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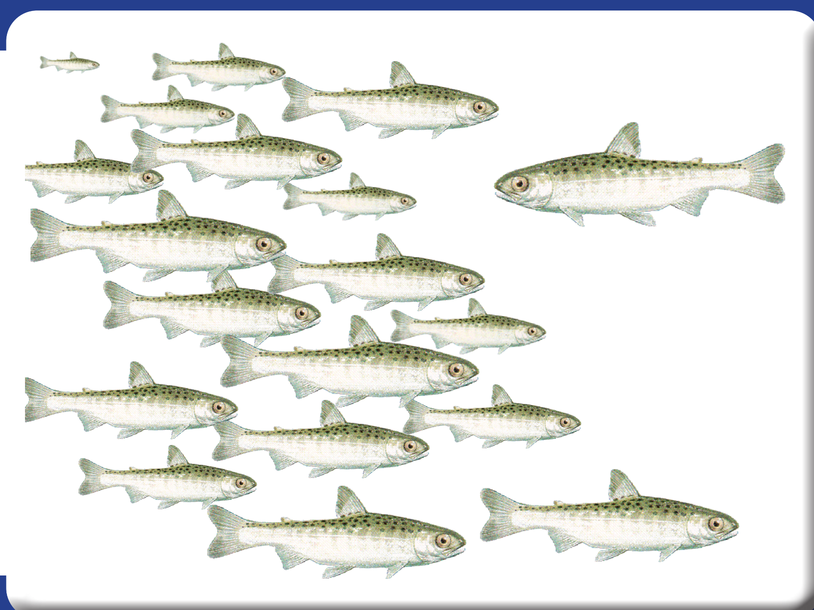
Chehalis River Smolt Production, 2022



by Daniel Olson and Marisa Litz

Washington Department of Fish & Wildlife

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Chehalis River Smolt Production, 2022

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Executive Summary

This report provides the 2022 results from the juvenile salmonid smolt monitoring study on the Chehalis River main stem near Rochester, WA. The primary objective of this study is to describe the freshwater production (e.g., smolt abundance) of Pacific salmon (*Oncorhynchus* spp.) and steelhead (*O. mykiss*) in the Chehalis River. Specifically, we describe the timing and diversity (body size, age structure, genetics) and estimates of abundance of juvenile outmigrants for wild coho salmon (*O. kisutch*), steelhead, and Chinook salmon (O. *tshawytscha*). Based on the location and timing of our study, the results reflect juveniles that completed their freshwater rearing phase in habitats upstream of river kilometer 84 (river mile 52) of the main stem Chehalis River.

To meet the study objectives, a 2.4 meter (8–foot) rotary screw trap was operated near river kilometer 84 (river mile 52) of the main stem Chehalis River from March 24 to July 25, 2022.

Coho outmigrants were predominately of the yearling (or “1+”) age class (81.6%) with rare occurrences of subyearlings (or “0+”) and 2-year-old outmigrants (18.1% and 0.3%, respectively). Fork length averaged 111.8 mm (± 7.2 standard deviation, SD) for subyearlings, 125.9 mm (± 12.2 SD) for yearlings, and 165.0 mm (one individual captured, no SD) for 2-year-olds. Abundance of wild coho outmigrants was estimated to be 163,354 (95% credible interval, CI = 118.767 – 246,552) with a coefficient of variation (CV) of 19.7% (Table 1).

Steelhead outmigrants ranged from Age-1 to Age-4 based on scales (47.8%, 42.8%, 8.2% and 1.3% for Age-1 through Age-4, respectively), indicating four different juvenile life histories. Fork length averaged 168.7 mm (± 20.6 SD) for Age-1, 165.4 mm (± 14.7 SD) for Age-2, 197.2 mm (± 22.0 SD) for Age-3, and 220.5 mm (± 6.4 SD) for Age-4. Abundance of wild steelhead outmigrants was estimated to be 36,236 (95% CI = 15,936 – 107,650) with a CV of 58.9% (Table 1).

Chinook outmigrants were subyearlings (Age-0). Fork length of Chinook transitional and smolt subyearlings increased steadily throughout the trapping period with an average of 49.1 mm (± 7.9 SD) in the first week of trapping and 106.6 mm (± 5.5 SD) in the last full week of trapping. Abundance of wild Chinook subyearling outmigrants was estimated to be 247,707 (95% CI = 215,914 – 289,634) with a CV of 7.9% (Table 1).

Table 1. Abundance of coho, steelhead, and Chinook outmigrants that completed their freshwater rearing phase upstream of river kilometer 84 (river mile 52) of the main stem Chehalis River.

Abundance Group	Origin	Life Stage	Age Class	Abundance (95% Credible Interval)	Coefficient of Variation (%)
Coho	Wild	Transitional, Smolt	Yearling	163,354 (118,767 – 246,552)	19.7
Steelhead	Wild	Transitional, Smolt	Yearling	36,236 (15,936 – 107,650)	58.9
Chinook	Wild	Transitional, Smolt	Subyearling	247,707 (215,914 – 289,634)	7.9

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. However, over this time, the work mostly focused on wild coho salmon (*O. kisutch*) to generate estimates at the basin scale. Results from this monitoring program demonstrated that the Chehalis River has a higher density of wild coho smolts (average 1,021 smolts mi^{-2} or 394 smolts km^{-2}) than any other western Washington watershed for which data currently exists (Litz et al. 2024). In addition, smolt abundance estimates from individual tributaries throughout the Chehalis River Basin were also generated in the 1980s and 1990s, but prior to 2017 had not been evaluated for nearly two decades. Currently, the method for basin scale juvenile population estimation uses back calculation based on recoveries of coded wire tags (CWTs), meaning that estimates for production are not available for at least a year following outmigration when returning adults are sampled for CWTs. Also, there is currently limited information on freshwater juvenile production of other salmonid species, including Chinook (*O. tshawytscha*) and chum (*O. keta*) salmon, steelhead (*O. mykiss*), and cutthroat trout (*O. clarkii*) in the Chehalis River basin. Recent efforts under the Chehalis Basin Strategy (http://chehalisbasinstrategy.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.

Smolt monitoring activities by WDFW were recently expanded to develop a more comprehensive understanding of freshwater production among multiple species of salmonids across different ecological regions in the Chehalis River basin (e.g., Olympic and Cascade mountains, Willapa Hills). Beginning in 2021, this expanded effort became a long-term component of the integrated status and trends monitoring program used to evaluate salmon and steelhead responses to changes in the riverine environment because of habitat restoration and protection actions and climate change (M&AMT 2021). Operating a smolt trap in a large river comes with significant operational challenges associated with maintaining both staff safety and fish health under dynamic environmental conditions. A pilot study was conducted in 2017 that tested a new trap design and multi-species trapping protocols. Since then, field seasons have benefited from refinements in the operational protocols, trap modifications, and analysis techniques (West et al. 2020; Olson et al. 2023).

Objectives

The primary objective of this study was to describe the freshwater production of salmon and steelhead in the Chehalis River. Specifically, we describe the abundance, timing, and diversity (body size, age structure, genetics) of juvenile outmigrants for wild coho salmon, steelhead, and Chinook salmon. Based on the location and timing of our study, the results reflect juveniles that completed their freshwater rearing phase in habitats upstream of river kilometer 84 (river mile 52) of the main stem Chehalis River (Figure 1). This report includes results from the 2022 field season.

Methods

Study Site

The Chehalis River is a large coastal watershed in western Washington that drains approximately 6,889 square kilometers from the Willapa Hills, Cascade Mountains, and Olympic Mountains into Grays Harbor. The Chehalis River is relatively low elevation (1 – 1,350 m) and low gradient with rain dominant hydrology. Land use in the basin is predominately timber production in headwater locations and private residential and agricultural in lower elevation locations. Some National Forest land is present in high elevation locations draining the Olympic Mountains. Native anadromous salmonids in the Chehalis River include spring and fall Chinook salmon, coho salmon, winter steelhead, and cutthroat trout. Chum salmon are present in the basin but occur downstream of the smolt trap location in this study.

Like other rivers in western Washington, juvenile Chinook salmon in the Chehalis River have a protracted outmigration period in their first year of life. Yearlings are rarely observed at the smolt trap or in the adult returns as determined from otoliths (Campbell et al. 2017). There are two predominant freshwater rearing strategies observed for juvenile Chinook salmon and these are observed at the smolt trap as a bimodal outmigration. 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 as soon as it is installed in mid-March but have been presumably outmigrating since January, based on observed data from 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.

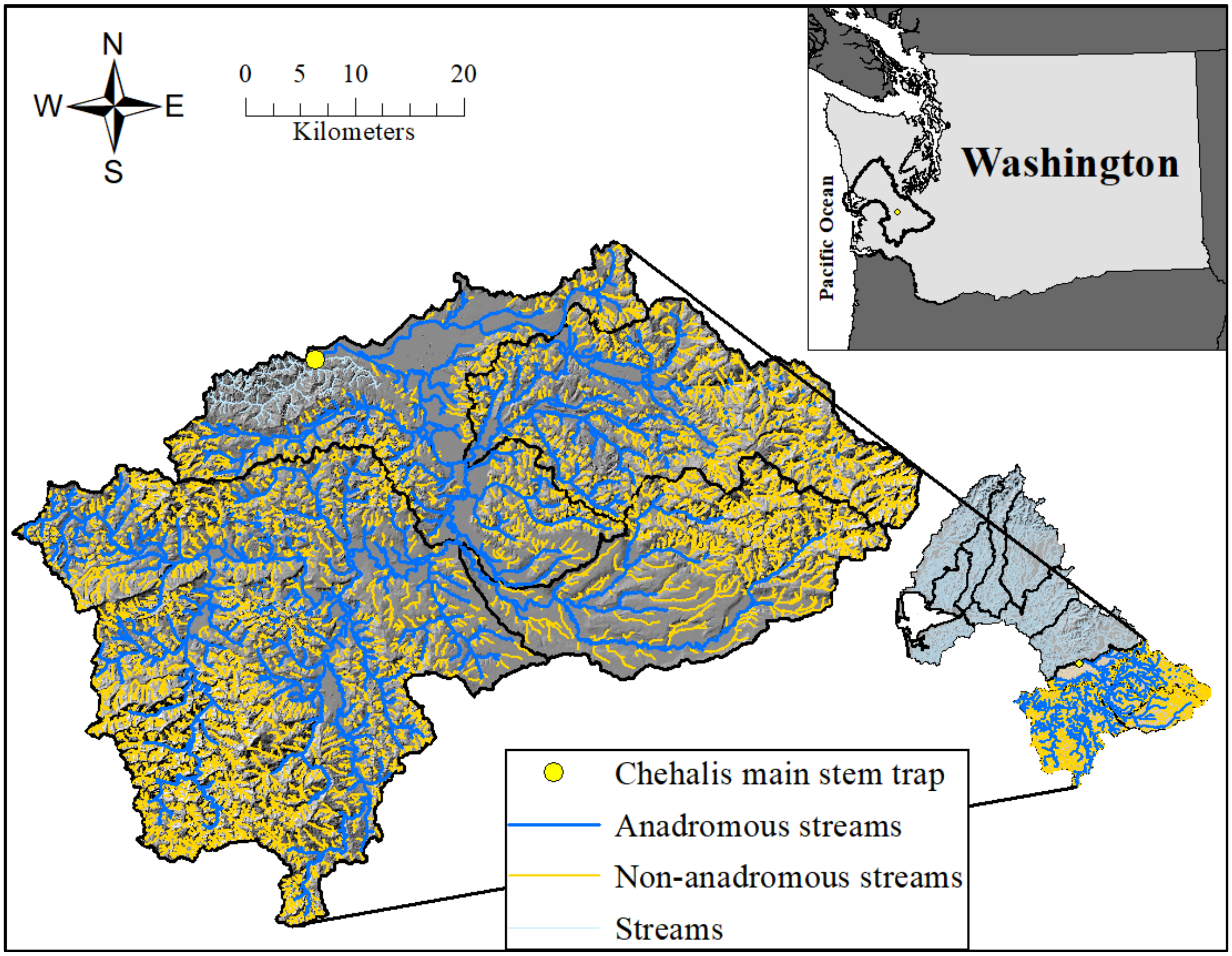

Figure 1. Main stem Chehalis River rotary screw trap. Anadromous streams represent stream habitat within the predicted coho salmon range of occurrence (1,390 km) using a 0.50 probability decision threshold upstream of the main stem Chehalis River rotary screw trap. Non-anadromous streams represent stream habitat outside the predicted coho salmon range of occurrence (3,358 km) upstream of the trap location (Walther 2021).

Trap Operation

A 2.4 m (8-foot) diameter rotary screw trap (RST) was operated near river kilometer 84 of the Chehalis River (Figure 2). The screw trap used internal flights rotating by water pressure to capture downstream migrants and funnel them into a holding area (live box) at the back of the trap where fish were held until sampling. This site was selected because it is the most downstream point in the main stem with suitable characteristics to maximize RST efficiency throughout the trapping period. Due to the location of this trap, the 2022 estimates represent a portion of the freshwater production in the Chehalis Basin as additional freshwater habitat occurs downstream (e.g., main stem, Black River, Satsop River, Wynoochee River, Wishkah River, and Hoquaim River). The trap was scheduled to operate continuously although unscheduled trap outages did occur due to high flow, high water temperatures, and debris.

Instantaneous water temperature and trap status information (e.g., fishing or not fishing, cone revolutions per minute) were collected at each fish sampling event ("trap check"). 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 temperature at 30-minute intervals. Data loggers were calibrated according to Winkowski et al. (2018). Stream flow was monitored by the USGS discharge gage in Grand Mound, Washington located in the main stem Chehalis River 12.3 km upstream of the trap location (USGS 12027500).

Figure 2. Chehalis River screw trap under low flow fishing conditions.

Fish Collection

Fish collection commenced on March 24, 2022, with the trap operating 24 hours per day, seven days per week. During this time, fish were removed from the live box once per day using a dip net and transferred to a trough with flowing river water. Fish were anaesthetized with tricaine methanesulfonate (MS-222) prior to enumeration and biological sampling. For each sampling event, five grams of MS-222 was diluted with water in a 500-ml container and roughly 15-25 ml of this diluted MS-222 solution was combined with roughly 2 L of freshwater prior to sampling the fish. Samplers continually evaluated fish response to the solution and aimed for the lowest dosages needed to complete biological sampling.

During sampling, all fish were identified to species and enumerated. Coho, steelhead, and Chinook were further categorized by life stage and age class, as described in Appendix A. Marks associated with trap efficiency trials (see Trap Efficiency Trials section) and hatchery origin (clipped adipose fin) were examined on all coho, steelhead, and Chinook. Hatchery origin coho and steelhead get released from multiple locations upstream of the trap site and are encountered at the trap (e.g., Skookumchuck hatchery). Fork length (FL) and scales were collected from a subsample of wild (adipose fin intact) coho, steelhead, Chinook, and cutthroat (Table 2). Genetic samples were also collected from lamprey to help identify population genetics for a collaborator.Table 2. Sample rates for biological data collection from wild juvenile salmonids.

Table 2. Sample rates for biological data collection from wild juvenile salmonids.

Sample Type	Species	Fry	Parr	Transitional/Smolt
Fork Length	Coho	1st 10 daily	1st 10 daily	1st 10 daily
	Steelhead	1st 10 daily[a]	1st 10 daily	All efficiency marked individuals (≤ 100 daily)
	Chinook	1st 10 daily	1st 10 daily	1st 10 daily
	Cutthroat	---	---	All individuals encounterd[b]
Scales	Coho	---	---	1st 5 daily
	Steelhead	---	---	1st 5 daily
	Chinook[b]	---	---	All ≥ 150mm
	Cuttthroat	---	---	All[c]
DNA	Coho	---	---	---
	Steelhead	---	---	---
	Chinook	---	---	---
	Cutthroat	---	---	---
	Lamprey	---	---	1st 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 developed for the Lower Columbia ESU monitoring program (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 [cutthroat], 301 – 499 mm FL [rainbow], or ≥ 500 mm [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 rearing years in freshwater as measured from scale samples. For coho salmon, all fry and parr were classified as subyearling and all smolts and transitionals were classified as yearling (Table 3). For steelhead, the field-assigned ‘yearlings’ could be any of 1-, 2-, 3-, or 4-year-old individuals that could not be distinguished by length in the field (Table 4). Therefore, the age composition of steelhead was further described using scale data.

Over the twenty-three years of trapping at the main stem Chehalis site, beginning in 1999, yearling Chinook salmon have rarely been observed and the vast majority of juvenile Chinook identified in the field get assigned to the subyearling age class based on fork length. While extremely rare, individuals > 150 mm are encountered that are outside of the fork length range of subyearling outmigrants and are categorized as yearling in the field. These individuals are often opportunistically sampled for scales to verify age (Table 5).

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

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 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	> 45
Adult (Resident RBT)	NA	Start – end	300 - 499
Adult (STLH kelt)	NA	Start – end	> 500

Table 5. Date and length criteria used for field calls of juvenile Chinook salmon.

Life Stage	Age Class	Date Range	Length Range (mm FL)
Fry	---	Start – end	≤ 45
Parr, Transitional, Smolt	Subyearling	Start – end	46 - 150
Transitional, Smolt	Yearling (+)	Start – end	> 150

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 species, origin, and life stages for which an estimate of outmigrant abundance was desired (Table 6). 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 Chinook, trap efficiency trials were conducted with transitional and smolt life stages because both constituted the subyearling life history stage for abundance estimation. Efficiency trials were not conducted on Chinook fry outmigrants as the trap did not operate for the full duration of the early timed outmigration; therefore, no estimate was generated for the Chinook fry life stage. 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 for coho and steelhead because it was assumed that these life stages were not actively outmigrating. 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 one hundred fish per species per day and five hundred per species per week for efficiency trials. However, this number varied based on fish capture rates throughout the season.

Table 6. 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 estimate were subyearling (SY) and yearling (Y). FL = Fork length.

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

Marked fish were released 4.5 km upstream of the trap location at the Independence Road bridge on the right bank, roughly 20 m upstream of the bridge (Table 6). Mark types and rotation schedules allowed fish data to be organized by week for the purpose of analysis. This was irrelevant for steelhead, however, because they were marked using individual PIT tags. The different mark types for each species are listed below (Table 7). All releases occurred within 1-3 hours of a trap check. All efficiency trials were conducted by marking up to 7 days per week and fishing the trap 24 hours per day. Missed trapping periods were accounted for via our statistical analyses described below.

Table 7. Trap efficiency marks and release locations for each abundance estimate group. Efficiency marks were coded wire tag (CWT), passive integrated transponder tag (PIT), and partial fin clip (PFC).

	Trap Efficiency Marks			Release location	
Abundance Group	Mark Types	Rotation Schedule	Mark Rotation	Description	Distance upstream of trap (rkm)
Coho	CWT, PFC	Weekly	2 weeks	Bridge	4.5
Steelhead	PIT	Individual	Individual	Bridge	4.5
Chinook	PFC	Weekly	2 weeks	Bridge	4.5

Assumption Testing

The six basic assumptions needed to 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 trails to ensure marks/tags were not lost, mark/tag detection trials to ensure that mark/tags were not missed and that they were reported correctly, and mark-related mortality trials to ensure marking/tagging did not affect behavior or survival.

Analysis

The Bayesian Time-Stratified Population Analysis System (BTSPAS, Bonner and Schwarz 2014) was used to estimate abundance of coho, steelhead, and Chinook. This method uses Bayesian p-splines and hierarchical modeling of trap efficiencies to determine abundances 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 used in 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 proportion of time sampled each week was included to adjust for missed catch during trap outages. Periods were added to the beginning and end of the trapping datasets to estimate the front and tail ends of the runs, as needed.

Prior to analysis, marks were removed when the trap did not continuously fish for 48 hours after release because it was assumed that all those marks were not available for recapture. For coho and Chinook, one period was added prior to the trapping dataset, with a total maiden catch set to zero to allow the model to estimate the front end of the run. Historically, very few outmigrants were observed in March and thus it was determined this was a valid assumption. Additionally, for Chinook, one period was added to the end of the dataset with a total maiden catch set to zero to allow the model to estimate the final tail of the run. For steelhead, two periods were added prior to the trapping dataset to estimate the front end of the run. For coho, steelhead, and Chinook estimates, a diagonal version of the BTSPAS model was used with model arguments as follows: number of chains = 4 for coho, steelhead, and Chinook. For coho and steelhead, iteration = 200,000, burn-in = 100,000, simulations = 50,000, and thin rate = 2. For Chinook, iterations = 50,000, burn-in = 25,000, simulations = 12,500, and thin rate = 2. Model convergence was assessed by visually inspecting the trace plots and using the potential scale reduction statistic, or Rhat. The Rhat statistic measures the ratio of the average variance draws within each chain to the variance of the pooled draws across chains; if all chains are at equilibrium, these will be the same and Rhat will be 1. If the chains have not converged to a common distribution, the Rhat statistic will be >1. Models were considered to have converged if MCMC chains were fully mixed based on visual inspection, and Rhat was less than 1.002 for all parameters (Gelman et al. 2004). The BTSPAS analysis was executed in R v.2021.11.2 (R Core Team, 2017) using the package BTSPAS (Bonner and Schwarz 2014).

Results

Summary of Fish Species Encountered

A diverse assemblage of fish species was encountered throughout the 2022 trapping season. Native fishes included juvenile coho and Chinook salmon, steelhead, cutthroat, and rainbow trout, mountain whitefish (*Prosopium williamsoni*), redside shiner (*Richardsonius balteatus*), dace (*Rhinichthys* spp.), largescale sucker (*Catostomus macrocheilus*), three-spine stickleback (*Gasterosteus aculeatus*), peamouth chub (*Mylocheilus caurinus*), northern pikeminnow (*Ptychocheilus oregonensis*), Pacific lamprey (*Entosphenus tridentatus*), western brook lamprey (*Lampetra richardsoni*), and sculpin (Cottidae). Non-native fishes included bluegill (*Lepomis* *macrochirus*), pumpkinseed (*L. gibbosus*), black crappie (*Pomoxis nigromacula*), American shad (*Alosa sapidissima*), brown bullhead (*Ameiurus nebulosus*), yellow bullhead (*A. natalis),* largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), and rock bass (*Ambloplites rupestris*).

Trap operation

The trap was operated from March 24 to July 25, 2022. There were twenty occurrences of trap outages (Appendix B). Of these, fourteen were unscheduled (e.g., debris stopping the trap). For the scheduled outages, the outage time was known precisely because the trap stopped fishing when staff lifted the cone during periods of high flows, high water temperatures, or heavy debris loads. For unscheduled trap outages, the outage time was estimated from visual inspection of the trap using a camera. Unlike previous seasons, algae loads were not a significant issue in 2022. This allowed for 24-hour trapping operations throughout the season.

Assumptions Testing Trials

In 2022, results from the mark retention trials indicated that mark/tag retention was high based on trials that lasted 24 hours. Estimated mark retention was 100% (coded wire tag = CWT, 157 out of 157 marked) for coho. averaged for of all technicians. PIT tag retention for steelhead was 100% (passive integrated transponder = PIT tag, 19 out of 19 marked). Overall, mark/tag related mortality was low. Estimated survival was 99.4% (CWT, 156 out of 157 marked) for coho and 94.7% for steelhead (PIT tag, 18 out of 19 tagged) over the 24-hour holding period. Tag-related mortality was not tested for Chinook in 2022.

Differences in initial capture probabilities due to body size were tested in 2022. Using a Kolmogorov–Smirnov test, the fork length of maiden captures versus recaptures did not differ significantly for coho during period 12 ($n = 143$ maiden and $n = 27$ recaptures, $D = 0.196$, $p = 0.347$), or for Chinook during period 18 ($n = 71$ maiden and $n = 55$ recaptures, $D = 0.138$ $p = 0.599$). For steelhead, PIT tagging allowed for logistic regression analysis of probability of recapture by fork length. The relationship between probability of recapture and fork length was not significant ($p = 0.26$).

Coho

The coho outmigrant estimate in 2022 included yearlings and subyearlings in both transitional and smolt life stages. Of these life stages, 97.4% of outmigrants observed were classified as the smolt phenotype, compared to transitional. Coho outmigrants were observed in low numbers the first week of trapping (beginning March 24, trapping period 4), peaked in May, and declined through June (ending trapping period 21, Figure 3, Appendix C).

Scale age data indicated a small subyearling component of the coho outmigration that began near the first week of June. Prior to this date, all scale sampled coho outmigrants were yearlings, except for one two-year-old individual. A total of 421 scale samples were collected and 89.3% were aged successfully. Age-1 coho were the dominant age class (81.6%), subyearlings were common (18.1%), and age 2 was rare (0.3%) (Figure 4, Table 8).

A total of 3,128 coho outmigrants were captured throughout the season (Appendix C). A total of 2,758 coho were marked and 79 were recaptured. Modeled weekly trap efficiencies ranged from 0.4% to 13.9%.

Trap efficiency and maiden catches can both be affected by river flows. In 2022, river flows were highly variable over the duration of the coho outmigration (Figure 5). Trap efficiencies and maiden catches can also be affected by water temperature. However, neither seem to have affected coho outmigration timing or abundance in a meaningful way (Figure 5 and Figure 6).

Abundance of wild coho outmigrants was estimated to be 163,354 (95% CI = 118,767 – 246,552) with a CV of 19.7%. On a basin wide scale, the coho estimates from the upstream Newaukum River and Upper Chehalis rotary screw traps contributed 31.2% and 14.9% to the total estimate at the main stem trap, respectively.

In 2020, the total number of adult coho spawners in the Chehalis River upstream of the trap site was estimated to be 7,752, producing a smolt-per-spawner estimate of 21.1 for the 2020 brood year of naturally spawning coho. Estimating coho productivity through time is a goal of this study going forward.

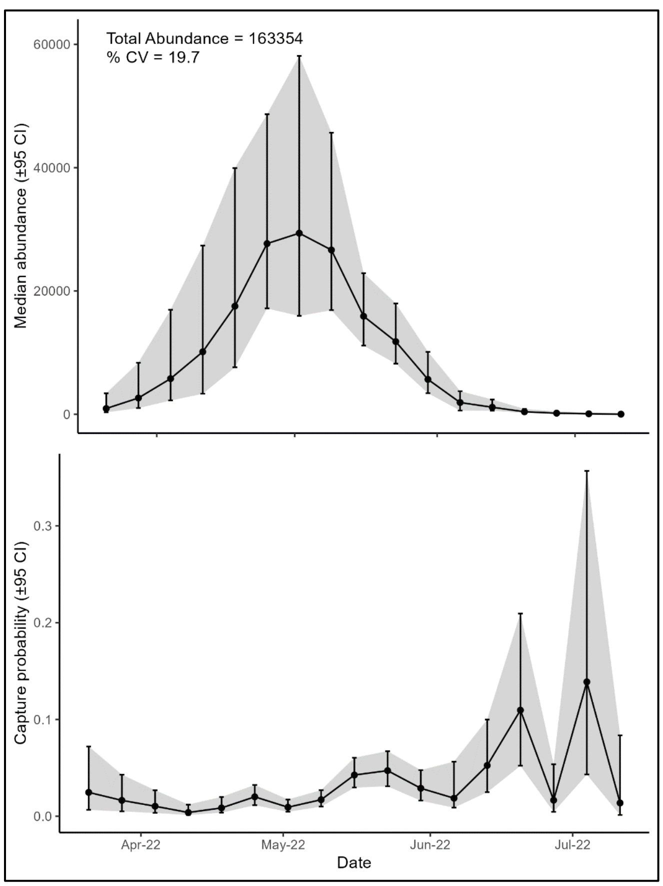

Figure 3. Number of outmigrants (top panel) and trap efficiency (bottom panel) by week for wild coho smolts and transitionals produced above the Chehalis River smolt trap in 2022**.** Error bars around trap efficiency estimates and shading around abundance estimates represent 95% credible intervals. Data provided in Appendix C.

Figure 4. Plot of date-length-age data from wild coho outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2022.

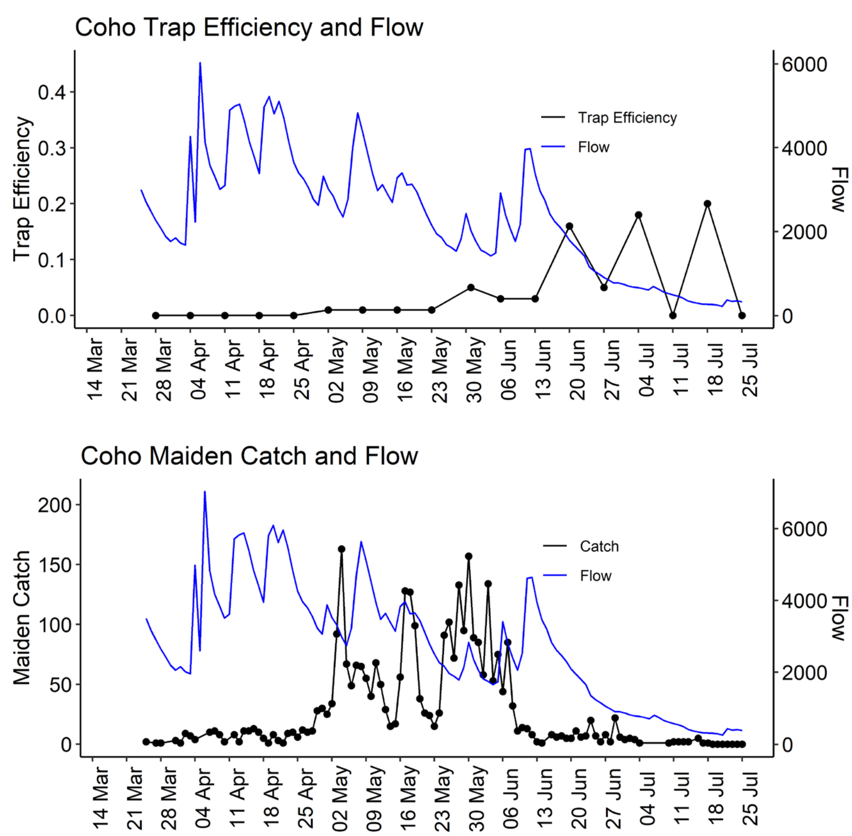

Figure 5. Coho wild transitional and smolt efficiency (top), maiden catch (bottom) and flow in cubic feet per second (cfs, top & bottom) as a function of period at the Chehalis smolt trap in 2022.

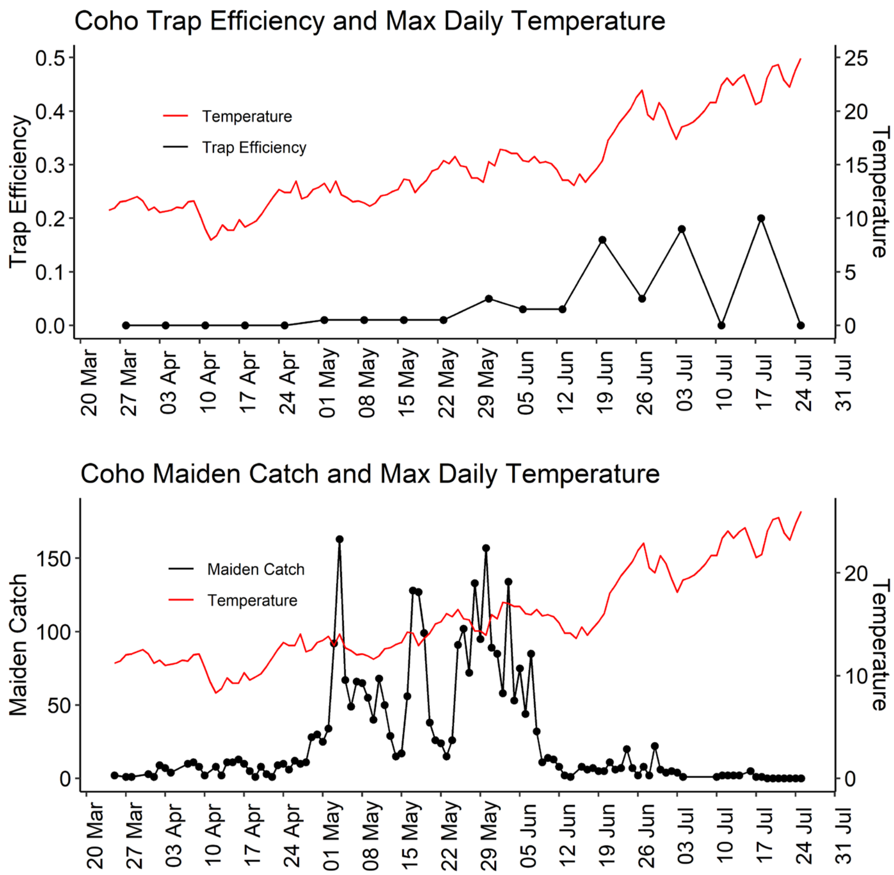

Figure 6. Coho wild transitional and smolt efficiency (top), maiden catch (bottom) and river water temperature (Degrees Celsius, top & bottom) as a function of period at the Chehalis smolt trap in 2022.

Table 8. Freshwater ages of wild coho outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2022. Data are scale ages of sampled juveniles by week.

Period	Start Date	End Date	No. Scales	Age-0	Age-1	Age-2	Not Determined
3	3/21	3/27	2		2		
4	3/28	4/3	17		14	1	2
5	4/4	4/10	17		15		2
6	4/11	4/17	32		28		4
7	4/18	4/24	25		20		5
8	4/25	5/1	35		30		5
9	5/2	5/8	35		31		4
10	5/9	5/15	35		32		3
11	5/16	5/22	35		34		1
12	5/23	5/29	35		33		2
13	5/30	6/5	35		30		5
14	6/6	6/12	30	5	22		3
15	6/13	6/19	25	13	10		2
16	6/20	6/26	27	19	6		2
17	6/27	7/3	23	22			1
18	7/4	7/10	2	2			
19	7/11	7/17	11	7			4
20	7/18	7/24					

Steelhead

The steelhead outmigrant estimate included both transitional and smolt life stages. Of these life stages, approximately 95.7% of outmigrants observed were classified as the smolt phenotype, compared to transitional. Steelhead outmigrant numbers were low during the first week of trapping, March 24 (trapping period 4), peaked in late May, and were last observed the week of June 28 (trapping period 18) (Figure 7, Appendix D).

Scale age data indicated that steelhead were Age-1, Age-2, Age-3, and Age-4 (Figure 8, Table 9). A total of 255 scale samples were collected and 62.4% were successfully aged. Fork lengths averaged 168.7 mm (± 20.6 SD), 165.4 mm (± 14.7 SD), 197.2 mm (± 22.0 SD), and 220.5 mm (± 6.4 SD) for Age-1 through Age-4, respectively. The age composition of successfully aged steelhead was 47.8% Age-1, 42.8% Age-2, 8.2% Age-3, and 1.3% Age-4.

A total of 413 steelhead outmigrants were captured throughout the season (Appendix D). Of these, 377 were marked and 7 were recaptured. Modeled weekly trap efficiencies ranged from 0.7% to 1.9%.

Trap efficiency and maiden catches can both be affected by river flows. River flows in 2022 were highly variable and consistently high (> 2,000 cfs, Figure 9). While data indicate that these flows did impact our maiden catch and trap efficiency, these impacts did not prevent us from generating an estimate (Figure 10).

The abundance of wild steelhead outmigrants was estimated to be 36,236 (95% CI = 15,936 – 107,650) with a CV of 58.9%. On a basin wide scale, the steelhead estimate from the Upper Chehalis trap contributed 28.2% to the total estimate at the main stem trap. An estimate of steelhead production from the Newaukum River was unreportable in 2022.

Steelhead contributing to the 2022 smolt outmigration came from the 2018 through 2021 brood years. Spawners above the smolt trap were estimated to be 1,733, 2,014, 2,791, and 2,143 for these years, respectively. The smolt-per-spawner estimates were 20.5, and 17.2 for brood years 2018 and 2019, respectively. Estimating steelhead productivity above the trap through time is a project goal.

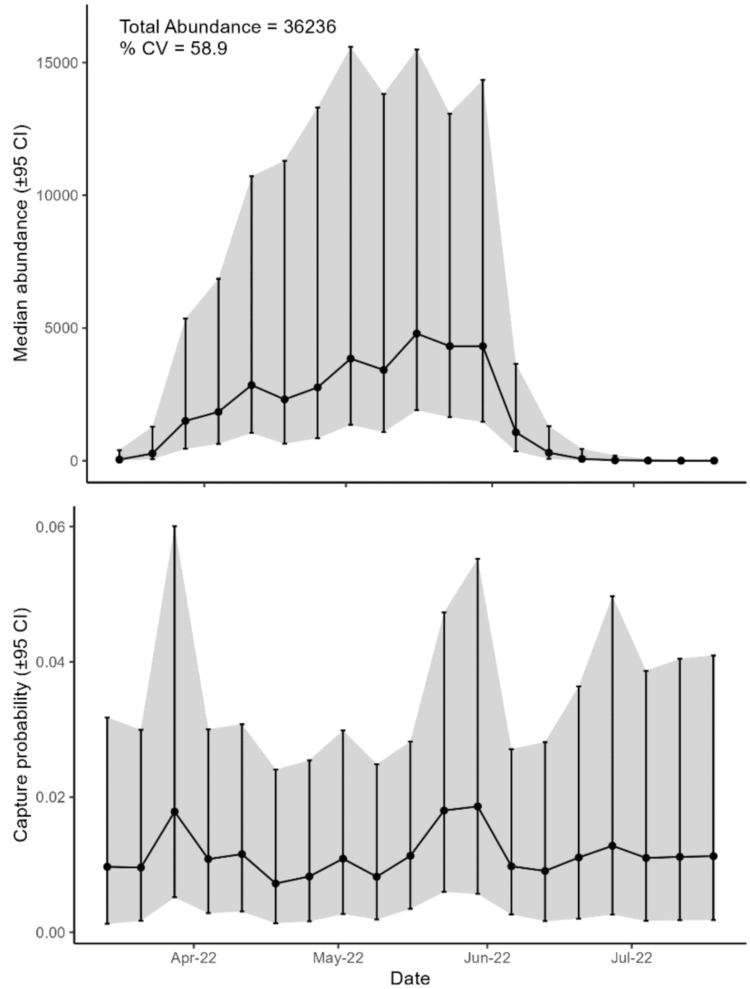

Figure 7. Number of outmigrants (top panel) and trap efficiency (bottom panel) by week for wild steelhead smolts and transitionals produced above the Chehalis River smolt trap in 2022**.** Error bars around trap efficiency estimates and shading around abundance estimates represent 95% credible intervals. Data provided in Appendix D.

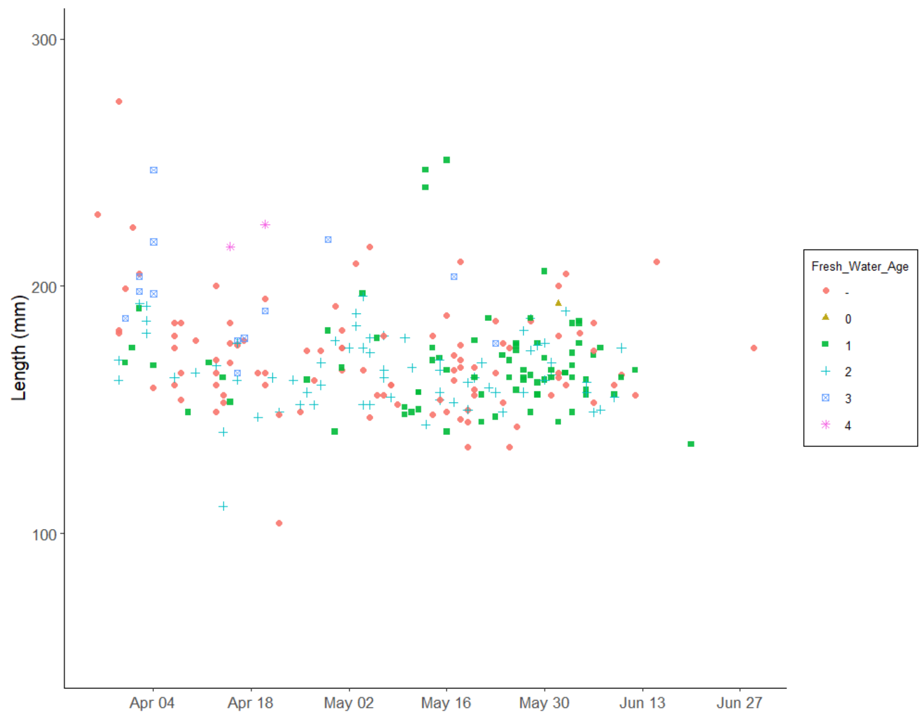

Figure 8. Plot of date-length-age data from wild steelhead outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2022.

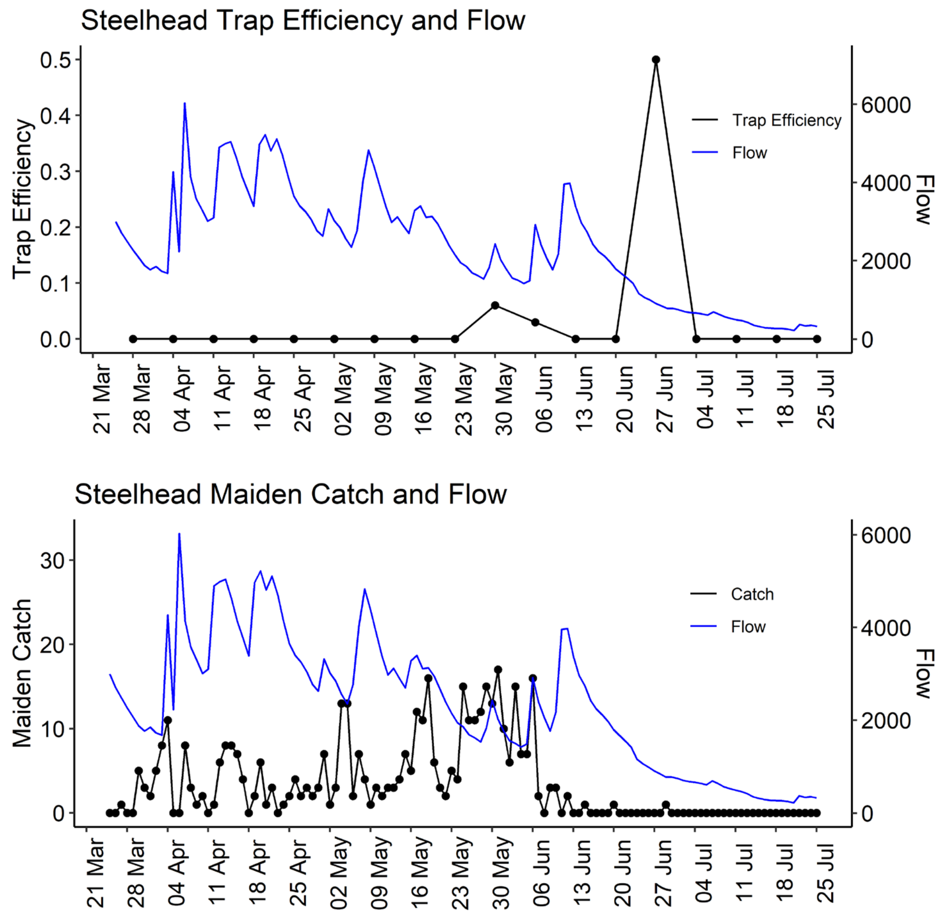

Figure 9. Steelhead wild transitional and smolt trap efficiency (top), maiden catch (bottom) and flow in cubic feet per second (cfs, top & bottom) as a function of period at Chehalis smolt trap in 2022.

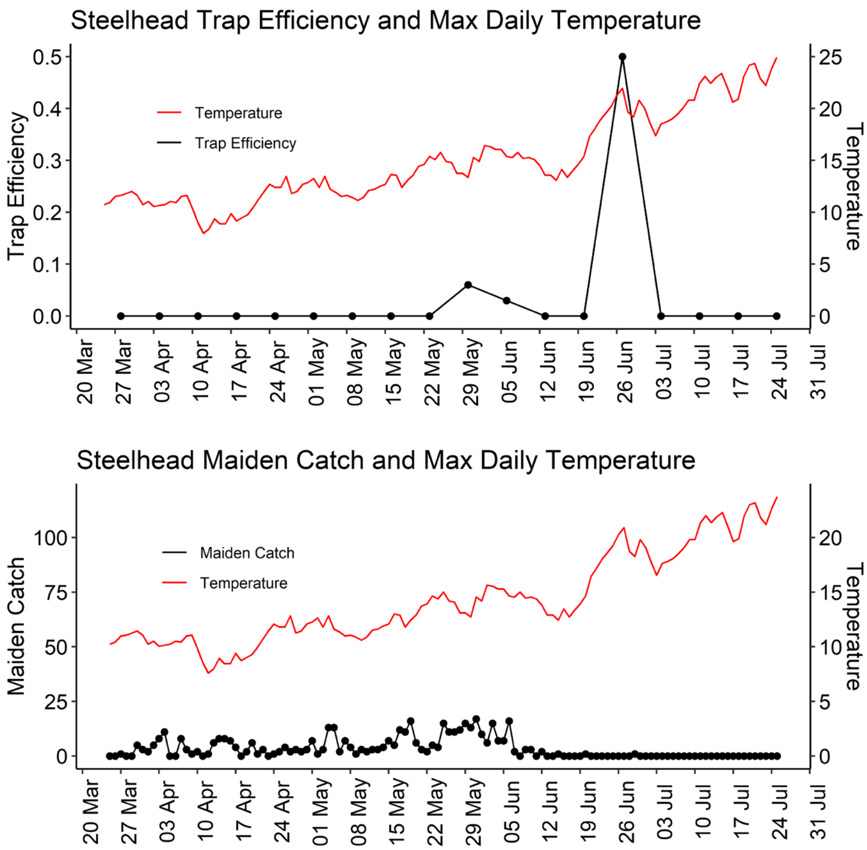

Figure 10. Steelhead wild transitional and smolt trap efficiency (top), maiden catch (bottom) and river temperature degrees Celsius (top & bottom) as a function of period at Chehalis smolt trap in 2022.

Table 9. Freshwater ages of wild steelhead outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2022. Data include scale ages of sampled juveniles by week.

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

Chinook

The Chinook outmigrant estimate was derived for the subyearling life history and included transitionals and smolts. Chinook outmigrants were observed in low numbers the first week of trapping March 24 (trapping period 4), peaked in late June, and declined through the rest of the trapping season (Figure 11).

Generally, all Chinook outmigrants were assumed to be Age-0. Subyearling Chinook ranged from 45 –140 mm. Fork length of Chinook increased steadily throughout the season with an average of 49.1 mm (± 7.9 SD) and 106.6 mm (± 5.5 mm SD) in the first and last full week of trapping, respectively (Figure 12).

In 2022, a total of 14,739 Chinook subyearling outmigrants were captured, 6,084 were marked, and 549 were recaptured (Appendix E). Modeled weekly trap efficiencies ranged from 1.4% to 30.9%.

Trap efficiency and maiden catches can both be affected by river flows. River flows in 2022 were highly variable and consistently high (>2,000 cfs, Figure 13). While data indicated flows impacted maiden catch and trap efficiency, these impacts did not affect abundance estimation (Figure 14). The abundance of wild Chinook subyearling outmigrants was estimated to be 247,707 (95% CI = 215,914 – 289,634) with a CV of 7.5%. On a basin wide scale, the Chinook estimates from the upstream Newaukum River and Upper Chehalis rotary screw traps contributed 16.4% and 8.0% to the total estimate at the main stem trap, respectively.

In 2021, the total number of adult spring Chinook that spawned in the Chehalis River above the trap site was estimated to be 2,445 (all NOR) and adult fall Chinook was estimated to be 2,404 (all

NOR), for a total of 4,849, producing an overall smolt-per-adult estimate of 51.1 for the 2021 brood year of naturally spawning Chinook. Estimating subyearling Chinook productivity through time is a goal of this study going forward.

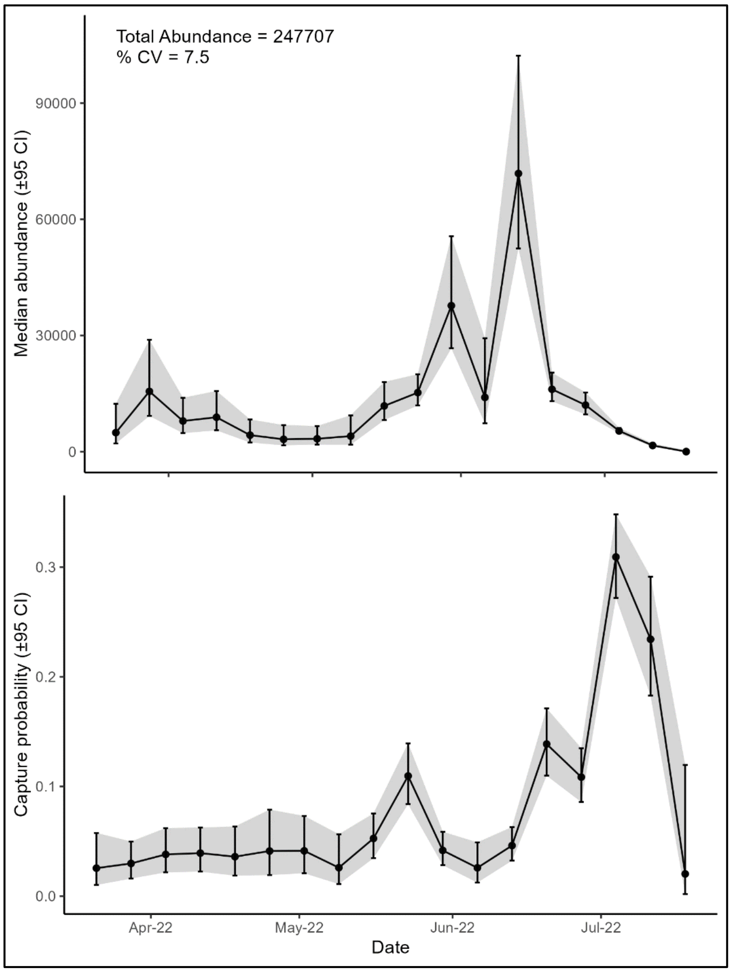

Figure 11. Number of outmigrants (top panel) and trap efficiency (bottom panel) by week for wild Chinook subyearlings produced above the Chehalis River smolt trap in 2022. Error bars and shading represent 95% credible intervals.

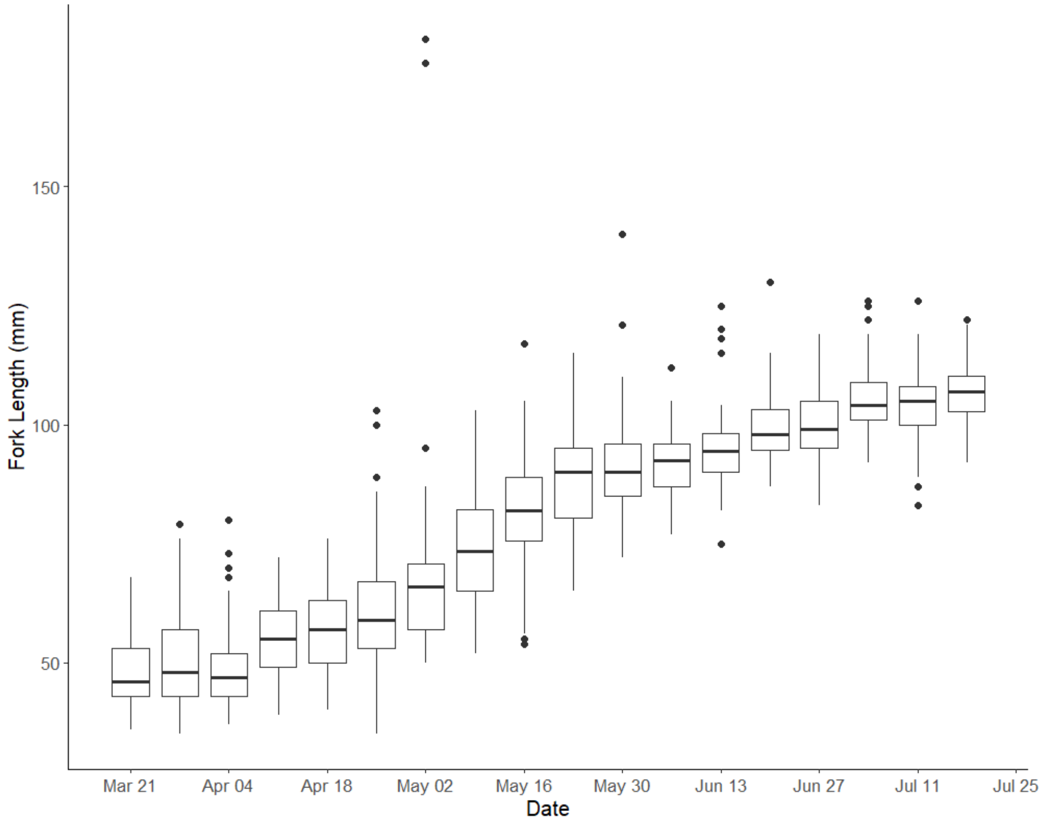

Figure 12. Box plots of fork lengths of wild Chinook outmigrants (transitionals, smolts) by week at the Chehalis River screw trap, 2022. Each box represents the median, first and third quartiles, whiskers represent the interquartile ranges, and dots represent outliers.

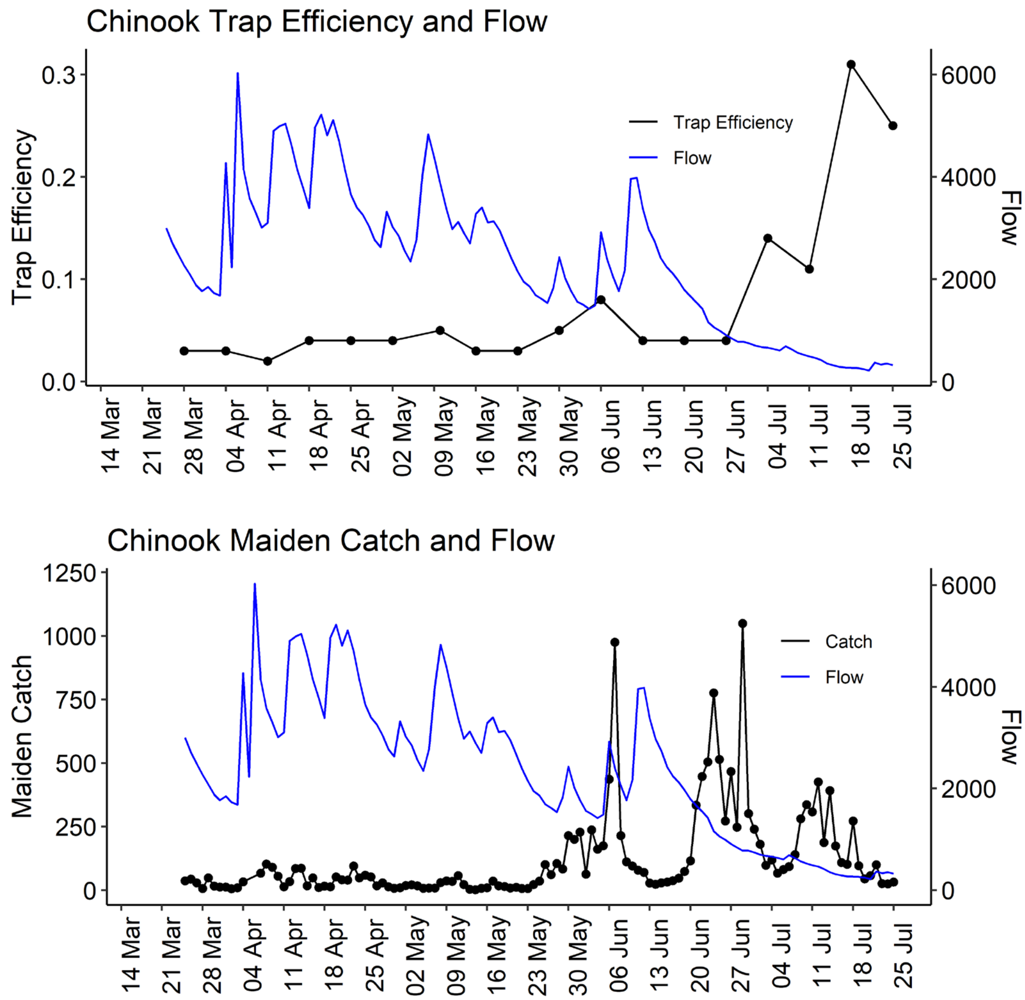

Figure 13. Chinook wild transitional and smolt trap efficiency (top), maiden catch (bottom) and flow in cubic feet per second (cfs, top & bottom) as a function of period at the Chehalis smolt trap in 2022.

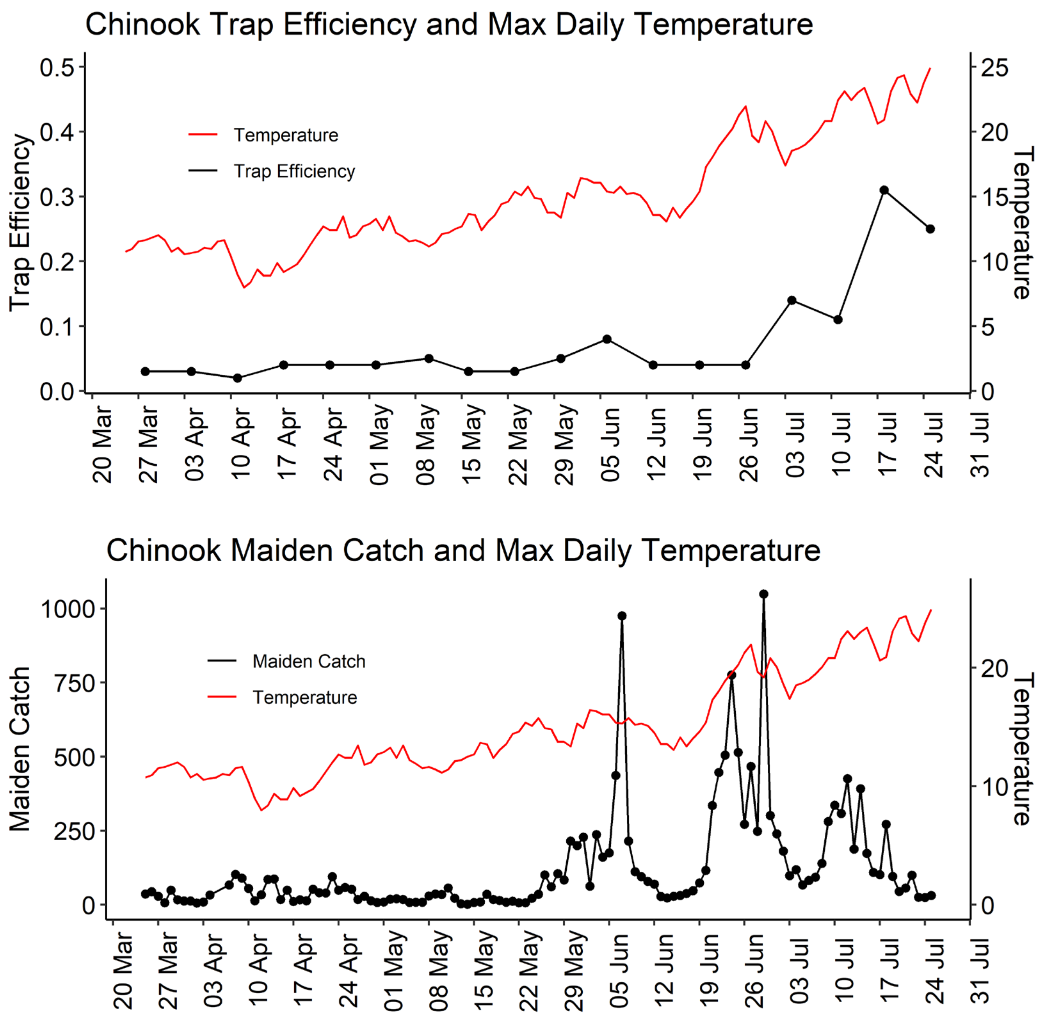

Figure 14. Chinook wild transitional and smolt trap efficiency (top), maiden catch (bottom) and river temperature degrees Celsius (top & bottom) as a function of period at the Chehalis smolt trap in 2022.

Table 10. Freshwater ages of wild Chinook outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2022. Data include opportunistic samples from large Chinook and scale ages from sampled juveniles by week.

Period	Start Date	End Date	No. Scales	Age-0	Age-1	Age-2	Not Determined
3	3/21	3/27					0
4	3/28	4/3					0
5	4/4	4/10					0
6	4/11	4/17					0
7	4/18	4/24					0
8	4/25	5/1	1	1			0
9	5/2	5/8					0
10	5/9	5/15	2	2			0
11	5/16	5/22	3	3			0
12	5/23	5/29	9	9			0
13	5/30	6/5	2	2			0
14	6/6	6/12	2	2			0
15	6/13	6/19	5	5			0
16	6/20	6/26	3	3			0
17	6/27	7/3	1	1			0
18	7/4	7/10	4	4			0
19	7/11	7/17					0
20	7/18	7/24					0

Discussion

Basin-wide Context

The abundance estimates provided in this report represent juvenile salmonids that completed their freshwater rearing in 2022 in habitats upstream of the trap location, specifically upstream of river kilometer 84 (river mile 52). The area upstream of the trap includes the upper Chehalis main stem, South Fork Chehalis River, Newaukum River, Skoookumchuck River, and other smaller tributaries. Large sub-basins of the Chehalis River watershed, including the Black River and Satsop River, flow into the Chehalis River downstream of the trapping location. In addition to freshwater production from these sub-basins, some juveniles that emerge from the gravel upstream of the trap location and redistribute to areas downstream of the trap location during their freshwater rearing period were not included in these estimates. This is especially true for Chinook fry (Zimmerman et al. 2024) and 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).

Estimates of annual freshwater production of wild coho smolts in the entirety of the Chehalis River Basin averaged 2.1 million (0.5 to 3.8 million) since WDFW began monitoring smolt production in the 1980s (Litz 2024). The proportion of coho habitat upstream of our trapping location represents approximately 30.6% of the rearing habitat relative to the entirety of the Chehalis Basin (Walther 2021). The proportion of freshwater production of coho salmon from upstream of our trapping location relative to basin-wide production has ranged from 9.3% to 24.0% in the years of which data are available (2017 – 2022). Based on these proportions, estimates of coho outmigrants from habitat upstream of river kilometer 84 suggest that a relatively small proportion of wild coho in the Chehalis River watershed complete their freshwater rearing in the upper Chehalis, South Fork Chehalis, Newaukum, Skoookumchuck, and other smaller tributaries upstream of the trap site. Conversely, a larger proportion of wild coho appear to complete their freshwater rearing in the main stem and tributaries downstream of the trap location which make up approximately 69.4% of coho salmon habitat in the Basin (Walther 2021). Spawning and rearing areas downstream of the trap location include off-channel sloughs and ponds along the main stem river, major tributaries such as the Black, Satsop, Wishkah, and Hoquiam rivers, and smaller tributaries including Porter and Cloquallum Creek.

There were two events between the summer of 2021 and the winter of 2021/2022 that may have impacted the survival of coho, steelhead, and Chinook in the Chehalis River basin prior to outmigrating in 2022. In June 2021, there was a heat dome over western Washington that significantly warmed the temperature of the Chehalis River (Table 11) and in January 2022, the second highest flood on record occurred. There were also other high-water events throughout the 2021/2022 winter season. The heat dome may have impacted the summer survival coho and steelhead parr and frequent flooding in the following months may have impacted their overwinter survival. Additionally, high flow in winter may have affected the in-gravel survival of Chinook, coho and steelhead redds through scour. The frequent flooding may have also flushed subyearling and yearling fish below the trap before operations began for the year, negatively biasing abundance estimates.

Estimates of juvenile coho production upstream of the mainstem rotary scew trap from 2017 – 2022 ranged from 163,354 to 463,566, with 2022 the lowest observed estimate in the six-year time series (Figure 15). Despite this, credible intervals have decreased compared to the first year of trapping, indicating that confidence in the production estimates is increasing (Figure 15). This has mainly been possible due to learning how the equipment operates best at this location and adapting field protocols and analytical methods to reduce bias and optimize precision. Also, estimates of wild coho production above the trap site from 2017 – 2020 were relatively consistent with WDFW monitoring results from the 1990s which also estimated 300,000 to 400,000 wild coho smolts produced upstream of the mainstem smolt trap (Seiler et al. 1997). However, wild coho production decreased in 2021 and 2022, and may have been the result of a historic heat dome event in June 2021 that impacted summer parr rearing in freshwater. Moreover, late fall 2021 and early winter 2022 were characterized by several high flow events above action stage that could have swept rearing coho downstream. If rearing habitat is a limiting factor for coho in the Chehalis Basin, as suggested in other streams in western Washington (Reeves et al. 1989), then restoration activities targeting floodplain reconnection should increase the productivity of coho in the Chehalis Basin, consistent with the goals of the Aquatic Species Restoration Plan (ASRPSC 2019).

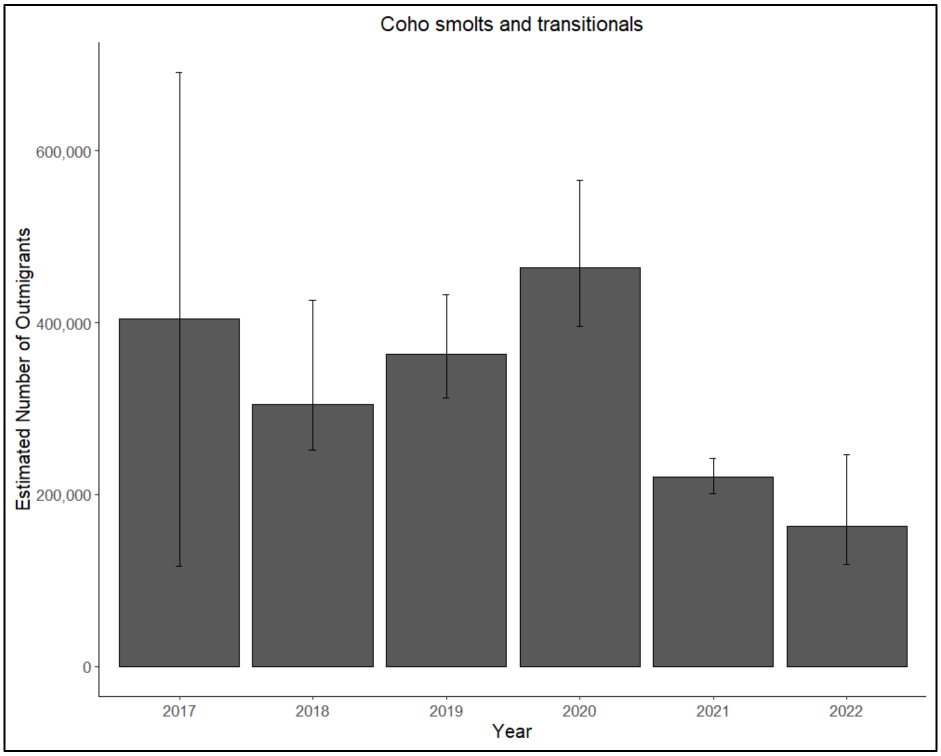

Figure 15. Annual time series of outmigrant abundance with 95% confidence intervals for wild coho smolts and transitionals produced above the Chehalis River smolt trap, 2017 - 2022.

This report provides the fifth reportable estimate of wild steelhead production from the Chehalis River basin upstream of river kilometer 84. The estimate of 36,236 steelhead outmigrants from the roughly 566 river km upstream of the trap (Statewide Integrated Fish Distribution, SWIFD, https://geo.nwifc.org/swifd/) corresponds to 64 wild steelhead smolts km^{-1}, which is roughly average compared to estimates in 2018 (32,058, 57 smolts km^{-1}), 2019 (29,024, 51 smolts km^{-1}), 2020 (38,647, 68 smolts km^{-1}), and 2021 (30,945, 55 smolts km^{-1}, Figure 16). These smolt densities are low compared to other western Washington watersheds where steelhead smolt estimates are available, such as the Coweeman River (average 243 smolts km^{-1}) or the Wind River (average 240 smolts km^{-1}) (T. Buehrens, personal communication). The reasons for these differences are not yet apparent and may reflect the difference between available versus suitable rearing habitat upstream of the Chehalis River trap. In contrast to the Coweeman and Wind rivers, much of the spawning and rearing habitats upstream of the trap on the Chehalis River are either low gradient main stem channel or small tributaries, neither of which have geomorphic characteristics typically associated with high quality steelhead spawning and rearing habitat in the Pacific Northwest (Gibbons et al. 1985). Of note, recent studies (Ashcraft et al. 2017, Ronne et al. 2018) identified the Upper Chehalis sub-basin, which is one of multiple sub-basins located upstream of the smolt trap, as a particularly productive steelhead spawning area. Over five years of monitoring, surveyors estimated 600 – 1,000 redds (or 900 – 1,800 steelhead spawners) in this area of the basin. Another possible explanation is that steelhead parr could rear downstream of the trap, however rearing areas downstream of the trap are generally low gradient main stem reaches, off-channel sloughs, and ponds along the main stem river. These habitat types are not considered high quality juvenile steelhead rearing habitat (Burnett et al. 2007). Additionally, summer stream temperatures downstream of the trap are outside optimal rearing conditions for juvenile salmon and steelhead

(Winkowskiet al. 2024). Unlike coho and Chinook, the production estimate for steelhead did not decline in 2022. This is possibly because of the tendency for steelhead to rear higher in the basin shielded them from higher flows and have access to more thermal refugia.

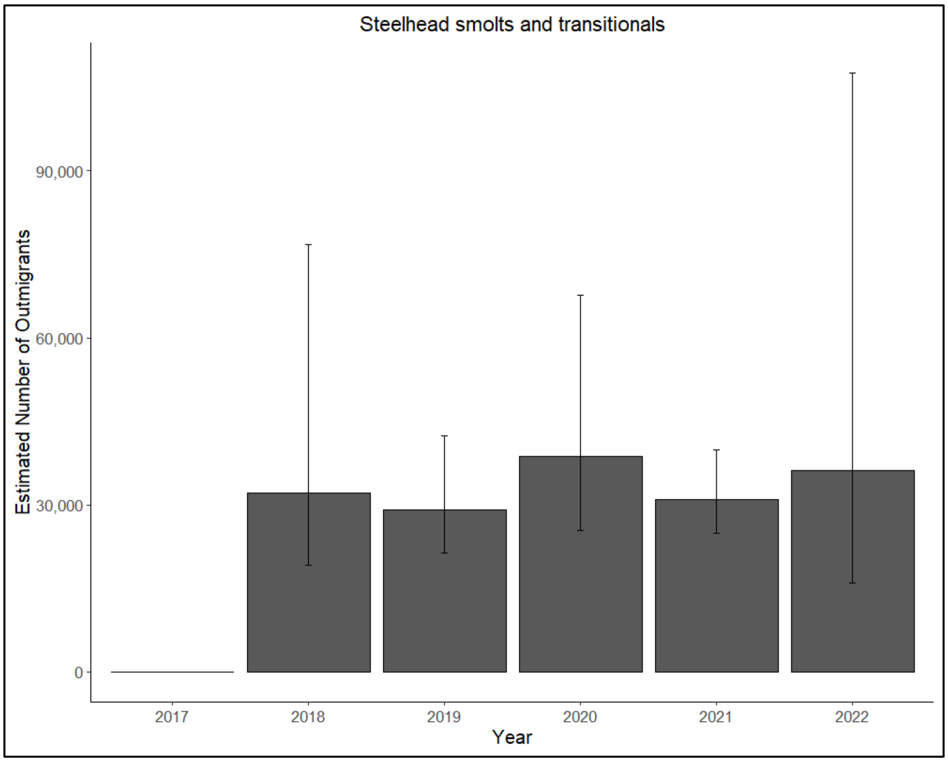

Figure 16. Annual time series of outmigrant abundance with error bars representing 95% credible intervals for wild steelhead smolts and transitionals produced above the Chehalis River smolt trap, 2017 - 2022.

The estimate of Chinook subyearling outmigrants represents a portion of the total freshwater production of Chinook upstream of the trap location in 2022 and does not include the earlier timed fry migrants. The estimate of 247,707 Chinook subyearling outmigrants in 2022 is the lowest of four reportable estimates above the Chehalis trapping location and was 43.8% lower than the 2021 estimate of 440,907 (Figure 17). In addition, the precision of the 2022 estimate was the most variable of the time series, meaning higher uncertainty compared to other years (Figure 17). The subyearling component of the outmigration represents the numbers of juveniles supported by freshwater habitats upstream of the trap site. Previous work demonstrated that >95% of adult Chinook returning to the upper Chehalis had a subyearling life history (Campbell et al. 2017). Fry migrants do not spend as much time rearing in freshwater habitats but rather make extensive use of estuary and nearshore growing environments prior to entering the ocean (Sandell et al. 2014, Beamer et al. 2005). 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 reflect a freshwater rearing capacity (Anderson and Topping 2018, Zimmerman et al. 2015). Additional Chinook production beyond this capacity appear to migrate downstream as fry in a density-dependent manner (Greene et al. 2005). Implementation of restoration activities within rearing habitat upstream of the trap site could result in fewer fry outmigrants as freshwater rearing capacity increases, although continued monitoring will be necessary to confirm this hypothesis.

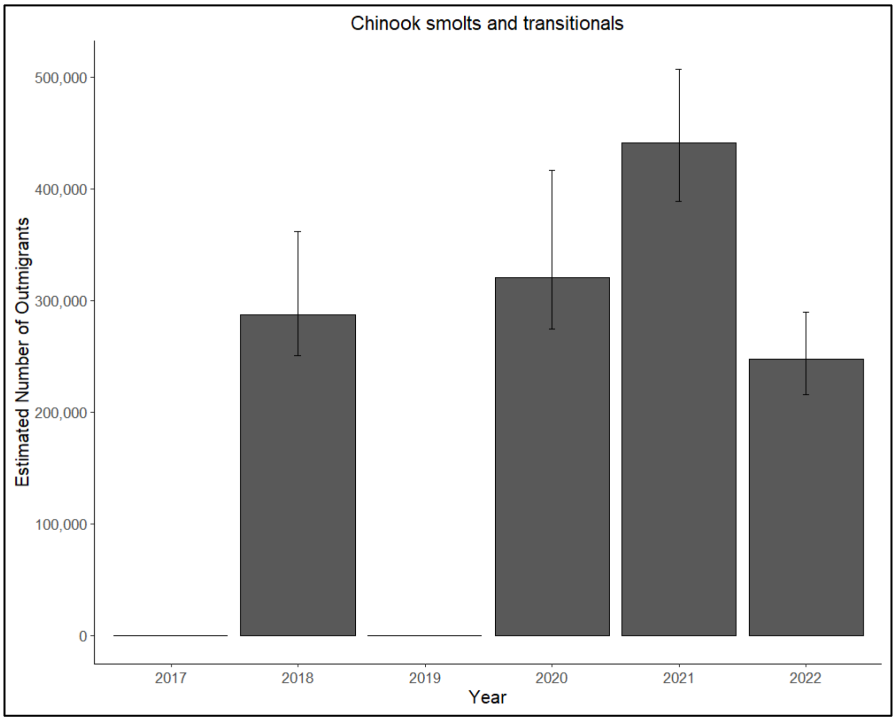

Figure 17. Annual time series of outmigrant abundance with error bars representing 95% confidence intervals for wild Chinook smolts and transitionals produced above the Chehalis River smolt trap, 2017 - 2022.

Next Steps

The main stem Chehalis River estimates presented here provide critical information for salmon and steelhead smolt production in the Chehalis Basin but trapping in this location presents many challenges. In 2022, challenges included high flows and warming stream temperatures towards the end of the trapping season. Despite this, 2022 was not characterized by high algal debris loads later in the season as in other years.

The 2022 season was the sixth year attempting a Chinook subyearling outmigration estimate (e.g., fishing into July), which was longer than the historical trapping seasons (e.g., historical trapping periods occurred April to May from 1999 – 2015). Temperature concerns are prevalent later in the season at this location on the Chehalis River and were no exception in 2022. For example, maximum daily temperatures during June and July peaked at 22.0°C and 29.5°C, respectively (Table 11). However, unlike 2019 – 2021, large algae aggregations were not as serious an issue at the trap in 2022.

With respect to environmental conditions, 2022 was the wettest season since operation as a rotary screw trap began in 2017. This caused the river to be at full bank width and river flows to be highly variable for much of the season (Figure 13), which impacted trap efficiency (Figures 5, 9, and 13). Despite these impacts on trap efficiency, estimates for coho, steelhead, and Chinook were still generated.

Adult northern pikeminnow and other piscivorous fish (e.g., smallmouth bass) were previously observed aggregating around the smolt trap and feeding on fish released from the trap. More adult pikeminnow were captured in 2022 (n = 170) compared to 2021 (n = 141 adults), 2020 (n = 16 adults), and 2019 (n = 59 adults), but fewer than 2018 (n = 439 adults). This large difference in adult pikeminnow catch may be attributed in part to differing trap positions between years. In 2018, trapping position was impeded by low water late in the season, prohibiting the trap from fishing at the most efficient velocities. In 2022, fishing late into the season likely increased the catch of pikeminnow. In 2023, the plan is to evaluate ways to mitigate the potential impact of northern pikeminnow on salmonids in the trap live box.

In 2022, a cellular trail camera was used to monitor the trap for screw stoppers. Prior to this, there was no way of knowing precisely when a trap stopper occurred. With the implementation of the cellular trail camera, stoppages were identified precisely, preserving data collected prior to the stoppage. Use of the trail camera also allowed more frequent monitoring of the trap and limited stoppages to less than 3 hours. Cellular trail cameras will continue to be used in the future and their use is recommended on other traps.

In summary, 2022 represented the fifth year that wild steelhead outmigrations and fourth year that wild Chinook outmigrations were described from the Chehalis River and the sixth time in two decades that wild coho outmigrations were specifically evaluated from the upper portion (upstream of the Black River) of the basin. In addition to abundance, life history characteristics and size of the outmigrants were described. Continuation of this monitoring will provide understanding of variability and trends in freshwater production over time. As part of a larger, integrated monitoring effort associated with the Chehalis Basin Strategy Aquatic Species Restoration Plan (http://chehalisbasinstrategy.com/), this status and trend information will inform future questions on the influence of habitat restoration projects or climate change impacts on freshwater production of salmon and steelhead in the Chehalis River.

Table 11. Mean and maximum of daily stream temperatures (°C) by month recorded at Chehalis River smolt trap near river km 84, 2018 - 2022.

Year	2018	2019	2020	2021	2022
Month		Maximum (°C)			
March	---	12.1	10.4	9.7	12.0
April	14.2	14.9	15.3	16.8	13.5
May	20.4	21.0	20.1	20.5	15.8
June	24.2	25.2	22.7	29.8	22.0
July	25.8	24.7	25.6	26.0	29.5

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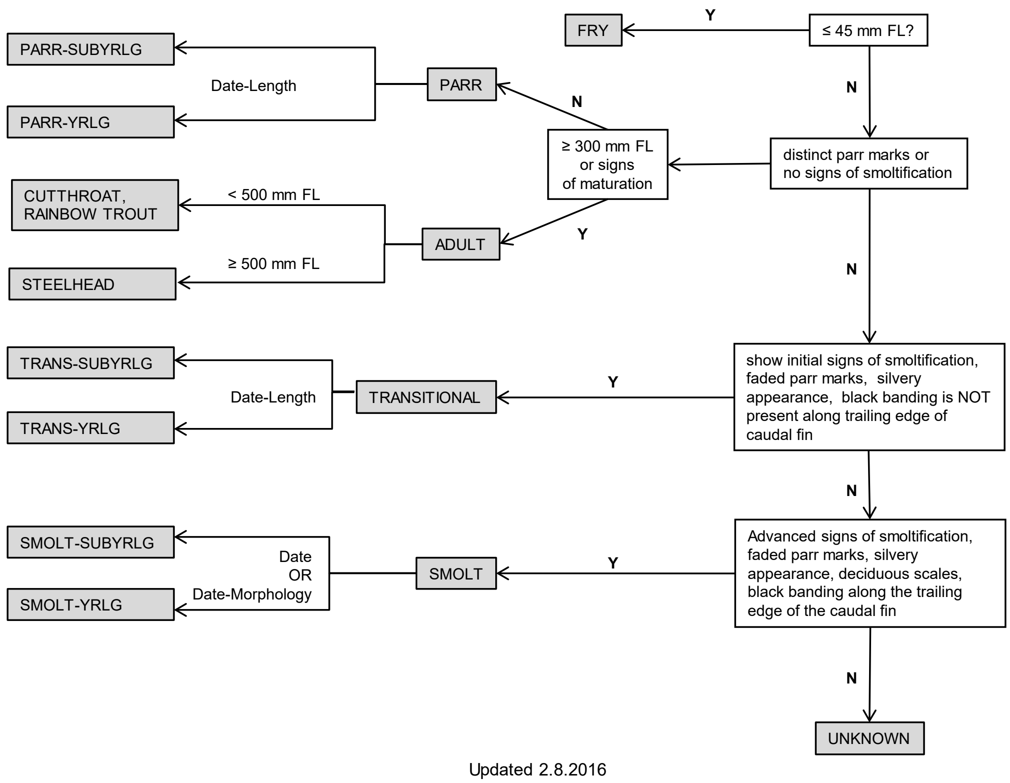
Appendices

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.



Appendix B. Chehalis River missed trapping periods 2022.

Last Time Observed Fishing	Time Not Fishing	Method to Determine Trap Not Fishing	Time Start Fishing again	Comments
3/27 1030	1.18 hr	Scheduled	3/27 1141	Trap Maintenance
3/28 1530	0.5 hr	Scheduled	3/28 1600	Trap Maintenance
4/4 1525	39.38 hr	Scheduled	4/6 0700	High debris loads
4/7 2200	9.5 hr	Visual	4/8 0730	Screw Stopper
4/15 1600	2.25 hr	Visual	4/15 1815	Screw Stopper
4/16 2140	0.21 hr	Visual	4/16 2153	Screw Stopper
4/16 2230	10.5 hr	Visual	4/17 0900	Screw Stopper
4/19 1730	1.58 hr	Visual	4/19 1905	Screw Stopper
4/19 1905	3.67 hr	Visual	4/19 2245	Screw Stopper
5/2 1930	2.16 hr	Visual	5/2 2140	Screw Stopper
5/2 2140	1.0 hr	Visual	5/2 2240	Screw Stopper
5/7 1735	0.67 hr	Visual	5/7 1814	Screw Stopper
5/9 0940	1.92 hr	Scheduled	5/9 1135	Trap Maintenance
5/19 0544	0.1 hr	Visual	5/19 0551	Screw Stopper
6/1 1025	9.58 hr	Scheduled	6/1 2000	Trap Maintenance
6/2 1006	1.24 hr	Scheduled	6/2 1130	Trap Maintenance
6/11 0250	2.16 hr	Visual	6/11 0500	Screw Stopper
6/11 0650	1.25 hr	Visual	6/11 0805	Screw Stopper
6/13 1250	1.07 hr	Visual	6/13 1546	Screw Stopper
6/14 1421	1.1 hr	Visual	6/14 1527	Screw Stopper

Appendix C. Final analysis mark-recapture data for wild coho outmigrants (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
4	3/22	3/28	3		4	0.57
5	3/29	4/4	13		24	1.00
6	4/5	4/11	31		31	0.71
7	4/12	4/18	52		60	1.00
8	4/19	4/25	35		38	1.00
9	4/26	5/2	113	1	150	1.00
10	5/3	5/9	453	8	557	1.00
11	5/10	5/16	264	1	275	1.00
12	5/17	5/23	438	6	457	1.00
13	5/24	5/30	484	23	676	1.00
14	5/31	6/6	368	19	480	0.86
15	6/7	6/13	196	5	165	1.00
16	6/14	6/20	25	4	32	1.00
17	6/21	6/27	56	3	61	1.00
18	6/28	7/4	38	7	44	1.00
19	7/5	7/11	1		3	1.00
20	7/12	7/18	10	2	13	1.00
21	7/19	7/25	1			1.00

*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.

Appendix D. Final analysis mark-recapture data for wild steelhead 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
4	3/22	3/28	1		1	0.57
5	3/29	4/4	15		30	1.00
6	4/5	4/11	13		14	0.71
7	4/12	4/18	31		34	1.00
8	4/19	4/25	12		15	1.00
9	4/26	5/2	20		22	1.00
10	5/3	5/9	39		43	1.00
11	5/10	5/16	21		27	1.00
12	5/17	5/23	52		55	1.00
13	5/24	5/30	66	4	78	1.00
14	5/31	6/6	40		72	0.86
15	6/7	6/13	26		10	1.00
16	6/14	6/20	1		2	1.00
17	6/21	6/27	1	1		1.00
18	6/28	7/4	1		1	1.00
19	7/5	7/11				1.00
20	7/12	7/18				1.00
21	7/19	7/25				1.00

*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.

Appendix E. Final analysis mark-recapture data for wild Chinook outmigrants (parr, transitionals, smolts) organized by time 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 time period (Prop Fished).

Period	Start Date*	End Date*	Total Mark	Total Recap	Total Capture	Prop fished
4	3/22	3/28	36	3	123	0.43
5	3/29	4/4	103	3	125	1.00
6	4/5	4/11	300	7	331	0.71
7	4/12	4/18	275	11	302	1.00
8	4/19	4/25	281	10	351	1.00
9	4/26	5/2	186	7	154	1.00
10	5/3	5/9	107	5	132	1.00
11	5/10	5/16	158	7	138	1.00
12	5/17	5/23	101	3	104	1.00
13	5/24	5/30	396	20	624	1.00
14	5/31	6/6	455	51	1,439	0.86
15	6/7	6/13	591	23	1,574	1.00
16	6/14	6/20	257	9	360	1.00
17	6/21	6/27	699	29	3,316	1.00
18	6/28	7/4	465	67	2,236	1.00
19	7/5	7/11	594	66	1,307	1.00
20	7/12	7/18	558	175	1,663	1.00
21	7/19	7/25	224	53	381	1.00

*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.

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