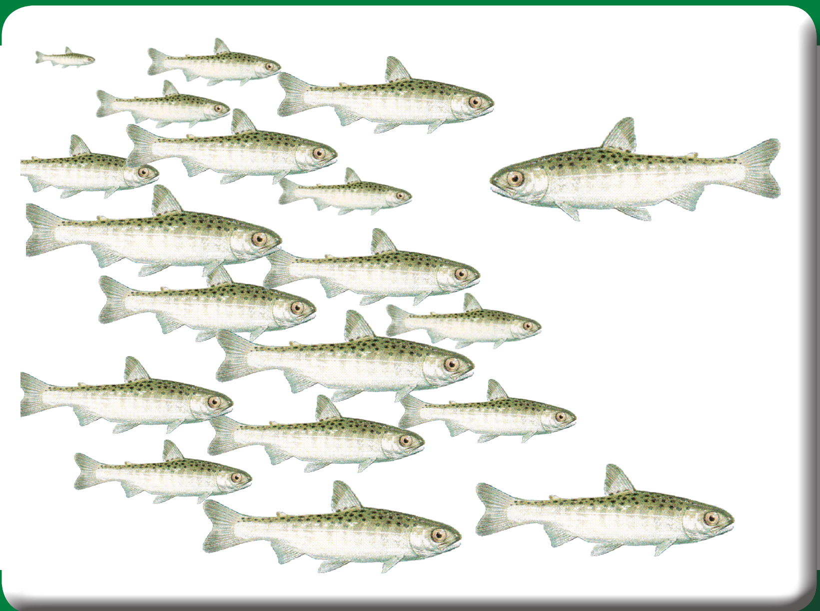
STATE OF WASHINGTON

April 2020

# Chehalis River Smolt Production, 2019



by Devin West, John Winkowski, and Marisa Litz

*Washington Department of Fish and Wildlife*
*Fish Program*
*Science Division*

FPA 20-05

# Chehalis River Smolt Production, 2019

**Washington Department of Fish and Wildlife**

Devin West
Fish Science Division
1111 Washington Street SE, Olympia WA 98501

John Winkowski
Fish Science Division
1111 Washington Street SE, Olympia WA 98501

Marisa Litz
Fish Science Division
1111 Washington Street SE, Olympia WA 98501

**April 2020**

# Acknowledgements

We would like to thank Brian Blazer, Shayne Noble, and Samuel Williams for field operations. We would also like to thank the Chehalis Indian Tribe for allowing land access and a private landowner for allowing us to access power and water.

This project was funded by the Washington State Legislature through a contract administered by the Washington State Recreation and Conservation Office.

**Recommended citation:** West, D., J. Winkowski, M. Litz. 2020. Chehalis River Smolt Production, 2019, FPA 20-05. Washington Department of Fish and Wildlife, Olympia, Washington.

# Table of Contents

# List of Tables

# List of Figures

# List of Appendices

# Executive Summary

This report provides the 2019 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) of juvenile outmigrants for wild coho salmon (*O. kisutch*), steelhead, and Chinook salmon (O. *tshawytscha*). In addition, we generated estimates of abundance for wild coho and steelhead in 2019, but not for Chinook. 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 27 to June 16, 2019.

Coho outmigrants were predominately yearlings, however scale age data indicated a small subyearling component of the coho outmigration starting sometime near the middle of May. Abundance of wild coho outmigrants was estimated to be 363,214 ± 31,169 standard deviation SD with a coefficient of variation CV of 8.5% (Table 1).

Steelhead outmigrants were one, two, and three years of age, indicating three different juvenile life histories. Fork length averaged 157.4 mm (± 11.9 mm SD) for one-year olds, 184.8 mm (± 26.9 mm SD) for two-year olds, and 245.4 mm (± 61.6 mm SD) for three-year olds. Abundance of wild steelhead outmigrants was estimated to be 29,024 ± 5,343 SD with a CV of 18.4% (Table 1).

Chinook outmigrants were subyearlings. High stream temperatures and associated issues precluded trapping over the entirety of the Chinook outmigration. Therefore, data collection was not adequate to produce an estimate of subyearling Chinook abundance. Fork length of Chinook transitional and smolt subyearlings increased steadily throughout the trapping period with an average of 50.5 mm (± 2.6 SD) and 74.2 mm ± 8.2 SD in the first and last full week of trapping, respectively.

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. NA indicates no abundance estimate was produced.

| Abundance Group | Origin | Life Stage | Age Class | Abundance ± Standard Deviation | Coefficient of Variation (%) |
|---|---|---|---|---|---|
| Coho | Wild | Transitional, Smolt | Subyearling, Yearling | 363,214 ± 31,169 | 8.5 |
| Steelhead | Wild | Transitional, Smolt | Yearling | 29,024 ± 5,343 | 18.4 |
| Chinook | Wild | Transitional, Smolt | Subyearling | NA | NA |

# Introduction

The Washington Department of Fish and Wildlife 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 (*Oncorhynchus kisutch*) and generated estimates of wild coho smolt abundance at a basin scale. Results from this monitoring program have demonstrated that the Chehalis River has a higher density of wild coho smolts (average 998 smolts $mi^{-2}$) than any other western Washington watershed for which data currently exists (Kendall et al. 2019). Smolt abundance estimates from individual tributaries were generated in the 1980s and 1990s but have not been evaluated for nearly two decades. Further, there is currently limited information on freshwater production of other salmonid species, including Chinook (*O. tshawytscha*) and chum (*O. keta*) salmon, and steelhead (*O. mykiss*) in the Chehalis River basin. Recent efforts under the Chehalis Basin Strategy (http://chehalisbasinstrategy.com/) to develop an Aquatic Species Restoration Plan have highlighted smolt (or juvenile outmigrant) data as an important information gap that will be useful for evaluating variability and trends in freshwater production over time and in response to restoration.

As a result, WDFW monitoring activities expanded in 2019 to develop a more comprehensive understanding of freshwater production among multiple species of salmonids and multiple locations in the Chehalis River basin. In the future, we anticipate that this expanded effort will become part of an integrated monitoring program used to evaluate salmon and steelhead responses to changes in the riverine environment as a result of habitat restoration actions and climate change (http://chehalisbasinstrategy.com/). 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 many refinements in the operational protocols and trap modifications (Winkowski and Zimmerman 2018).

## Objectives

The primary objective of this study is 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) 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. This report includes results from the 2019 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 to 1,350 m) and low gradient with a 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 fall and spring Chinook salmon, coho salmon, winter steelhead, and cutthroat trout (*O. clarkii*). Chum salmon are present in the basin but occur downstream of the smolt trap location in this study.

Similar to 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 are termed 'fry' (defined as juveniles ≤ 45 mm fork length, FL), which are individuals that outmigrate 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 other smolt traps in the Puget Sound and other areas (Anderson and Topping 2018; Zimmerman et al. 2015; Kiyohara and Zimmerman 2012; Groot and Margolis 1991). 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.

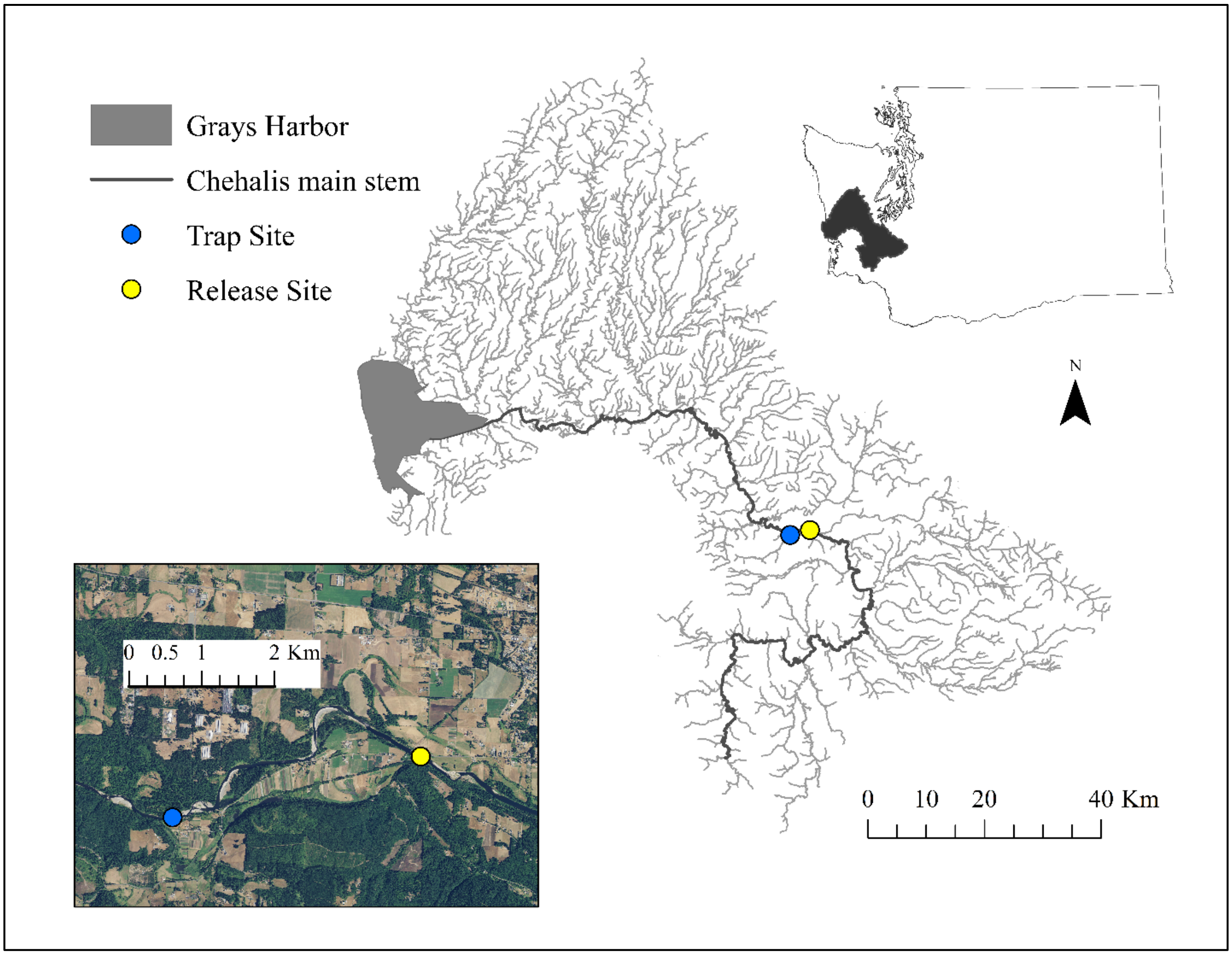



Figure 1. Location of screw trap (blue dot) and release site for marked fish (yellow dot) in the Chehalis River, WA.

## Trap Operation

A 2.4 m (8-foot) diameter rotary screw trap (RST) was operated near river kilometer 84 of the Chehalis River. This site was selected because it is the most downstream point in the basin with suitable characteristics to maximize RST efficiency throughout the trapping period. Due to the location of this trap, our estimates represent a portion of the freshwater production in the Chehalis River 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, debris, and trap outages.

River temperature and trap status data (e.g., fishing or not fishing, cone revolutions per minute) were collected at each trap check. Instantaneous stream temperature was collected at the start of each sampling event and 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. Stream flow is 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 sampling commenced in the morning on a daily basis and was adjusted to earlier times as stream temperatures increased to >18°C throughout the season. Crews monitored the live box several times daily and modified sampling protocols in response to environmental conditions, such as earlier or multiple checks to minimize risk on fish health. Fish were removed from the live box on the back of the trap using a dip net, transferred to 5-gallon buckets, and moved to a trough with flowing river water for sampling and tagging. 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 7-8 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 below (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. We expected to capture hatchery origin coho and steelhead, which are released from multiple locations upstream of the trap site (e.g., Skookumchuck hatchery). Fork length and scales were collected from a subsample of wild (adipose fin intact) coho, steelhead, and Chinook (Table 2). We collected scale samples from coho in three distinct size classes (see Table 2) in order to inform the age class-length-date criteria used for categorizing subyearlings versus yearlings in the field.

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

| Sample Type | Species | Fry | Parr | Transitional/Smolt |
|---|---|---|---|---|
| Fork Length | Coho | 1st 50 per week | 1st 50 per week | 1st 50 per week |
| | Steelhead | 1st 50 per week[a] | 1st 50 per week | All Efficiency marked individuals (100/day) |
| | Chinook | 1st 50 per week | 1st 50 per week | 1st 50 per week |
| Scales | Coho | --- | --- | 1st 5 per week per size class (<100 mm, 100-149 mm, ≥ 150mm) |
| | Steelhead | --- | --- | 1st 20 per week |
| | Chinook[b] | --- | --- | --- |

[a]Trout fry included both steelhead/rainbow trout and cutthroat.
[b]No scale samples were collected from Chinook.

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 are 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 years in freshwater. For coho salmon all fry and parr were classified as subyearling and all smolts and transitionals were classified as yearlings (Table 3). For steelhead, the field-assigned 'yearlings' could be any of 1, 2, and 3-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. The majority of outmigrating Chinook salmon in the Chehalis River are subyearlings. Individuals > 150 mm are well outside of the fork length range of subyearling outmigrants and were labeled as yearlings in the field (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 | --- | March 1 – July 30 | ≤ 45 mm |
| Parr | Subyearling | March 1 – July 30 | 46 – 89 mm |
| Transitional, Smolt | Yearling | March 1 – July 30 | ≥ 90 mm |

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 | --- | March 1 – July 30 | ≤ 45 |
| Parr | Subyearling | March 1 – July 30 | 46 – 75 |
| Parr | Yearling (+) | March 1 – July 30 | 75 – 299 |
| Transitional, Smolt | Yearling (+) | March 1 – July 30 | 90 – 299 |
| Adult (Resident RBT) | Adult | March 1 – June 30 | 300 – 499 |
| Adult (STLH kelt) | Adult | March 1 – June 30 | > 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 | --- | March 1 – June 30 | ≤ 45 |
| Parr, Transitional, Smolt | Subyearling | March 1 – June 30 | 46 – 150 |
| Transitional, Smolt | Yearling (+) | March 1 – June 30 | > 150 |

## Trap Efficiency Trials

We used a single trap, mark-recapture study design stratified by week 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 we intended to estimate outmigrant abundance (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. Within the season, when wild fish numbers were low, we experimented with supplementing mark groups with hatchery origin fish. However, preliminary analyses suggested recapture rates differed when comparing wild and hatchery fish. Therefore, hatchery fish were ultimately not included in our calculation to estimate abundance of natural origin fish. For

Chinook, trap efficiency trials were conducted with transitional and smolt life stages because these were the life stages for which we intended to generate an abundance estimate. We did not conduct efficiency trials on Chinook fry outmigrants. In 2019, we did not operate the trap for the full duration of the early or late- timed outmigration; therefore, no abundance estimate was generated for Chinook fry or Chinook transitional and smolt life stages. 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 we 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. Our goal was to mark a maximum of 100 fish per species per day and 500 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 | Note |
|---|---|---|---|---|
| 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 (Figure 1, Table 7).

Mark types and rotation schedules allowed fish data to be organized by week for the purpose of analysis. This was irrelevant for steelhead, however, which 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. Warming stream temperatures after June 3 necessitated major changes with our trapping operation including ceasing all our efficiency trials. Prior to June 3, coho, steelhead, and Chinook efficiency trials were conducted over the entirety of the trapping season with minimal exceptions.

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

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

## Analysis

We used the Bayesian Time-Stratified Population Analysis System (BTSPAS, Bonner and Schwarz 2014) to estimate abundance of coho, steelhead, and Chinook (Table 6). The BTSPAS method uses Bayesian P-splines and hierarchical modeling of trap efficiencies, which allow for estimation during missed trapping days and for time strata with minimal efficiency data (Bonner and Schwarz et al. 2011). Data input for analysis were organized by week and included 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.

We used the diagonal version of the BTSPAS model that assumed all marks were recaptured during the time strata period (i.e., week) in which they were released. This assumption was met by the collected data. Prior to analysis, we removed any marks for which the trap did not continuously fish for 48 hours after release because these marks were not available for recapture. The BTSPAS analysis was executed in R v.3.4.1 (R Core Team, 2017) using the package BTSPAS (Bonner and Schwarz 2014).

# Results

## Summary of Fish Species Encountered

We encountered a diverse assemblage of fish species throughout the 2019 trapping season. Native fish included juvenile coho and Chinook salmon, steelhead, and cutthroat and rainbow trout, mountain whitefish (*Prosopium williamsoni*), redside shiner (*Richardsonius balteatus*), dace species (*Rhinichthys* spp.), largescale sucker (*Catostomus macrocheilus*), three-spine stickleback (*Gasterosteus aculeatus*), peamouth chub (*Mylocheilus caurinus*), northern pikeminnow (*Ptychocheilus oregonensis*), Pacific lamprey (*Entosphenus tridentatus*), and sculpin species (Cottidae). Non-native fish included American shad (*Alosa sapidissima*), bluegill (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), rock bass (*Ambloplites rupestris*), and other unidentified sunfish species (Centrarchidae).

## Trap operation

We operated the trap from March 27, 2019 to June 16, 2019. We had 24 occurrences of trap outages (Appendix B). For all occasions, the outage time was known exactly because the trap stopped fishing when staff intentionally lifted the cone during periods of high flows, warm water temperatures, and heavy debris loads. Individual outages were less than 24 hours except for a high flow event on April 12$^{th}$, which resulted in a 3-day outage in trap operation. During the first trapping period in June, river conditions exceeded our staff's capacity to continue trapping operations according to protocol (e.g., 24-hr operation). The trap outages resulted from a combination of warm stream temperatures and heavy algal growth that accumulated in the cone and live box. For the remainder of the trapping period, trapping time was limited to when crews were physically present on the trap, during the coolest water temperatures of the day, and fish were sampled as they entered the live box.

## Assumptions for Mark-Recapture Estimates

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 random representative sample (i.e., marked and unmarked fish are completely mixed), and 6) mark status is reported correctly.

Assumption 1 is technically violated because all fish are emigrating. However, we adjusted the approach to assume that the entirety of the population passed the trap during the period of trap operation. Therefore, to meet assumption 1, we trapped over the entire outmigration for coho and steelhead, minimized predation by checking the trap box multiple times per day, and statistically adjusted for missed trapping days.

To meet assumption 2, we followed standardized marking and tagging protocols with known mortality and estimated mark retention by holding a subsample of fish for 24 hours after marking. Results indicated that mark retention was high. Estimated mark retention was 100% (CWT, 43 out of 43 marked) for coho and 100% (PIT, 13 out of 13 marked) for steelhead.

To meet assumption 3, we used standard procedures for marking, marked healthy fish only, and held a subsample of marked fish overnight to assess mark related mortality. Results indicated that mark-related mortality was low. Estimated survival was 100% (CWT, 43 out of 43 marked) for coho and 100% for steelhead (PIT tags, 13 out of 13 tagged) over the 24-hour holding period.

To meet assumption 4, we stratified data by week to minimize heterogeneity in initial capture probabilities over time. Temporal variability in capture probability was expected due to environmental conditions, such as flows or turbidity that changed substantially between the beginning of trap operation in March and the end of trap operation in June. We also tested for differences in initial capture probabilities due to body size using a Kolmogorov–Smirnov test. The fork length of maiden captures versus recaptures did not differ for coho ($D = 0.097$, $p = 0.97$), steelhead ($D = 0.093$, $p = 0.626$), or Chinook ($D = 0.1785$, $p = 0.3146$) for most periods. However, a significant difference was found during periods 8 through 10 in our coho ($D = 0.31$, $p = 5.6596\text{-}10$). For coho during these periods, maiden captures were smaller than recaptures.

To meet assumption 5, we released fish in an upstream location that was 4.5 km (2.8 miles) upstream from the trap location with multiple bends and complex habitat (e.g., wood, split channels) between the release location and the smolt trap where marked fish were recaptured.

To meet assumption 6, we attempted to minimize error through staff training and careful examination of every fish. Two samplers inspected every fish and agreed on mark status designations. All coho were scanned for CWT and visually inspected for caudal clips. All steelhead were scanned for PIT tags and visually inspected for PIT scars. All Chinook were visually inspected for caudal clips.

### Coho

The coho outmigrant estimate included yearlings with both transitional and smolt life stages. Of these life stages, over 99% of outmigrants observed were classified as the "smolt" phenotype as compared to transitional. Coho outmigrants were observed in low numbers the first week of trapping (March 27$^{th}$, trapping period 1), peaked in late April and early May, and trailed off the first week of June (trapping period 11, Figure 3, Appendix C).

Scale age data indicated the subyearling component of the outmigration started sometime near the middle of May, and that prior to this date all outmigrants were one year of age (Figure 4, Table 8, Table 9, Table 10).

A total of 28,878 coho outmigrants were captured throughout the season (Appendix C). A total of 3,116 coho were marked and 261 were recaptured. Modeled weekly trap efficiencies ranged from 1.6 to 11.9%.

Abundance of wild coho outmigrants was estimated to be 363,214 ± 31,169 (SD) with a CV of 8.5%.

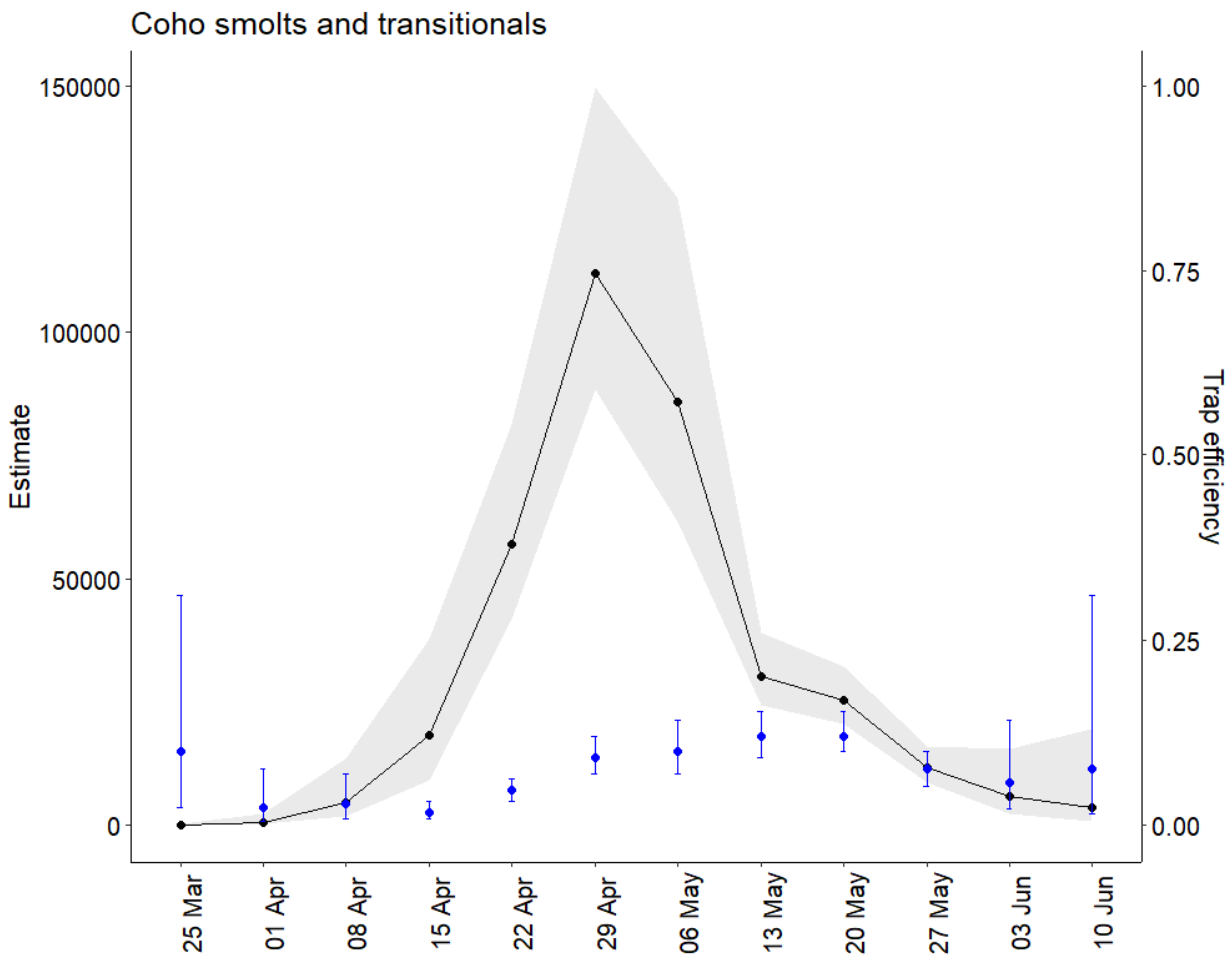



Figure 3. Migration timing of wild coho outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2019. Data are abundance (black line) and trap efficiency (blue dots) with 95% confidence intervals (shading for abundance, bars for efficiency) by week. Data provided in Appendix C.

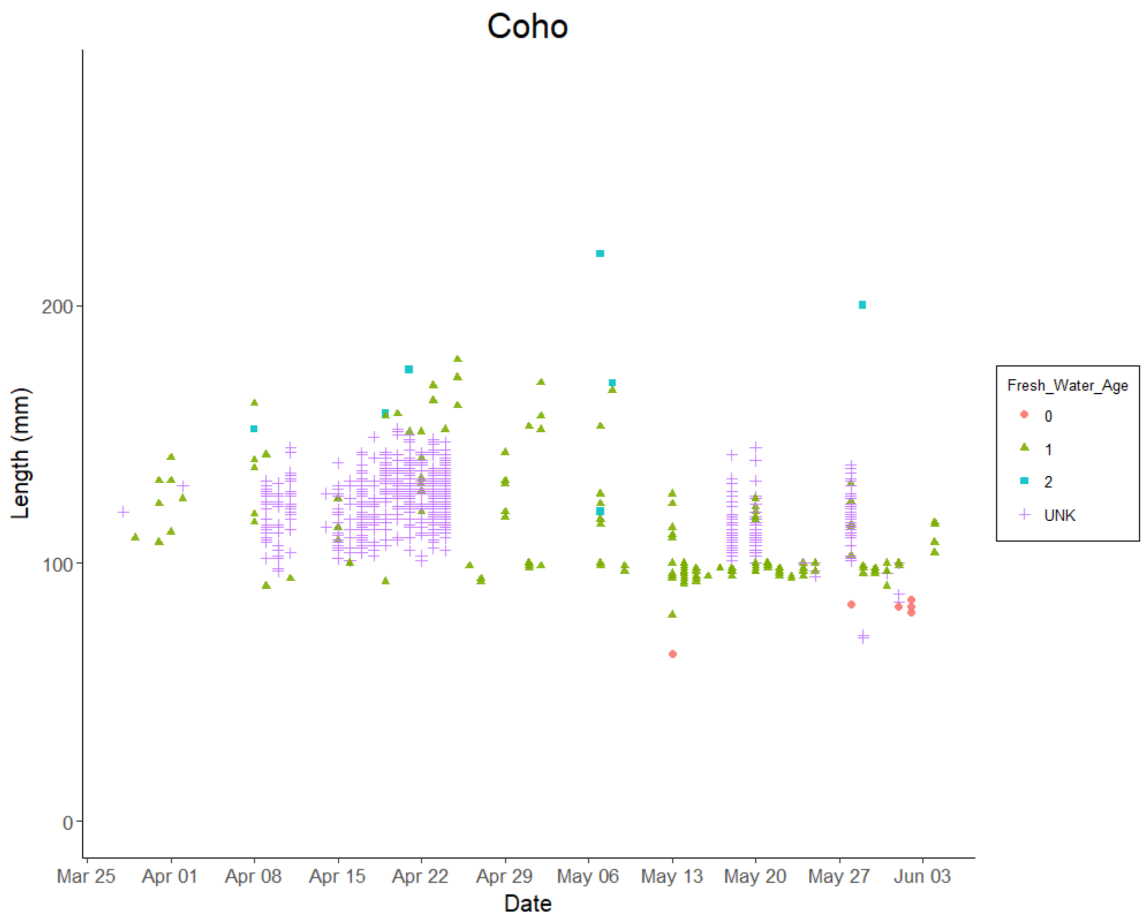



Figure 4. Plot of date-length-age data from wild coho outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2019.

Table 8. Freshwater ages of wild coho outmigrants < 100 mm (transitionals, smolts) at the Chehalis River screw trap, 2019. Data are scale ages of sampled juveniles by week.

| Period | Start Date | End Date | No. Scales | Age-0 | Age-1 | Age-2 | Not Determined |
|---|---|---|---|---|---|---|---|
| 1 | 3/25 | 3/31 | 0 | 0 | 0 | 0 | 0 |
| 2 | 4/01 | 4/07 | 0 | 0 | 0 | 0 | 0 |
| 3 | 4/08 | 4/14 | 2 | 0 | 2 | 0 | 0 |
| 4 | 4/15 | 4/21 | 2 | 0 | 2 | 0 | 0 |
| 5 | 4/22 | 4/28 | 3 | 0 | 3 | 0 | 0 |
| 6 | 4/29 | 5/05 | 3 | 0 | 3 | 0 | 0 |
| 7 | 5/06 | 5/12 | 3 | 0 | 3 | 0 | 0 |
| 8 | 5/13 | 5/19 | 36 | 1 | 35 | 0 | 0 |
| 9 | 5/20 | 5/26 | 20 | 0 | 18 | 0 | 2 |
| 10 | 5/27 | 6/02 | 20 | 5 | 12 | 0 | 3 |
| 11 | 6/03 | 6/09 | 0 | 0 | 0 | 0 | 0 |
| 12 | 6/10 | 6/16 | 0 | 0 | 0 | 0 | 0 |

Table 9. Freshwater ages of wild coho outmigrants 100 – 149 mm (transitionals, smolts) at the Chehalis River screw trap, 2019. Data are scale ages of sampled juveniles by week.

| Period | Start Date | End Date | No. Scales | Age-0 | Age-1 | Age-2 | Not Determined |
|---|---|---|---|---|---|---|---|
| 1 | 3/25 | 3/31 | 4 | 0 | 4 | 0 | 0 |
| 2 | 4/01 | 4/07 | 4 | 0 | 4 | 0 | 0 |
| 3 | 4/08 | 4/14 | 5 | 0 | 5 | 0 | 0 |
| 4 | 4/15 | 4/21 | 7 | 0 | 7 | 0 | 0 |
| 5 | 4/22 | 4/28 | 5 | 0 | 5 | 0 | 0 |
| 6 | 4/29 | 5/05 | 7 | 0 | 7 | 0 | 0 |
| 7 | 5/06 | 5/12 | 6 | 0 | 6 | 0 | 0 |
| 8 | 5/13 | 5/19 | 8 | 0 | 8 | 0 | 0 |
| 9 | 5/20 | 5/26 | 12 | 0 | 10 | 0 | 2 |
| 10 | 5/27 | 6/02 | 7 | 0 | 7 | 0 | 0 |
| 11 | 6/03 | 6/09 | 5 | 0 | 5 | 0 | 0 |
| 12 | 6/10 | 6/16 | 0 | 0 | 0 | 0 | 0 |

Table 10. Freshwater ages of wild coho outmigrants ≥ 150 mm (transitionals, smolts) at the Chehalis River screw trap, 2019. Data are scale ages of sampled juveniles by week.

| Period | Start Date | End Date | No. Scales | Age-0 | Age-1 | Age-2 | Not Determined |
|---|---|---|---|---|---|---|---|
| 1 | 3/25 | 3/31 | 0 | 0 | 0 | 0 | 0 |
| 2 | 4/01 | 4/07 | 0 | 0 | 0 | 0 | 0 |
| 3 | 4/08 | 4/14 | 2 | 0 | 1 | 1 | 0 |
| 4 | 4/15 | 4/21 | 5 | 0 | 3 | 2 | 0 |
| 5 | 4/22 | 4/28 | 7 | 0 | 7 | 0 | 0 |
| 6 | 4/29 | 5/05 | 4 | 0 | 4 | 0 | 0 |
| 7 | 5/06 | 5/12 | 4 | 0 | 2 | 2 | 0 |
| 8 | 5/13 | 5/19 | 0 | 0 | 0 | 0 | 0 |
| 9 | 5/20 | 5/26 | 0 | 0 | 0 | 0 | 0 |
| 10 | 5/27 | 6/02 | 1 | 0 | 0 | 1 | 0 |
| 11 | 6/03 | 6/09 | 0 | 0 | 0 | 0 | 0 |
| 12 | 6/10 | 6/16 | 0 | 0 | 0 | 0 | 0 |

## Steelhead

The steelhead outmigrant estimate included both transitional and smolt life stages. Of these life stages over 99% of outmigrants observed were classified as the "smolt" phenotype as compared to transitional. Steelhead outmigrant numbers were low during the first week of trapping March 27$^{th}$ (trapping period 1), peaked around late April, and were last observed the week of May 27$^{th}$ (trapping period 10, Figure 5, Appendix D).

Scale age data indicated that the sampled steelhead were one, two, and three years of age (Figure 6, Table 11). Fork length averaged 157.4 mm (± 11.9 mm SD) for one-year olds, 184.8 mm (± 26.9 mm SD) for two-year olds, and 245.4 mm (± 61.6 mm SD) for three-year olds.

A total of 1,570 steelhead outmigrants were captured throughout the season (Appendix D). A total of 1,016 steelhead were marked and 75 were recaptured. Modeled weekly trap efficiencies ranged from 3.2 to 21.4%.

Abundance of wild steelhead outmigrants was estimated to be 29,024 ± 5,343 (SD) with a CV of 18.4%.

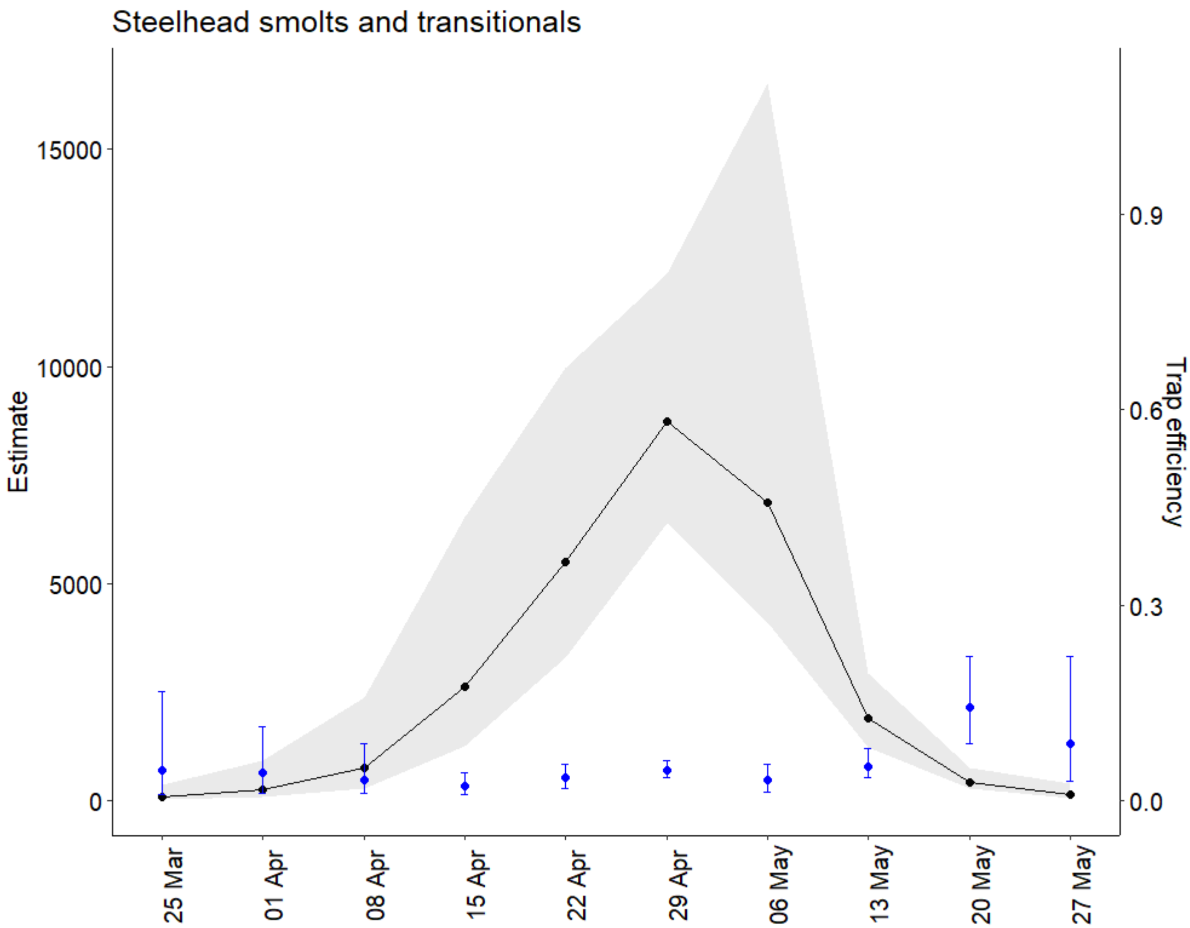



Figure 5. Migration of wild steelhead outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2019. Data are abundance (black line) and trap efficiency (blue dots) with 95% confidence intervals (shading for abundance, bars for efficiency) by week. Data provided in Appendix D.

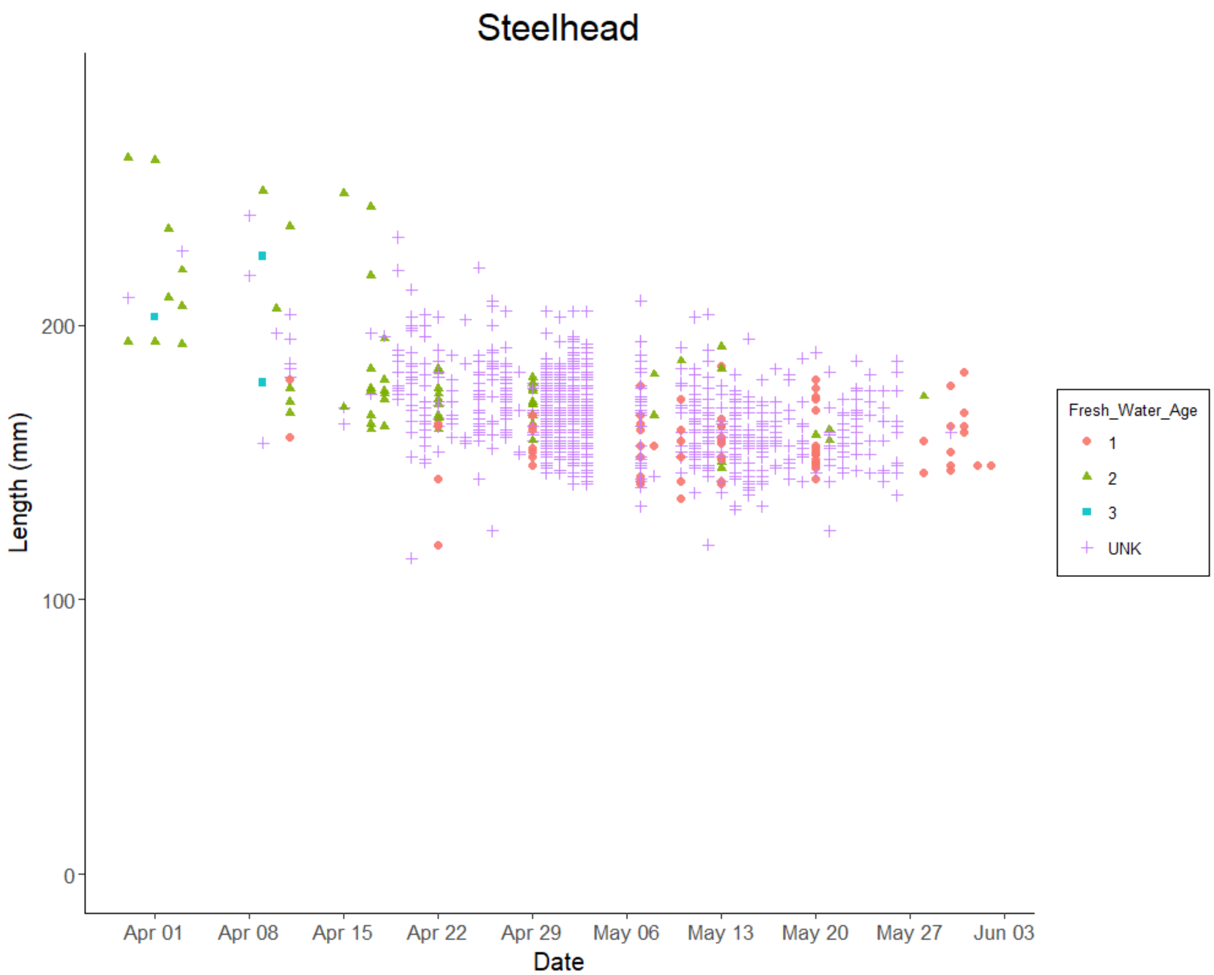



Figure 6. Plot of date-length-age data from wild steelhead outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2019.

Table 11. Freshwater ages of wild steelhead outmigrants (transitionals, smolts) at the Chehalis River screw trap, 2019. Data are scale ages of sampled juveniles by week.

| Period | Start Date | End Date | No. Scales | Age-1 | Age-2 | Age-3 | Not Determined |
|---|---|---|---|---|---|---|---|
| 1 | 3/25 | 3/31 | 3 | | 2 | | 1 |
| 2 | 4/01 | 4/07 | 13 | | 7 | 2 | 4 |
| 3 | 4/08 | 4/14 | 16 | 2 | 6 | 2 | 6 |
| 4 | 4/15 | 4/21 | 20 | | 16 | | 4 |
| 5 | 4/22 | 4/28 | 20 | 4 | 10 | | 6 |
| 6 | 4/29 | 5/05 | 20 | 7 | 10 | | 3 |
| 7 | 5/06 | 5/12 | 22 | 16 | 3 | | 3 |
| 8 | 5/13 | 5/19 | 19 | 11 | 4 | | 4 |
| 9 | 5/20 | 5/26 | 20 | 16 | 3 | | 1 |
| 10 | 5/27 | 6/02 | 15 | 13 | 1 | | 1 |
| 11 | 6/03 | 6/09 | 0 | | | | |
| 12 | 6/10 | 6/16 | 0 | | | | |

## Chinook

Our goal was to generate a precise and unbiased estimate of the Chinook ‘subyearling’ life history outmigration that included transitionals and smolts. However, due to environmental conditions described in the “*Trap Operation”* section above, we violated Assumption 1 of trapping over the entirety of the outmigration. During trapping operations, Chinook outmigrants were observed in low numbers the first week of trapping (March 27$^{th}$, trapping period 1), and consistently increased through the first week of June when we had to alter our trapping procedures to account for environmental conditions (Appendix E). These observations suggest that we did not capture the entirety of the outmigration. Therefore, we were not able to generate a precise and unbiased Chinook estimate of abundance in 2019.

Scale age data were not collected from Chinook in 2019 (Figure 7) as all fish > 45 mm were assumed to be subyearlings. Of these subyearlings, Chinook fork lengths ranged from 45 – 99 mm throughout the season. Fork lengths of Chinook subyearlings increased steadily throughout the season with an average of 50.5 mm (± 2.61 mm SD) and 74.3 mm (± 8.28 mm SD) in the first and last full week of trapping, respectively (Figure 7).

In 2019, a total of 92,738 Chinook subyearling outmigrants were captured, 3,250 Chinook were marked, but only 226 were recaptured (Appendix E; Periods 1 – 12). Modeled weekly trap efficiencies ranged from 2.4 to 13.0%.

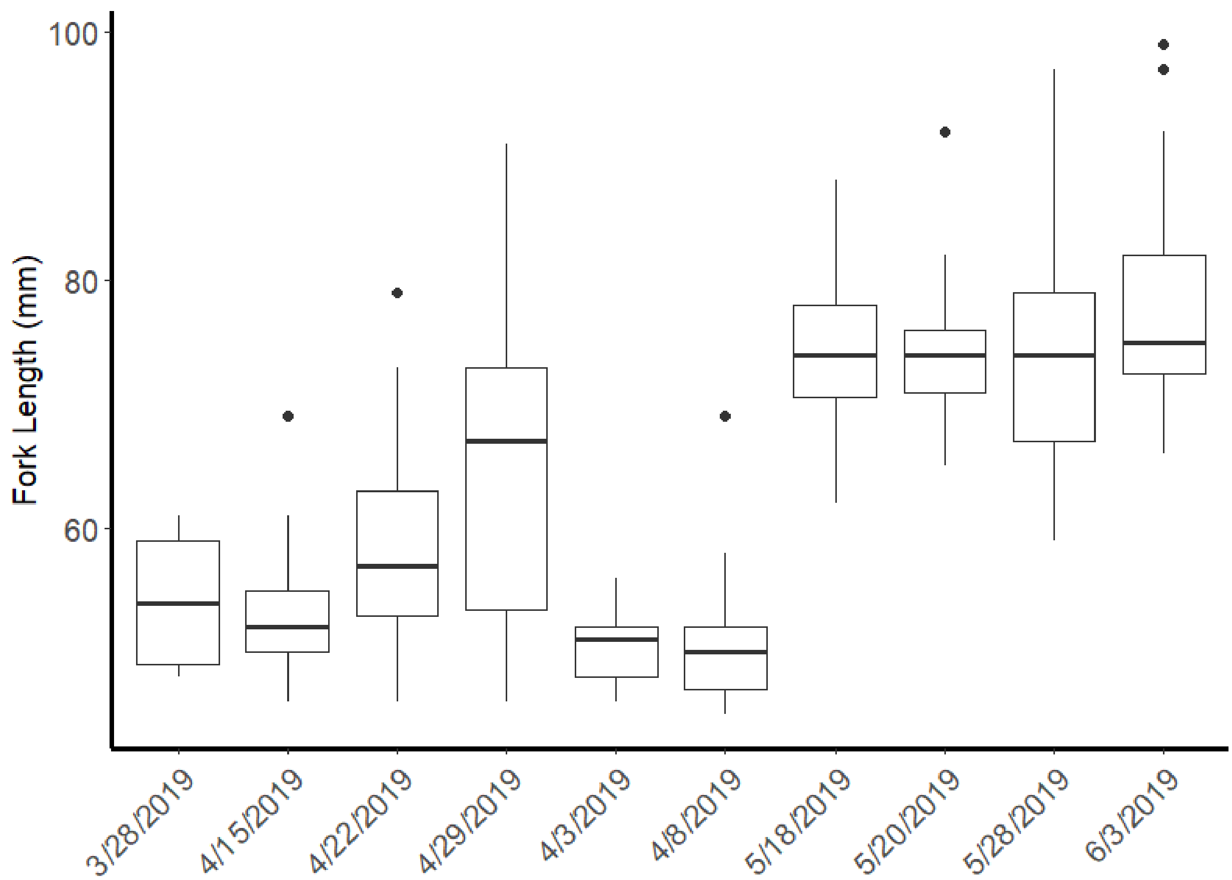



Figure 7. Box plots of fork lengths of wild Chinook outmigrants (transitionals, smolts) by week at the Chehalis River screw trap, 2019. Box's represent the median, first and third quartiles, whiskers represent the interquartile ranges, and dots represent outliers.

# Discussion

## Basin-wide Context

The abundance estimates provided in this report represent juvenile salmonids that completed their freshwater rearing in habitats upstream of the trap location, specifically the production from upstream of river kilometer 84. 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, juveniles that emerge from the gravel upstream of the trap location but redistribute to areas downstream of the trap location during their freshwater rearing period, are also not included in the estimate. This caveat is especially true for coho salmon known to redistribute in a downstream direction during the fall months in search of suitable overwintering habitat.

Annual freshwater production of wild coho smolts in the entirety of the Chehalis River has averaged 2 million (0.5 to 3.7 million) since WDFW began monitoring smolt production in the 1980s (Kendall et al. 2019). Our estimate of 363,214 coho outmigrants from habitat upstream of river kilometer 84 indicates that a relatively small proportion of all wild coho in the Chehalis River watershed complete their freshwater rearing in the upper Chehalis, South Fork Chehalis, Newaukum, Skoookumchuck, and other small tributaries upstream of the trap site. Conversely, a large proportion of wild coho appear to complete their freshwater rearing in the main stem and tributaries downstream of the trap location. 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 Hoquaim rivers, and minor tributaries including Porter and Cloquallum Creek. Our estimate of wild coho production in 2019 is comparable to estimates produced in 2017 and 2018 (Figure 8). Additionally, precision of our estimate has increased compared to our first year of producing an estimate (Figure 8). Finally, our estimates of wild coho production above the trap site from 2017 to 2019 are consistent with WDFW monitoring results from the 1990s that also estimated 300,000 to 400,000 wild coho smolts were produced upstream of the mainstem smolt trap (Seiler et al. 1997).

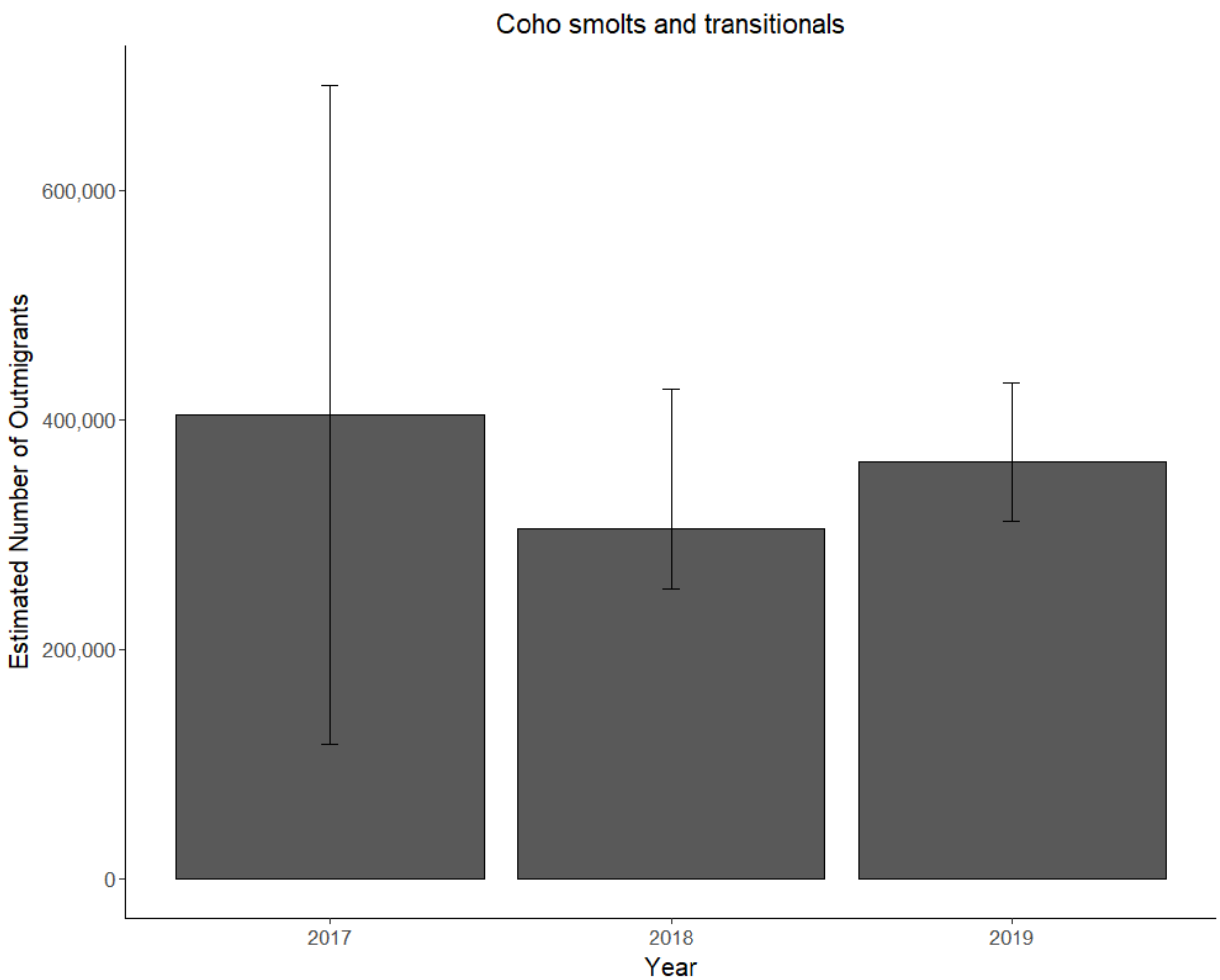



Figure 8. Annual time series of outmigrant abundance with 95% confidence intervals for wild coho smolts and transitionals produced above the Chehalis River smolt trap, 2017-2019.

This report provides the second reportable estimate of wild steelhead production from the Chehalis River basin upstream of river kilometer 84. Our estimate of 29,024 steelhead outmigrants from the estimated 566 river km upstream of the trap (Statewide Integrated Fish Distribution, SWIFD, https://geo.nwifc.org/swifd/) corresponds to 51 wild steelhead smolts per km, which is slightly lower compared to our 2018 estimate of 32,058 steelhead outmigrants which corresponds to 57 smolts per km. This smolt density is low compared to other western Washington watersheds where steelhead smolt estimates are available, such as the Coweeman River (average 243 smolts per km) or the Wind River (average 240 smolts per km) (T. Buehrens, WDFW personal communication). The reasons for these differences are not yet apparent and may reflect the difference between available stream miles 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 are geomorphic characteristics typically associated with high quality steelhead spawning and rearing habitat in the Pacific Northwest (Gibbons et al. 1985). Of note, a recent study (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 spawning area. Over five years of monitoring, surveyors estimated 600 to 1,000 redds (900 to

1,800 steelhead spawners) in this area of the basin. Although steelhead outmigrant estimates are not available from the Upper Chehalis sub-basin, this area has high gradient, coarse substrate habitat typically associated with rearing of juvenile steelhead. 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 (J. Winkowski, WDFW unpublished data).

We were not able to generate a Chinook subyearling outmigrant estimate for 2019 due to violating the assumption of trapping over the entire outmigration. In 2018, 83.5% of the subyearling Chinook outmigration was captured in the same time frame we trapped in 2019. Thus, we may not have missed a large proportion of the outmigration in 2019, however we do not have additional years of data to support this.

Generating a ‘subyearling’ estimate is relevant to habitat restoration planning because the ‘subyearling’ component of the outmigration represents the numbers of juveniles that are supported by freshwater habitats upstream of the trap site. 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 have concluded that estimates of this life history 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). Extending this density-dependent migration hypothesis to the Chehalis River will require additional years of juvenile monitoring coupled with adult Chinook spawner data above the trap location.

## Next Steps

The main stem Chehalis River estimates presented here provide critical information for salmon and steelhead smolt production in the basin but trapping in this location presents many challenges. In 2019, these challenges included high flows, warm stream temperatures, filamentous algae, and adult pikeminnow predation. Additional description of these issues and our approaches to address them are described below. This season was our second year attempting a Chinook subyearling outmigration estimate (e.g., fishing through July), which is longer than the historical trapping seasons (e.g., typically April-May from 1999-2015), and we experienced similar issues to those faced in 2018. Stream temperature concerns are prevalent later in the season at this location in the Chehalis River. For example, maximum daily temperatures during May and June peaked at 21.0℃ and 25.2℃, respectively, which was concurrent with increasing Chinook catch and a reduction of one crew member (Figure 9). Similar to 2018, large algae aggregations were a serious issue, completely plugging the cone and live box (Figure 10). Algae issues were unpredictable and several times resulted in relatively high juvenile Chinook mortality. Issues with algae led to limiting fishing periods to when crew were present on the trap. As limited operations continued, we evaluated the situation and concluded that the best course of action would be to cease trapping before the Chinook subyearling outmigration was complete, and therefore we were unable to produce an abundance estimate. Protocols followed in 2018 and 2019 (e.g., 24-hr fishing later in the season) are proving to be extremely challenging considering environmental conditions (e.g., temperature) and limited resource allocations for this project (e.g., staffing). For these reasons, we will be re-evaluating methods and considering alternatives, such as sub-sampling, for generating an estimate for subyearling Chinook abundance in the future.

Adult northern pikeminnow and other piscivorous fish (e.g., smallmouth bass) are problematic surrounding the smolt trap. Common observations include predatory fish striking the surface shortly after releasing captured salmon downstream of the trap, congregations of predatory fish near the upstream release site, and regurgitated smolts and engorged predators in the live box. We constructed and installed a volitional release chamber under the deck of our screw trap in an attempt to allow sampled fish time to acclimate to the river prior to release. We instructed the crews to monitor the live box for adult northern pikeminnow. However, we caught fewer adult pikeminnow in 2019 (59 adults) compared to 2018 (439 adults). This large difference in adult pikeminnow catch may be attributed in part to differing trap positions between years. For part of 2018, we fished multiple trap positions including one with slower water velocity. This trap position may have facilitated entry into the trap by pikeminnow, which would reflect relatively high capture numbers in 2018. In 2019, we continuously fished one position with relatively high water velocity. Although we cannot directly measure predation on our mark groups released upstream, we could compare capture efficiencies between our current upstream release location and release location in closer proximity to the trap site. We will discuss feasibility for paired releases for 2020.

In summary, 2019 represents the second year for which wild Chinook and steelhead outmigrations have been described from the Chehalis River and the third time in two decades that wild coho outmigration has been specifically evaluated from the upper portion (upstream of the Black River) of the basin. In addition to abundance, we have described the timing, age structure, and size of the outmigrants as these are characteristics that 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 Chehalis Basin Strategy Aquatic Species Restoration Plan (http://chehalisbasinstrategy.com/), 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 Chehalis River.

Table 12. Mean of daily stream temperatures (°C) by month recorded at Chehalis River smolt trap near river km 84, 2019.

| Month | Mean (°C) |
|---|---|
| March | 7.3 |
| April | 11.3 |
| May | 16.6 |
| June | 16.8 |
| July | 20.2 |

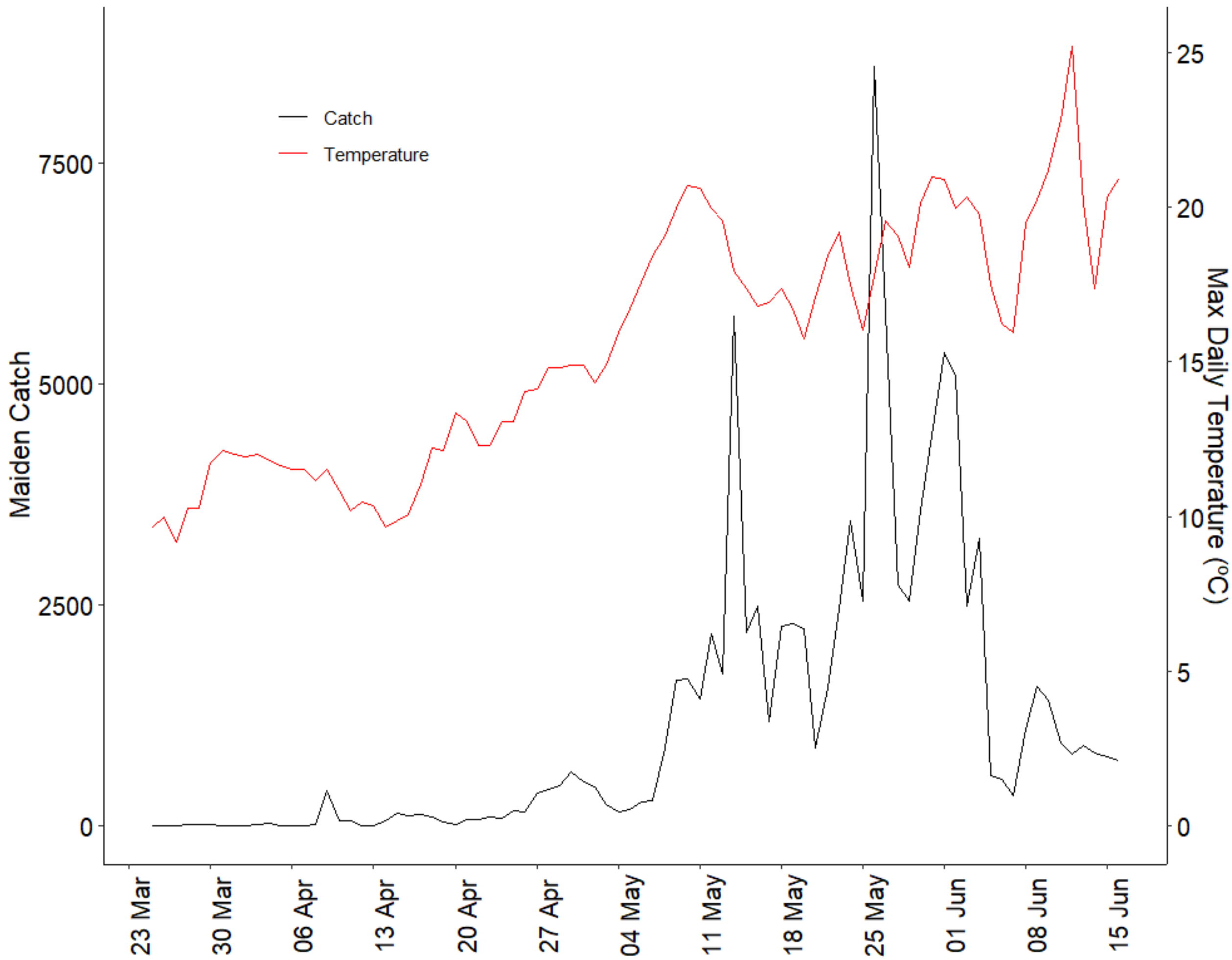



Figure 9. Chinook maiden catch and maximum daily stream temperature (°C) at the Chehalis River smolt trap, 2019.

Figure 10. Filamentous algae collected in a single day of operations at the Chehalis River screw trap, June 2018.

# References

Anderson, J. H., and P. C. Topping. 2018. Juvenile life history diversity and freshwater productivity of Chinook Salmon in the Green River, Washington. North America Journal of Fisheries Management **38**:180-193.

Ashcraft, S., C. Holt, M. Scharpf, M. Zimmerman, and N. VanBuskirk. 2017. Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2013-2017, FPT 17-12. Washington Department of Fish and Wildlife, Olympia, Washington, https://wdfw.wa.gov/publications/01970/.

Beamer, E. M., A. McBride, C. M. Greene, R. Henderson, G. M. Hood, K. Wolf, K. Larsen, C. Rice, and K. L. Fresh. 2005. Skagit River Chinook Recovery Plan. Appendix D. Delta and nearshore restoration for the recovery of wild Skagit River Chinook salmon: Linking estuary restoration to wild Chinook salmon populations., http://www.skagitcoop.org/index.php/documents/.

Bonner, S.J. and Schwarz, C.J., 2011. Smoothing population size estimates for time-stratified mark–recapture experiments using Bayesian P-splines. *Biometrics*, *67*(4), pp.1498-1507.

Bonner, S.J. and Schwarz, C.J., 2014. BTSPAS: Bayesian Time Stratified Petersen Analysis System. *R package version*.

Burnett, K. M., G. H. Reeves, D. J. Miller, S. Clarke, K. Vance-Borland, K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. *Ecological Applications* 17(1): 66-80.

Campbell, L. A., A. M. Claiborne, S. Ashcraft, M. S. Zimmerman, and C. Holt. 2017. Final Report: Investigating Juvenile Life History and Maternal Run Timing of Chehalis River Spring and Fall Chinook Salmon Using Otolith Chemistry, FPT 17-15. Washington Department of Fish and Wildlife, Olympia, Washington, https://wdfw.wa.gov/publications/01985/.

Chehalis Basin Strategy. 2020. http://chehalisbasinstrategy.com/

Gibbons, R. G., P. K. J. Hahn, and T. H. Johnson. 1985. Determining MSH steelhead spawning escapement requirements, Report 85-11. Washington State Game Department, Olympia, WA.

Greene, C. M., D. W. Jensen, G. R. Pess, E. A. Steel, and E. Beamer. 2005. Effects of environmental conditions during stream, estuary, and ocean residency on Chinook salmon return rates in the Skagit River, Washington. Transactions of the American Fisheries Society **134**:1562-1581.

Groot, C. and Margolis, L. eds., 1991. *Pacific salmon life histories*. UBC press.

Kendall, N. W., D. Rawding, and J. Weinheimer 2019. 2019 wild coho forecasts for Puget Sound, Washington Coast, and Lower Columbia., Washington Department of Fish and Wildlife, Olympia, Washington FPA 02038. https://wdfw.wa.gov/publications/02038/.

Kiyohara, K., and M. S. Zimmerman. 2012. Evaluation of juvenile salmon production in 2011 from the Cedar River and Bear Creek, FPA 12-01. Washington Department of Fish and Wildlife, Olympia, Washington, https://wdfw.wa.gov/publications/01380/.

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ronne, L., N. Vanbuskirk, C. Holt, and M. Zimmerman. 2018. Spawner Abundance and Distribution of Salmon and Steelhead in the Upper Chehalis River, 2017-2018, FPT 18-09. Washington Department of Fish and Wildlife, Olympia, Washington, https://wdfw.wa.gov/publications/02034/.

Sandell, T., J. Fletcher, A. McAninch, and M. Wait. 2014. Grays Harbor Juvenile Fish Use Assessment: 2013 Annual Report. Wild Fish Conservancy, prepared for the Chehalis Basin Habitat Work Group, http://wildfishconservancy.org/projects/grays-harbor-juvenile-salmon-fish-community-study.

Seiler, D., P. Hanratty, S. Neuhauser, P. Topping, M. Ackley, and L.E. Kishimoto. 1997. Wild Salmon Production and Survival Evaluation. USFWS Sport Fish Restoration Contract F-112-R-5. State of Washington Department of Fish and Wildlife, Olympia, Washington. 98504-1091.

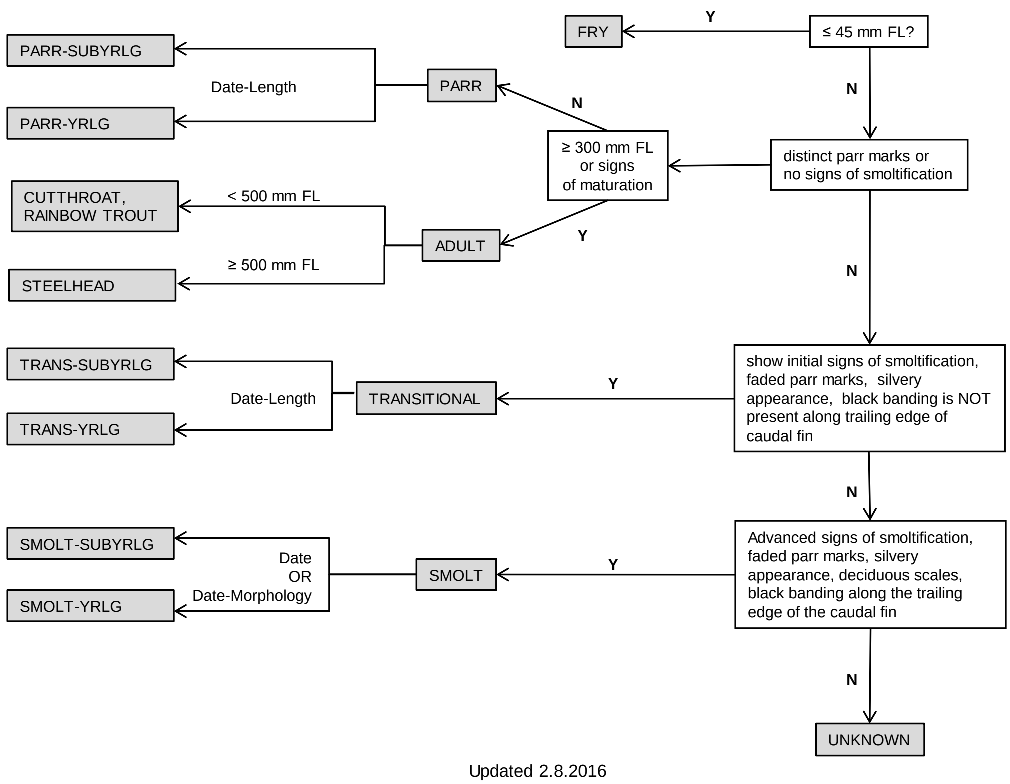
Volkhardt, G. C., S. L. Johnson, B. A. Miller, T. E. Nickelson, and D. E. Seiler. 2007. Rotary screw traps and inclined plane screen traps. Pages 235-266 *in* D. H. Johnson, B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O-Neil, and T. N. Pearsons, editors. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

Winkowski, J., and M. S. Zimmerman. 2018. Chehalis River Smolt Production, 2018. Washington Department of Fish and Wildlife, Olympia, Washington. FPA 19-01. https://wdfw.wa.gov/publications/02042/.

Zimmerman, M. S., C. Kinsel, E. Beamer, E. J. Connor, and D. E. Pflug. 2015. Abundance, survival, and life history strategies on juvenile migrant Chinook Salmon in the Skagit River, Washington. Transactions of the American Fisheries Society **144**:627-641.

# 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 2019. All missed trapping periods occurred by staff pulling the trap.

| Last Time Observed Fishing | Method to Determine Trap Not Fishing | Time Start Fishing again | Comments |
|---|---|---|---|
| 4/03/19 19:00 | Pulled trap | 4/04/19 7:45 | ~1600 one day. Other fish numbers were low didn't want to risk box overload in evening |
| 4/12/19 9:20 | Pulled trap | 4/15/19 8:30 | High flows and debris in river |
| 5/08/19 9:01 | Pulled trap | 5/08/19 18:18 | Algae issues |
| 5/27/19 10:38 | Pulled trap | 5/27/19 12:38 | Trap jammed with debris |
| 5/28/19 00 or 12am | Pulled trap | 5/28/19 6:00 | High algae issues |
| 6/05/19 9:04 | Pulled trap | 6/05/19 18:03 | High water temps and algae issues |
| 6/05/19 22:01 | Pulled trap | 6/06/19 5:00 | High water temps and algae issues |
| 6/06/19 9:01 | Pulled trap | 6/06/19 18:00 | High water temps and algae issues |
| 6/06/19 22:01 | Pulled trap | 6/07/19 5:05 | High water temps and algae issues |
| 6/07/19 8:56 | Pulled trap | 6/07/19 17:59 | High water temps and algae issues |
| 6/07/19 22:02 | Pulled trap | 6/08/19 5:00 | High water temps and algae issues |
| 6/08/19 9:01 | Pulled trap | 6/08/19 18:00 | High water temps and algae issues |
| 6/08/19 22:01 | Pulled trap | 6/09/19 4:59 | High water temps and algae issues |
| 6/09/19 9:01 | Pulled trap | 6/09/19 17:59 | High water temps and algae issues |
| 6/09/19 22:01 | Pulled trap | 6/10/19 4:59 | High water temps and algae issues |
| 6/10/19 9:01 | Pulled trap | 6/10/19 11:59 | High water temps and algae issues |
| 6/10/19 14:01 | Pulled trap | 6/10/19 17:59 | High water temps and algae issues |
| 6/10/19 22:01 | Pulled trap | 6/11/19 4:59 | High water temps and algae issues |
| 6/11/19 9:01 | Pulled trap | 6/11/19 12:00 | High water temps and algae issues |
| 6/11/19 14:01 | Pulled trap | 6/12/19 5:00 | High water temps and algae issues |
| 6/12/19 9:01 | Pulled trap | 6/13/19 5:00 | High water temps and algae issues |
| 6/13/19 9:00 | Pulled trap | 6/14/19 5:00 | High water temps and algae issues |
| 6/14/19 9:00 | Pulled trap | 6/15/19 5:00 | High water temps and algae issues |
| 6/15/19 9:00 | Pulled trap | 6/16/19 5:00 | High water temps and algae issues |

Appendix C. Mark-recapture data for wild coho outmigrants (transitionals, smolts) organized by time 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 time period (Prop Fished).

| Period | Start Date* | End Date* | Total Mark | Total Recap | Total Capture | Prop fished |
|---|---|---|---|---|---|---|
| 1 | 3/25 | 3/31 | 5 | 1 | 5 | 0.65 |
| 2 | 4/01 | 4/07 | 5 | 0 | 11 | 0.92 |
| 3 | 4/08 | 4/14 | 37 | 0 | 83 | 0.63 |
| 4 | 4/15 | 4/21 | 288 | 4 | 290 | 0.95 |
| 5 | 4/22 | 4/28 | 557 | 25 | 2621 | 1 |
| 6 | 4/29 | 5/05 | 545 | 46 | 10,139 | 1 |
| 7 | 5/06 | 5/12 | 203 | 19 | 7,878 | 0.94 |
| 8 | 5/13 | 5/19 | 503 | 66 | 3,609 | 1 |
| 9 | 5/20 | 5/26 | 500 | 63 | 3,187 | 1 |
| 10 | 5/27 | 6/02 | 473 | 35 | 805 | 0.95 |
| 11 | 6/03 | 6/09 | 0 | 2 | 188 | 0.55 |
| 12 | 6/10 | 6/16 | 0 | 0 | 62 | 0.22 |

*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. Mark-recapture data for wild steelhead outmigrants (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 |
|---|---|---|---|---|---|---|
| 1 | 3/25 | 3/31 | 3 | 0 | 3 | 0.65 |
| 2 | 4/01 | 4/07 | 4 | 0 | 14 | 0.92 |
| 3 | 4/08 | 4/14 | 6 | 1 | 22 | 0.63 |
| 4 | 4/15 | 4/21 | 73 | 1 | 77 | 0.95 |
| 5 | 4/22 | 4/28 | 147 | 7 | 277 | 1 |
| 6 | 4/29 | 5/05 | 467 | 31 | 615 | 1 |
| 7 | 5/06 | 5/12 | 94 | 1 | 309 | 0.94 |
| 8 | 5/13 | 5/19 | 148 | 14 | 148 | 1 |
| 9 | 5/20 | 5/26 | 62 | 18 | 89 | 1 |
| 10 | 5/27 | 6/02 | 12 | 2 | 16 | 0.95 |

*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. 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). No estimate was produced from data due to violating the assumption of trapping over the entirety of the outmigration.

| Period | Start Date* | End Date* | Total Mark | Total Recap | Total Capture | Prop fished |
|---|---|---|---|---|---|---|
| 1 | 3/25 | 3/31 | 3 | 0 | 5 | 0.65 |
| 2 | 4/01 | 4/07 | 0 | 0 | 22 | 0.92 |
| 3 | 4/08 | 4/14 | 100 | 7 | 559 | 0.63 |
| 4 | 4/15 | 4/21 | 496 | 14 | 560 | 0.95 |
| 5 | 4/22 | 4/28 | 545 | 17 | 1,339 | 1 |
| 6 | 4/29 | 5/05 | 506 | 37 | 2,525 | 1 |
| 7 | 5/06 | 5/12 | 200 | 10 | 8,289 | 0.94 |
| 8 | 5/13 | 5/19 | 500 | 66 | 17,864 | 1 |
| 9 | 5/20 | 5/26 | 500 | 24 | 21,698 | 1 |
| 10 | 5/27 | 6/02 | 400 | 51 | 23,683 | 0.95 |
| 11 | 6/03 | 6/09 | 0 | 0 | 9,969 | 0.55 |
| 12 | 6/10 | 6/16 | 0 | 0 | 6,225 | 0.22 |

*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.