

Newaukum River Smolt Production, 2024



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Authors

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Executive Summary

This report provides the results from the 2024 juvenile salmonid monitoring study on the Newaukum River main stem near Centralia, Washington. The primary objective of this study is to describe the freshwater production (e.g., smolt abundance) of Pacific salmon (*Oncorhynchus* spp.) and steelhead trout (*O. mykiss*) in the Newaukum River. Specifically, we describe the abundance, timing, and diversity (body size, age structure, run timing) of juvenile outmigrants for wild coho salmon (*O. kisutch*), steelhead trout, and Chinook (*O. tshawytscha*). Based on the location and timing of the study, the results reflect juveniles that completed their freshwater rearing phase in habitats upstream of river kilometer 9.35 (river mile 5.8) of the main stem Newaukum River.

To meet the study objectives, a 1.5-meter (5-foot) rotary screw trap was operated near river kilometer 9.35 (river mile 5.8) of the main stem Newaukum River from March 13 to June 27, 2024.

Coho outmigrants were predominately of the yearling (or “1+”) age class (95.7%). Scale age data indicated that there was a smaller 2+ year-old component of the coho out-migration (3.5%) that started late April. Scale age data also indicated that there was a small subyearling (“0” age class) component of the coho out-migration (0.9%) that started in early June. The average fork length of all outmigrant coho was 114.8 mm ($\pm$ 9.8 mm standard deviation SD). The average fork length of known subyearlings was 103.7 mm ($\pm$ 5.3 mm SD), known yearlings was 114.6 mm ($\pm$ 9.4 mm SD), and two-year-old outmigrants was 126.1 mm ($\pm$ 10.8 mm SD). Abundance of wild coho outmigrants in 2024 was estimated to be 100,711 (95% CI: 80,586 – 132,683) with a coefficient of variation (CV) of 13.1%.

Steelhead outmigrants ranged from Age-1 to Age-3 based on scales (54.4%, 42.3%, and 3.3% for Age-1 through Age-3, respectively), indicating three different juvenile life histories. Outmigrant timing was concurrent for all age classes. The average fork length for all measured steelhead was 151.0 mm ($\pm$ 23.9 mm SD). Fork length averaged 138.2 mm ($\pm$ 21.9 mm SD) for Age-1, 165.8 mm ($\pm$ 15.8 mm SD) for Age-2, and 175.4 mm ($\pm$ 5.8 SD) for Age-3. Abundance of wild steelhead outmigrants was estimated to be 7,374 (95% CI = 5,702 – 9,843) with a CV of 14.2%.

Chinook salmon in coastal Washington begin their downstream migration as Age-0 fish (fry and subyearlings). Typically, the majority of Chinook fry ($\leq$ 45 mm fork length) out-migrate when flow conditions are not suitable for smolt trapping in the Chehalis Basin (e.g., January and February). Therefore, the goal was to estimate the subyearling smolt ($>$ 45 mm fork length) component of the Chinook out-migration that generally occurs from March – July. Fork lengths of all subyearling Chinook increased steadily throughout the trapping period and averaged 46.8 mm ($\pm$ 5.7 mm SD) and 94.5 mm ($\pm$ 6.7 mm SD) in the first and last sampled week of trapping, respectively. Approximately 87.7% of the total catch of wild Chinook outmigrants were $>$ 45 mm. Abundance of wild Chinook subyearling smolt outmigrants was estimated to be 49,624 (95% CI = 44,539 – 56,411) with a CV of 6.1%.

Introduction

The Washington Department of Fish and Wildlife (WDFW) has monitored freshwater production of juvenile Pacific salmon (*Oncorhynchus* spp.) in the Chehalis River since the early 1980s. Over this time, the work has focused on wild coho salmon (*O. kisutch*) and estimates of wild coho smolt abundance have been generated at the basin scale. Results from the monitoring program have demonstrated that the Chehalis River has a higher density of wild coho smolts (average 1,021 smolts mi⁻² [394 smolts km⁻²]) than any other western Washington watershed for which data currently exists (Litz 2024). Previously, smolt abundance estimates from individual tributaries throughout the Chehalis River Basin were generated in the 1980s and 1990s but were not evaluated during the next two decades. Earlier estimates only focused on coho, thus providing limited information on freshwater production of other salmonid species, including Chinook (*O. tshawytscha*) and steelhead trout (*O. mykiss*). Recent efforts under the Chehalis Basin Strategy (<https://officeofchehalisbasin.com/>) to develop a monitoring and adaptive management plan (M&AMT 2021) as part of the larger Aquatic Species Restoration Plan (ASRPSC 2019) have highlighted the need for annual smolt (or juvenile outmigrant) data that will be critical for evaluating variability and trends in juvenile freshwater production over time.

The Newaukum River was selected for long-term annual monitoring of smolt and adult abundance in 2019 to collect baseline information prior to “early action” restoration projects associated with the Chehalis Basin Strategy’s Aquatic Species Restoration Program which is focused on enhancing aquatic habitats in the basin. Importantly, the Newaukum River supports runs of coho salmon, steelhead trout, cutthroat, fall Chinook salmon, and is known to support a relatively large proportion (2000 – 2021 average = 28%) (Ronne et al. 2023) of the spring Chinook spawning population in the Chehalis River Basin. Additionally, the Chehalis Basin Collaborative for Salmon Habitat (Lead Entity) designated the Newaukum River as a “pilot watershed” associated with the Coast Salmon Partnership’s Prioritized Watershed Restoration Program (<https://www.coastsalmonpartnership.org/current-initiatives/pwr/>), and a prioritized restoration plan for the headwaters was completed in 2023 (Harma et al. 2023). To date, more than 30 fish passage projects have been completed in the Newaukum River basin. For these reasons, accurate and precise estimates of salmon and steelhead smolt populations (e.g., freshwater production) in the Newaukum River are critical for monitoring status and trends of salmon and steelhead populations and responses to habitat restoration.

Objectives

The primary objective of this study is to describe the freshwater production of salmon and steelhead in the Newaukum River. Abundance, timing, and diversity (body size, age structure, run timing) of juvenile outmigrants for wild coho salmon, steelhead, Chinook salmon, and cutthroat trout (*O. clarkii*) are described. Based on the location and timing of the study, the results reflect juveniles that completed their freshwater rearing phase in habitats upstream of river kilometer 9.35 (river mile 5.8) of the main stem Newaukum River between March 13 to June 27, 2024.

Methods

Study Site

The Newaukum River is a major sub-basin of the Chehalis River, a large coastal drainage in Southwest Washington State. The Newaukum River is comprised of three forks (North, Middle, and South Fork), multiple smaller tributaries, and a main stem that drains approximately 450 square kilometers from the

foothills of the Cascade mountains. The main stem Newaukum enters the Chehalis River at approximately river kilometer 121 (mile 75.2), just south of the city of Centralia. The Newaukum River is relatively low elevation (~48 to 909 m) and low gradient with a rain dominant hydrology. Land use in the basin is predominately industrial timber production in the headwater locations and private residential and agricultural in lower elevation locations. Native anadromous salmonids in the Newaukum River include coho salmon, winter steelhead, spring and fall Chinook salmon, and cutthroat trout. A hatchery program for coho and steelhead is operated by the Onalaska School District in the South Fork Newaukum upstream of the smolt trap.

Like other rivers in western Washington, juvenile Chinook salmon in the Chehalis River have a protracted out-migration period during their first year of life. Yearlings are rarely observed at the Chehalis main stem smolt trap or in adult returns as determined from otoliths (Campbell et al. 2017; 2023; Winkowski and Zimmerman 2018). The Chehalis main stem trap is downstream of the Newaukum trap; therefore, juvenile Chinook salmon in the Newaukum presumably exhibit a similar life history behavior of out-migrating as subyearlings. There are two predominant freshwater rearing strategies observed for juvenile Chinook salmon at both the Chehalis main stem and Newaukum smolt traps, and they are distinguishable as bimodal out-migration peaks. The first pulse of outmigrants is termed 'fry' (defined as juveniles ≤ 45 mm fork length [FL]), which are individuals that out-migrate almost immediately after emergence. Fry are observed at the smolt trap beginning in early March but have been presumably out-migrating since January, based on other smolt traps in the Puget Sound and other areas (Anderson and Topping 2018; Groot and Margolis 1991; Kiyohara and Zimmerman 2012; Zimmerman et al. 2015). The second pulse of Chinook outmigrants are termed 'subyearlings', which are individuals that grow in freshwater for weeks to months after emergence and are observed at the smolt trap between the months of March and July. Subyearlings are the focus of production estimates in the Newaukum River which are presented in this report.

The trapping location (Figure 1) on the Newaukum River (46°37'0.56 N, 122°56'12.51 W) was selected for multiple reasons, including access for installation, operation, and removal, water velocity, river depth and width, and location within the stream network, described by West et al. (2020). In 2023, it was estimated that 91% of adult spring Chinook and 94% of fall Chinook salmon spawned upstream of the trap site producing the subyearling outmigrants in 2024 (Ronne et al. 2025). In 2022, 100% of adult coho salmon spawned upstream of the trap, producing the yearling outmigrants in 2024 (Ronne et al. 2024). Likewise, all adult steelhead that reproduced in the Newaukum from 2021-2023, producing Age 1, Age-2, and Age-3 smolts, spawned above the trap site.

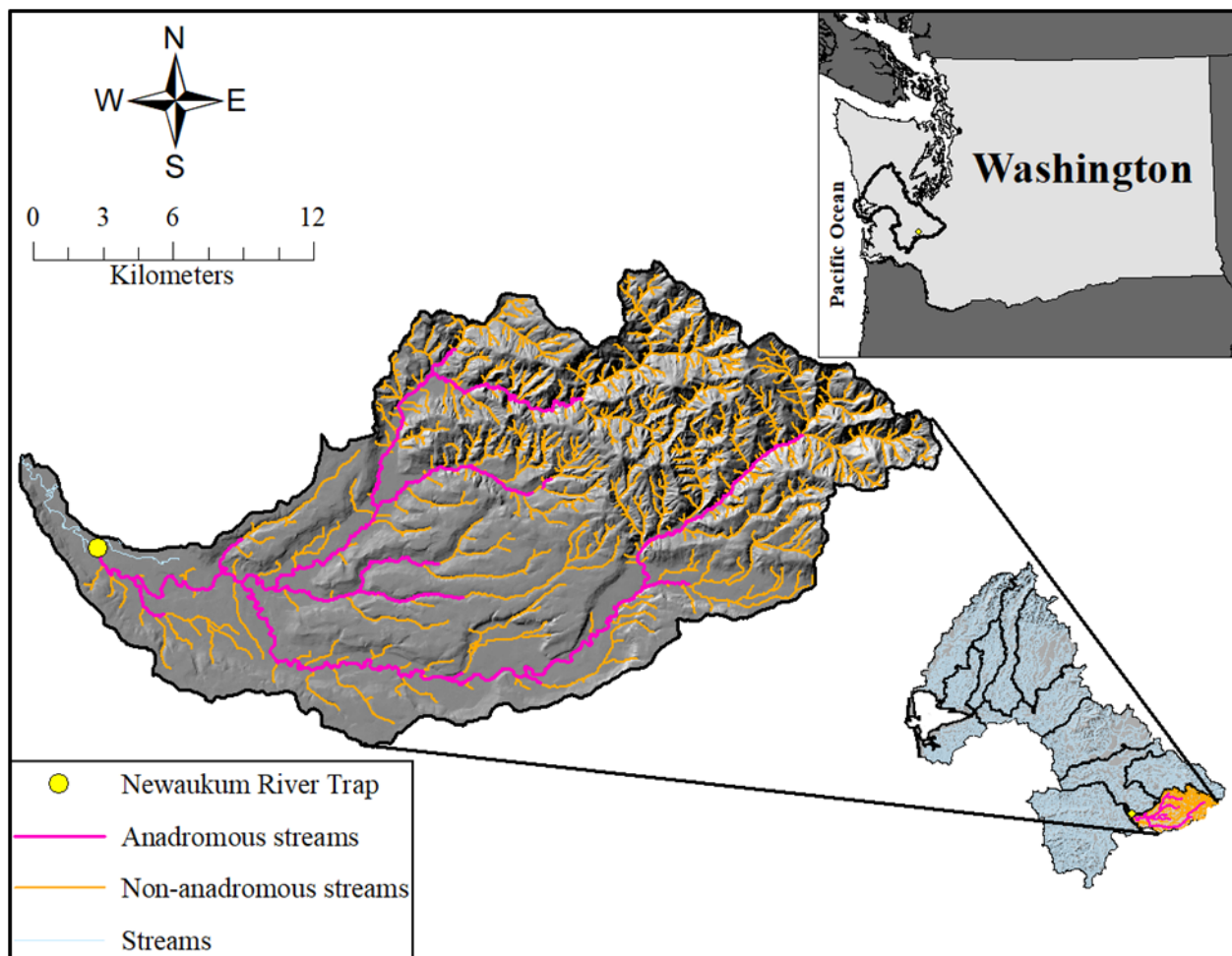


Figure 1. Newaukum River rotary screw trap location. Anadromous streams represent stream habitat within the predicted coho salmon range of occurrence (112.5 km) using a 0.50 probability decision threshold (Walther 2021) upstream of the Newaukum River rotary screw trap. Non-anadromous streams represent stream habitat outside the predicted coho salmon range of occurrence (565.7 km) upstream of the trap location. Marked fish were released 3.9 km upstream of the trap location at the Rush Road bridge on the right bank, directly under the bridge.

Trap Operation

A 1.5 m (5-foot) diameter rotary screw trap (RST) was operated near river kilometer 9.35 of the Newaukum River in 2024 (Figure 2). The trap was scheduled to operate continuously from March 13 through June 27, although unscheduled trap outages did occur due to high flow and debris. The outages were due to high flow or heavy debris and some lasted longer than 24 hours. (Appendix B).

Stream temperature and trap status information (e.g., fishing or not fishing, cone revolutions per minute) were collected daily at the start of each sampling event. Water temperatures in fish holding containers were monitored throughout sampling events. Stream temperature was also monitored with a temperature data logger (HOBO 64K Pendant) deployed adjacent to the trap and cabled to the bank that collected and logged temperature at 30-min intervals. Data loggers were calibrated according to

Winkowski et al. (2018). Stream flow is monitored by the USGS discharge gage Newaukum River near Chehalis, Washington (USGS 12025000) which is located 2.7 km downstream of the trap site.



Figure 2. Newaukum River trap site.

Fish Collection

Fish sampling commenced each morning daily and was adjusted to earlier times as daytime stream temperatures increased to $> 18^{\circ}\text{C}$ throughout the season. Crews monitored river flows and weather several times daily and modified operations in response to environmental conditions, such as earlier or multiple checks to minimize temperature impacts on fish health. Fish were removed from the live box and moved to small dish tubs for sampling. Fish were anaesthetized with tricaine methanesulfonate (MS-222) prior to enumeration and biological sampling. An anaesthetizing solution was created by diluting 10 – 25 ml of a MS-222 solution (5 g of MS-222 dissolved in 500 ml of water in a 500 ml container) into 2 – 3 L of water. This solution was replaced as necessary. Samplers continually evaluated fish response to the solution and targeted the lowest dosages needed to complete biological sampling.

During sampling, all fish were identified to species and enumerated. Coho, steelhead, Chinook, cutthroat, and lamprey (*Entospenus tridentus* and *Lampetra planeri*) were further categorized by life stage and age class as described below. Marks associated with trap efficiency trials (see Trap Efficiency Trials section) and hatchery origin (clipped adipose fin) were examined on all Chinook, coho, and steelhead. Fork lengths (mm) and scales were systematically collected from a subsample of wild (adipose fin intact) coho and steelhead, and all cutthroat (Table 1). No scales were collected from Chinook (only fork lengths). Genetic samples were collected from Chinook to help better understand composition of spring, fall, and heterozygote genotypes among the outmigrants. Fin clips were also collected from lamprey for an unrelated population genetics study (see Silver et al. 2025).

Table 1. Sample rates for biological data collection from wild juvenile salmonids.

Sample Type	Species	Fry	Parr	Transitional/Smolt
Fork Length	Coho	1 st 10 daily	1 st 10 daily	1 st 10 daily
	Steelhead	1 st 10 daily ^a	1 st 10 daily	All efficiency marked individuals (≤ 100 daily)
	Chinook	1 st 10 daily	1 st 10 daily	1 st 10 daily
	Cutthroat	---	---	All individuals encountered ^b
Scales	Coho	---	---	1 st 5 daily
	Steelhead	---	---	1 st 5 daily
	Chinook ^c	---	---	All > 150mm
	Cutthroat	---	---	All ^b
DNA	Coho	---	---	---
	Steelhead	---	---	---
	Chinook	1 st 10 daily up to 50 per week	---	1 st 10 daily up to 50 per week
	Cutthroat	---	---	---
	Lamprey	---	---	1 st 10 per life stage per week

^a Trout fry included both steelhead/rainbow trout and cutthroat.

^b Includes adults

^c No scale samples were collected from Chinook or cutthroat.

Life stage categories followed WDFW protocols (see Appendix A for life stage decision tree). The five life stage categories include fry, parr, transitional, smolt, and adult. Fry and adults were assigned based on length criteria (fry ≤ 45 mm FL and adults ≥ 300 mm FL [cutthroat], 300 – 499 mm FL [rainbow], or ≥ 500 mm FL [steelhead]). Parr, transitional, and smolt life stages were assigned based on phenotypic traits. Parr had distinct parr marks or showed no signs of smoltification, transitionals showed initial signs of smoltification (i.e., silvery appearance and faded parr marks), and smolts showed advanced signs of smoltification (i.e., faded parr marks, deciduous scales, silvery appearance, black banding along the trailing edge of the caudal fin, and translucent pectoral and pelvic fins).

Age class represented the number of years in freshwater as inferred from body length and, in the case of steelhead, measured from scale samples. Most out-migrating Chinook salmon in the Newaukum River were subyearlings. However, individuals ≥ 150 mm were typically larger than the fork length range of subyearling outmigrants and were thus labeled as yearlings (Table 2). For coho salmon, all fry and parr were classified as subyearlings, and all smolts and transitionals were classified as yearlings (Table 3). For steelhead, the field-assigned ‘yearlings’ were a mix of Age-1, Age-2, and Age-3 fish that could not be distinguished by length in the field (Table 4). Therefore, the age composition of steelhead was further described using scale data.

Table 2. Date and length criteria used for field calls of juvenile Chinook.

Life Stage	Age Class	Date Range	Length Range (mm FL)
Fry	---	Start – End	≤ 45
Parr, Transitional, Smolt	Subyearling	Start – End	> 45
Transitional, Smolt	Yearling	Start – End	> 150

Table 3. Date and length criteria used for field calls of juvenile coho.

Life Stage	Age Class	Date Range	Length Range (mm FL)
Fry	---	Start – End	≤ 45
Parr	Subyearling	Start – End	> 45
Transitional, Smolt	Yearling	Start – End	> 45

Table 4. Date and length criteria used for field calls of juvenile steelhead trout.

Life Stage	Age Class	Date Range	Length Range (mm FL)
Fry	---	Start – End	≤ 45
Parr	NA	Start – End	> 45
Transitional, Smolt	Yearling (+)	Start – End	90 – 299
Adult*	NA	Start – End	300 – 499
Adult**	NA	Start – End	≥ 500

*Cutthroat/ Resident Rainbow **Steelhead

Genetics

Genetic samples were collected from subyearling migrant Chinook captured at the screw trap to document diversity at Single Nucleotide Polymorphism (SNP) loci highly correlated with spring and fall run timing of adult Chinook within the Chehalis basin (Thompson et al. 2019). Fin clips were collected from Chinook fry (juveniles ≤ 45 mm FL) and subyearlings (juveniles > 45 mm FL in the transitional or smolt life stage). However, the fry samples were collected to help supplement a different fry trapping study in the basin (Zimmerman et al. 2023, 2025). Only subyearling smolt and transitional genetics are included in the current study. The first 10 Chinook encountered daily were sampled for genetics, up to 50 per week. Tissue was collected from the caudal fin and placed on DNA collection blotter paper and stored in plastic bags with desiccant beads until sent to the lab for processing.

Genomic DNA was isolated from fish tissue with Machery-Nagel silica-based column extraction kits following the manufacturers protocol for animal tissues. Chinook salmon-specific SNPs were genotyped using a cost-effective method based on a custom amplicon sequencing called Genotyping in Thousands (GTseq) (Campbell et al. 2015). For each sample, pools were sequenced, de-multiplexed, and genotyped by generating a ratio of allele counts. The process had four segments: extraction, library preparation, sequencing, and genotyping. The GTseq SNP panel used to infer adult run timing phenotype had 298 autosomal SNP loci, one sex ID SNP locus, and 33 run timing SNP loci. Run timing SNP loci comprise the

two used in previous genetic analysis of Chehalis Chinook salmon (Thompson et al. 2019) and 31 additional run timing markers identified as important markers by Koch and Narum (2020) and Thompson et al. (2020).

Trap Efficiency Trials

A single trap, mark-recapture study design stratified by week was used to estimate juvenile salmon and steelhead abundance (Volkhardt et al. 2007). The mark-recapture design consisted of counting maiden caught fish (maiden captures) in the trap and marking a known number of the captured fish for release at an upstream location (marks). Marked fish that were recaptured in the trap after release (recaptures) were enumerated to calculate trap efficiency. Maiden captures, marks, and recaptures were stratified by week to account for heterogeneity in trap efficiency throughout the season. Weekly estimate periods began on Monday and ended on Sunday.

Trap efficiency trials were conducted with predetermined species, origin, and life stage groups to estimate outmigrant abundance (Table 5). Species included in the trap efficiency trials were coho, steelhead, and Chinook. All trap efficiency trials were conducted with wild (adipose fin intact) fish. For coho and steelhead, trap efficiency trials were conducted with transitional and smolt life stages. Fry and parr life stages were not included in the trap efficiency trials because it was assumed that these life stages were not actively out-migrating. For Chinook, trap efficiency trials were conducted with transitional and smolt life stages because those were the life stages for which an abundance estimate was desired. The trap did not operate for the full duration of the early-timed fry out-migration period; therefore, no estimate was generated for Chinook fry and this life stage was not included in the trap efficiency trials. Fish in good physical condition were selected for efficiency trials whereas fish in poor physical condition were enumerated and released downstream. The goal was to mark a maximum of 100 fish per species per day and up to 500 per species per week for efficiency trials; however, the actual number varied based on fish capture rates throughout the season.

Table 5. Abundance estimate groups defined by species, origin, life stage, and age class. Life stages included in the estimates were transitional (T), and smolt (S). Age classes included in the estimates were subyearling (SY) and yearling (Y). Steelhead age classes included age 1-, 2-, and 3-year-old smolts (Y+). FL = fork length.

Abundance Group	Origin	Life Stage	Age Class	Note
Coho	Wild	T, S	Y, SY	
Steelhead	Wild	T, S	Y+	
Chinook	Wild	T, S	SY	FL > 45 mm

Marked fish were released 3.9 km upstream of the trap location at the Rush Road bridge on the right bank, directly under the bridge.

Mark types and rotation schedules allowed the data to be stratified by week for the purpose of analysis. Different mark types were used for salmon and steelhead (Table 6). Releases generally occurred within 1 to 3 hours of the start of a trap check.

Table 6. Trap efficiency marks and release locations for each abundance estimate group. Efficiency marks were visible implant elastomer tag (VIE) and passive integrated transponder tag (PIT).

Abundance Group	Trap Efficiency Marks			Release location	
	Mark Types	Rotation Schedule	Mark Rotation	Description	Distance upstream of trap (river km)
Coho	PIT	Individual	Individual	Bridge	3.9
Steelhead	PIT	Individual	Individual	Bridge	3.9
Chinook	VIE	Weekly	4 weeks	Bridge	3.9

Assumption Testing

The six basic assumptions that must be met for unbiased estimates in mark-recapture studies include: 1) the population is closed, 2) marks are not lost, 3) marking does not affect behavior, 4) initial capture probabilities are homogenous, 5) the second sample is a random representative sample (i.e., marked and unmarked fish are completely mixed), and 6) mark status is reported correctly (Volkhardt et al. 2007). Throughout the season, multiple trials were conducted to reduce the probability of any assumption violations. These included mark/tag retention trials to ensure marks/tags were not lost, mark/tag detection trials to ensure that marks/tags were not missed and were reported correctly, and mark-related mortality trials to ensure marking/tagging did not affect behavior or survival.

Analysis

Estimates of abundance for coho, steelhead, and Chinook were generated using the R package Bayesian Time-Stratified Population Analysis System (BTSPAS), developed by Bonner and Schwarz (2014), using R version 4.3.1 (R Core Team 2023). The method uses Bayesian P-splines and hierarchical modeling of trap efficiencies to determine abundance with known precision through time, which allows for estimation during missed trapping days and for time strata with minimal efficiency data (Bonner and Schwarz 2011). Data for the analysis were stratified by week and included the total catch of unmarked fish (i.e., maiden captures), marks released, marks recaptured, and proportion of time sampled. The model assumed all marks were recaptured during the time strata period (i.e., week) in which they were released. This assumption was mostly supported by the collected data. Though there was some delay in recapturing all species modeled, it was not significant enough to compensate using the non-diagonal model. Marks, marks released, and marks recaptured were removed as needed prior to analysis to account for missed trapping periods. The proportion of time sampled each week was included to adjust for missed catch. To model the initial tail of the run, two periods were added for coho and steelhead, and one period was added for Chinook. To model the final tail of the run, one period was added for Chinook as catches had not reached zero by the end of the trapping season.

For missed trapping periods, the BTSPAS model produced estimates with known precision using the entire season's dataset by fitting a spline through those dates. For coho, steelhead, and Chinook estimates, the BTSPAS diagonal model was used with model arguments as follows: each model was run with four Markov chain Monte Carlo (MCMC) chains and each chain had a total 100,000 draws (iterations) with the first 50,000 discarded as warmup (burn-in). A thinning rate of two was used to reduce autocorrelation in MCMC draws of the posterior distribution of each model parameter and to limit the file size due to computer memory limitations, for a total of 25,000 simulations. Model convergence was assessed by visually inspecting the trace plots and using the Brooks-Gelman-Rubin (BGR; Rhat) statistic. Models were considered to have converged if MCMC chains were fully mixed based on visual inspection,

the smallest number of effective draws was >1,000, and Rhat was less than 1.1 for all parameters (Gelman et al. 2004).

Results

Summary of Fish Species Encountered

A diverse assemblage of fish species was encountered throughout the 2024 trapping season. Native fishes included juvenile Chinook and coho salmon, steelhead and cutthroat trout, mountain whitefish (*Prosopium williamsoni*), redbelt shiner (*Richardsonius balteatus*), longnose dace (*Rhinichthys cataractae*), speckled dace (*R. osculus*), largescale sucker (*Catostomus macrocheilus*), three-spine stickleback (*Gasterosteus aculeatus*), northern pikeminnow (*Ptychocheilus oregonensis*), Pacific lamprey, brook lamprey, and sculpin species (Cottidae). Non-native fishes included bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), rock bass (*Ambloplites rupestris*), and yellow bullhead (*Ameiurus natalis*).

Trap Operation

The trap operated from March 13 to June 27, 2024. There were five occurrences of trap outages (Appendix B). For three of the five outages, the outage time was known exactly because the trap stopped fishing when staff intentionally lifted the cone during periods of high flows or trap maintenance. Outages 1 and 3 were due to a debris stopping the cone. The non-planned outages averaged 4.5 hours in duration.

Assumption Testing Trials

Results indicated that mark/tag retention was high based on trials that lasted 24 hours. The estimated mark retention was 100% (PIT tags, 112 out of 112 tagged) for coho, 95.5% for steelhead (PIT tags, 21 out of 22 tagged), and 100% (VIE, 203 out of 203 marked) for Chinook. We also found that mark/tag related mortality was low. Estimated survival over a 24-hour holding period was 100% for coho (PIT tag, 112 out of 112 tagged), 100% for steelhead (PIT tags, 22 out of 22 tagged), and 99% (VIE 201 out of 203) for Chinook.

Differences in capture probabilities due to body size in coho and steelhead were tested using logistic regression. For Chinook salmon, a Kolmogorov-Smirnov test was used. The relationship between probability of recapture and fork length was not significant for coho ($p = 0.12$) or steelhead ($p = 0.06$). The fork length of maiden captures did not differ significantly from Chinook recaptures during the peak of the run ($D = 0.18$, $p = 0.06$).

Coho

The coho outmigrant estimate included both subyearlings and yearlings in transitional and smolt life stages. Approximately 88.5% of the outmigrants observed at the trap were categorized as the 'smolt' phenotype whereas 11.5% were categorized as the 'transitional' phenotype. Coho outmigrants were observed in lower numbers in the first week of trapping during the second week of March (beginning March 11, trapping period 3), peaked in late April, and were last observed on June 18 (trapping period 17) (Appendix C.).

Scale age data indicated most smolt were Age-1 (95.7%), with a small Age-0 (subyearling) (0.9%) and Age-2 component for the coho out-migration (3.5%) (Figure 3, Table 7). The fork length of known sub-

yearling outmigrants averaged 103.7 mm (± 5.3 mm SD), the average fork length of known Age-1 outmigrants averaged 114.6 mm (± 9.4 mm SD), and the fork length of known Age-2 outmigrants averaged 126.1 mm (± 10.8 mm SD). Fork length for all measured outmigrants averaged 114.8 mm (± 9.8 mm SD).

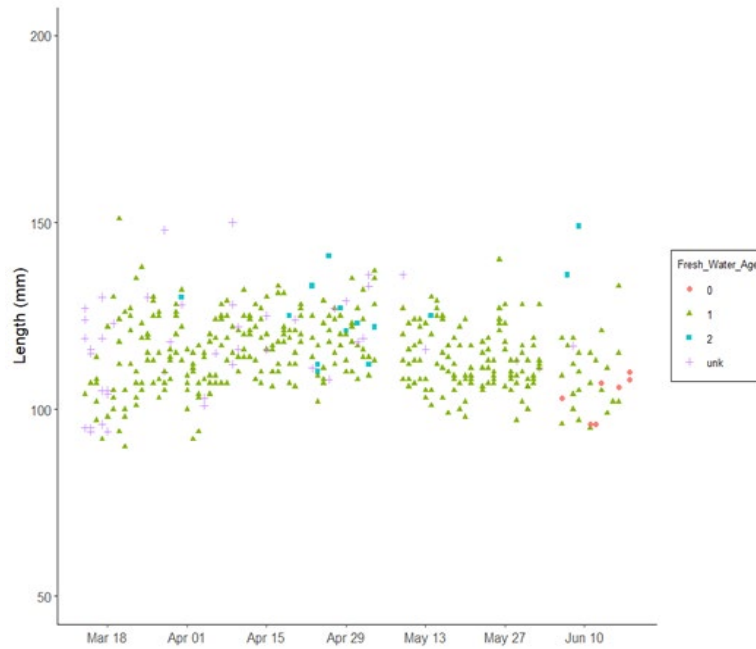


Figure 3. Plot of length and age by date for wild coho outmigrants (transitionals, smolts) at the Newaukum River screw trap, 2024.

Table 7. Freshwater ages of wild coho outmigrants (transitionals, smolts) at the Newaukum River screw trap, 2024. Data are counts of scale ages of sampled juveniles by week. ND indicates no data.

Period	Start Date	End Date	No. Scales	Age-0	Age-1	Age-2	ND
1	3/11	3/17	20		8		12
2	3/18	3/24	35		31		4
3	3/25	3/31	35		29	1	5
4	4/1	4/7	35		32		3
5	4/8	4/14	35		30		5
6	4/15	4/21	35		31	1	3
7	4/22	4/28	30		22	5	3
8	4/29	5/5	30		21	4	5
9	5/6	5/12	20		19		1
10	5/13	5/19	34		32	1	1
11	5/20	5/26	30		30		
12	5/27	6/2	35		33		2
13	6/3	6/9	16	1	12	2	1
14	6/10	6/16	16	4	12		
15	6/17	6/23	2	2			
16	6/24	6/30	0				

A total of 3,153 coho outmigrants were captured, 2,632 coho were marked, and 115 were recaptured (Appendix C.). Modeled weekly trap efficiencies ranged from 2.2% to 16.6%.

Abundance of 2024 wild coho outmigrants was estimated to be 100,711 (95% CI = 80,586 – 132,683) with a CV of 13.1% (Figure 4., Table 8). The Rhat value for coho was 1.001, suggesting good model convergence. In 2024, coho smolt production outmigrating from the Newaukum River was approximately 40.0% of the total coho smolt production in the Chehalis River Basin above the Mainstem Chehalis smolt trap based on preliminary estimates of abundance above the main stem trap.

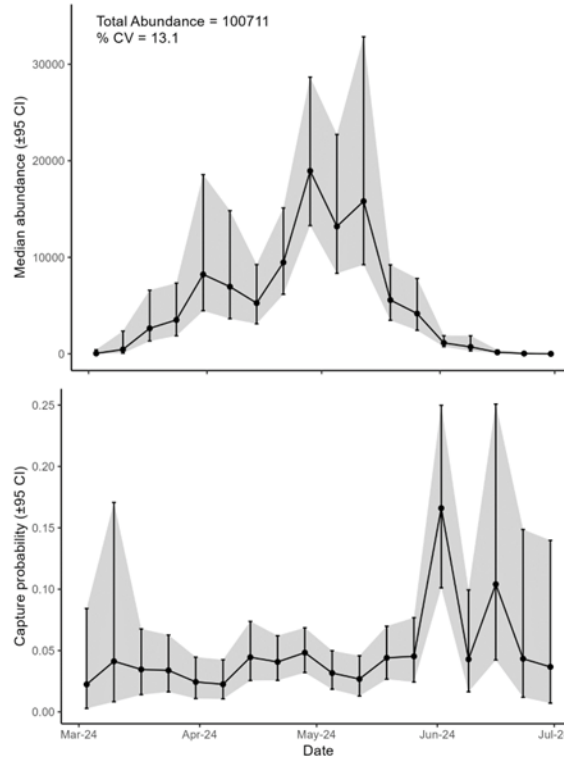


Figure 4. Number of out-migrants (top panel) and trap efficiency (bottom panel) by week for wild coho yearlings produced above the Newaukum River smolt trap in 2024. Error bars and shading around point estimates represent 95% confidence intervals.

Table 8. Final outmigrant abundance estimates.

Species	Origin	Life Stage(s)	Age	Abundance (95% CI)	CV (%)
Coho	Wild	Smolts and transitionals	1	100,711 (80,586 – 132,683)	13.1
Steelhead	Wild	Smolts and transitionals	1+	7,374 (5,702 – 9,843)	14.2
Chinook	Wild	Smolts and transitionals	0	49,624 (44,539 – 56,411)	6.1

In 2022, the total number of adult coho spawners in the Newaukum River upstream of the trap site was estimated to be 8,290 (Ronne et al. 2024), producing a smolt-per-spawner estimate of 12.1 for the 2022 brood year of naturally spawning coho. Estimates of coho smolts-per-spawner have reached 139.7 for brood year 2019 to a low of 47.0 in brood year 2021. Tracking smolts-per-spawner as a metric of coho productivity has been a project goal and in 2024 we are able to see the initial results of that effort (Figure 5). Results from the 2019-2022 seasons show signs of density dependence. However, more data and a more detailed analysis are needed to confirm these observations.

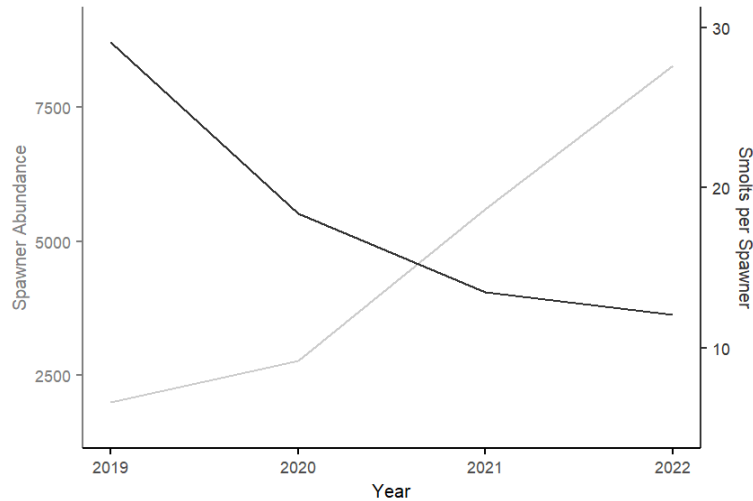


Figure 5. Time series plot of wild coho adult spawner abundance upstream of the smolt trap (gray line) and smolts-per-spawner estimates (black line) from the 2019 – 2022 brood years.

Steelhead

The steelhead outmigrant estimate included both transitional and smolt life stages. Of these life stages, approximately 92.7% of outmigrants observed were classified as the smolt phenotype, compared to 7.3% transitional. Steelhead outmigrant numbers were low during the first week of trapping, March 11 (trapping period 3), peaked in early April, and were last observed the week of June 2 (trapping period 14) (Figure 5, Table 9, Appendix D).

Table 9. Freshwater ages of wild steelhead outmigrants (transitionals, smolts) at the Newaukum River screw trap, 2024. Data are counts of scale ages of sampled juveniles by week. ND indicates no data.

Period	Start Date	End Date	No. Scales	Age-0	Age-1	Age-2	Age-3	ND
1	3/11	3/17	18		1	2		15
2	3/18	3/24	32		5	17	1	11
3	3/25	3/31	31		17	8	1	5
4	4/1	4/7	35		13	16	2	4
5	4/8	4/14	35		15	13	2	5
6	4/15	4/21	30		16	7	1	6
7	4/22	4/28	25		15	7		3
8	4/29	5/5	24		10	12		2
9	5/6	5/12	15		10	5		
10	5/13	5/19	14		9	3		2
11	5/20	5/26	3		3	0		
12	5/27	6/2	6		5	1		

Scale age data indicated that sampled steelhead were Age-1 (54.4%), Age-2 (42.3%), and Age-3 (3.3%) (Figure 6, Table 9). Fork length averaged 138.2 mm ($\pm$ 21.9 mm SD) for Age-1, 165.8 mm ($\pm$ 15.8 mm SD) for Age-2, 175.4 mm ($\pm$ 5.8 mm SD) for Age-3, and 151.0 mm ($\pm$ 23.9 mm SD) for all.

A total of 601 steelhead outmigrants were captured, 564 steelhead were marked, and 52 were recaptured (Appendix D). Modeled weekly trap efficiencies ranged from 8.3% to 9.5%. The abundance of wild steelhead outmigrants was estimated to be 7,374 (95% CI = 5,702 – 9,843). Steelhead smolt production outmigrating from the Newaukum River was approximately 18.1% of the total steelhead smolt production in the Chehalis River Basin above the main stem Chehalis smolt trap in 2024 based on preliminary estimates of abundance.

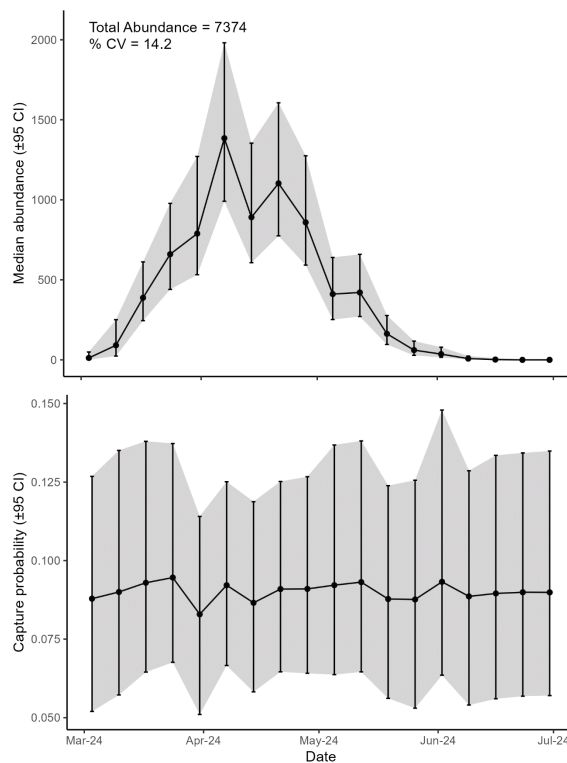


Figure 6. Number of out-migrants (top panel) and trap efficiency (bottom panel) by week for wild steelhead outmigrants produced above the Newaukum River smolt trap in 2024. Error bars and shading around point estimates represent 95% confidence intervals.

Steelhead contributing to the 2024 smolt outmigration came from the 2021 through 2023 brood years. For the 2021 brood, there were 1,214 spawners above the trap. Based on scale ages, it was determined that 3,581 smolts from that brood out-migrated at Age-1 in 2022, 4,509 at Age-2 in 2023, and 240 at Age-3 in 2024, for a total smolt production of 8,329. This produced a total smolt-per-spawner estimate of 6.9 for the 2021 brood year. This value may be biased low because juvenile steelhead abundance was not reportable in 2022 as we did not trap during the early part of the smolt outmigration. Estimating steelhead productivity above the trap through time is an ongoing project goal.

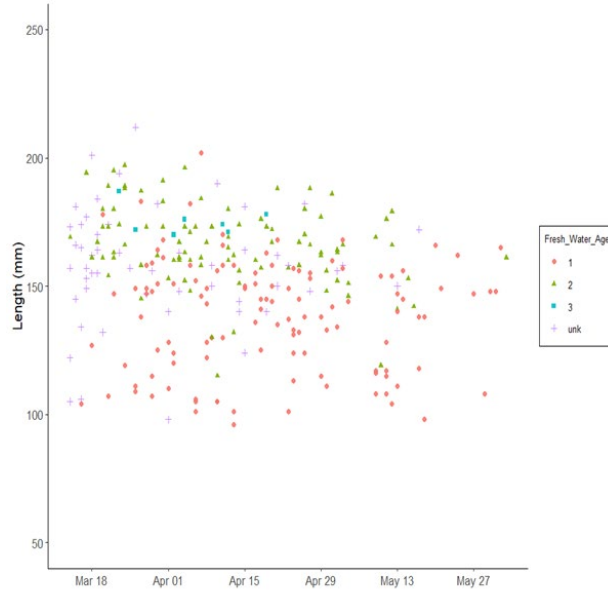


Figure 7. Plot of length and age by date for wild steelhead outmigrants (transitionals, smolts) at the Newaukum River screw trap, 2024.

Chinook

The Chinook outmigrant estimate was derived for the ‘subyearling’ life history that included transitionals and smolts. Chinook outmigrants were observed in low weekly numbers ($n < 75$) the first two weeks of trapping (beginning March 11, trapping period 1), peaked in early June, and were declining in numbers again by the last week of trapping when we pulled the trap due to low flows (ending June 27, trapping period 17) (Appendix E.).

Scale age data were not collected from Chinook as all juvenile fish were assumed to be subyearlings. Fork length of Chinook subyearlings (fry, parr, transitionals and smolts) increased steadily throughout the trapping period with an average of 46.8 mm (± 5.7 mm SD) and 94.5 mm (± 6.7 mm SD) in the first and last sampled week of trapping, respectively (Figure 7).

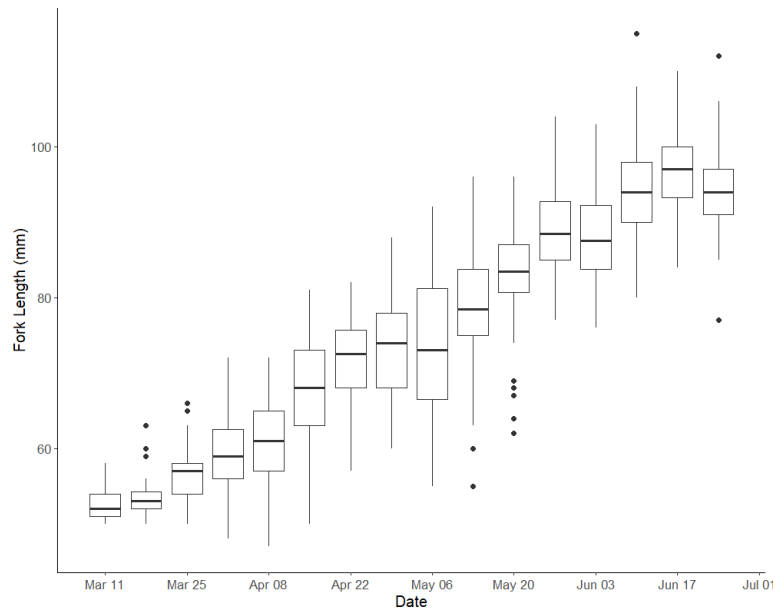


Figure 8. Box plot of fork lengths of wild Chinook subyearling outmigrants (transitionals, smolts) by week at the Newaukum River screw trap, 2024. Each box represents the median, second and third quartiles, whiskers represent the interquartile ranges, and dots represent outliers.

A total of 5,583 Chinook subyearling outmigrants (not including fry or parr) were captured: 4,117 were marked and 707 were recaptured. Modeled weekly trap efficiencies ranged from 6.7% to 27.1% (Appendix E).

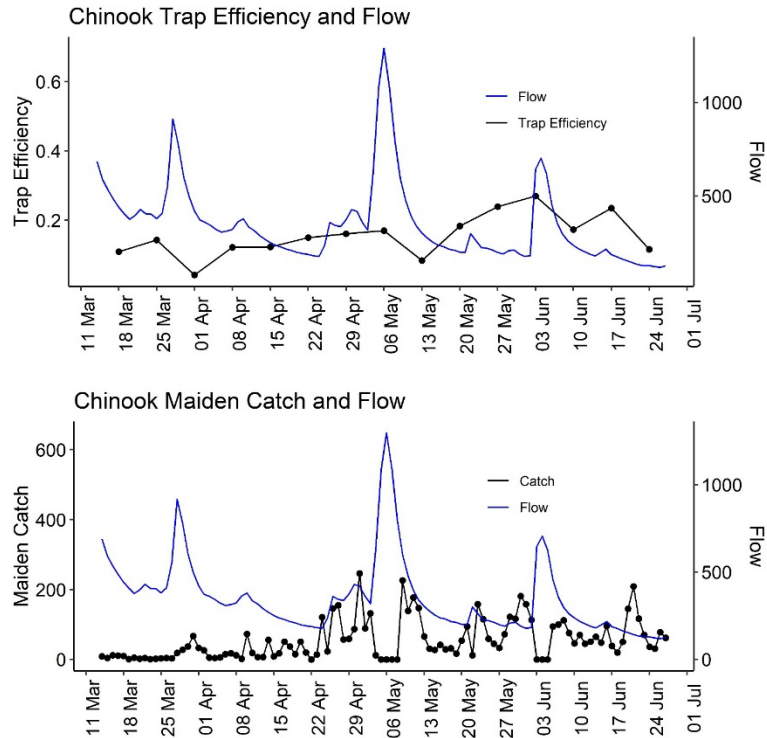


Figure 9. Wild Chinook transitional and smolt raw trap efficiency (top), maiden catch (bottom) and flow in cubic feet per second (cfs, top & bottom) as a function of period at the Newaukum River smolt trap, 2024.

Abundance of wild Chinook subyearling outmigrants (not including fry or parr) was estimated to be 49,624 (95% CI = 44,539 – 56,411) with a coefficient of variation (CV) of 6.1% (Figure 9, Table 8). The Rhat value for Chinook was 1.001, suggesting good model convergence. Chinook smolt outmigration from the Newaukum River was approximately 24.8% of the total Chinook smolt production in the Chehalis River Basin above the main stem Chehalis smolt trap in 2024 based on preliminary estimates of abundance.

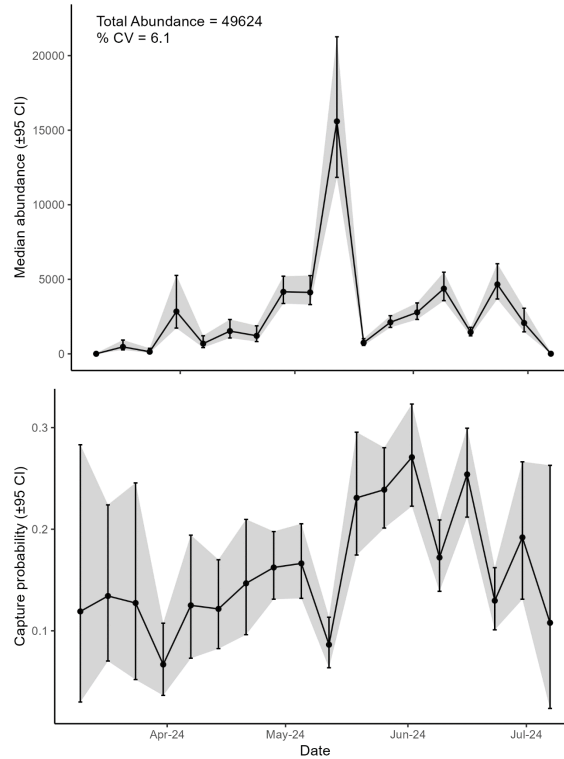


Figure 10. Number of outmigrants (top panel) and trap efficiency (bottom panel) by week for wild Chinook subyearlings produced above the Newaukum River smolt trap in 2024. Error bars and shading around point estimates represent 95% confidence intervals.

The total number of adult spring Chinook spawners in the Newaukum River in 2023 upstream of the trap site was estimated to be 348, and adult fall Chinook was estimated to be 295 (total Chinook spawners = 643, Ronne et al. 2025), producing an overall smolt-per-spawner estimate of 72.2 for the 2023 brood year of naturally spawning Chinook. Tracking smolts-per-spawner as a metric of Chinook productivity has been a project goal and in 2024, we are able to see the initial results of that effort (Figure 10). Scouring and egg-to-smolt survival is a likely contributor to Chinook freshwater survival, but less likely to be a primary driver of smolt-per-spawner ratio in coho or steelhead that rear in freshwater for a longer period of time.

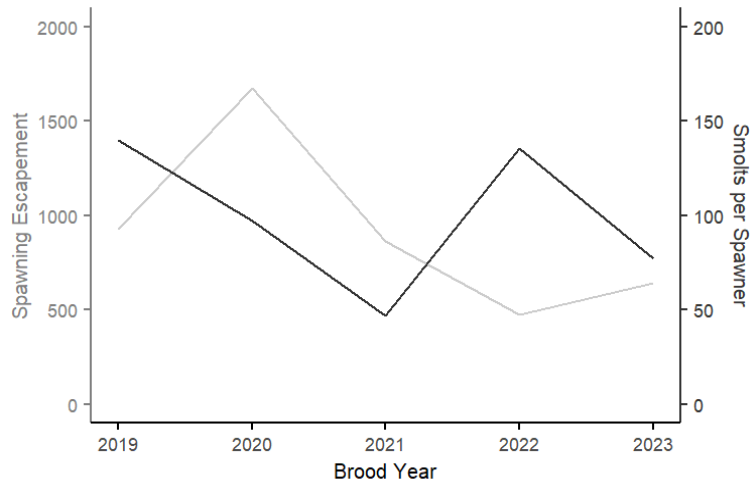


Figure 11. Time series plot of wild Chinook adult spawner abundance upstream of the smolt trap (gray line) and smolts-per-spawner estimates (black line) from the 2019 – 2023 brood years.

Chinook subyearling abundance by run type

A total of 618 juvenile Chinook tissue samples from the Newaukum River smolt trap were sent to the lab for processing in 2024. Of those, SNP genotypes were successfully obtained from 534 samples (86.4%). Chinook subyearlings had one of three genotypes associated with run-timing: homozygous spring (two copies of a spring allele), homozygous fall (two copies of a fall allele), or heterozygote (one spring allele and one fall allele, unknown run timing). Proportions of spring, fall, and heterozygote genotypes by week were apportioned according to the weekly abundance estimates with known precision based on results from the mark-recapture study (Figure 10, Table 10, Table 11). No fish were sampled in the first or final three weeks of trapping; however, the model predicted abundance during those periods, so proportions in these weeks were based on determinations from the next week or the week prior. If the correlation of the SNP genotype and adult run timing phenotype still holds, the Chinook subyearling outmigration abundance estimate consisted of an estimated 7,467 (15.2%) spring homozygous Chinook, 28,366 (57.9%) fall homozygous Chinook, and 13,149 (26.8%) heterozygotes Chinook.

Table 10. Counts of Chinook genotypes in sampled outmigrant by period.

Start Date	End Date	Period	Spring	Heterozygote	Fall	Total
3/11	3/17	1	NA	NA	NA	NA
3/18	3/24	2	10	3	8	21
3/25	3/31	3	6	0	6	12
4/1	4/7	4	14	3	9	26
4/8	4/14	5	7	3	15	44
4/15	4/21	6	9	5	16	43
4/22	4/28	7	6	5	19	42
4/29	5/5	8	8	10	19	46
5/6	5/12	9	5	11	13	28
5/13	5/19	10	6	19	13	27
5/20	5/26	11	1	13	20	31
5/27	6/2	12	8	14	28	46
6/3	6/9	13	1	12	27	38
6/10	6/16	14	0	13	8	8
6/17	6/23	15	3	14	9	14
6/24	6/30	16	0	6	33	38
Totals			84	131	243	464

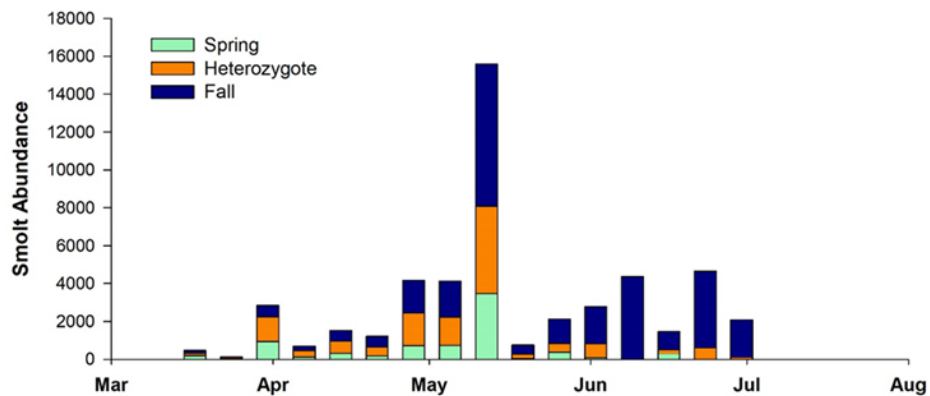


Figure 12. Chinook subyearling genotype estimates from the Newaukum River trap by week. Genotypes are associated with adult run timing in Chehalis Chinook salmon (Thompson et al. 2019).

Table 11. Chinook subyearling outmigrant genotype abundance by period at the Newaukum River screw trap, 2024.

Start Date	End Date	Period	Spring	Heterozygote	Fall	Total
4-Mar	10-Mar	1	3	2	2	6
11-Mar	17-Mar	2	195	117	156	468
18-Mar	24-Mar	3	39	65	39	143
25-Mar	31-Mar	4	925	1,322	595	2,842
1-Apr	7-Apr	5	109	344	235	688
8-Apr	14-Apr	6	320	639	568	1,527
15-Apr	21-Apr	7	173	491	549	1,213
22-Apr	28-Apr	8	724	1,719	1,719	4,161
29-Apr	5-May	9	736	1,473	1,914	4,123
6-May	12-May	10	3,465	4,620	7,507	15,592
13-May	19-May	11	24	241	482	747
20-May	26-May	12	368	460	1,289	2,118
27-May	2-Jun	13	73	732	1,977	2,782
3-Jun	9-Jun	14	0	0	4,375	4,375
10-Jun	16-Jun	15	312	208	936	1,456
17-Jun	23-Jun	16	0	613	4,045	4,658
24-Jun	30-Jun	17	0	104	1,969	2,073
1-Jul	7-Jul	18	0	1	10	10
			7,467	13,149	28,366	7,467
			(15.2%)	(26.8%)	(57.9%)	(15.2%)

Cutthroat

While cutthroat trout were not a focus of the study, they were encountered at the trap, and although efficiency trials were not conducted, the total number of fish caught equaled 5. Of these, 5 scales were sampled and 4 successfully aged (Figure 11 and Table 12).

The cutthroat outmigration included both transitional and smolt life stages. Of these life stages, approximately 80.0% of outmigrants observed were classified as the smolt phenotype, compared to 20.0% transitional. Cutthroat outmigrant numbers were low throughout the season but seem to be encountered most frequently later in the season.

Scale age data indicated that sampled cutthroat were Age-1 (25.0%), and Age-2 (75.0%) (Figure 11, Table 12). Fork length for the one Age-1 cutthroat encountered was 97 mm, averaged 169.7 mm (± 22.5 mm SD) for Age-2, and 163.8 mm (± 41.3 mm SD) overall.

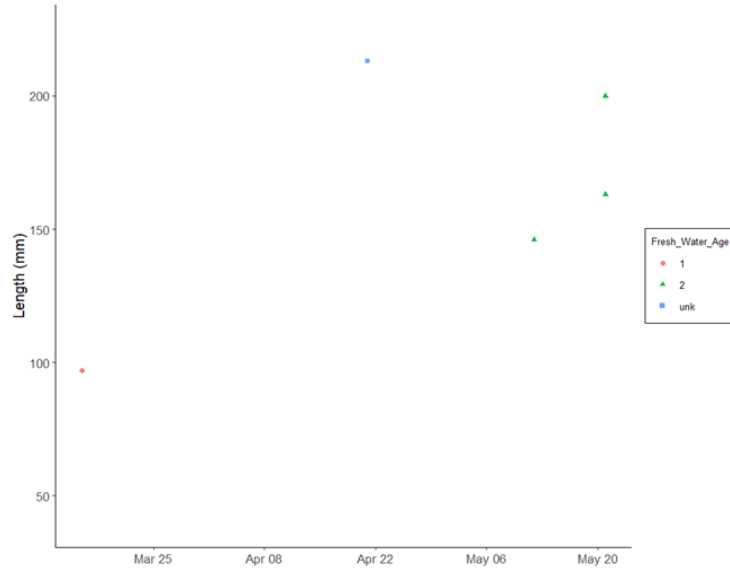


Figure 13. Plot of length and age by date for wild cutthroat the Newaukum River screw trap, 2024.

Table 12. Freshwater ages of wild cutthroat at the Newaukum River screw trap, 2024. Data are counts of scale ages of sampled individuals by week. ND indicates no age determined from scales.

			No.					
Period	Start Date	End Date	Scales	Age-0	Age-1	Age-2	Age-3	ND
1	3/11	3/17	1		1			
2	3/18	3/24	0					
3	3/25	3/31	0					
4	4/1	4/7	0					
5	4/8	4/14	0					
6	4/15	4/21	1					1
7	4/22	4/28	0					
8	4/29	5/5	0					
9	5/6	5/12	1			1		
10	5/13	5/19	0					
11	5/20	5/26	2			2		
12	5/27	6/2	0					
13	6/3	6/9	0					
14	6/10	6/16	0					
15	6/17	6/23	0					
16	6/24	6/30	0					

Discussion

Basin-wide Context

This report presents results from the 2024 salmon and steelhead smolt out-migration of the Newaukum River, the sixth year since 1988 when any smolt monitoring has been conducted in this sub-basin. The abundance estimates provided in this report represent juvenile salmonids that completed their freshwater rearing in habitats upstream of the trap location, specifically production from upstream of river kilometer 9.35 (river mile 5.8). However, some juveniles emerge from the gravel upstream of the trap location and redistribute to areas downstream of the trap location during their freshwater rearing period and are not included in these estimates. This caveat is especially true for coho salmon which are known to redistribute in a downstream direction during the fall months in search of suitable overwintering habitat (Winkowski et al. 2018).

The 2024 juvenile coho estimate increased by 33.2% from the 2023 estimate (100,711 compared to 75,630) and the CV increased slightly from 9.8% in 2023 to 13.1% in 2024 (Figure 12). This increase in wild coho production coincided with an increase in adult returns: 5,594 coho returned to the Newaukum in 2021 compared to 8,290 in 2022 (Ronne et al. 2023; 2024). It may indicate good survival during the critical periods of freshwater rearing, including the summer parr period in 2023 and overwinter period in 2023 and 2024.

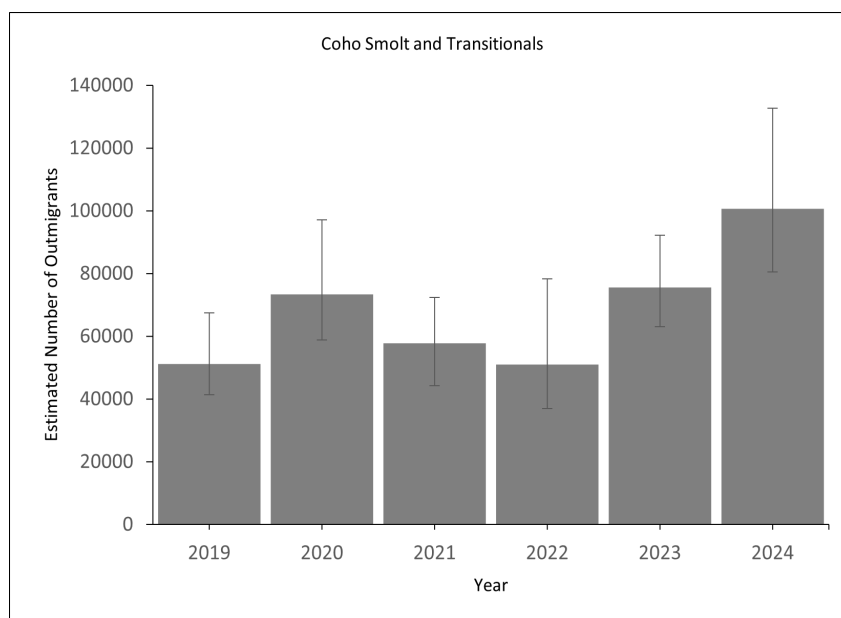


Figure 14. Time series of 2019–2024 estimates with 95% confidence intervals of wild coho juvenile outmigrants at the Newaukum River smolt trap.

From 2019 to 2022, an estimate of wild juvenile steelhead outmigrants was unreportable due to missing the early portion of the out-migration. The trapping season in 2024 marks the second year that a reportable steelhead production estimate was generated (Figure 13). Factors that may have contributed to the generation of a steelhead production estimate include early March install combined with good flows and few outages. It is a goal to use further reportable estimates to generate a correction factor to apply to previous out migrations to generate production estimates for 2019 – 2022.

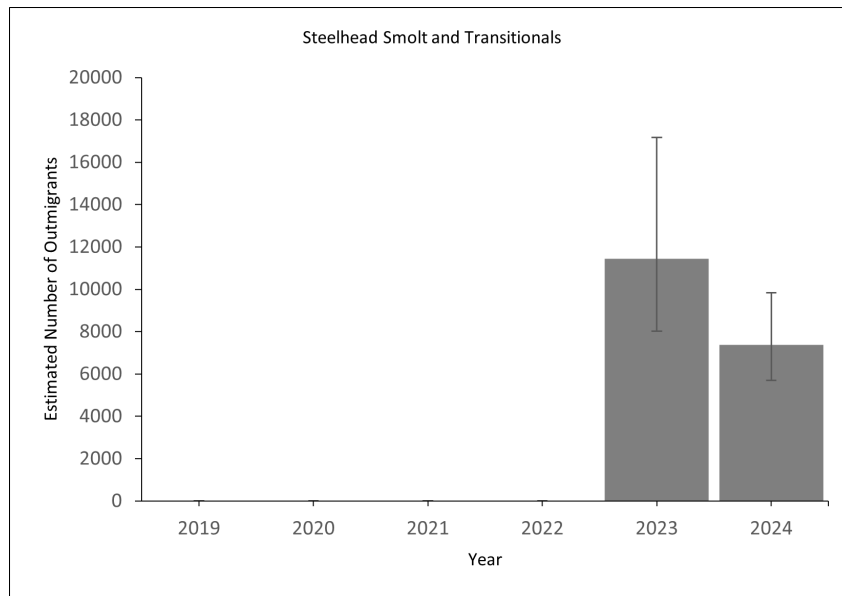


Figure 15. Times series of 2019 – 2024 estimates with 95% confidence intervals of wild steelhead juvenile outmigrants at the Newaukum River smolt trap. Note that the 2019 – 2022 estimates are not considered reportable.

The abundance estimate for Chinook salmon represents the subyearling component of the out-migration upstream of the trap location and does not include the earlier timed fry migrants. However, the subyearling estimate is relevant to habitat restoration planning because the subyearling component of the out-migration represents the numbers of juveniles that are supported by freshwater habitats upstream of the trap site. Fry migrants spend less time rearing in freshwater habitats. A companion study in 2024 estimated that fry outmigration from the Newaukum River was 54,745 (Zimmerman et al. 2025), comparable to the number of subyearling outmigrants that we estimate from the same cohort. Fry migrants move downstream shortly after emergence and make extensive use of the lower river, estuary and nearshore growing environments prior to entering the ocean (Beamer et al. 2005, Sandell et al. 2014). Other studies in western Washington have observed that, within a watershed, the numbers of subyearling Chinook outmigrants are relatively consistent from year to year and have concluded that abundance of the subyearling life history reflects a freshwater rearing capacity whereas the abundance of fry is highly variable from year to year and reflects density-dependent migration of this life history (Anderson and Topping 2018; Zimmerman et al. 2015). Freshwater rearing appears to be critical for survival of Chinook returning to the Newaukum River. Evaluation of otoliths from adult Chinook returning to the Newaukum River in 2016 (Campbell et al. 2017; 2023) found that 95% (37 out of 39) adults entered the estuary at the subyearling, as opposed to fry, life stage. If rearing capacity is reached, additional juvenile Chinook may migrate downstream as fry in response to density-dependence (Greene et al. 2005). Extending this density-dependent migration hypothesis to the Newaukum River will require additional years of juvenile monitoring coupled with adult Chinook spawner data above the trap location.

The 2024 Chinook estimate saw a 23.0% decrease from the 2023 estimate (40,639 compared to 64,472) and the CV decreased from 10.7% in 2023 to 6.1% in 2024 (Figure 14). This decrease in wild juvenile Chinook production corresponded with increased adult returns: there were 476 Chinook

spawners in the Newaukum in 2022, and 643 in 2023 (Ronne et al. 2024; 2025). Resultantly, smolts-per-spawner decreased by nearly half from 135.4 in brood year 2022 to 77.2 in 2023.

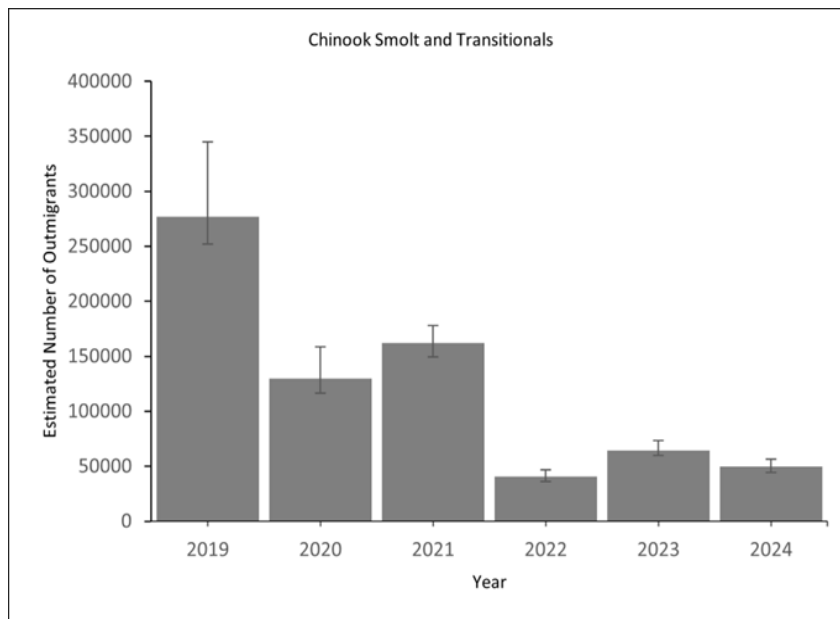


Figure 16. Time series of 2019–2024 estimates with 95% confidence intervals of wild Chinook juvenile outmigrants at the Newaukum River smolt trap.

This was the third year that genetic samples were taken from subyearling Chinook > 45 mm. Results indicate a decrease in spring Chinook (15.2% compared to 20.5% in 2023), a decrease in fall Chinook (57.9% compared to 61.6% in 2023), and an increase in heterozygote (26.8% compared to 17.9% in 2023). The proportions are similar to those observed in a companion fry trapping study on the Newaukum (Zimmerman et al. 2025), which identified that the Newaukum produces a higher proportion of spring Chinook than the neighboring Skookumchuck River (Zimmerman et al. 2025). This could be a place to prioritize conservation or restoration to support this vulnerable run type.

Operating multiple smolt traps in the Chehalis basin allows comparison of smolt abundance estimates from specific locations, providing a finer scale resolution of freshwater production at the sub-basin level. Annual freshwater production of wild coho smolts in the Chehalis River Basin has averaged 2.2 million (range = 0.5 to 3.7 million) since WDFW began monitoring in the 1980s (Litz 2024). From 2017 – 2022, coho smolt abundance in the Chehalis Mainstem above river km 84 (river mile 52) averaged ~330,000 (Olson and Litz 2024). Therefore, the area above river km 84 contributes to roughly 15% of the coho smolt production in the basin. In 2024 specifically, preliminary estimates of coho smolt abundance at the mainstem Chehalis River smolt trap were 251,906 (188,999 – 382,872 95% CI). Therefore, in 2024, the Newaukum River coho abundance estimate (100,711) represents approximately 40.0% of the coho production above river km 84 of the mainstem Chehalis River. This percentage has increased each season since 2022. Above river km 84, the Newaukum Basin only represents approximately 8% of the available anadromous stream segments, suggesting it produces a disproportionately high percentage of coho from this area of the Chehalis Basin (Walther 2021). This information is critical for conservation and restoration planning and for understanding status and trends of salmon smolt abundance in different locations in the basin and how they could be influenced by changes to the physical environment (e.g., restoration or climate change).

Next Steps

Smolt trapping on the Newaukum River presents several operational challenges, particularly during high flows and heavy debris events. In 2024, we addressed many of these issues by streamlining our response protocols. A department-wide emphasis on safety was a key driver behind these improvements. One major change involved halting trapping operations proactively—before flows reached unsafe levels. Combined with the implementation of a cellular trail camera, this approach reduced the number of stoppage events from seven in 2023 to just two in 2024. It also shortened the average duration of each stoppage by about an hour compared to last season.

Within the trapping season, mean monthly stream temperatures steadily increased from 7.8°C in March, to approximately 15.9°C in June (Table 13). Overall, 2024 was cooler than previous years in the later part of the season. However, March and April were warmer than most of the previous years.

Continued access from the west bank of the river is critical to our operations. It provides the necessary elevation to reach the trap during high flows and enables fishing under conditions that east bank access cannot support. The current access route passes through a tree farm with relatively young trees. However, the 2024 season may be the last we can drive through this area, as the trees have grown to a point where vehicle access is becoming increasingly difficult. Negotiations with the landowners are needed to establish a more permanent access route to the river.

In 2024, the Chinook subyearling outmigration peaked twice—once in mid-May and again in early June. As Chinook catch increased from May to June, average monthly stream temperatures also rose, from 12.5 °C to 15.9 °C (Table 13). While stream temperatures were not a significant concern later in the season, fish were processed earlier in the morning to take advantage of the cooler water temperatures.

Table 13. Time series of mean monthly stream temperatures °C recorded at Newaukum River smolt trap near river km 9.35 from 2020 – 2024.

Year	2020	2021*	2022	2023	2024
Month	Mean (°C)	Mean (°C)	Mean (°C)	Mean (°C)	Mean (°C)
March	7.1	7.2	8.4	6.6	7.8
April	10.7	11.6	9.0	8.7	10.4
May	14.0	15.1	11.5	15.2	12.5
June	15.1	20.2	14.8	17.7	15.9
July	18.6	-	21.3	22.1	-

*Temperature data at Newaukum River trap site during 2021 trapping season are unavailable. Temperature data are from Stan Hedwall Park, 5.85 Rkm below trap site.

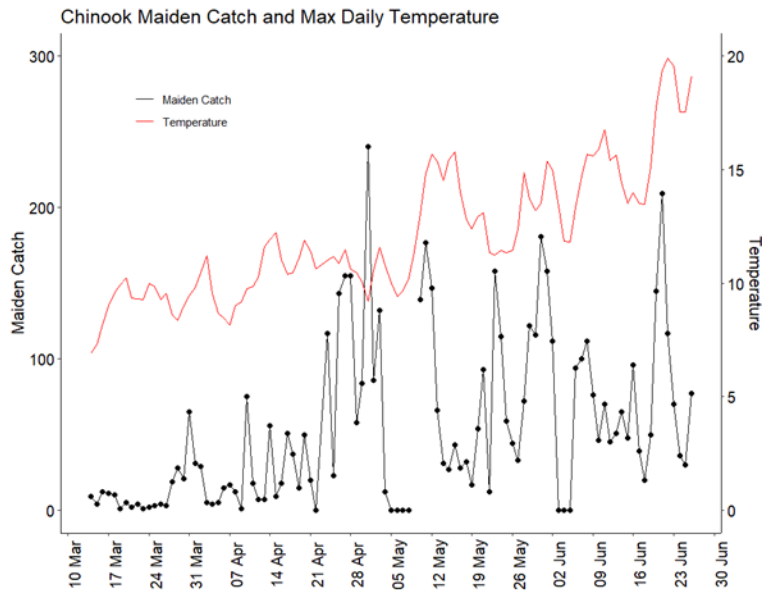


Figure 17. Chinook maiden catch and maximum daily stream temperature (°C) at the Newaukum River smolt trap in 2024.

In summary, 2024 represents the sixth year for which wild coho, steelhead, and Chinook out-migrations have been described from any location in the Newaukum River in three decades. For the second time a production estimate for steelhead was produced. Our goal remains to get the trap installed as early as weather and river conditions will allow. For all three species, biological diversity was described (timing, age structure, and size) for outmigrants, as these characteristics reflect how the existing habitat contributes to freshwater production of salmon and steelhead. Continuation of this monitoring in future years will provide understanding of variability and trends in freshwater production over time. As part of a larger, integrated monitoring effort associated with the Aquatic Species Restoration Plan, this baseline information should also inform future questions on the influence of habitat restoration projects or climate change impacts on freshwater production of salmon and steelhead in the Newaukum River.

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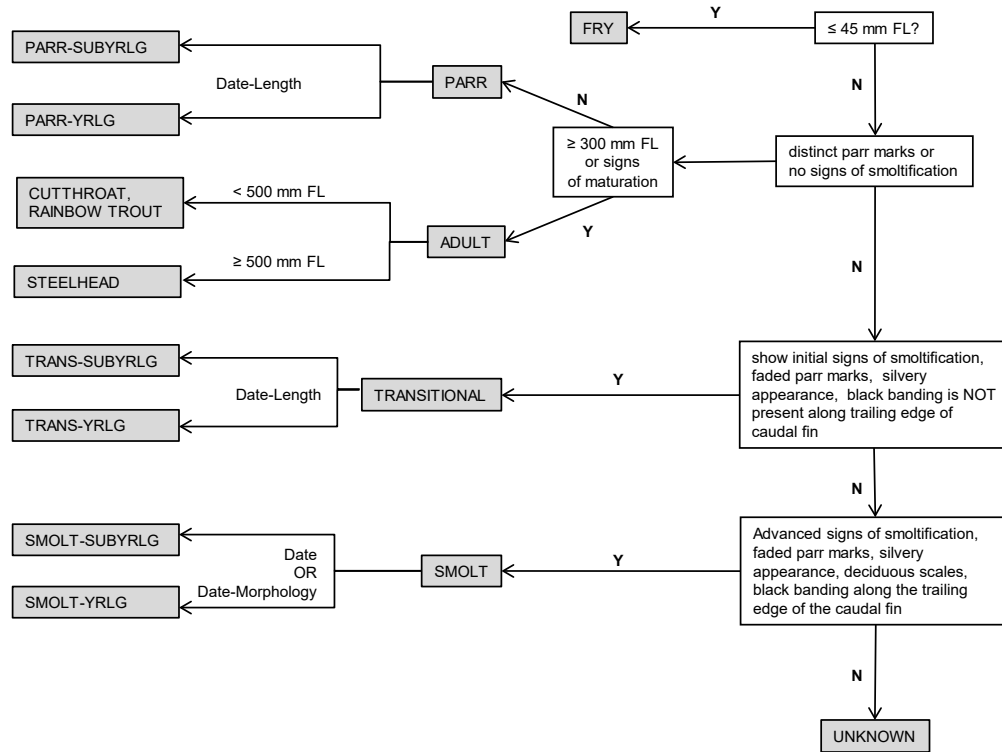
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Appendices

Appendix A. Decision tree for assigning life stages of juvenile outmigrants developed by the Washington Department of Fish and Wildlife to ensure consistency in data collection protocols across juvenile trapping projects.



Updated 2.8.2016

Appendix B. Newaukum River missed trapping periods 2024.

Last Time Observed Fishing	Time Stopped Fishing	Method to Determine Trap Not Fishing	Time Resume Fishing	Comments
4/14 0500	4/14 0500	Trail Camera	4/14 0900	Screw Stopper
NA	4/21 0800	Visual	4/22 1400	Trap Pulled/Moved
4/30 1200	4/30 1200	Trail Camera	4/30 1700	Screw Stopper
NA	5/4 0740	Visual	5/8 1000	Trap Pulled/Flow
NA	6/2 0720	Visual	6/5 0830	Trap Pulled/Flow
4/14 0500	4/14 0500	Trail Camera	4/14 0900	Screw Stopper

Appendix C. Mark-recapture data for wild coho out-migrants (transitionals, smolts) organized by period.

Data are the combined counts of subyearling and yearling coho. Dataset includes total marks released (Total Mark), total marks recaptures (Total Recap), total maiden captures (Total Captures), and the proportion of time the trap fished during the period (Prop Fished).

Period	Start Date*	End Date*	Total Mark	Total Recap	Total Capture	Prop fished
1**	2/26	3/3	0	0	0	0.001
2**	3/4	3/10	0	0	0	0.001
3	3/11	3/17	98	1	67	0.715
4	3/18	3/24	119	4	119	1
5	3/25	3/31	200	2	203	1
6	4/1	4/7	155	3	156	1
7	4/8	4/14	225	14	225	0.976
8	4/15	4/21	328	15	385	1
9	4/22	4/28	444	20	754	0.821
10	4/29	5/5	312	9	346	0.825
11	5/6	5/12	239	3	239	0.56
12	5/13	5/19	242	12	245	1
13	5/20	5/26	137	6	190	1
14	5/27	6/2	99	22	187	1
15	6/3	6/9	16	0	18	0.568
16	6/10	6/16	16	4	17	1
17	6/17	6/23	2	0	2	1
18	6/24	6/30	0	0	0	0.429

*Start and End Date reflect the dates of maiden captures to which the release and recapture data are applied for estimation. Release dates start and end one day before the recapture dates.

**Added periods to bring the model to zero

Appendix D. Mark-recapture data for wild steelhead out-migrants (transitionals, smolts) organized by period. Dataset includes total marks released (Total Mark), total marks recaptures (Total Recap), total maiden captures (Total Captures), and the proportion of time the trap fished during the period (Prop Fished). No estimate was produced from data due to low recapture numbers and violating the assumption of trapping over the entirety of the out-migration.

Period	Start Date*	End Date*	Total Mark	Total Recap	Total Capture	Prop Fished
1**	2/26	3/3	0	0	0	0.001
2**	3/4	3/10	0	0	0	0.001
3	3/11	3/17	27	2	28	0.715
4	3/18	3/24	61	9	63	1
5	3/25	3/31	63	2	63	1
6	4/1	4/7	129	11	131	1
7	4/8	4/14	72	7	72	0.976
8	4/15	4/21	82	7	102	1
9	4/22	4/28	62	5	66	0.821
10	4/29	5/5	25	7	29	0.825
11	5/6	5/12	23	1	24	0.56
12	5/13	5/19	14	0	14	1
13	5/20	5/26	2	1	3	1
14	5/27	6/2	4	0	6	1
15	6/3	6/9	0	0	0	0.568
16	6/10	6/16	0	0	0	1
17	6/17	6/23	0	0	0	1
18	6/24	6/30	0	0	0	0.429

*Start and End Date reflect the dates of maiden captures to which the release and recapture data are applied for estimation. Release dates start and end one day before the recapture dates.

**Added periods to bring the model to zero

Appendix E. Mark-recapture data for wild Chinook outmigrants (transitionals, smolts) organized by period.

Dataset includes total marks released (Total Mark), total marks recaptures (Total Recap), total maiden captures (Total Captures), and the proportion of time the trap fished during the period (Prop Fished).

Period	Start Date*	End Date*	Total Mark	Total Recap	Total Capture	Prop Fished
1	3/4	3/10	0	NA	0	0.001
2	3/11	3/17	46	5	46	0.715
3	3/18	3/24	17	2	18	1
4	3/25	3/31	166	7	191	1
5	4/1	4/7	83	10	86	1
6	4/8	4/14	179	21	182	0.976
7	4/15	4/21	120	18	178	1
8	4/22	4/28	442	72	555	0.821
9	4/29	5/5	370	62	566	0.825
10	5/6	5/12	465	37	755	0.56
11	5/13	5/19	169	42	172	1
12	5/20	5/26	433	106	506	1
13	5/27	6/2	304	81	754	1
14	6/3	6/9	415	72	428	0.568
15	6/10	6/16	367	96	370	1
16	6/17	6/23	434	55	605	1
17	6/24	6/30	107	21	171	0.429
18	7/1	7/7	0	NA	0	0.001
1	3/4	3/10	0	NA	0	0.001

Comments: Total captures are wild Chinook. All marks and recaptures are wild Chinook caught in the Newaukum trap to which a VIE mark was applied for trap efficiency trials.

* Start and End Date reflect the dates of maiden captures to which the release and recapture data are applied for estimation. Release dates start and end one day before the recapture dates.