon Longitudinal Distribution

Nearshore Chinook salmon longitudinal distribution was evaluated by comparing catch rates between reservoir zones and distance along the reservoir axis. GPS coordinates of each trap were converted to a percent of the reservoir length along the centerline to estimate distance from the head of the reservoir (HoR 0%, at dam 100%). The centerline of each reservoir was digitized in QGIS and sampling locations were snapped to the nearest location on the centerline to determine distance. Catches and catch per unit effort (CPUE, number of fish captured per 24 hr set) were compared between reservoir zones and sampling periods to evaluate nearshore distribution. Catch was plotted versus percent of reservoir length to further evaluate patterns of catch. Sizes of Chinook salmon captured in nearshore traps were evaluated using summary statistics.

Offshore catch and CPUE were evaluated by station and net set locations were converted to percent of reservoir length to allow for evaluation of catch in relation to distance from the head of the reservoir. Catch was plotted by station and versus percent of reservoir length, as well as by month to evaluate patterns of catch. Sizes of Chinook salmon captured in offshore traps were evaluated using summary statistics. Exploratory data analysis was completed to evaluate the relationship between water temperature, net depth and Chinook salmon catch rates. Net temperature of gill nets was estimated by taking the mean temperature of the vertical temperature profile across the range of depths spanned by the gill net. This exploratory analysis revealed that Chinook salmon were never caught in offshore nets with mean temperature greater than 20°C, thus the nets set at those temperatures were dropped from subsequent Chinook salmon CPUE comparisons among reservoir zones. All other net depths were aggregated for analyses in this report, however detailed catch and CPUE for all net depths including those over 20ºC has been retained in the Appendix of this report (Appendix Table A2).

Chinook Salmon Abundance Index

CPUE was used as an abundance index and was compared to dam operations. Too few marked Chinook salmon were recaptured to allow for a mark-recapture based abundance estimate. Dam operations data were downloaded from the USACE Northwestern Division Dataquery 2.0 web portal[4]. Data was obtained for percent full conservation pool, forebay elevation, and flow in and out of each reservoir.

Copepod Infestation

Copepod infestation was evaluated by calculating the prevalence rate as the number of fish with copepods present versus the total number of fish assessed. This evaluation was completed for all salmonid species captured.

Chinook Salmon Growth

Change in mean fork length and weight between early summer and fall sampling was evaluated for natural origin Chinook salmon to estimate growth in the reservoir. Growth will be evaluated for hatchery Chinook in 2024 as well, however this analysis was not possible with 2023 data because only one hatchery subyearling was captured during the early summer period.

Catch Composition and Predator Bycatch

Catch composition of all sets was evaluated using both total catch and CPUE. Predator bycatch was further evaluated using total catch and CPUE but only for fish greater than 200mm and for species known to be piscivorous.

Results: Reservoir Study Summary through 31 Dec 2023

Limnological sampling

Lookout Point Reservoir

Vertical profiles of temperature, and dissolved oxygen were taken in Lookout Point Reservoir across the duration of the sampling period (late June – early December). Turbidity profiles were added later in the sampling period and were recorded starting in October. Thermal stratification in Lookout Point Reservoir was pronounced in June and July with surface temperatures of over 20ºC (Figure 18). As summer progressed, all depths of the reservoir warmed, with temperatures of 19-21ºC seen down to 30 m depth in August. Later in the season and as reservoir elevations dropped with the drawdown, the reservoir was well mixed with little change in temperature with depth. By the end of the sampling period in December, reservoir water temperatures had dropped to 8ºC. With temperatures optimum for juvenile Chinook salmon rearing between 12 and 17 degrees Celsius (Independent Science Panel 1996), it would suggest that Lookout Point reservoir had unsuitably warm temperatures across all depths (no thermal refuge) during August and September, except for a small pocket in the forebay where depths exceeded 30 m. However, this pocket also had low dissolved oxygen (DO) (<5 mg/L) that would have produced stressful conditions for juvenile salmonids. Juvenile salmonids begin to show symptoms of oxygen stress (reduced swimming efficiency, reduced growth and food conversion efficiency) below 6 mg/L, with most fish exhibiting impairment below 4.25 mg/L (Bjornn and Reiser 1991). All other depths and sampling periods had sufficient DO for salmonid use. Turbidity in Lookout Point Reservoir was high (exceeding 200 NTU), particularly in November

[4] https://www.nwd-wc.usace.army.mil/dd/common/dataquery/www/

coinciding with peak drawdown and in early December during a storm event when the reservoir elevation was rapidly increased for flood control (Figure 18).

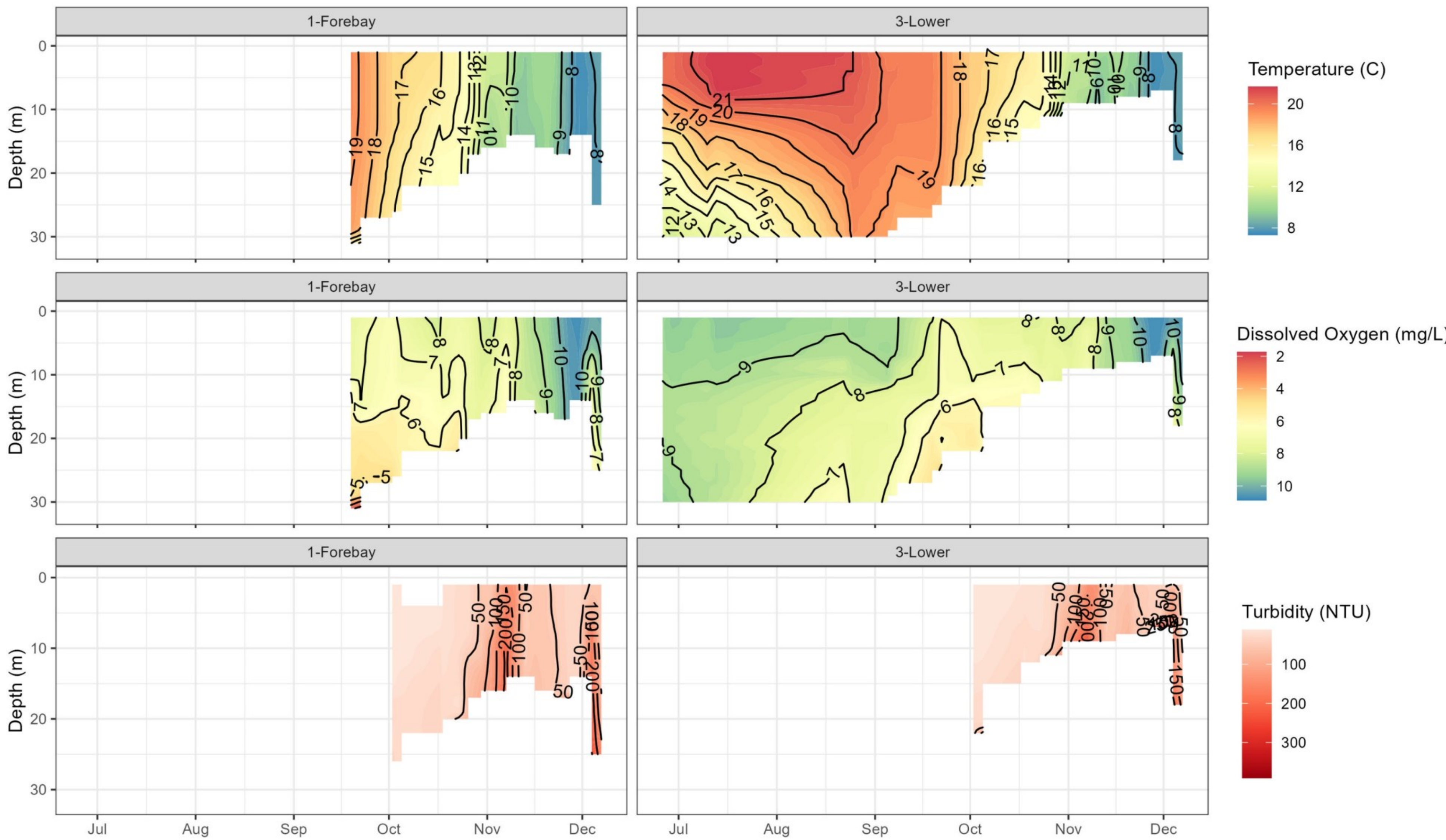


Figure 18. Lookout Point vertical temperature (ºC), dissolved oxygen (mg/L) and turbidity (NTU) profiles taken at the Forebay and Lower limnology stations. Note that the Forebay location was added in mid-September. Turbidity sampling was added in October. Depths with no fill indicate no data. In October-December, depths with no fill at the bottom of the profile represent the maximum depth of the station due to lowering reservoir elevations during the drawdown. The gap in turbidity data at the surface for the forebay in October represents data removed due to a sensor issue.

Green Peter Reservoir

Vertical profiles of temperature and dissolved oxygen were recorded in Green Peter Reservoir from late June through early October, coinciding with fish sampling weeks. Profiles were taken down to 30m depth until mid-September, after which profiles were taken down to each station's maximum depth. Water surface temperatures during summer ranged from 20-25ºC, with pronounced thermal stratification (Figure 19). The thermocline depth varied across the season, ranging from approximately 9 m down to 25 m. Below the thermocoline, temperatures were less than 10ºC. Because Green Peter has a greater maximum depth than Lookout Point Reservoir, depths with suitable temperature and dissolved oxygen for salmonid use persisted throughout the sampling season. Turbidity profiles were not taken in Green Peter Reservoir during 2023 sampling; however, turbidity data was collected by the USGS in the Green Peter tailrace between mid-August and the end of the year[5]. The USGS data shows relatively low turbidity (<2 FNU) through early October, before drastically increasing during the fall coinciding with the drawdown (see report cover photo, taken 11/6/2023), with values regularly exceeding 200 FNU and peaks of over 1,000 FNU. Turbidity data were not collected at the USGS site in previous years. .

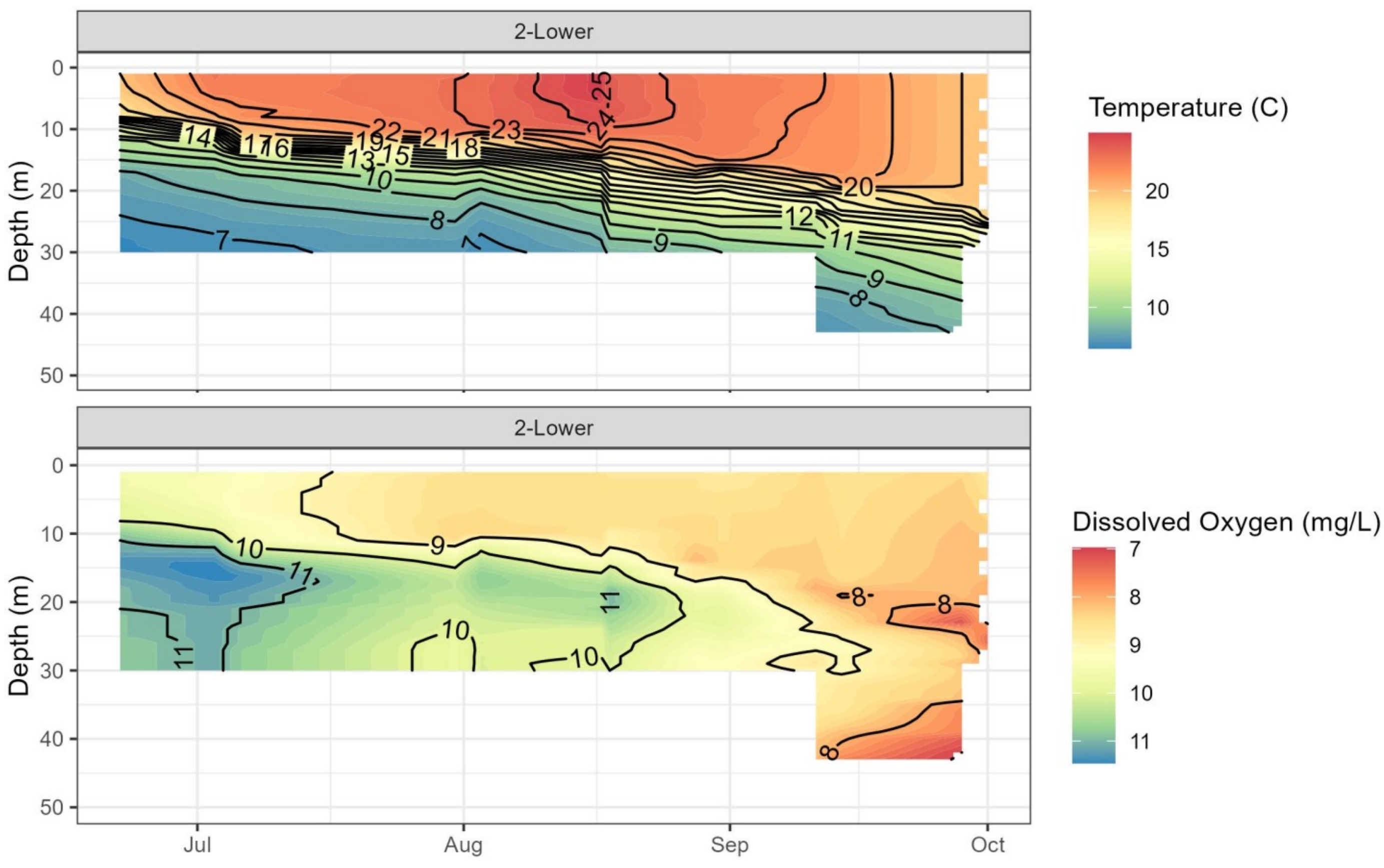


Figure 19. Green Peter vertical temperature (ºC), dissolved oxygen (mg/L) profiles taken at the Forebay and Lower limnology stations. Only the Lower station is presented because the forebay was only sampled on two occasions. Turbidity was not sampled in Green Peter Reservoir because sampling in that reservoir ended prior to obtaining a YSI capable of measuring turbidity. The forebay is not shown here for Green Peter because it was only sampled one week.

[5] https://waterdata.usgs.gov/monitoring-location/14186200/#parameterCode=63680&showMedian=false&startDT=2023-07-01&endDT=2023-12-31

Summary of fish sampling effort

While fish sampling was initially planned to begin in early May, initiation of sampling was delayed until mid-June because our net supplier had supply chain issues and missed their delivery deadline. We received our first shipment of nets during the 24th week of the year (June 11 – June 17, 2023), and immediately conducted test deployments in Green Peter Reservoir to work out any issues with net configurations and logistics associated with the deployment and operation of the trap nets. Sampling began in earnest the following week. Effort by reservoir, sampling week and gear type are summarized in Table 8. Sampling with nearshore nets in Green Peter Reservoir was conducted between mid-June and early July (see Appendix Figure A5 for a map of trapping locations). Nearshore sampling in Lookout Point reservoir occurred between late June and mid-July (Appendix Figure A4). Offshore sampling using suspended gill nets was conducted in Green Peter Reservoir between late July and the end of September. No offshore sampling was conducted in Green Peter after September because the CFS boat moored on that reservoir sunk on 10/2/2023. Due to the reservoir drawdown, there was no safe routine access to the reservoir for the purposes of this study, thus sampling was suspended for the year. Offshore gill net sampling in Lookout Point reservoir was conducted between mid-August and early December. Effort (# of sets and sampling weekly instead of biweekly) increased in the late fall because effort was reallocated to Lookout Point reservoir after sampling on Green Peter was suspended.

Table 8. Sampling effort by statistical week. Effort (number of 24 hr sets) is shown for each gear type and reservoir. Values are the total number of sets (net depths aggregated) with the number of sets with mean temperature below 20°C in parentheses.

Reservoir	Week	Start	End	Oneida	Box minnow	Gill net 30'	Gill net 80'
Green Peter	24	6/15/2023	6/15/2023	2 (0)	0 (0)	0 (0)	0 (0)
	25	6/20/2023	6/22/2023	12 (1)	29 (0)	0 (0)	0 (0)
	27	7/3/2023	7/5/2023	12 (0)	30 (0)	0 (0)	0 (0)
	31	7/31/2023	8/2/2023	0 (0)	0 (0)	21 (14)	2 (0)
	33	8/17/2023	8/17/2023	0 (0)	0 (0)	9 (6)	0 (0)
	35	8/28/2023	8/30/2023	0 (0)	0 (0)	26 (12)	0 (0)
	37	9/11/2023	9/13/2023	0 (0)	0 (0)	26 (23)	0 (0)
	39	9/28/2023	9/30/2023	0 (0)	0 (0)	26 (21)	0 (0)
Lookout Point	26	6/26/2023	6/28/2023	9 (0)	25 (3)	0 (0)	0 (0)
	28	7/10/2023	7/12/2023	9 (0)	26 (0)	0 (0)	0 (0)
	34	8/22/2023	8/24/2023	0 (0)	0 (0)	24 (12)	0 (0)
	36	9/5/2023	9/7/2023	0 (0)	0 (0)	23 (22)	0 (0)
	38	9/19/2023	9/21/2023	0 (0)	0 (0)	24 (24)	0 (0)
	40	10/2/2023	10/4/2023	0 (0)	0 (0)	24 (24)	0 (0)
	42	10/17/2023	10/19/2023	0 (0)	0 (0)	24 (24)	0 (0)
	43	10/23/2023	10/25/2023	0 (0)	0 (0)	24 (24)	0 (0)
	44	10/30/2023	11/1/2023	0 (0)	0 (0)	22 (22)	0 (0)
	45	11/7/2023	11/9/2023	0 (0)	0 (0)	24 (24)	0 (0)
	46	11/13/2023	11/15/2023	0 (0)	0 (0)	36 (36)	0 (0)
	47	11/20/2023	11/21/2023	0 (0)	0 (0)	24 (24)	0 (0)
	48	11/27/2023	11/29/2023	0 (0)	0 (0)	24 (24)	0 (0)
	49	12/4/2023	12/6/2023	0 (0)	0 (0)	36 (36)	0 (0)

Nearshore Chinook salmon longitudinal distribution

Lookout Point

Across the 2023 nearshore sampling period (mid-June through mid-July), only 17 subyearling Chinook salmon were captured in box minnow and Oneida lake traps in Lookout Point Reservoir, of which 16 where natural origin and 1 was a hatchery origin Chinook salmon (Table 9). All but one Chinook salmon were captured in Oneida lake traps. Based on fork length, all fish captured were subyearlings (Table 9).

The majority of trap sets had zero Chinook salmon catch, however, those that did were in the Upper and Middle reservoir zones, with 13 caught in the Upper zone nearest the head of the reservoir, 4 in the Middle zone, and zero captured in the Lower zone (Table 9, Figure 20). These results suggest that subyearling Chinook salmon in June and July in the nearshore environment were predominantly located in the upper and middle zones of the reservoir, however low catch rates require that this pattern be interpreted with caution. Because only two weeks were sampled in the nearshore environment, changes in nearshore longitudinal distribution were not evaluated over time. Detailed catch and catch per unit effort (CPUE) information for nearshore trapping in both reservoirs is presented in Appendix Table A1. Weekly mean surface water temperatures of nearshore trap sets ranged from 21.0 - 23.6ºC depending on the zone and sampling week, with the coolest temperatures generally seen in the Upper zone (Table 10).

Green Peter

No subyearling Chinook salmon were captured in nearshore traps set in Green Peter reservoir. Weekly mean surface water temperatures of trap locations ranged from 20.0 – 24.2ºC, depending on zone and sampling week, with temperatures approximately 1ºC cooler at trapping locations in the Quartzville arm than the rest of the reservoir (Table 10). See Appendix Table A1 for detailed effort and CPUE data.

Table 9. Fork lengths of subyearling Chinook salmon (CHS) caught in nearshore traps. Lengths are fork length measured in millimeters. Trapping occurred during weeks 24, 25 and 27 in Green Peter Reservoir, but no CHS were captured.

							Fork length (mm)		
Month	**Week**	**Reservoir**	**Zone**	**Net Type**	**Species**	**Catch**	**Mean**	**Min**	**Max**
June	26	Lookout Point	middle	oneida	CHS-Natural	4	87.2	80	92
June	26	Lookout Point	upper	box minnow	CHS-Natural	1	80	80	80
June	26	Lookout Point	upper	oneida	CHS-AD	1	95	95	95
June	26	Lookout Point	upper	oneida	CHS-Natural	3	81	73	90
July	28	Lookout Point	upper	oneida	CHS-Natural	8	84.8	77	100

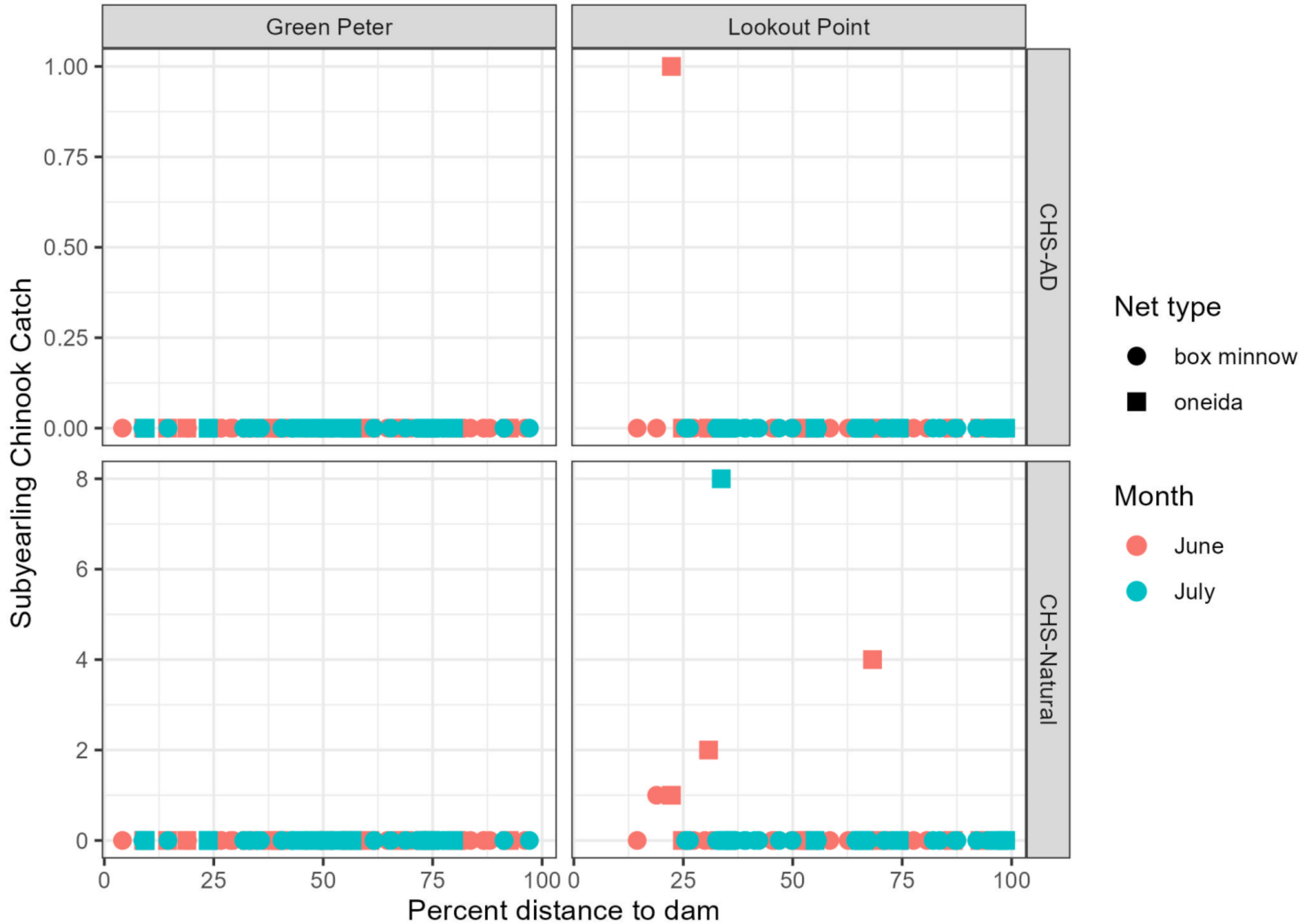


Figure 20. Subyearling Chinook salmon catch in nearshore traps in Lookout Point and Green Peter reservoirs by sampling month and gear type (box minnow or Oneida lake trap) relative to the percent distance to the dam along the reservoir centerline.

Table 10. Water surface temperatures at nearshore trapping locations. Values shown are the mean, with the range in parentheses.

			Reservoir zone			
Reservoir	Month	Week	Lower	Middle	Upper	Quartzville
Green Peter	6	24	20 (20 - 20)	21 (21 - 21)	-	-
	6	25	21.2 (20.6 - 22)	21.4 (20.7 - 22.1)	21.2 (20.7 - 22)	20.3 (19.9 - 21)
	7	27	23.9 (23.2 - 24.6)	24.2 (23.4 - 24.8)	24.4 (23.7 - 24.9)	23.5 (22.1 - 24.3)
Lookout Point	6	26	21.9 (21.5 - 22.4)	22 (21.1 - 22.6)	21 (17.4 - 22.6)	-
	7	28	23.3 (22.7 - 24.1)	23.6 (23.2 - 24)	23.1 (21.7 - 23.9)	-

Offshore Chinook salmon longitudinal distribution

Lookout Point

Offshore suspended gill net sampling in Lookout Point reservoir was conducted from late August through early December. In Lookout Point reservoir, a total of 13 Chinook salmon were caught over the course of the sampling season, of which 9 were hatchery origin (six pit-tagged as part of the bulk marking effort and 3 ad-clipped hatchery Chinook), and 4 were natural origin (Table 11, Figure 21). Based on evaluation of fork lengths, all were subyearlings (Table 11, Figure 26).

Due to dropping reservoir elevations and shallow depths in the upper zone of the reservoir, offshore gill netting was restricted to stations downstream of station A4 for the duration of the offshore sampling period (only the middle and lower zones sampled). As the drawdown progressed, nets that were intended for use at stations A4-6 were relocated downstream to increase the number of nets set at permanent sites (A1-A3) and temporary sampling stations were additionally established between permanent sites to increase spatial coverage (A1.5, A2.5, and A3.5). Because of low catch rates, the ability to draw inferences on the offshore longitudinal distribution of Chinook salmon is limited, however general distribution patterns of catch are described here. No Chinook salmon were captured during August gill netting (Figure 21, Figure 22, Table 12). In September, two hatchery origin Chinook salmon were captured, one of which was sampled at station A3 (middle of reservoir near Signal Point boat launch) and the other at A1 nearest the dam in the forebay. During October, four subyearling Chinook salmon were captured spread across A1-A3. Chinook salmon caught in November (n=7) were sampled in A1-A2. No Chinook salmon were captured in the first week of December (last week of sampling). Overall, the distribution of offshore catches reflects the shrinking footprint of the reservoir during the drawdown period. Detailed catch and CPUE data for each sampling week and zone is provided in Appendix Table A2.

Green Peter

Offshore sampling in Green Peter was conducted from late July through the end of September using suspended gill nets. Only one subyearling Chinook salmon was caught during offshore sampling in Green Peter Reservoir (Table 11, Figure 21). The lone specimen was a 119 mm fork length natural origin subyearling, caught at station A5 in the upper zone of the reservoir at the end of September. Because only one specimen was captured, no inferences can be drawn regarding the longitudinal distribution of Chinook salmon in Green Peter reservoir. Detailed effort and CPUE data for offshore sampling is provided in Appendix Table A2.

Table 11. Fork lengths of subyearling Chinook salmon (CHS) caught in offshore suspended gill nets. Lengths are fork length measured in millimeters. Weeks not listed had no CHS catch.

							Fork length (mm)		
Month	**Week**	**Reservoir**	**Zone**	**Net Type**	**Species**	**Catch**	**Mean**	**Min**	**Max**
September	39	Green Peter	A5	gill net 30'	CHS-Natural	1	119	119	119
September	38	Lookout Point	A1	gill net 30'	CHS-AD	1	136	136	136
September	38	Lookout Point	A3	gill net 30'	CHS-AD	1	132	132	132
October	40	Lookout Point	A3	gill net 30'	CHS-Natural	1	140	140	140
October	42	Lookout Point	A1	gill net 30'	CHS-AD	1	159	159	159
October	43	Lookout Point	A1.5	gill net 30'	CHS-Natural	1	130	130	130
October	43	Lookout Point	A2	gill net 30'	CHS-AD	1	139	139	139
November	46	Lookout Point	A1	gill net 30'	CHS-AD	1	130	130	130
November	46	Lookout Point	A1	gill net 30'	CHS-Natural	1	150	150	150
November	46	Lookout Point	A1.5	gill net 30'	CHS-AD	2	145.5	144	147
November	46	Lookout Point	A2	gill net 30'	CHS-AD	1	138	138	138
November	46	Lookout Point	A2	gill net 30'	CHS-Natural	1	202	202	202

Month	Week	Reservoir	Zone	Net Type	Species	Catch	Fork length (mm) Mean	Min	Max
November	48	Lookout Point	A1	gill net 30'	CHS-AD	1	144	144	144

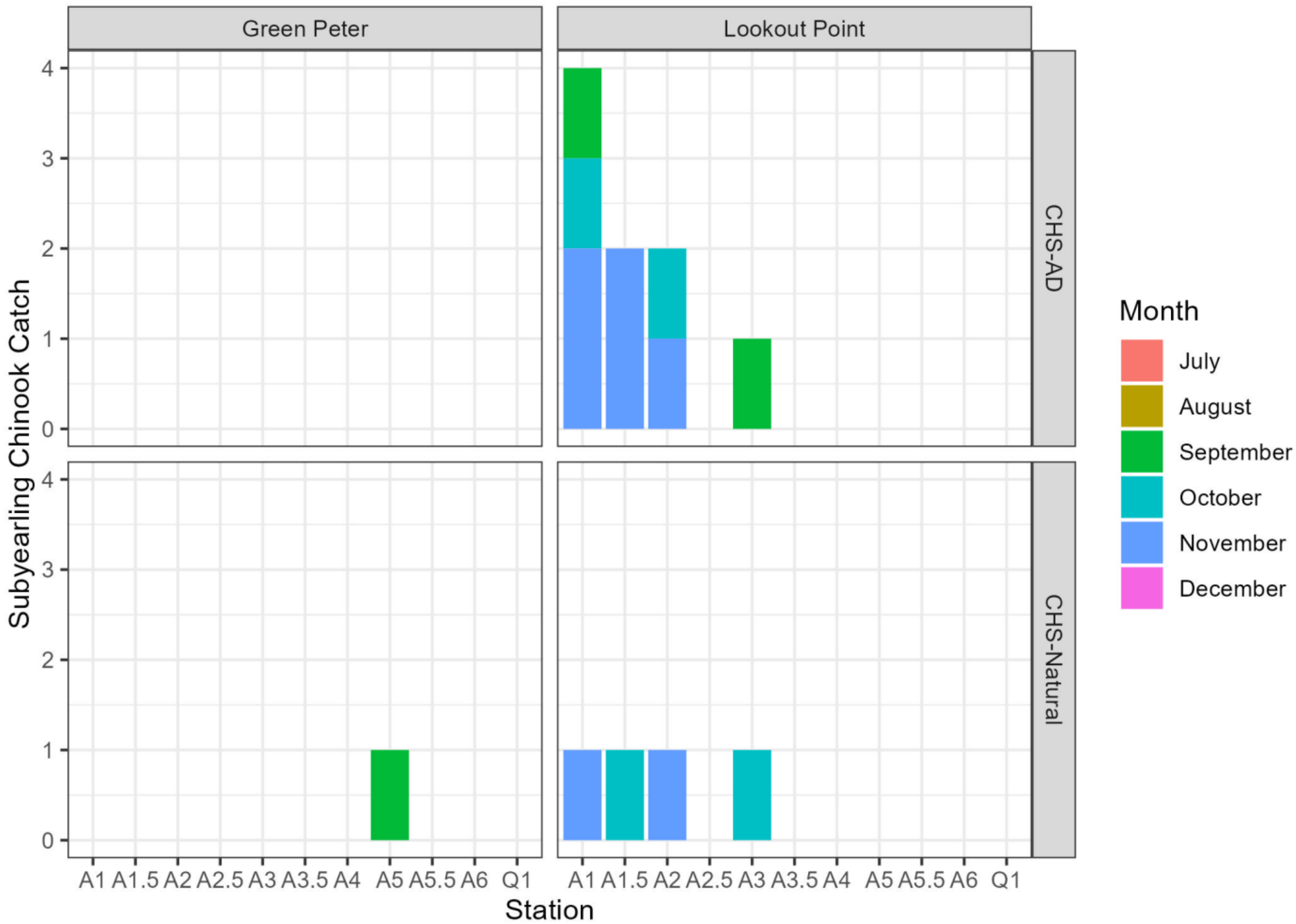


Figure 21. Total catch of subyearling Chinook salmon in gill nets set offshore in Green Peter and Lookout Point reservoirs by station. Station A1 is at the dam, and station A6 is most upstream at the head of the reservoir (HoR).

Abundance index of Chinook salmon within longitudinal reservoir zones

Catch per unit effort (CPUE) was used as an abundance index to compare hatchery and natural origin subyearling Chinook salmon catches between reservoir longitudinal zones. CPUE was calculated for each set and species as the number of fish captured per 24 hr set. Mean CPUE was evaluated for each reservoir, sampling week, gear type and reservoir longitudinal zone. CPUE was used to display spatial and temporal patterns of catch in relation to reservoir elevation and dam operations, but due to very low catch rates, these results must be interpreted cautiously and should not be used to evaluate the effects of the injunction measures on juvenile salmon.

Lookout Point

Statistical comparisons of CPUE were not made between reservoir zones or dam operational periods due to very low catch rates, but during nearshore sampling in June and July, mean CPUE of both natural and hatchery origin Chinook salmon tended to be higher in the Upper and Middle reservoir zones in comparison to the Lower zone (Figure 22, Table 12). The nearshore sampling period in 2023 occurred after the initiation of reservoir drawdown associated with the interim injunction measures (Figure 22). Offshore gill net mean CPUE for hatchery Chinook salmon suggests offshore abundance was highest in late September in the middle zone, then was highest in the lower zone in mid-November during peak drawdown when only the lower zone remained (Figure 22). Similarly, catches suggest natural origin Chinook salmon offshore CPUE peaked in the middle zone during early October and in the lower zone in mid-November (Figure 22).

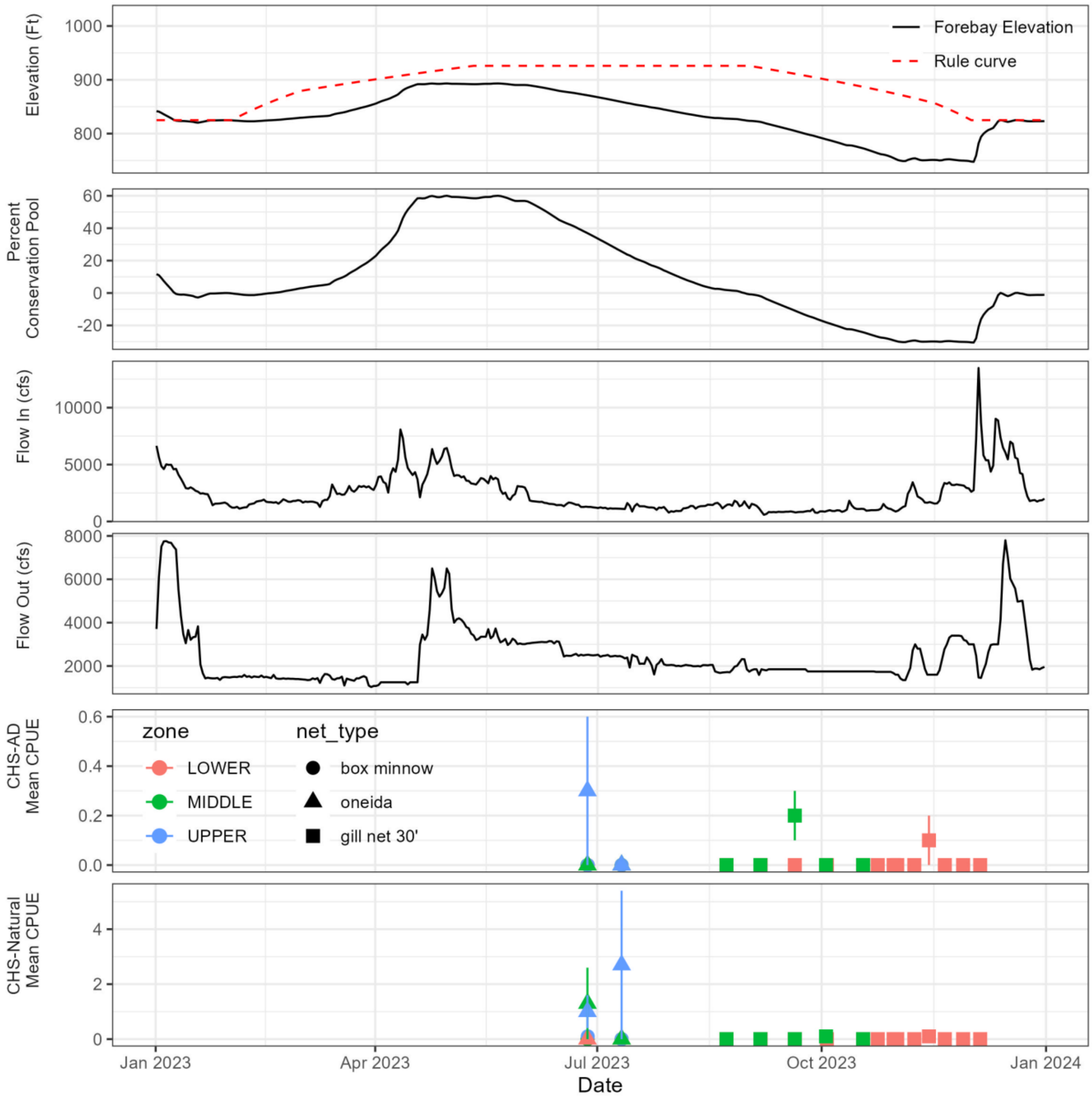


Figure 22. Lookout Point Reservoir elevation (percent of full conservation pool elevation and forebay elevation relative to rule curve) and flow in and out of the reservoir (cfs) in comparison to hatchery (CHS-AD) and natural origin (CHS-Natural) subyearling Chinook salmon mean CPUE. Mean CPUE is for all nets set in each sampling week and is plotted on the x-axis by the mean sampling date for the week. Mean CPUE is presented for each reservoir longitudinal zone and net type. CPUE for gill net sets is shown for only nets with mean temperature of less than 20 ºC with all net depths combined.

Green Peter

Only one Chinook salmon was captured in Green Peter reservoir offshore in the upper zone during late September during the drawdown and coinciding with an increase in flow out (cfs) of the reservoir (Figure 23). No comparisons are being made of CPUE due to insufficient catches and suspension of offshore sampling, which occurred in early October.

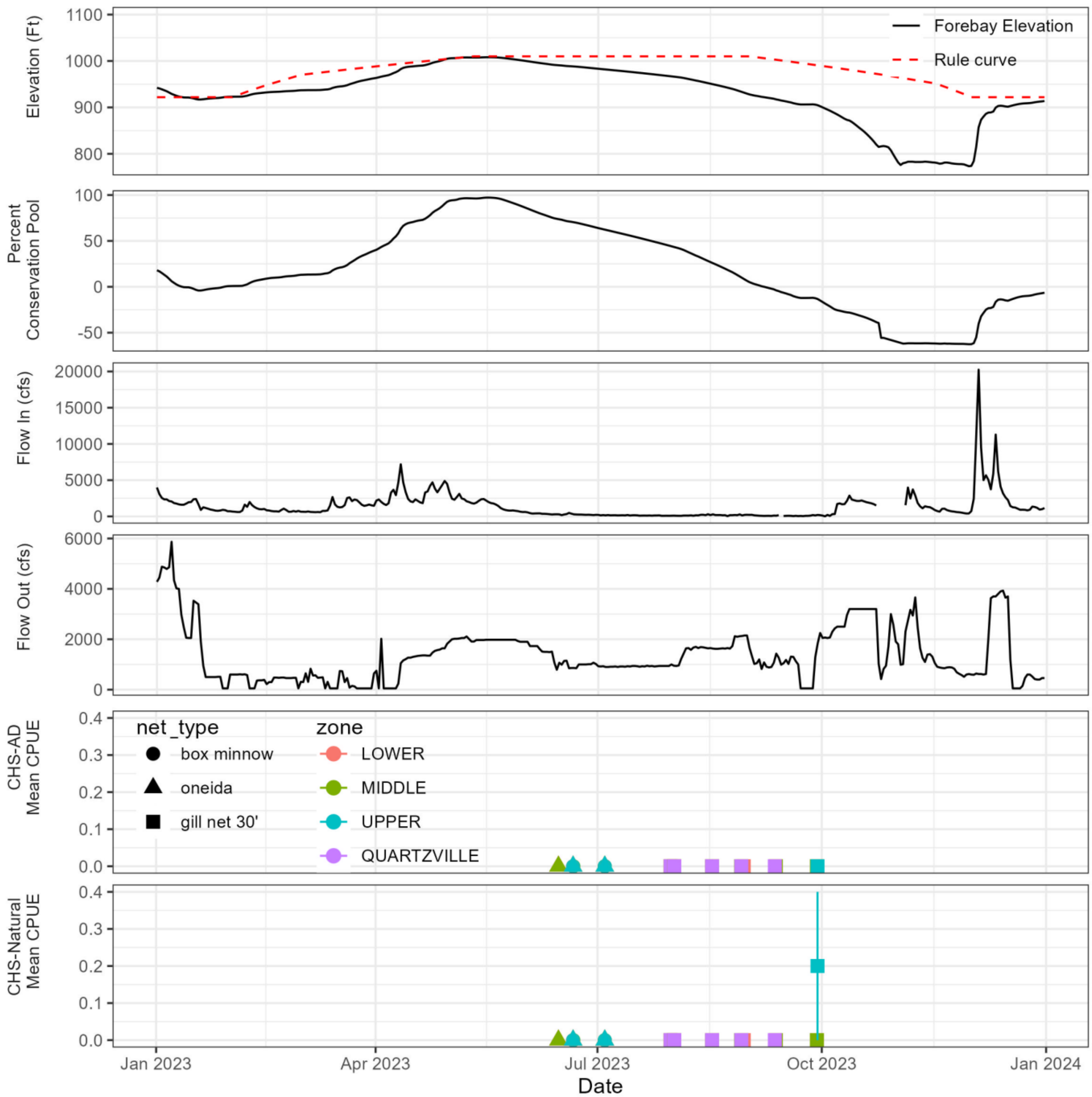


Figure 23. Green Peter Reservoir elevation (percent of full conservation pool elevation and forebay elevation relative to rule curve) and flow in and out of the reservoir (cfs) in comparison to natural origin (CHS-Natural) subyearling Chinook salmon mean CPUE. Mean CPUE is presented for each reservoir longitudinal zone and net type. Mean CPUE is for all nets set in each sampling week and is plotted on the x-axis by the mean sampling date for the week. CPUE for gill net sets is shown for only nets with mean temperature of less than 20 ºC with all net depths combined. No hatchery (CHS-AD) Chinook salmon were captured in this reservoir.

Table 12. Total CHS catch and percentage of catch caught in each reservoir zone in relation to how full the reservoir was during fish sampling. Total catch is summed across all gear types and includes both hatchery and natural origin Chinook salmon. Reservoir fullness was assessed by the minimum and maximum percent of full conservation pool elevation observed during fish sampling days.

		% Cons. Pool			Percent of CHS catch by zone			
Reservoir	**Month**	**Min**	**Max**	**Total Catch**	**LOWER**	**MIDDLE**	**UPPER**	**QUARTZVILLE**
Green Peter	6	69.5	73.9	0	-	-	-	-
Green Peter	7	43.7	63.0	0	-	-	-	-
Green Peter	8	7.1	43.7	0	-	-	-	-
Green Peter	9	-15.9	-2.5	1	0	0	100	0
Lookout Point	6	35.2	37.9	9	0	44.4	55.6	-
Lookout Point	7	23.9	26.6	8	0	0	100	-
Lookout Point	8	1.5	2.0	0	0	0	-	-
Lookout Point	9	-12.0	-1.6	2	0	100	-	-
Lookout Point	10	-29.8	-17.6	4	75	25	-	-
Lookout Point	11	-30.3	-29.3	7	100	-	-	-
Lookout Point	12	-24.5	-12.6	0	-	-	-	-

Chinook salmon catch by net temperature and depth

Temperatures in both reservoirs, but particularly in Lookout Point were high during much of the sampling season. Subyearling Chinook salmon catch was examined by net temperature to examine trends in Chinook salmon habitat use. Water surface temperature was used for nearshore traps while the mean temperature of the vertical temperature profile over the range of depths spanned by each net was used for gill nets. This evaluation is observational and opportunistic as the sampling design was not intended to evaluate catch by temperature or depth.

General patterns observed are that Chinook salmon were captured in nearshore traps up to 23.6°C (Figure 24). In the offshore environment, Chinook salmon were captured from 7.8 to 20.0°C. The lone Chinook salmon captured in Green Peter reservoir was captured in a 5 m deep gill net set in September (Figure 25). Chinook salmon in Lookout Point Reservoir were captured from 0 to 12 m depth. Numerous deeper nets were set primarily during late summer and early fall to try to target 15°C but zero Chinook salmon were captured in the deeper nets.

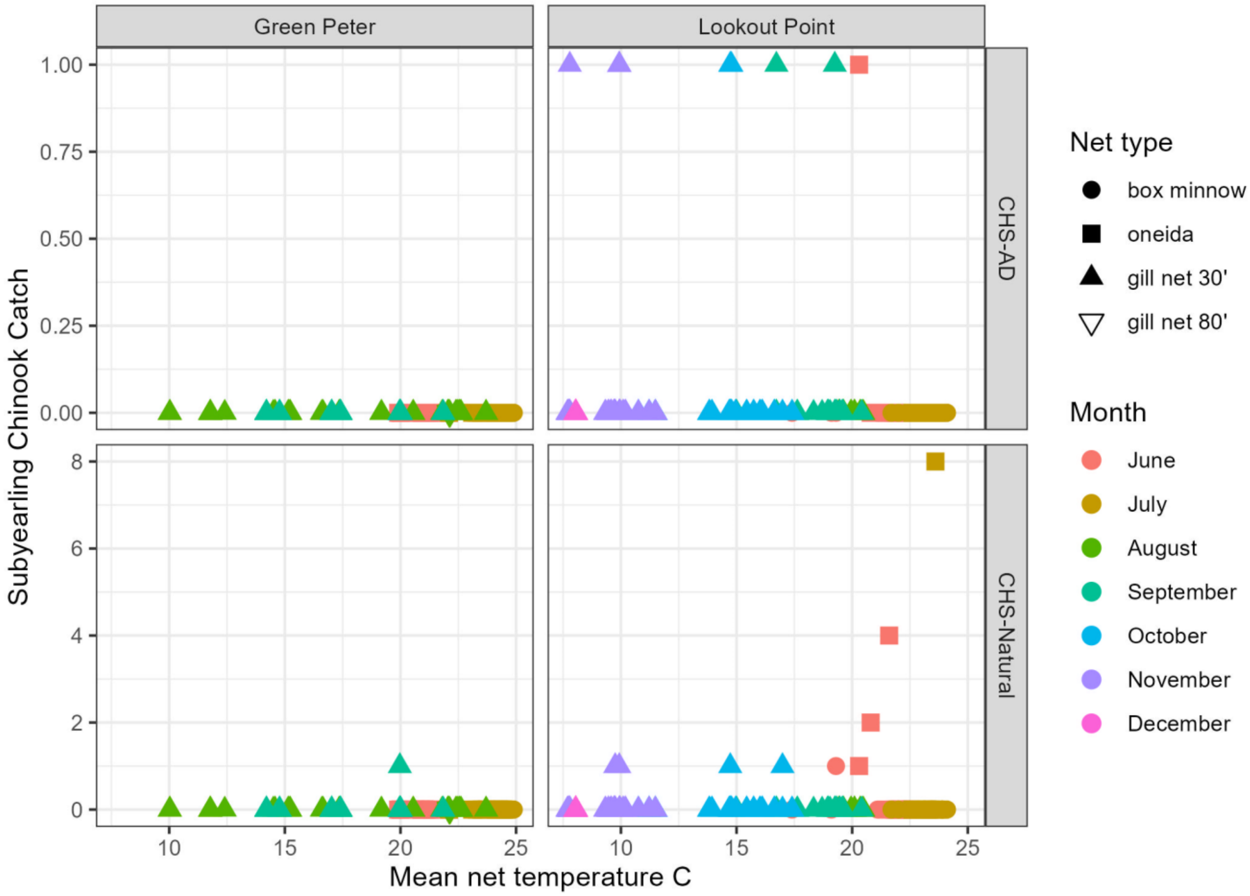


Figure 24. Catch of subyearling Chinook salmon (marked and natural origin combined) by mean net/trap temperature (ºC). Mean net water temperature is surface temperature for nearshore traps (box minnow and Oneida), and the mean temperature of the limnology profile over the range of depths covered by gill nets.

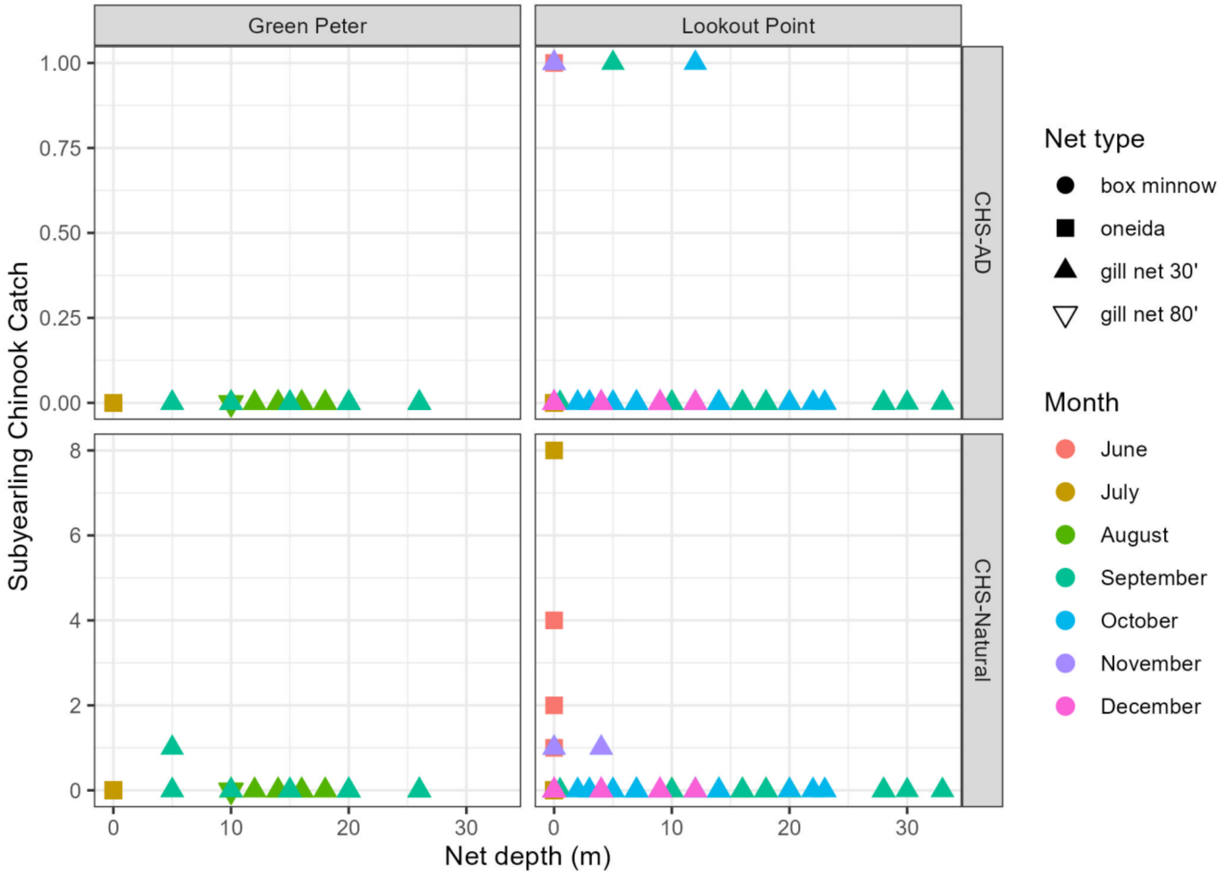


Figure 25. Catch of subyearling Chinook salmon (marked and natural origin combined) in nets by mean net/trap depth (m). Net depth is the top of the net.

Reservoir Recaptures

During the course of reservoir sampling, we recaptured seven PIT tagged subyearling Chinook salmon marked and release by the bulk marking project, all within Lookout Point Reservoir (Table 13). One Chinook salmon was released in spring (5/30/2023) at the head of the reservoir (Black Canyon) release site and recaptured approximately a month later in the Upper zone of the reservoir. Of the fall bulk releases, one Chinook salmon released from Signal Point boat launch (Middle reservoir zone – A3) was released on 9/18/2023 and recaptured in the forebay (A1) a month later. Three fish released on 9/18/2023 at the head of reservoir Black Canyon site were recaptured, two of which were recaptured a day later in the middle zone of the reservoir. The final recapture from that group was recaptured over a month after release in the Lower zone (A2). Lastly, two fish released on 11/9/2023 in the Hills Creek Dam tailrace were recaptured five days later in the Lower zone at gill net stations in or near the forebay (A1 and A1.5). No statistical comparison of travel times in response to dam operations is possible because of low recapture rates, but we did observe that the two fish released during the maximum drawdown period (November) rapidly transited downstream to the forebay (Table 13).

We additionally PIT tagged subyearling Chinook salmon captured in box minnow (n=1) and gill nets (n=3) that were in good physical condition. Of the fish tagged, one was a natural origin Chinook salmon captured in late June, while the remaining three were hatchery origin (ad-clipped) but with no PIT tag

Table 13. Capture information for PIT tagged subyearling hatchery Chinook salmon recaptured during reservoir sampling. Release information (release site and date), capture information (reservoir zone, net type, capture date and capture fork length), and travel time are provided. Shading distinguishes different release groups.

Tag code	Release Site	Release date	Capture reservoir	Capture zone	Net type	Recapture date	Travel time (days)	Fork length (mm)
3D6.15348010F9	LOP Head of Reservoir - Black Canyon	5/30/2023	Lookout Point	UPPER	oneida	6/26/2023	27	95
3DD.003E56DA4A	LOP Forebay - Signal Point	9/18/2023	Lookout Point	LOWER (A1)	gill net 30'	10/19/2023	31	159
3D6.1534843D2A	LOP Head of Reservoir - Black Canyon	9/18/2023	Lookout Point	MIDDLE (A3)	gill net 30'	9/19/2023	1	132
3DD.003E4C26BB	LOP Head of Reservoir - Black Canyon	9/18/2023	Lookout Point	MIDDLE (A3.5)	gill net 30'	9/19/2023	1	136
3DD.003E571ABF	LOP Head of Reservoir - Black Canyon	9/18/2023	Lookout Point	LOWER (A2)	gill net 30'	10/23/2023	35	139
3DD.003E55F157	Hills Creek Dam Tailrace	11/9/2023	Lookout Point	LOWER (A1)	gill net 30'	11/14/2023	5	130
3DD.003E56771E	Hills Creek Dam Tailrace	11/9/2023	Lookout Point	LOWER (A1.5)	gill net 30'	11/14/2023	5	147

Growth of juvenile salmon

We looked at changes in fork length of juvenile Chinook salmon over time in Lookout Point to evaluate size and growth (Figure 26, Table 14). Only one hatchery Chinook salmon was captured in early summer (late June-mid July), but in fall hatchery Chinook salmon were of similar size to natural origin Chinook salmon (Table 14). Natural origin Chinook salmon captured in early summer had a mean fork length of 84 mm, which increased to a mean of 156 mm for natural origin Chinook salmon captured during fall sampling (Table 14). This represents an average growth rate of 0.61 mm fork length/day between mean capture dates.

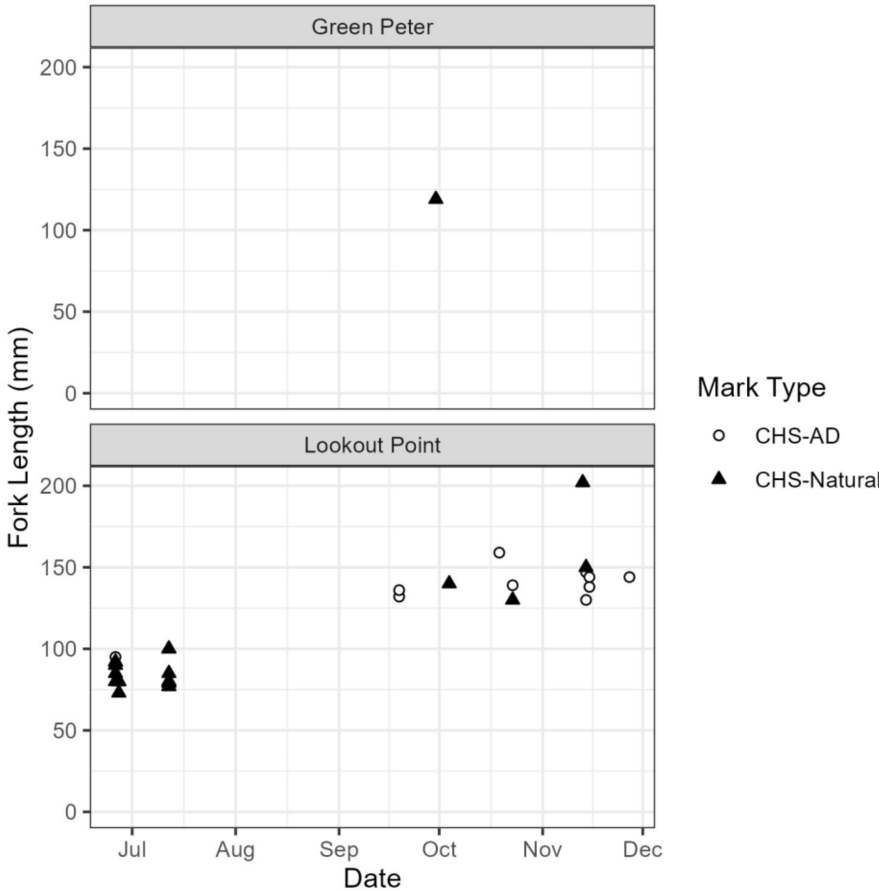


Figure 26. Fork length (mm) of subyearling Chinook salmon caught in Lookout Point and Green Peter reservoirs.

Table 14. Mean fork length and weight of natural origin Chinook salmon caught in Lookout Point Reservoir by season.

Season	Mean Capture Date	Species	N	Mean fork length (mm)	SE fork length	Mean weight (g)	SE weight
summer	7/4/2023	CHS-Natural	16	84.4	0.5	8.3	0.2
fall	10/29/2023	CHS-Natural	4	155.5	8.0	58.1	11.1

Copepod infection prevalence

All fish handled were examined for parasitic copepod presence on the gills and fins. The number and sizes of salmonids examined for parasitic copepod presence are presented in Table 15 for each species and reservoir. No fish captured during the sampling period had copepods (prevalence rate of 0% for all species and sampling weeks) (Table 15).

Table 15. Parasitic copepod infection prevalence for salmonids captured in Green Peter and Lookout Point reservoirs. Number of fish examined for copepod presence (N), mean and range of fork length and copepod prevalence rate (# fish with copepods/N) are presented.

Reservoir	Species	N	Mean Capture Week	Mean Fork Length (mm)	Min Fork Length (mm)	Max Fork Length (mm)	Copepod Prevalence
Green Peter	CHS-Natural	1	39	119	119	119	0.0%
	CUT	4	29.5	184.2	165	217	0.0%
	KOK	16	35.5	157.7	75	307	0.0%
	RBT	11	31	261.9	225	290	0.0%
Lookout Point	CHS-AD	10	41.9	136.4	95	159	0.0%
	CHS-Natural	20	30.4	98.6	73	202	0.0%
	RBT	1	38	432	432	432	0.0%

Catch composition

Catch composition by reservoir, month and species is provided below in Table 16, and detailed total catch and CPUE by sampling week and gear type is provided in Appendix Tables A1 and A2.

In Lookout Point Reservoir, the most abundant fish encountered was white crappie (Table 16). Numerous nearshore trap sets had very large catches in June and July of young of the year crappie *spp.* (classified as white crappie for reporting based on the recommendation of ODFW district biologists). These sets also had high catches of young of the year largemouth bass. Later in the season, the most abundant fish species caught in gill nets was walleye. Fork lengths for all fish species captured are provided in Appendix Figures A6-A8, however as our sampling methods were targeted for small fish, the sizes of fish captured may not be reflective of the true size distribution of fish species present in the reservoir.

Catches in Green Peter Reservoir were numerically dominated by bluegill of multiple size/age classes in June and July nearshore sampling. Bass were also encountered in moderate numbers in nearshore traps. Kokanee and *O. mykiss* had the highest catch rates in offshore gill net sampling. Fork lengths for all species captured are in Appendix Figures A6-A8.

Table 16. Total fish catch by reservoir by month for each species encountered. CHS-Natural – Natural origin Chinook salmon, CHS-AD – hatchery Chinook salmon, UnID Salmonid – unidentified salmonid, KOK – kokanee, CUT - Cutthroat trout, RBT- *O. mykiss*, SMB - Smallmouth Bass, LMB - Largemouth bass, WAL – Walleye, BLC - Black Crappie, BLG - Bluegill, NPM - Northern Pikeminnow, BBH- brown bullhead, LSS - Large-scale sucker.

Reservoir	Month	CHS-Natural	CHS-AD	UnID Salmonid	KOK	CUT	RBT	SMB	LMB	WAL	WHC	BLC	BLG	NPM	BBH	SCU	LSS	Total Catch
Green Peter	June	0	0	0	0	1	0	8	52	0	0	2	348	1	0	0	0	412
	July	0	0	0	1	2	3	26	2	0	0	1	253	2	0	0	0	290
	August	0	0	0	7	0	8	1	0	0	0	0	0	0	0	0	0	16
	September	1	0	0	8	1	0	0	0	0	0	0	1	0	0	0	0	10
Lookout Point	June	8	1	0	0	0	0	1	283	4	6,474	0	0	0	0	16	1	6,779
	July	8	0	0	0	0	0	1	109	1	6,000	0	0	3	1	1	0	6,116
	August	0	0	0	0	0	0	0	0	29	2	0	0	0	0	0	0	31
	September	0	2	0	0	0	1	0	1	59	4	0	0	0	0	0	0	65

October	2	2	0	0	0	0	0	0	85	3	2	0	0	0	0	0	90
November	2	5	1	0	0	0	0	0	7	2	1	0	0	0	0	0	10
December	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Predator bycatch

Capture methods were targeted to sample juvenile Chinook salmon and other small fish, thus we only evaluated predator (>200 mm fork length piscivorous fish species) captured as bycatch and we did not systematically sample the entire size range of the predator community. Large (>200 mm) bycatch excluded from this analysis were Chinook salmon subyearlings, largescale suckers, kokanee and brown bullhead as these species do not typically consume fish prey as a significant portion of their diet. Total catch and catch per unit effort (CPUE, fish/24h set) were used to assess relative abundance of predator bycatch (Table 17). Catch per unit effort (CPUE) was used as a measure of relative abundance for predators for each reservoir, gear type and to assess general distribution patterns among reservoir longitudinal zones.

We encountered a total of 14 predators in Green Peter Reservoir and 10 predators in Lookout Point Reservoir during the 2023 sampling period. Green Peter predator sized fish were all captured in the Lower zone and were comprised of *O. mykiss* (200-290 mm), smallmouth bass (200-220 mm) and cutthroat trout (217 mm) (Table 17, Figure 27). Lookout Point predators were captured in all zones of the reservoir in low numbers and were comprised of walleye (213-560 mm), smallmouth bass (200-220 mm), northern pikeminnow (210 mm), *O. mykiss* (432 mm), white crappie (305 mm)), black crappie (305-310 mm) and unidentified adult salmonid (this live fish was loosely hooked to the gill net and fell out of the net before being processed, estimated at 550 mm) (Table 17, Figure 27). Smaller (<200 mm) walleye were abundant in Lookout Point Reservoir, suggesting that the predator sized population is likely considerably larger than our results from small mesh gill nets indicate.

Table 17. Total catch, mean CPUE and lengths of predator species over 200mm caught as bycatch during the sampling period by month and reservoir zone (includes all net depths). RBT – *O. mykiss*, SMB – Small mouth bass, CUT – cutthroat, NMP – northern pikeminnow, WAL – walleye, BLC – black crappie, WHC – white crappie, UnID Salmonid – unidentified adult salmonid. *Estimated length

Reservoir	Month	Net Type	Zone	Species	Total Catch	Effort (# Sets)	Mean CPUE	Mean Fork Length (mm)	Min Fork Length (mm)	Max Fork Length (mm)
Green Peter	7	gill net 80'	LOWER	RBT	3	1	3	256.7	225	280
	7	gill net 80'	LOWER	SMB	1	1	1	200	200	200
	8	gill net 30'	LOWER	RBT	2	15	0.13	269.5	255	284
	8	gill net 30'	LOWER	SMB	1	15	0.07	220	220	220
	8	gill net 80'	LOWER	RBT	6	1	6	262	225	290
	9	gill net 30'	LOWER	CUT	1	21	0.05	217	217	217
Lookout Point	6	oneida	MIDDLE	SMB	1	3	0.33	220	220	220
	7	oneida	UPPER	NPM	1	3	0.33	210	210	210
	7	oneida	UPPER	SMB	1	3	0.33	200	200	200
	9	gill net 30'	MIDDLE	RBT	1	23	0.04	432	432	432
	10	gill net 30'	LOWER	WAL	2	73	0.03	386.5	213	560
	10	gill net 30'	MIDDLE	BLC	1	13	0.08	310	310	310
	10	gill net 30'	MIDDLE	WHC	1	13	0.08	305	305	305
	11	gill net 30'	LOWER	BLC	1	116	0.01	305	305	305

Reservoir	Month	Net Type	Zone	Species	Total Catch	Effort (# Sets)	Mean CPUE	Mean Fork Length (mm)	Min Fork Length (mm)	Max Fork Length (mm)
	11	gill net 30'	LOWER	UnID Salmonid	1	116	0.01	550*	550*	550*

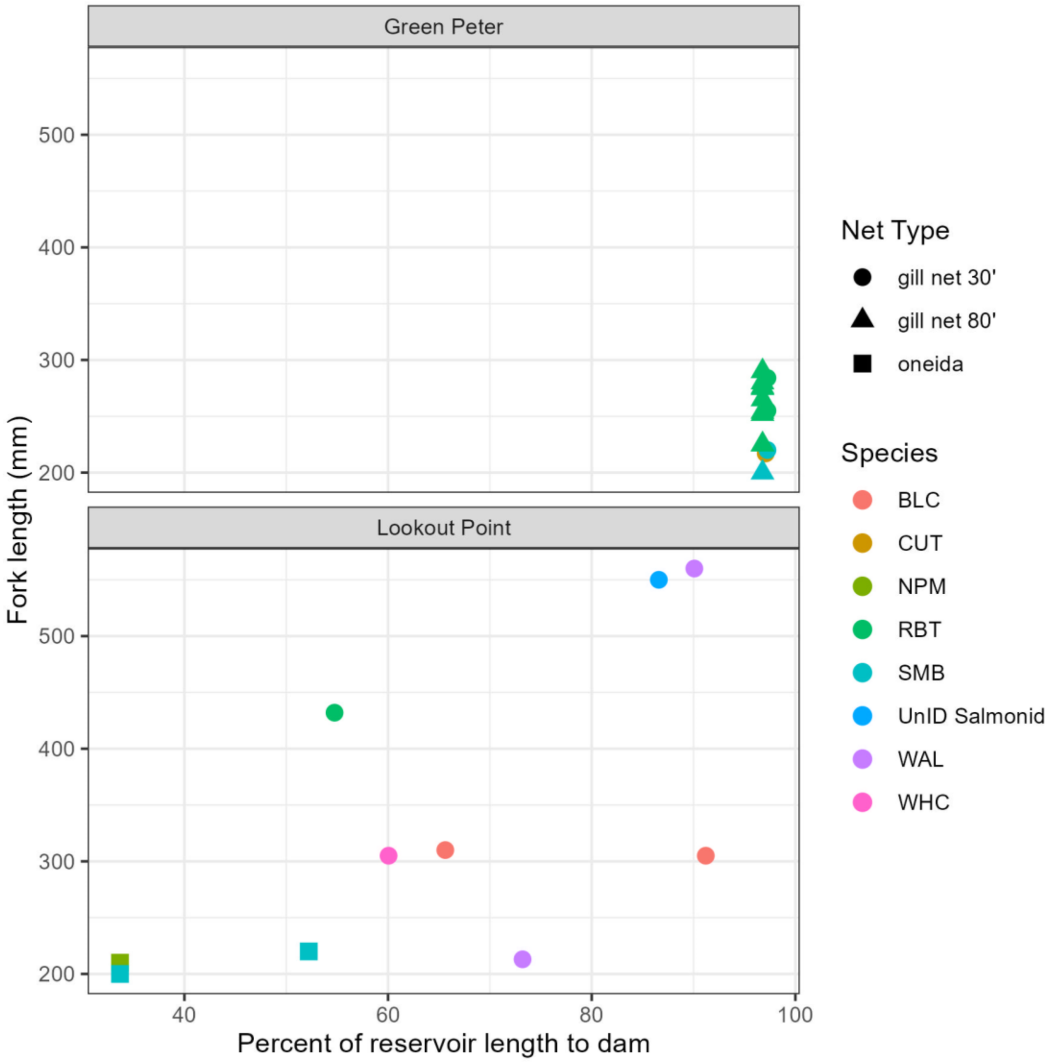


Figure 27. Fork lengths of predators >200mm captured in Green Peter and Lookout Point reservoirs in relation to percent of reservoir length to the dam (0=HoR, 100=dam).

DISCUSSION

This biannual report summarizes the efforts and results of bulk marking and reservoir distribution studies completed during the reporting period of July through December 2023 and to date, including final reporting for all 2023 activities completed from contract award through December 2023. Rotary Screw Trap results are presented in a separate report.

The bulk marking project was a significant undertaking aimed at understanding the movement patterns of juvenile Chinook salmon across various basins, with a particular focus on how Willamette Valley Project dam operations can influence those movement patterns. Across the Upper Willamette River Basin, the project aimed to tag juvenile Chinook salmon across the Middle Fork Willamette, South Santiam, North Santiam, and South Fork McKenzie River basins. The objectives sought to tag tens of thousands of fish in each basin to provide a comprehensive dataset for subsequent tracking and analysis. By the end of the year, we had tagged and released 178,858 juvenile Chinook salmon in the project area.

In the Middle Fork Willamette Basin, our goal was to PIT tag and release 67,000 sub-yearling Chinook salmon of the Middle Fork Willamette stock. We nearly met this target, releasing 66,096 fish, which represented 98.6% of the planned total. Observations of mortality and tag shedding rates are critical for evaluating the impact of the tagging process on fish health. In the Middle Fork Willamette Basin, an estimated mortality rate of 0.44% and a tag shed rate of 0.37% were observed. These low rates suggest that the tagging process was minimally invasive and that the majority of tagged fish remained viable for subsequent tracking and analysis. In the South Santiam River Basin, we exceeded our tagging and release target for sub-yearling Chinook salmon, with 36,267 fish released against a goal of 36,000. The mortality rate of 0.41% and tag shed rate of 0.28% were well within the acceptable range. In the North Santiam River Basin, the program achieved 99.7% of its target, with 38,891 tagged fish released. However, this basin faced a significant challenge in the form of a furunculosis outbreak at the Marion Forks Hatchery. This outbreak led to an alarming mortality rate of 7.5%, highlighting the importance of disease management and monitoring in hatchery operations as well as the need for robust disinfection protocols and swift response measures to mitigate such risks. The South Fork McKenzie River Basin also faced challenges due to pathogen outbreaks, impacting the overall success of the tagging program. Despite these challenges, 37,604 PIT tagged sub-yearling Chinook salmon were released, representing 96.4% of the target. The relatively high observed mortality rate of 3.5% reflects the impact of the pathogens on fish health. Our tagging efforts were mostly successful, especially considering the challenges we faced from a delayed project start and from the disease outbreaks. Additionally, outside of a brief temporal window at Marion Forks (late June/early July), our mortality rates and tag shedding rates were generally quite low, suggesting that the majority of the tagged fish were healthy at the time of release. This is crucial for ensuring the validity of subsequent movement pattern analyses, as it confirms that the majority of tagged fish could contribute meaningful data.

The recapture of PIT-tagged juvenile Chinook salmon in the Upper Willamette River Basin provided insight into the post-release movement patterns of those fish. A total of 2,772 PIT-tagged juvenile Chinook salmon were redetected across various observation locations in the basin resulting in an overall redetection rate of 1.5 percent. Across all basins we observed that the further downstream a fish was released the faster it travelled through the project. For example, travel time from release to the Cougar Dam Tailrace was shorter for fish released into the forebay compared to those released at the head of reservoir. Fish released in the Cougar forebay on November 14th, 2023 had a median travel time of 0.9 days to the Cougar Tailrace, whereas those released at the head of reservoir on November 13th, 2023 had a median travel time of 4.0 days.

There was also evidence that dam operations impacted travel times and rates. For example, mean travel time from head of Fall Creek reservoir to the Fall Creek tailrace went from 130.5 days for fish that were released on June 12th (full pool), to 24.4 days for fish released on September 28th (end of drawdown from 750ft to 738 feet), to 1.8 days for fish that were released on November 6th (middle of first low drawdown). Similarly, in the Cougar project area, the results illustrated that travel times were influenced by dam operations and reservoir elevation levels. Initial releases at Cougar in the late summer, under conditions of slow reservoir drafting and exclusive powerhouse flow, resulted in longer travel times for the juveniles to reach the tailrace. This contrasted sharply with releases during the fall drawdown period, where substantially shorter travel times were recorded, suggesting enhanced migratory passage efficiency as a result of lower forebay elevation and regulating outlet operations. The Hills Creek releases further emphasized the significance of dam operations on migration efficiency. Early releases at the head of the reservoir experienced prolonged travel times, aligning with periods of higher forebay elevations and consistent powerhouse flows. However, releases made in anticipation of or during fall drawdown operations saw markedly faster travel times, highlighting the roll of operational strategies in facilitating fish passage.

Unfortunately, we did not have enough recoveries to make meaningful insights about the impact of the deep drawdowns at Lookout Point and Green Peter reservoirs. The addition of the Lebanon Dam PIT antennas on the South Santiam River mid-season will help future iterations of this project evaluate the deep drawdown at Green Peter Reservoir. Currently there are no operational PIT detection arrays downstream of Lookout Point Reservoir. Adding detection arrays downstream of Lookout Point Reservoir may benefit the evaluation of the efficacy of the Lookout Point Reservoir deep drawdown on fish passage at Lookout Point Dam. However, it is important to note that PIT detection in the Willamette basin has many current challenges such as the limited numbers of PIT tagged salmonids present, challenges associated with installing and maintaining PIT detection systems in the basin, and unknown detection efficiencies. With additional PIT detection, there may still be an inability to collect enough data to draw meaningful conclusions, especially is the short timeframes associated with the injunction period (through 2024).

The incorporation of additional detections in future analyses would enhance our understanding of juvenile Chinook salmon migration and survival through the study area. With a more comprehensive dataset, including higher rates of detection, a broader spatial distribution of detection locations, and an in-depth understanding of PIT tag detection efficiency at those locations, it becomes feasible to conduct in-depth analyses such as survival estimates from release to recapture. Those types of estimates can offer insights into the mortality rates during migration, factors influencing survival, and the effectiveness of different migration pathways. In future reports, we aim to integrate those types of analyses to provide a more detailed understanding of the dynamics affecting juvenile Chinook salmon within the project area.

On Lookout Point Reservoir, nearshore trapping in 2023 occurred between June 26 and July 12 and was delayed from our target start of early May due to supply chain and permitting delays. During this period, we only captured 17 subyearling Chinook salmon and no juvenile *O. mykiss*. In comparison, past nearshore sampling in Lookout Point Reservoir using identical gear types (Oneida and box traps) and sampling design that sampled from March 05, 2014 through June 20, 2014 captured a total of 1,697 subyearling Chinook salmon, of which only 0.18% were captured during June (Monzyk et al. 2015). In that study, peak capture rates occurred in April and May, together comprising 95% of total catch. Our low catch rate was most likely due to missing the key period of the outmigration season and that we sampled after nearshore surface temperatures had risen to unsuitable levels of salmonids. Surface water temperatures at trap locations were over 20ºC for the duration of sampling, except for a few isolated traps in the upper zone of the reservoir. Nearshore trapping was conducted in Green Peter Reservoir in 2023 from June 15 through July 05, but zero subyearling Chinook salmon or *O. mykiss* were captured during this period. No previous nearshore sampling exists for comparison of capture rates for Green Peter, but our low capture rates in both reservoirs are likely explained by the delayed start to the season and unsuitably warm water surface temperatures during the sampling period. In 2024, nearshore trapping will begin in both reservoirs in February and be suspended in mid-June or when surface waters exceed 20ºC to increase capture rates and reduce potential harm to fish held in unsuitable temperatures.

Offshore catch rates were also extremely low. In Lookout Point Reservoir, offshore suspended small mesh gill netting was conducted between August 22 and December 6 at biweekly or weekly intervals. Over that period, only 13 subyearling Chinook salmon were captured from 296 gill nets (0.04 Chinook salmon/net) in waters less than 20ºC (309 total sets all temperatures). Comparatively, ODFW captured a total of 1,090 subyearling Chinook from 282 gill net sets (3.9 Chinook salmon/net) conducted over July-August and October-November in 2014 in Lookout Point Reservoir. This drastic difference in catch per net likely stems from multiple causes. First, the gill nets used in 2023 were of much smaller surface area and contained smaller mesh sizes than those used previously by ODFW. While efforts were taken to duplicate ODFW's custom net specifications, supply chain issues and the timeline of the project necessitated using available nets of different specifications. Compared by net area, nets used in 2023 were 16.5 m^2 (9.1 x 1.8m) compared with 112 m^2 (24.4 x 4.6m) in 2014. Expanding by the number of net sets in each respective study, our gill net effort by net area in 2023 was effectively 15% of that of ODFW's efforts in 2014. Net area accounts for some of the difference in catch rates, but not all as our catch was approximately 1% of ODFW's. It is also possible that our catches were lower due to using smaller mesh sizes (2023: 9.5, 12.7 and 15.9 mm square mesh; 2014: 9.5, 12.7, 19.1 and 25.4 mm). Most of our Chinook salmon catch was in 15.9 mm mesh, followed by 12.7 with no catch in 9.5 mm. At the time of this report, catch by mesh size for ODFW's work was not available to us, however in future we may further examine catch by mesh size to better understand the impacts of mesh size on our catch rates. We are currently in the process of ordering custom nets matching the ODFW specifications for use in 2024 offshore sampling. Other factors that may have come into play to reduce Chinook salmon catch rates include the drawdown, high turbidity, high temperatures throughout the water column during August and September, or potentially lower numbers of Chinook salmon upstream of Lookout Point Reservoir.

The low catch rates for juvenile Chinook salmon in 2023 reservoir sampling severely hinder or eliminate our ability to draw inference regarding distributional patterns, abundance and effects of injunction measures on outmigrants. We can report and compare general patterns of reservoir catch and CPUE, however, results should be interpreted with caution and should not be used alone to evaluate success of injunction measures. With that caveat, our results suggest that in June and July in Lookout Point Reservoir, Chinook salmon in nearshore habitat were primarily located in the upper zone of the reservoir. These results contrast with past studies where all Chinook salmon captured in June were found in the Lower zone in 2014, with peak catches in the Upper zone occurring earlier in the season (Monzyk et al. 2015). It is possible that the Chinook salmon we captured in late June/early July were late migrants and do not reflect the dominant outmigration distributional pattern or timing. Alternatively, it is possible that high water temperatures were affecting Chinook salmon migratory behavior and habitat use. In the offshore environment, we saw a general pattern of catches shifting to the downstream stations during fall as the drawdown progressed. At peak drawdown, only the lower zone (stations A1-A2) remained sampleable, while all upstream stations had become dewatered. In comparison, past evaluations observed a bimodal distribution in summer (higher catch rates in A1 and A5) in summer with a shift to greater catches in the lower zone (A1 and A2) later in fall (Monzyk et al. 2015). By compacting the accessible reservoir habitat in late fall, the drawdown may have concentrated Chinook salmon in the lower zone or Chinook salmon may not have entered the reservoir until after the sampling period. RST captures at the Lookout Point tailrace trap in 2023 show peak natural origin Chinook salmon catch in January, mid-spring (Late April through mid-May), and December coinciding with spill events, with few captures between June and the end of October (EAS 2024b). At the Lookout Point head of reservoir trap location, catch peaked in April/May with a much smaller second peak in December (EAS 2024b). Together, the RST results suggest that fish may have been primarily moving in spring before reservoir sampling began and again in December at or after the conclusion of reservoir sampling. A concurrent ongoing USGS acoustic telemetry study evaluating juvenile Chinook salmon movement also had lower than anticipated observations of Chinook salmon using the reservoir environment, and more detections upstream of the reservoir (Toby Kock, USGS, personal communication). High water temperatures in Lookout Point throughout the reservoir water column in August and September could explain a delay in reservoir entrance. As only one subyearling Chinook salmon was captured in Green Peter Reservoir, we cannot speak to any patterns of longitudinal distribution for that reservoir.

We observed zero incidence of *S. californiensis* copepod infection (0% prevalence rate) in any target or non-target species over the duration of 2023 sampling in either reservoir. This is greatly reduced from prevalence rates observed in previous years and in contrast with results seen in catches above and below the reservoir in RSTs in

2023. Past work observed a 75% prevalence rate of copepod infection in reservoir rearing subyearling Chinook salmon October-November in Lookout Point Reservoir during 2014 (Monzyk et al. 2015). Similar magnitude prevalence rates were seen in 2012 and 2013, with a trend of increasing prevalence over the July through December period) (Monzyk et al. 2015). At the Lookout Point Reservoir tailrace RST location, copepod infection prevalences in 2023 were 32% and 34% for natural origin and hatchery Chinook salmon respectively, compared with 0.7% for natural origin Chinook salmon above the reservoir at the Lookout Point head of reservoir trap location (EAS 2024b). Given that RST results indicate elevated copepod infection downstream of the reservoir, in contrast to our results, we interpret our 0% prevalence rate as potentially an artifact of our small salmonid sample size or possibly a difference in protocol. Our teams will be reviewing protocol in February 2024 to ensure consistency with current and past evaluations for *S. californiensis.*

Our limnology results indicate clear temperature concerns for salmonids in Lookout Point Reservoir during August and September in 2023. From mid-August through late September, the water column down to 30 m was 19-21ºC. At that time, the maximum depth in the forebay was approximately 35 m, and depths greater than 30 m had low dissolved oxygen that would have presented stressful conditions for salmonids (less than 5 mg/L) (Bjornn and Reiser 1991). Thus, during peak temperatures there was essentially no suitable habitat in Lookout Point reservoir for salmonids. In 2017 and 2018, temperatures above 18ºC occurred during late summer down to approximately 20 m, however the maximum depth of the reservoir was greater, and a layer of suitable temperature remained throughout the season (Kock et al. 2019b). The drawdown, which reduced reservoir elevations relative to past years, may have contributed to the change in conditions. Other potential causes include Hills Creek operations, and differences in flows or inflow temperatures between years. A visual comparison of river temperatures at the MF Willamette River Below North Fork Oakridge USGS gage (14148000) upstream of Lookout Point Reservoir for June-September of 2017, 2018 and 2023 shows no drastic differences in water temperatures between years, however 2023 did have slightly warmer temperatures in June by approximately 1 to 2 ºC (no apparent differences for other months).

Our limnology vertical profiles in Lookout Point reservoir and USGS Green Peter tailrace monitoring also identified concerns with high turbidity levels in both reservoirs during the drawdown, with turbidity exceeding 200 NTU in November and December during the peak of the drawdown. Suspended sediments have been associated with negative effects on the spawning, growth, and reproduction of salmonids (Bash et al. 2001). Past studies have found high levels to be fatal to salmonids while lower levels may cause reduced foraging capability, reduced growth, resistance to disease and impaired migration (Lloyd 1987). Adverse effects have been associated with turbidity levels as low as 18-70 NTU (Gregory 1992). Laboratory studies have found that juvenile steelhead and coho avoid areas with mean turbidity of 167 NTUs or higher but no avoidance was seen at the 57-77 NTU range (Sigler et al. 1984). Based on these past studies, the elevated turbidity levels seen in Lookout Point and Green Peter reservoirs may have caused avoidance behavior or had other adverse impacts on juvenile salmonids. This may be reflected in the relatively modest estimated growth rate seen in 2023 in Lookout Point for natural origin Chinook salmon caught between early summer and fall. The mean growth rate (0.61 mm of fork length/day) observed in 2023 for natural origin Chinook salmon was comparable to rates seen in 2011 (0.61 mm/d fork length) but less than rates observed during 2012-2014 (0.84-0.86 mm/d fork length) (Monzyk et al. 2015).

It is possible that higher turbidity may have reduced predation pressure on juvenile salmonids from resident piscivores that rely on visual foraging, as has been documented in other systems (Gregory and Levings 1998). In Lookout Point Reservoir, most predator size (>200 mm) bycatch were walleye, crappie spp., smallmouth bass, *O. mykiss* and northern pikeminnow, however, our sampling methods were not designed to capture predator sized fish. Past work that assessed the predator community in Lookout Point Reservoir during 2013-2015 identified northern pikeminnow, crappie spp., largemouth bass, and walleye as the most abundant predators (Brandt et al. 2016). In floating gill nets, northern pikeminnow were the most abundant species in 2013-2015 (Brandt et al.

2016), however in our floating gill nets, walleye (not exclusively >200mm) comprised the greatest proportion of the catch, suggesting their relative abundance may have increased since the previous assessment. We intend to set AFS experimental sinking gill nets in 2024 to strategically sample the predator community to better understand the current species composition, size structure and abundance.

REFERENCES CITED

Bash J., Berman C. and Bolton S. 2001. Effects of turbidity and suspended solids on salmonids. Washington State Transportation Center. Final Research Report - Research Project T1803, Task 42, submitted to the Washington State Department of Transportation.

Bjornn, T. C., and D. W. Reiser. 1991. Habitat Requirements of Salmonids in Streams. Chapter 4 of Influences of Forest and Rangeland Management on Salmonid fishes and their habitats. American Fisheries Society Special Publication 19:83–138.

Brandt, J. R., Monzyk, F. M., Romer, J. D. and R. Emig. 2016. Status and trends of predator species in Lookout Point Reservoir. Final Report to the U.S. Army Corps of Engineer, Task Order W9127N-10-2-0008. Oregon Department of Fish and Wildlife, Corvallis. Available at: https://odfw-wsrme.forestry.oregonstate.edu/sites/default/files/reservoir-research/status_and_trends_of_predator_species_in_lookout_point_reservoir-with_npm_rt_-final.pdf

Columbia Basin Fish and Wildlife Authority Integrated Hatchery Operations Team (IHOT). 1994. Policies and procedures for Columbia Basin anadromous salmon hatcheries. Available at: https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/Hat99-001CIntegratedHatcheryOperationsTeam1994%20Policy%20and%20Procedures%20for%20Columbia%20Basin%20Anadromous%20Salmonid%20Hatcheries.pdf

Environmental Assessment Services (EAS). 2024a. Willamette Valley fish passage monitoring via rotary screw traps. Draft annual report. Submitted to the US Army Corps of Engineers Portland District.

Environmental Assessment Services (EAS). 2024b. Downstream juvenile fish passage monitoring via rotary screw traps. Draft annual report. Submitted to the US Army Corps of Engineers Portland District.

Gregory, R. S. 1992. The influence of ontogeny, perceived risk of predation and visual ability on the foraging behavior of juvenile Chinook Salmon. Pages 271-284 in D. J. Stouder, K. L. Fresh, and R. J. Feller, editors. Theory and application in fish feeding ecology, v. 18.

Gregory R.S., and Levings C.D. 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. Transactions of the American Fisheries Society. 127:275-285.

Independent Science Group. 1996. Return to the River Report. Document number 96-6, Northwest Power Planning Council Independent Scientific Advisory Board, Portland, OR.

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

Keefer, M. L., Taylor, G. A., Garletts, D. F., Helms, C. K., Gauthier, G. A., Pierce, T. M., and Caudill, C. C., 2013. High-head dams affect downstream fish passage timing and survival in the Middle Fork Willamette

River. River Research and Applications 29: 483–492. Published online 6 January 2012 in Wiley Online Library(wileyonlinelibrary.com) DOI: 10.1002/rra.1613.

Kock, T.J., Perry, R.W., Hansen, G.S., Haner, P.V., Pope, A.C., Plumb, J.M., Cogliati, K.M., and Hansen, A.C., 2019a. Evaluation of Chinook salmon (Oncorhynchus tshawytscha) fry survival at Lookout Point Reservoir, western Oregon, 2017: U.S. Geological Survey Open-File Report 2019-1011, 42 p., https://doi.org/10.3133/ofr20191011.

Kock, T.J., Perry, R.W., Hansen, G.S., Haner, P.V., Pope, A.C., Plumb, J.M., Cogliati, K.M., and Hansen, A.C., 2019b. Juvenile Chinook salmon (Oncorhynchus tshawytscha) survival in Lookout Point Reservoir, Oregon, 2018: U.S. Geological Survey Open-File Report 2019–1097, 41 p., https://doi.org/10.3133/ofr20191097.

Lloyd, D.S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management 7: 34-45.

Monzyk F.R., Emig R., Romer J.D., Friesen T.A. 2013. Life-history characteristics of juvenile spring Chinook salmon rearing in Willamette Valley reservoirs. Work completed for compliance with the 2008 Willamette Project Biological Opinion, USACE funding: 2012. Available at: https://odfw-wsrme.forestry.oregonstate.edu/sites/default/files/reservoir-research/life-history_characteristics_in_reservoirs_annual_report_2012_-final.pdf

Monzyk F.R., Emig R., Romer J.D., Friesen T.A. 2015. Life-history characteristics of juvenile spring Chinook salmon rearing in Willamette Valley reservoirs. Work completed for compliance with the 2008 Willamette Project Biological Opinion, USACE funding: 2014. Available at: https://odfw-wsrme.forestry.oregonstate.edu/sites/default/files/reservoir-research/life-history_characteristics_in_reservoirs_2014_-final.pdf

NMFS (NOAA National Marine Fisheries Service). 2008. Endangered Species Act Section 7(a)(2) Consultation: Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act, Essential Fish Habitat Consultation. NMFS Northwest Region F/NWR/2000/02117.

Northwest Marine Technology, Inc. (NMT). 2017. Visible Implant Elastomer Tag Project Manual: Guidelines on planning and conducting projects using VIE. Available at: https://www.nmt.us/wp-content/uploads/2017/11/VIE-Project-Manual-Nov-2017-1.pdf

PIT Tag Steering Committee. 2014. PIT tag marking procedures manual (version 3.0). Available at: https://www.ptagis.org/content/documents/2014-mark-procedures-manual.pdf

Pollock, K. H., Nichols, J. D., Brownie, C., & Hines, J. E. 1990. Statistical inference for capture-recapture experiments. Wildlife monographs, 3-97.

Romer, J. D., Monzyk, F. R., Emig, R., Friesen, T. A., 2014. Juvenile salmonid outmigration monitoring at Willamette Valley Project reservoirs. Prepared by Oregon Department of Fish and Wildlife, Willamette Research, Monitoring, and Evaluation Program for U.S. Army Corps of Engineers, Portland District during 2013 with final report delivered September 2014; Contract W9127N-10-2-0008-0035.

Romer, J. D., Monzyk, F. R., Emig, R., Friesen, T. A., 2015. Juvenile salmonid outmigration monitoring at Willamette Valley Project reservoirs. Prepared by Oregon Department of Fish and Wildlife, Willamette Research, Monitoring, and Evaluation Program for U.S. Army Corps of Engineers, Portland District during 2014 with final report delivered September 2015; Contract W9127N-10-2-0008-0035.

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

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

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113: 142-150.

USFWS (U.S. Fish and Wildlife Service). 2008. Biological opinion on the continued operation and maintenance of the Willamette River Basin Project and effects to Oregon chub, bull trout, and bull trout critical habitat Designated under the Endangered Species Act. Oregon Fish and Wildlife Office.

APPENDIX

Figure A1. Box minnow trap deployment.

Figure A2. Oneida trap deployment.

Figure A3. Gill net deployment.

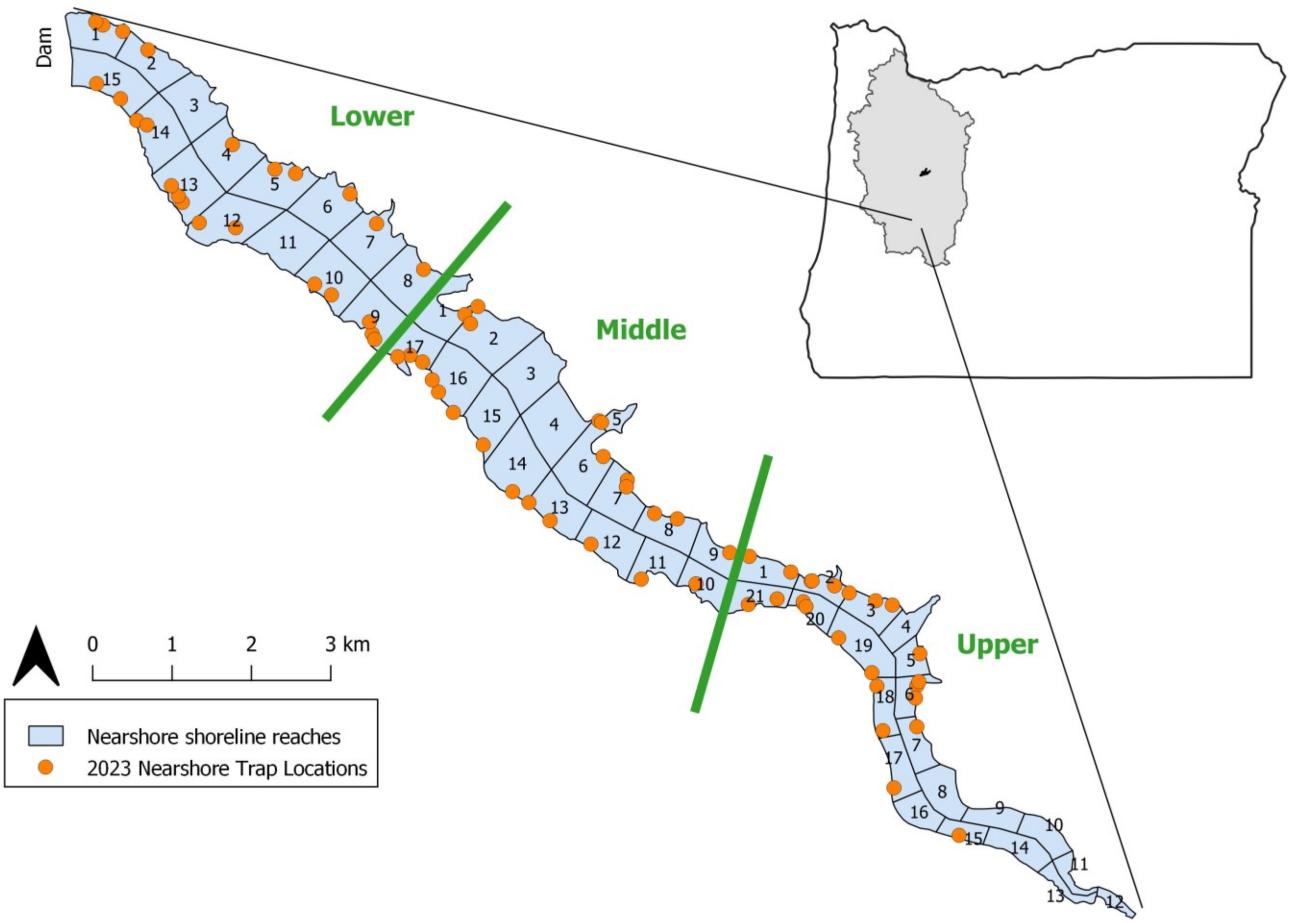


Figure A4. 2023 Nearshore trap locations for Lookout Point Reservoir.

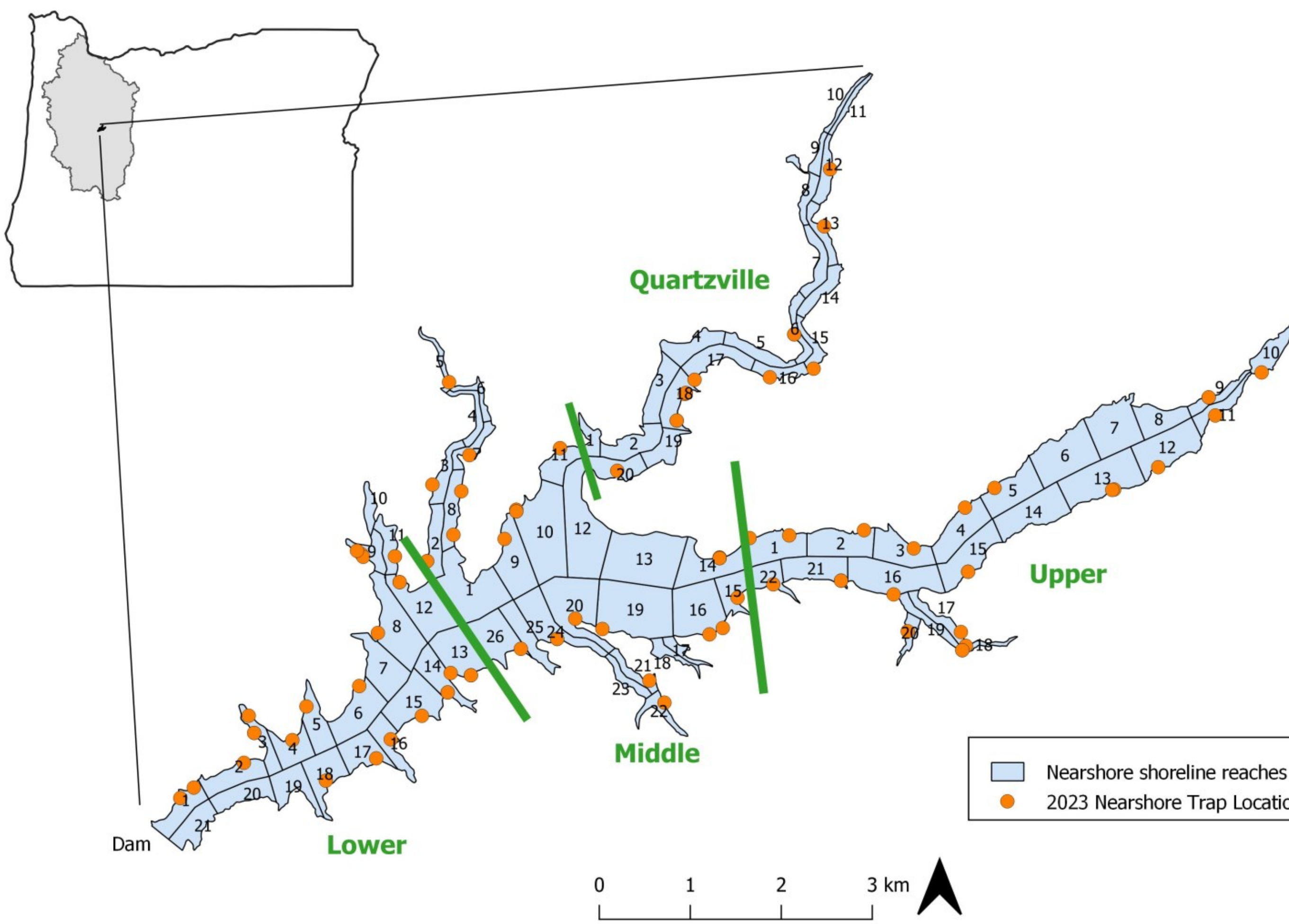


Figure A5. 2023 Nearshore trap locations for Green Peter Reservoir.

Table A1. Total catch and mean CPUE for nearshore trap sets. Total catch is presented for each species, followed by mean CPUE in parentheses. "Water temp. C" represents mean water surface temperature at trap sites.

Reservoir	Week	Zone	Net type	Net depth (m)	Effort (# sets)	Total catch	Water temp. C	CHS-Natural	CHS-AD	CUT	BBH	LSS	BLC	WHC	BLG	SMB	LMB	WAL	NPM	SCU
Green Peter	24	lower	oneida	0	1	30	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	28 (28)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	24	middle	oneida	0	1	101	21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	100 (100)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	25	lower	box minnow	0	9	0	21.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	25	middle	box minnow	0	8	5	21.3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.2)	1 (0.1)	1 (0.1)	0 (0)	1 (0.1)	0 (0)
Green Peter	25	Quartzville	box minnow	0	3	1	20.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	25	upper	box minnow	0	9	16	21.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (0.7)	0 (0)	10 (1.1)	0 (0)	0 (0)	0 (0)
Green Peter	25	lower	oneida	0	3	30	21.3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	29 (9.7)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)
Green Peter	25	middle	oneida	0	3	60	21.4	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	1 (0.3)	0 (0)	50 (16.7)	2 (0.7)	6 (2)	0 (0)	0 (0)	0 (0)
Green Peter	25	Quartzville	oneida	0	3	51	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	49 (16.3)	0 (0)	2 (0.7)	0 (0)	0 (0)	0 (0)
Green Peter	25	upper	oneida	0	3	118	20.9	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	83 (27.7)	3 (1)	32 (10.7)	0 (0)	0 (0)	0 (0)
Green Peter	27	lower	box minnow	0	9	1	23.9	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	27	middle	box minnow	0	9	6	24.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (0.6)	0 (0)	1 (0.1)	0 (0)	0 (0)	0 (0)
Green Peter	27	Quartzville	box minnow	0	3	16	23.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.7)	14 (4.7)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	27	upper	box minnow	0	9	9	24.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	8 (0.9)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	27	lower	oneida	0	3	20	23.9	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	18 (6)	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)
Green Peter	27	middle	oneida	0	3	71	24.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	70 (23.3)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	27	Quartzville	oneida	0	3	85	23.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	84 (28)	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)
Green Peter	27	upper	oneida	0	3	77	24.1	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	1 (0.3)	0 (0)	72 (24)	2 (0.7)	1 (0.3)	0 (0)	0 (0)	0 (0)
Lookout Point	26	lower	box minnow	0	8	124	22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	122 (15.2)	0 (0)	0 (0)	2 (0.2)	0 (0)	0 (0)	0 (0)
Lookout Point	26	middle	box minnow	0	9	207	22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	181 (20.1)	0 (0)	0 (0)	26 (2.9)	0 (0)	0 (0)	0 (0)
Lookout Point	26	upper	box minnow	0	8	71	20.9	1 (0.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.1)	0 (0)	0 (0)	51 (6.4)	3 (0.4)	0 (0)	15 (1.9)
Lookout Point	26	lower	oneida	0	3	3003	21.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3003 (1001)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	26	middle	oneida	0	3	1906	21.9	4 (1.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1700 (566.7)	0 (0)	1 (0.3)	200 (66.7)	1 (0.3)	0 (0)	0 (0)
Lookout Point	26	upper	oneida	0	3	1466	21.2	3 (1)	1 (0.3)	0 (0)	0 (0)	1 (0.3)	0 (0)	1461 (487)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	28	lower	box minnow	0	9	74	23.3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	72 (8)	0 (0)	0 (0)	1 (0.1)	0 (0)	0 (0)	1 (0.1)
Lookout Point	28	middle	box minnow	0	8	35	23.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	23 (2.9)	0 (0)	0 (0)	12 (1.5)	0 (0)	0 (0)	0 (0)
Lookout Point	28	upper	box minnow	0	9	76	23.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	40 (4.4)	0 (0)	0 (0)	36 (4)	0 (0)	0 (0)	0 (0)
Lookout Point	28	lower	oneida	0	3	2151	23.1	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	2150 (716.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	28	middle	oneida	0	3	1846	23.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1844 (614.7)	0 (0)	0 (0)	1 (0.3)	1 (0.3)	0 (0)	0 (0)
Lookout Point	28	upper	oneida	0	3	1942	22.9	8 (2.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1871 (623.7)	0 (0)	1 (0.3)	59 (19.7)	0 (0)	3 (1)	0 (0)

Table A2. Total catch and mean CPUE for offshore net sets. Total catch is presented for each species, followed by mean CPUE in parentheses. "Water temp. C" represents mean water temperature of the vertical temperature profile over the range of depths covered by the net.

Reservoir	Week	Zone	Net Type	Net depth (m)	Effort (# sets)	Total catch	Water temp. C	CHS-Natural	CHS-AD	UnID Salmonid	CUT	KOK	RBT	BLC	WHC	BLG	SMB	LMB	WAL
Green Peter	31	A1	gill net 30'	10	1	3	22.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)

Reservoir	Week	Zone	Net Type	Net depth (m)	Effort (# sets)	Total catch	Water temp. C	CHS-Natural	CHS-AD	UnID Salmonid	CUT	KOK	RBT	BLC	WHC	BLG	SMB	LMB	WAL
Green Peter	31	A1	gill net 80'	10	1	4	22.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (3)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)
Green Peter	31	A1	gill net 80'	10	1	9	22.1	0 (0)	0 (0)	0 (0)	0 (0)	3 (3)	6 (6)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A2	gill net 30'	14	1	0	15.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A2	gill net 30'	14	2	0	15.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A3	gill net 30'	16	1	0	11.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A3	gill net 30'	16	2	1	11.8	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A4	gill net 30'	14	2	1	14.6	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A5	gill net 30'	12	1	0	20.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A5	gill net 30'	12	2	0	20.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A6	gill net 30'	10	1	0	22.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	A6	gill net 30'	10	2	0	22.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	Q1	gill net 30'	16	1	0	11.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	Q1	gill net 30'	16	2	0	11.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	Q1	gill net 30'	18	1	0	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	31	Q1	gill net 30'	18	2	0	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	A1	gill net 30'	18	1	0	14.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	A1	gill net 30'	20	1	0	12.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	A2	gill net 30'	16	1	0	16.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	A3	gill net 30'	16	1	0	16.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	A4	gill net 30'	12	1	0	21.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	A4	gill net 30'	14	1	0	19.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	A5	gill net 30'	10	1	0	23.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	A5.5	gill net 30'	10	1	0	23.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	33	Q1	gill net 30'	14	1	0	19.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A1	gill net 30'	10	3	0	22.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A1	gill net 30'	12	2	0	22.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A2	gill net 30'	14	3	0	22.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A2	gill net 30'	18	1	0	17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A3	gill net 30'	16	3	0	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A3	gill net 30'	20	3	2	15.2	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A4	gill net 30'	16	3	0	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A4	gill net 30'	18	1	0	17.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	A5	gill net 30'	10	3	0	22.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	Q1	gill net 30'	14	3	0	22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	35	Q1	gill net 30'	18	1	0	17.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	37	A1	gill net 30'	20	5	0	17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	37	A2	gill net 30'	20	6	0	17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	37	A3	gill net 30'	20	4	0	17.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	37	A4	gill net 30'	20	4	0	17.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	37	A5	gill net 30'	10	3	0	21.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	37	Q1	gill net 30'	20	4	0	17.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	39	A1	gill net 30'	26	6	4	14.2	0 (0)	0 (0)	0 (0)	1 (0.2)	3 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	39	A2	gill net 30'	15	2	0	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	39	A2	gill net 30'	26	2	1	14.2	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	39	A3	gill net 30'	15	1	0	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Reservoir	Week	Zone	Net Type	Net depth (m)	Effort (# sets)	Total catch	Water temp. C	CHS-Natural	CHS-AD	UnID Salmonid	CUT	KOK	RBT	BLC	WHC	BLG	SMB	LMB	WAL
Green Peter	39	A3	gill net 30'	26	3	1	14.8	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	39	A4	gill net 30'	26	4	2	14.8	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Green Peter	39	A5	gill net 30'	5	4	3	20	1 (0.2)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)
Green Peter	39	Q1	gill net 30'	15	4	0	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	34	A1	gill net 30'	16	3	1	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)
Lookout Point	34	A1	gill net 30'	20	3	1	19.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)
Lookout Point	34	A2	gill net 30'	14	3	0	20.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	34	A2	gill net 30'	18	3	8	19.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	8 (2.7)
Lookout Point	34	A3	gill net 30'	12	3	8	20.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	8 (2.7)
Lookout Point	34	A3	gill net 30'	16	3	8	20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.7)	0 (0)	0 (0)	0 (0)	6 (2)
Lookout Point	34	A3.5	gill net 30'	10	3	2	20.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.7)
Lookout Point	34	A3.5	gill net 30'	14	3	3	20.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (1)
Lookout Point	36	A1	gill net 30'	18	1	0	19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	36	A1	gill net 30'	20	1	1	18.9	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Lookout Point	36	A1	gill net 30'	28	1	0	18.3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	36	A1	gill net 30'	30	1	0	18.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	36	A1	gill net 30'	33	2	0	15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	36	A2	gill net 30'	14	3	0	19.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	36	A2	gill net 30'	16	3	1	19.3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)
Lookout Point	36	A3	gill net 30'	14	3	2	19.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.7)
Lookout Point	36	A3	gill net 30'	16	3	0	19.3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	36	A3.5	gill net 30'	0.5	1	0	20.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	36	A3.5	gill net 30'	10	2	2	19.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)
Lookout Point	36	A3.5	gill net 30'	12	2	0	19.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	38	A1	gill net 30'	0	2	1	16.7	0 (0)	1 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	38	A1	gill net 30'	28	6	0	17.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	38	A2	gill net 30'	18	6	1	19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)
Lookout Point	38	A3	gill net 30'	5	3	44	19.2	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	43 (14.3)
Lookout Point	38	A3	gill net 30'	7	3	10	19.3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (0.7)	0 (0)	0 (0)	0 (0)	8 (2.7)
Lookout Point	38	A3.5	gill net 30'	0	4	5	16.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	2 (0.5)	0 (0)	0 (0)	1 (0.2)	1 (0.2)
Lookout Point	40	A1	gill net 30'	22	3	0	16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	40	A1	gill net 30'	23	3	0	16.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	40	A1.5	gill net 30'	20	1	0	16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	40	A2	gill net 30'	14	6	0	16.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	40	A2	gill net 30'	20	1	0	16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	40	A3	gill net 30'	2	3	16	17.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	15 (5)
Lookout Point	40	A3	gill net 30'	4	3	10	17	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9 (3)
Lookout Point	40	A3.5	gill net 30'	0	4	2	13.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	1 (0.2)
Lookout Point	42	A1	gill net 30'	12	6	1	14.8	0 (0)	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	42	A2	gill net 30'	7	6	3	15.4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (0.5)
Lookout Point	42	A2.5	gill net 30'	0	3	0	16.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	42	A2.5	gill net 30'	3	6	15	15.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	15 (2.5)
Lookout Point	42	A3	gill net 30'	0	3	0	13.9	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	43	A1	gill net 30'	7	6	5	14.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (0.8)
Lookout Point	43	A1.5	gill net 30'	0	3	23	14.7	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	22 (7.3)

Reservoir	Week	Zone	Net Type	Net depth (m)	Effort (# sets)	Total catch	Water temp. C	CHS-Natural	CHS-AD	UnID Salmonid	CUT	KOK	RBT	BLC	WHC	BLG	SMB	LMB	WAL
Lookout Point	43	A1.5	gill net 30'	9	3	2	14.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	1 (0.3)
Lookout Point	43	A2	gill net 30'	0	3	7	14.7	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (2)
Lookout Point	43	A2	gill net 30'	5	3	0	15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	43	A2.5	gill net 30'	0	6	3	14.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)	1 (0.2)	0 (0)	0 (0)	0 (0)	1 (0.2)
Lookout Point	44	A1	gill net 30'	0	2	0	11.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A1	gill net 30'	0	1	0	11.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A1	gill net 30'	4	2	2	11.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)
Lookout Point	44	A1	gill net 30'	4	1	0	11.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A1	gill net 30'	9	1	0	10.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A1.5	gill net 30'	0	2	0	11.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A1.5	gill net 30'	0	1	0	11.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A1.5	gill net 30'	4	2	1	11.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.5)
Lookout Point	44	A1.5	gill net 30'	4	1	1	11.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Lookout Point	44	A2	gill net 30'	0	2	0	11.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A2	gill net 30'	0	1	0	11.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A2	gill net 30'	4	2	4	11.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (2)
Lookout Point	44	A2	gill net 30'	4	1	1	11.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Lookout Point	44	A2	gill net 30'	9	2	0	10.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	44	A2	gill net 30'	9	1	1	10.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	45	A1	gill net 30'	0	3	0	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	45	A1	gill net 30'	4	3	0	10.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	45	A1	gill net 30'	9	3	0	10.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	45	A1.5	gill net 30'	0	3	0	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	45	A1.5	gill net 30'	4	3	0	10.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	45	A2	gill net 30'	0	3	0	10	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	45	A2	gill net 30'	4	3	4	10.2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (1.3)
Lookout Point	45	A2	gill net 30'	9	3	0	10.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A1	gill net 30'	0	3	1	9.9	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A1	gill net 30'	4	3	1	9.8	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A1	gill net 30'	9	3	0	9.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A1	gill net 30'	12	3	0	9.3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A1.5	gill net 30'	0	6	2	9.9	0 (0)	2 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A1.5	gill net 30'	4	3	0	9.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A1.5	gill net 30'	9	3	0	9.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A2	gill net 30'	0	6	2	9.9	1 (0.2)	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A2	gill net 30'	4	3	1	9.8	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	46	A2	gill net 30'	9	3	0	9.5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A1	gill net 30'	0	2	0	9.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A1	gill net 30'	4	2	0	9.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A1	gill net 30'	9	2	0	9.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A1	gill net 30'	12	2	0	9.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A1.5	gill net 30'	0	4	0	9.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A1.5	gill net 30'	4	2	1	9.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A1.5	gill net 30'	9	2	1	9.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A2	gill net 30'	0	4	1	9.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.2)

Reservoir	Week	Zone	Net Type	Net depth (m)	Effort (# sets)	Total catch	Water temp. C	CHS-Natural	CHS-AD	UnID Salmonid	CUT	KOK	RBT	BLC	WHC	BLG	SMB	LMB	WAL
Lookout Point	47	A2	gill net 30'	4	2	0	9.6	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	47	A2	gill net 30'	9	2	0	9.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A1	gill net 30'	0	2	1	7.8	0 (0)	1 (0.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A1	gill net 30'	4	2	0	7.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A1	gill net 30'	9	2	0	7.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A1	gill net 30'	12	2	0	7.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A1.5	gill net 30'	0	4	0	7.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A1.5	gill net 30'	4	2	0	7.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A1.5	gill net 30'	9	2	0	7.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A2	gill net 30'	0	4	0	7.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A2	gill net 30'	4	2	0	7.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	48	A2	gill net 30'	9	2	0	7.8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A1	gill net 30'	0	3	0	8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A1	gill net 30'	4	3	0	8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A1	gill net 30'	9	3	0	8.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A1	gill net 30'	12	3	0	8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A1.5	gill net 30'	0	6	0	8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A1.5	gill net 30'	4	3	0	8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A1.5	gill net 30'	9	3	0	8.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A2	gill net 30'	0	6	0	8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A2	gill net 30'	4	3	0	8	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Lookout Point	49	A2	gill net 30'	9	3	0	8.1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

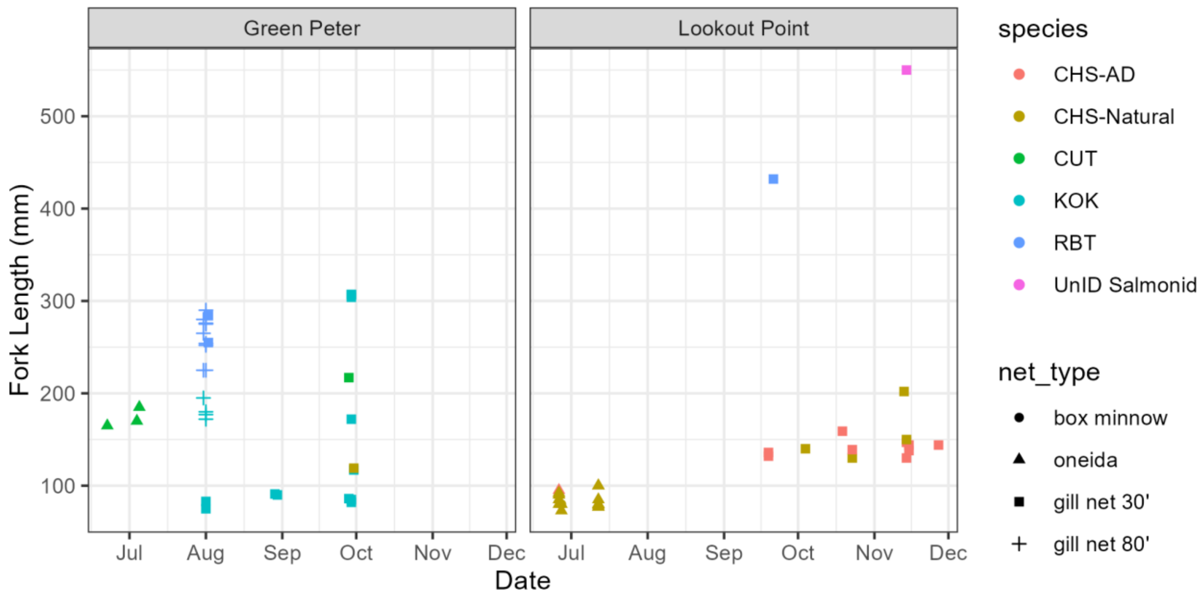


Figure A6. Fork lengths of all salmonid species captured in reservoir sampling by sampling date.

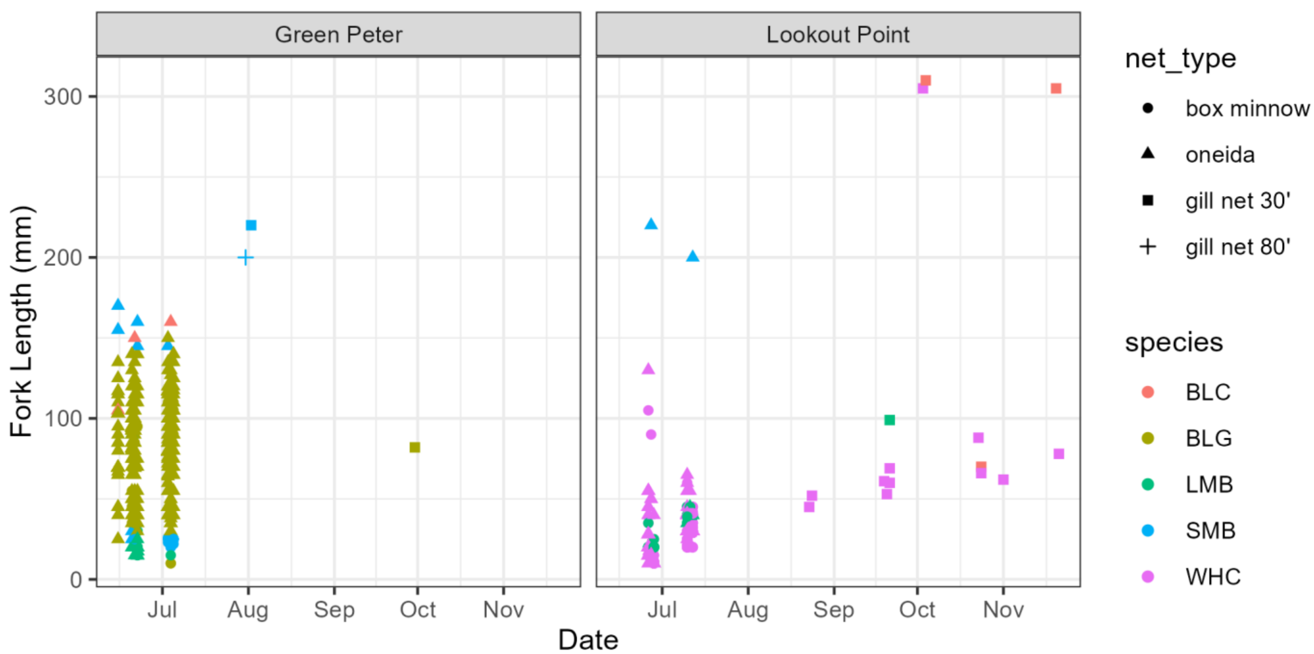
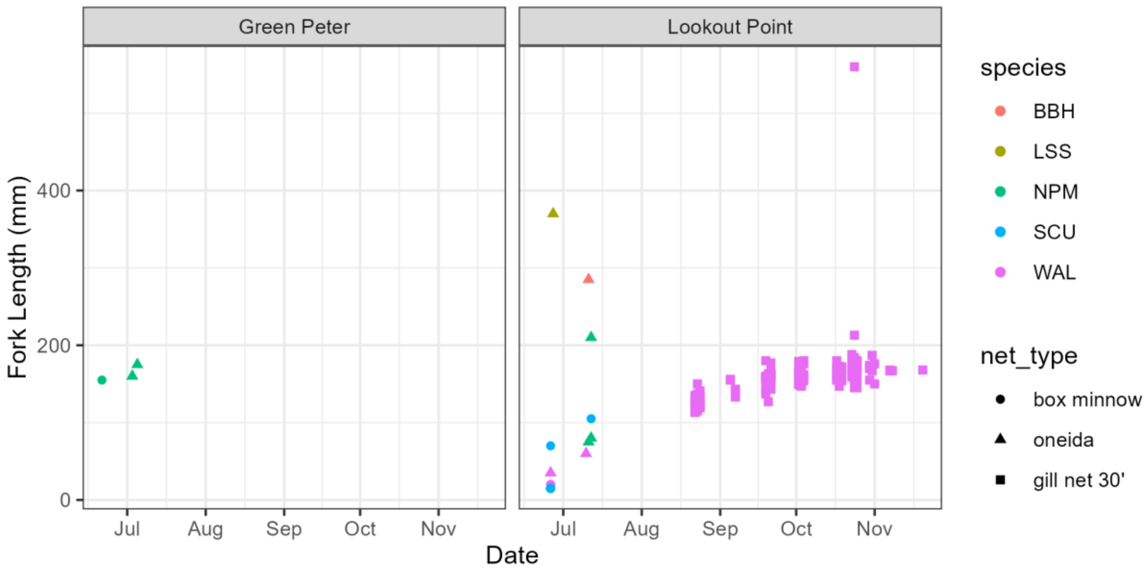


Figure A7. Fork lengths of centrarchid species captured in reservoir sampling by sampling date.


Green Peter
Lookout Point
Fork Length (mm)
400
200
0
Jul
Aug
Sep
Oct
Nov
Date
species
BBH
LSS
NPM
SCU
WAL
net_type
box minnow
oneida
gill net 30'