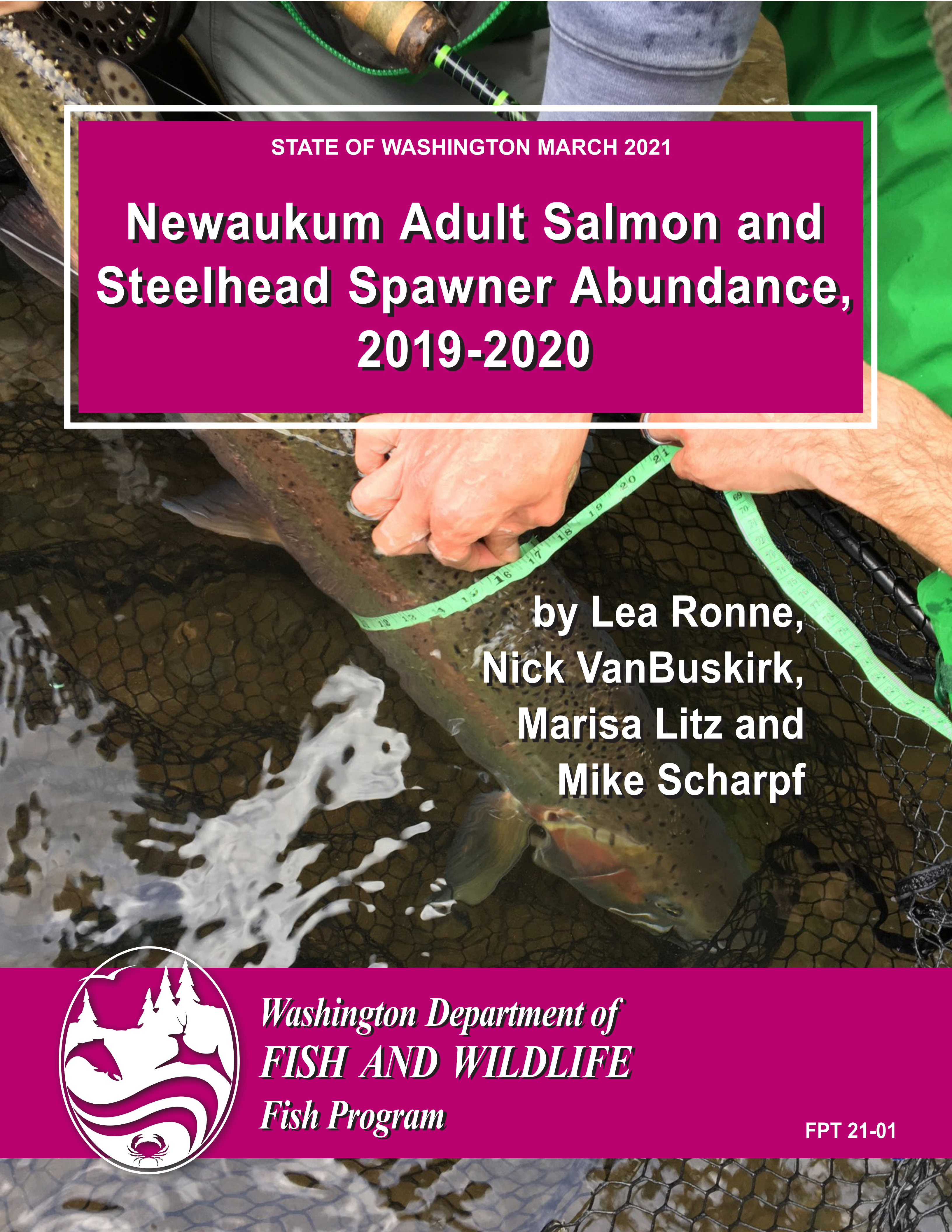

STATE OF WASHINGTON MARCH 2021

Newaukum Adult Salmon and Steelhead Spawner Abundance, 2019-2020

by Lea Ronne,
Nick VanBuskirk,
Marisa Litz and
Mike Scharpf

Washington Department of
FISH AND WILDLIFE
Fish Program

FPT 21-01

Newaukum Adult Salmon and Steelhead Spawner Abundance, 2019-2020

Lea Ronne[1], Nick VanBuskirk[1], Marisa Litz[2] and Mike Scharpf[1]

Author information:

[1]Washington Department of Fish and Wildlife Region 6 Fish Management, 48 Devonshire Road, Montesano, WA 98563

[2]Washington Department of Fish and Wildlife, Fish Science Division1111 Washington St SE, Olympia WA 98501

Acknowledgements

We would like to thank Curt Holt, with Washington Department of Fish and Wildlife (WDFW), for his assistance and helpful comments on this work, and our surveyors for collecting data and samples during the 2019/2020 field season: Keith Brady, Justin Miller-Nelson, Callie Miller, Oliver Crew, and Amy Edwards. Thanks to the Onalaska High School teacher Kevin Hoffman and his students Ethan Cameron and Landon Snodgrass for their help surveying Gheer Creek. Thanks to Kim Figlar-Barnes who helped with organization of data and biological samples. Scale ages were provided by WDFW Fish Ageing and Otolith Laboratory staff. We would also like to thank the small private landowners and Weyerhaeuser Corporation for allowing access to survey on their property. This work was funded by the Washington State Legislature and the Office of the Chehalis Basin.

Recommended citation: Ronne L., N. VanBuskirk, M. Litz and M. Scharpf. 2021. Newaukum Adult Salmon and Steelhead Spawner Abundance, 2019-2020, Washington Department of Fish and Wildlife, Olympia, Washington. FPT 21-01

Table of Contents

List of Tables

List of Figures

Executive Summary

The Newaukum River basin was selected as a “pilot watershed” in 2015 by Chehalis Lead Entity to help guide and monitor restoration projects in the Chehalis River basin and to determine how climate change may affect the salmonid populations in the basin (http://www.chehalisleadentity.org/our-work/). Both an adult and juvenile monitoring program have since been implemented in the basin, allowing for adult and juvenile in-stream production estimates. This report covers the first survey season (2019-2020) of intensive adult spawner monitoring in the Newaukum basin for spring and fall Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*), and steelhead trout (*O. mykiss*); hereafter referred to as Chinook, coho, and steelhead.

A census redd survey was conducted for all salmonids for the 2019-2020 season in the Newaukum basin (total escapement for Chinook and coho in the 2019 run year and steelhead escapement in run year 2020). However, due to the broad distribution of coho in small creeks and tributaries, we were unable to completely survey all spawning habitat in the first year. The majority of spawning habitat was surveyed, and either a supplemental survey or a redd mile^{-1} estimate was used to expand redds for un-surveyed spawning habitat to generate a total estimate. The unsampled tributaries included in the total estimate represent areas that were historically expanded for stock assessment estimates (C. Holt, WDFW, personal communication). Major findings for the 2019-2020 season were:

- Spring and fall Chinook overlapped in spawning both spatially and temporally, but there appeared to be some spatial and temporal separation based on densities of spring and fall Chinook in the upper South Fork Newaukum. Total spring and fall Chinook estimates for the 2019 run year were 175 and 858, respectively.
- Spring Chinook spawned throughout the main stem Newaukum River, suggesting some may move into the lower Newaukum from the Chehalis River just before spawning. Additional effort tracking spring Chinook holding patterns would be needed to confirm this hypothesis.
- Although fall Chinook spawned throughout the lower North and South Fork Newaukum River and main stem, there was a high density (12-24 redds mile^{-1}) of fall Chinook that spawned from Leonard Rd down to Jackson Hwy in the lower South Fork Newaukum.
- Coho was the most abundant salmonid species in the Newaukum basin in the 2019/2020 run year with 1,988 spawners estimated. Middle Fork Newaukum River and Kearney Creek had some of the highest densities of spawning coho and there was little spawning in the main stem.
- Steelhead was the second most abundant species in the basin with 1,103 spawners estimated. Steelhead were mostly distributed in the upper North and South Forks of the Newaukum River with very little spawning in the main stem and Middle Fork Newaukum. No spawning occurred downstream of the smolt trap.

On average (run years 2000 to 2019), the Newaukum River contributed between 18% and 45% of the Chehalis River spring Chinook population compared to the rest of the Chehalis River basin. However, the abundance of spring Chinook has been declining in the Newaukum and Chehalis rivers since 2000, and the Newaukum River’s contribution of spring Chinook to the overall population has also been declining. With long term monitoring of the Newaukum River, our program will generate a time series of species distribution, abundance, life history diversity, and other population-level metrics that will be valuable as restoration projects are implemented throughout the upper Chehalis Basin.

Introduction

In 2007 and 2009, large-scale flooding in the Chehalis River basin occurred, resulting in closures of parts of I-5, property damage, economic losses, and public health and safety risks. As a result, the Chehalis Basin Strategy was developed as a process to identify ways to protect communities and fish from flooding and restore habitat to support aquatic species (http://chehalisbasinstrategy.com/). The Newaukum sub-basin was selected in 2015 by the Lead Chehalis Entity as important and established as a "pilot watershed" for early projects to help guide restoration throughout the Chehalis River basin (http://www.chehalisleadentity.org/our-work/). An integrated program to monitor the amount of adult salmon returning to their freshwater spawning habitat and the amount of juvenile production occurring at the watershed scale (West et al. 2020) was determined to be the best way to evaluate salmon and steelhead response to changes in riverine habitat as a result of restoration actions and climate change. The Newaukum sub-basin was selected, in part, because it supports a spawning population of spring Chinook Salmon (*Oncorhynchus tshawytscha*) and has contributed anywhere from 18% to 45% (29% average from 2000-2019) of the total Chehalis River basin spring Chinook Salmon (Appendix A). There is growing concern about the status of this population in the Chehalis River basin, so restoration and other activities are being developed to help support the population, whose numbers have shown a downward trend over the last two decades.

Intensive monitoring of abundance, distribution, and run timing of adult salmonids for this study started in the Newaukum sub-basin in September 2019. Limited monitoring in the basin has occurred for decades to produce estimates used for management and stock assessment purposes. Spawning ground surveys (redd counts and live counts), along with carcass sampling, are the common methods used to assess abundance and biological characteristics of adult salmonid spawners and generate a value known as escapement (i.e., the amount of salmon not caught by commercial or recreational fisheries that return to their natal habitat, Johnson et al. 2007). Spring and fall Chinook Salmon (*O. tshawytscha*), Coho Salmon (*O. kisutch*), and winter-run steelhead trout (*O. mykiss*), hereafter referred to as Chinook, coho, and steelhead, were previously known to spawn in the Newaukum sub-basin and were the focus of this study. Other salmonids are either not currently found in the Newaukum (Chum Salmon *O. keta*, Pink Salmon *O. gorbuscha*, and Sockeye Salmon *O. nerka*) or were not a focal species (Cutthroat trout *O. clarkii* and resident rainbow trout). Surveys were conducted from September 2019 to June 2020 throughout the known distribution of each species and additional effort was made to document the upper limits of each species' spawning distribution. These surveys expanded upon the spatial coverage of long-term index reaches surveyed by the Washington Department of Fish and Wildlife (WDFW) for stock assessment purposes (Appendix B).

Objectives

The overall goal of this study was to describe the abundance, spawn timing, spatial distribution, and life history diversity of adult spring and fall Chinook, coho, and steelhead in the Newaukum River sub-basin during return years 2019/2020, and to determine the abundance of adult spawners above the juvenile smolt trap (Figure 1). In order to accomplish this goal, our objectives were to:

- Conduct weekly surveys by foot or boat (as conditions allowed) and collect information on redds, live fish, and carcasses;
- Conduct a peak survey on any potential spawning habitat not covered on a weekly basis;
- Supplement carcass surveys with hook and line sampling to collect biological samples;
- Calculate the abundance of each species above and below the smolt trap; and
- Summarize results related to timing, spatial distribution, and life history diversity of spawners.

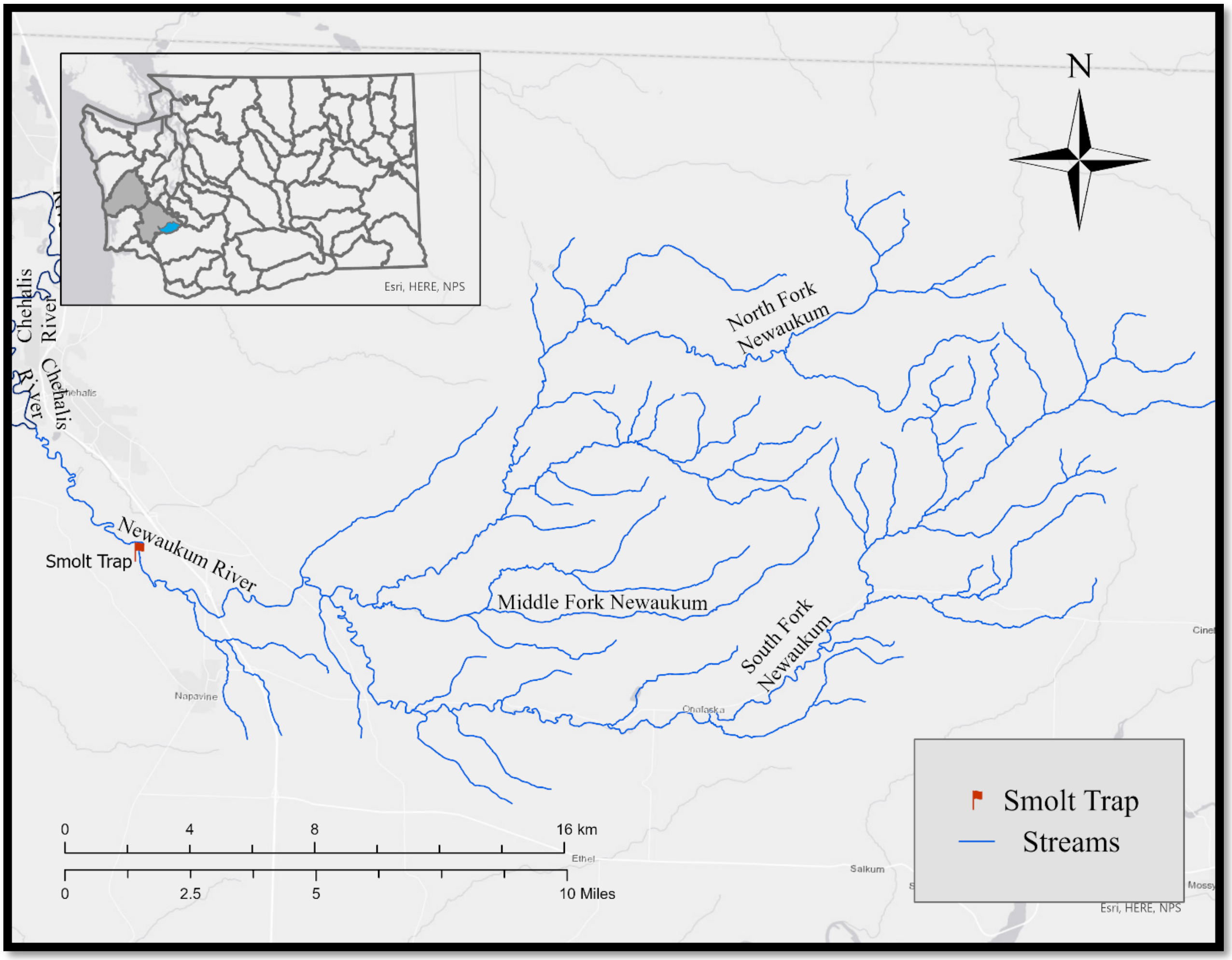

Figure 1. Overview map of the Newaukum River sub-basin of the greater Chehalis River basin, showing the juvenile smolt trap site.

Methods

Study Area

The study area focused on the Newaukum River, a sub-basin of the Chehalis River. Prior to 2019, index reaches surveyed for salmon and steelhead were designed as part of a Chehalis River basin-wide stock assessment effort with limited spatial coverage within the Newaukum River sub-basin. In 2019, the spatial and temporal coverage within the basin was expanded to cover as much of the spawning habitat as possible for each species.

There were two primary types of surveys used for this project: index and supplemental. Index surveys were designed to cover all or most of the available anadromous spawning areas and occurred approximately every seven days. These surveys were conducted throughout the spawn timing for all salmon and steelhead in the project area. Supplemental surveys were performed during the peak spawning activity for each species to cover any potential spawning habitat that was logistically unfeasible to survey on a weekly basis. The observational relationships between index and supplemental surveys were used to expand supplemental survey observations to account for the entire spawning season.

Data Collection

Spawning ground surveys were conducted from September 2019 through June 2020, covering the spawn timing for all salmonid species of focus. Surveys included locating and monitoring redds, counting live and dead fish, and sampling carcasses for adipose mark status (marked/unmarked), coded-wire tag (CWT) status, and biological collections (e.g., scales for ageing and tissue for genetics).

Each redd was identified to species, flagged, numbered, and georeferenced. Since spatial and temporal overlap in spawning activity occurs between fall Chinook and coho, and between coho and steelhead, surveyors were trained to recognize subtle redd differences between each species based on habitat use and redd structures (Burner 1951; Gallagher et al. 2007). In addition, surveyors continually explored potential spawning areas through supplemental and exploratory surveys above and below known spawning habitat.

We followed the WDFW Region 6 District 17 protocol to assign run type (spring or fall) to Chinook redds based on timing, redd condition, and phenotypic characteristics, behavior, and condition of any associated live fish observed within close proximity of the redd. These assignments also used information on fall Chinook behavior and activity, flow levels, and other spawning activity within the basin. Redds constructed after October 15th were all assumed to be fall Chinook, but redds constructed on or prior to October 15th were assigned either spring or fall Chinook based on weight of evidence criteria (Appendix C). If a surveyor was unable to make an informed decision on run type of a redd constructed on or prior to October 15th, the redd was designated spring Chinook.

Carcasses were opportunistically recovered during redd surveys and sampled for species, sex, adipose mark status, CWT presence, and biological data. Mark status and CWTs were used to determine if adult spawners were of hatchery origin (HOR). Sex and fork length were collected to assist with life history diversity metrics. Three or more scales were collected from each Chinook carcass and six or more scales from each steelhead for ageing. Hook and line sampling of live steelhead was used to supplement biodata. Tissue samples were collected from carcasses that were classified as spring Chinook for potential use in future genetic studies.

Analysis

Estimates of abundance were based on 1) enumerated redds in index reaches, 2) enumerated and expanded redds in supplemental reaches, and 3) redd density (redd mile^{-1}) expansion for unsurveyed habitat where spawning may have occurred combined with a species-specific expansion factor. Redds observed in supplemental reaches were expanded by the ratio of visible-to-cumulative redds observed in the nearest applicable index reach. The visible-to-cumulative ratio refers to the number of redds visible in an index reach on the day of, or within one day of, the supplemental survey, divided by the cumulative redds observed in that reach for the entire spawning season. The timing of supplemental surveys was selected to coincide with when the highest proportion of total redds for the season were visible. The visible-to-cumulative expansion factor was applied if the visible-to-cumulative ratio was $\geq$0.20 at the time when the supplemental survey occurred. If the visible-to-cumulative ratio was $<$0.20, the number of observed redds in the supplemental reach was included in the abundance estimate, but no expansion was applied. The result of this calculation was the estimate of the total number of redds in the supplemental survey reach for the season.

Species-specific expansion for Chinook assumed 1.0 female adult per redd and 1.5 males per female, which is the standard expansion used by WDFW for stock assessment in western Washington. For coho, the expansion from redd estimate to adult spawners assumed 1.0 female per redd and 1.0 male per female, which is also the standard expansion used by WDFW for stock assessment in western

Washington. For steelhead, the expansion from redd estimate to adult spawners assumed 0.81 females per redd and 1.0 male per female and is based on previous trap studies conducted in Snow Creek, Washington (USFWS and WDG 1980; Freymond 1982). The steelhead expansion factor reflected a combination of multiple redds built by a single female steelhead, and an assumed one-to-one ratio for male and female steelhead. The redd based estimation methodology is based on multiple assumptions, including:

Assumption 1: redds are correctly identified to species;
Assumption 2: survey reaches provide representation of spatial and temporal distribution of redds;
Assumption 3: true redds are accurately distinguished from natural scour and test digs in the field;
Assumption 4: ratio of fish per redd is constant among years and is accurately represented by the species-specific expansion factor; and
Assumption 5: there is no difference in spawn timing distribution between supplemental reaches and index reaches used in the visual-to-cumulative ratio expansions (proportional visibility of redds between related index reaches and supplemental reaches).

The steelhead redd counts were partitioned as early or late to align with WDFW methodology, whereby early steelhead redds (on or before March 15th) were assumed to be of hatchery origin and late steelhead redds (after March 15th) were assumed to be of wild origin. Early redds were assumed to be of hatchery origin as many hatchery steelhead programs in western Washington produce fish with early run and spawn timing. However, winter steelhead hatchery production in the Chehalis River basin comes from integrated programs that use natural origin (NOR) fish with spawn timing that more closely aligns with natural origin stocks. Therefore, we also collected information from live steelhead in the basin to generate a separate hatchery estimate based on visual mark status.

Recovered carcasses of adult Chinook, coho, and both live and dead (carcasses) of steelhead were used to determine the ratio of hatchery- to natural-origin fish (HOR:NOR) based on the adipose fin and CWT status. Steelhead origin was further validated by scale growth patterns as determined by the WDFW Otolith and Ageing Lab. Life history diversity was assessed based on age structure (years in freshwater and the ocean) and summarized for the sampled population. Age data were not collected from coho in 2019, as all coho were assumed to be age 3 (Weitkamp et al. 1995, Seamons et al. 2020).

Spatial distribution of all spawning fish was visualized using ArcGIS Pro by plotting redds and redds mile^{-1} for each species. Spawning locations were documented in map form by overlaying the areas surveyed as index and supplemental reaches. Spatial distribution of spawning activity was also summarized for each species and represented as the proportion of redds in main stem versus tributary habitat. These calculations were based on the total number of redds and included redds estimated from visible to cumulative expansions in supplemental reaches.

We covered the majority of spawning habitat for coho; however, widespread distribution throughout the basin made it difficult to cover all the spawning habitat in the first year of the study. For areas that were not covered by either index or supplemental surveys, but where estimates had previously been included in the stock assessments, we expanded the redd count using the nearest applicable redds mile^{-1} density or used an average density value obtained from multiple similar streams.

Results

Abundance

During the 2019-2020 survey season, the estimated abundance of spring Chinook was 175 adults, fall Chinook was 858 adults, coho was 1,988 adults, and steelhead was 1,103 adults (Table 1). For the 2019 run year, there was no evidence of hatchery origin (HOR) spring or fall Chinook found in the Newaukum River basin. By contrast, both 2019 coho and 2020 steelhead had HOR spawners present, each contributing to the basin at approximately 6% HOR rate. For steelhead, using the hatchery cutoff date of March 15th, which is standard throughout much of western Washington, HOR was estimated at 12% instead of 6% HOR determined by visual observations of carcasses and lives. For coho in Gheer Creek, a location where hatchery juveniles are released annually, HOR rate was calculated separately from the rest of the basin due to the high density (135 fish $mile^{-1}$) and percentage of HOR coho (92%) on the spawning grounds. In all, there were 108 adult coho estimated for 0.8 miles of Gheer Creek, and 99 were of hatchery origin.

Table 1. Abundance estimates for 2019 returns of spring Chinook Salmon, fall Chinook Salmon, Coho Salmon, and 2020 returns of steelhead trout above and below the smolt trap located on the Newaukum River. Two estimates were completed for steelhead trout, one using observational criteria based on biological data collected and the other using a standard March 15th hatchery cutoff date.

	HOR	**NOR**	**Total**	Below Smolt Trap	Above Smolt Trap
Spring Chinook Salmon	0	175	**175**	17	158
Fall Chinook Salmon	0	858	**858**	88	770
Coho Salmon	202	1786	**1988**	4	1984
Steelhead*	66	1037	**1103**	0	1103
Steelhead**	133	970	1103	0	1103

* HOR/NOR estimate based on biological data collected
** HOR/NOR estimate based on March 15th cutoff date historically used by WDFW

Run Timing

The first spring Chinook redds were observed in mid-September 2019, equivalent to statistical week (week of the year, SW) 38 (Figure 2, Appendix D). Peak spawning was the end of September/beginning of October (SW 40). The first fall Chinook redd was observed in SW 40 during the peak spawn timing of spring Chinook. Fall Chinook spawning peaked at the end of October (SW 43) but fall Chinook continued to spawn for five weeks past the peak week to the end of November (SW 48). The first coho redds were observed during the peak of fall Chinook spawning at the end of October (SW 43). Coho had bimodal spawning peaks; the first occurred at the end of November (SW 48/49) and the second three weeks later in December (SW 51/52). Spawning occurred primarily in mid-basin areas like Middle Fork Newaukum and Kearney Creek during the first peak, whereas during the second peak, spawning occurred primarily in the upper portions of South Fork Newaukum. Spawn timing for steelhead began mid-February 2020 (SW 8) and peaked mid-April (SW 16). Steelhead continued to spawn for an additional six weeks through the end of May 2020 (SW 22).

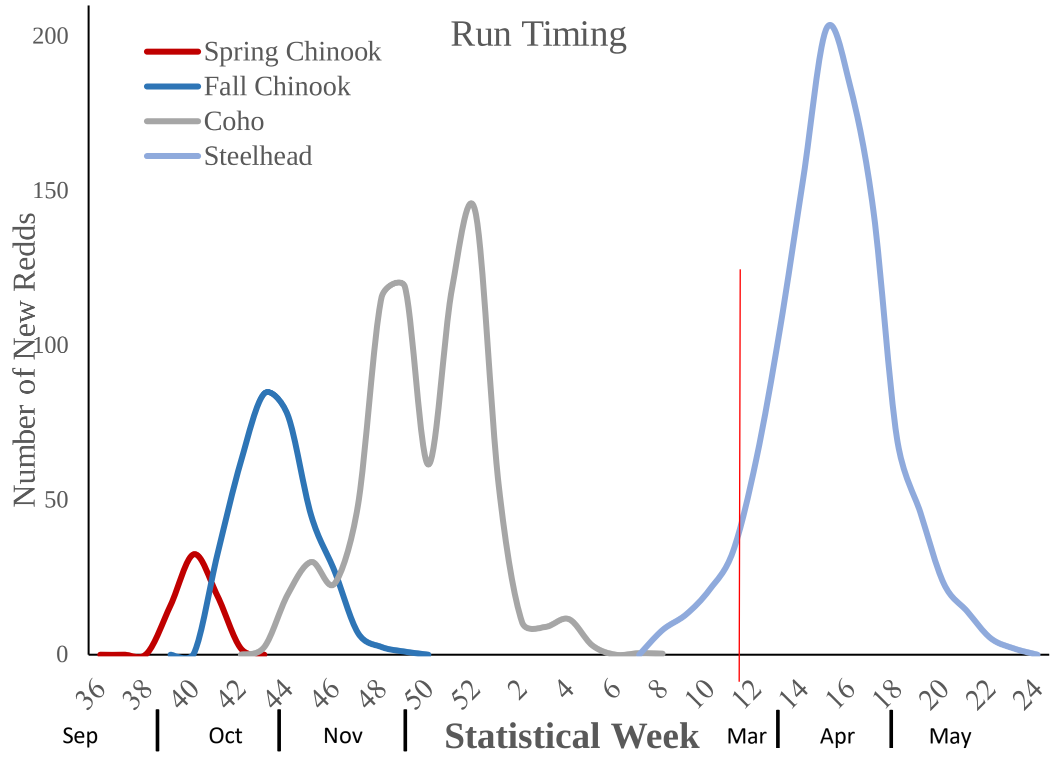

Figure 2. Run timing for 2019-2020 Pacific Salmon and 2020 steelhead trout in the Newaukum River basin based on a three-week rolling average of new redds observed. Red line shows the standard March 15th cutoff date that the Washington Department of Fish and Wildlife uses for distinguishing hatchery origin from natural origin steelhead trout.

Life History Diversity

Adult salmon and steelhead life history diversity metrics included age and sex composition, length data, and origin status (hatchery or natural). We collected biological data from five spring Chinook carcasses in 2019; one was scale age 2, three were scale age 3, and one was scale age 5. All spring Chinook carcasses encountered were not adipose clipped (unmarked, UM). Due to carcass decomposition, length and sex were not determined. By contrast, we collected biological data from 38 fall Chinook carcasses in 2019 and 60% were female (n=18) and 40% male (n=12), including one jack. The average lengths (cm ± SD) of female, male, and jack Chinook recovered were 77.8 ± 5.5, 82 ± 8.4, and 45 (n=1), respectively. For fall Chinook carcasses sampled in 2019, 3% were scale age 2 (n=1), 21% were scale age 3 (n=7), 52% were scale age 4 (n=17), and 24% were scale age 5 (n=8) (Figure 3). None of the fall Chinook carcasses recovered in 2019 were adipose clipped (AD), indicating they were all of natural origin.

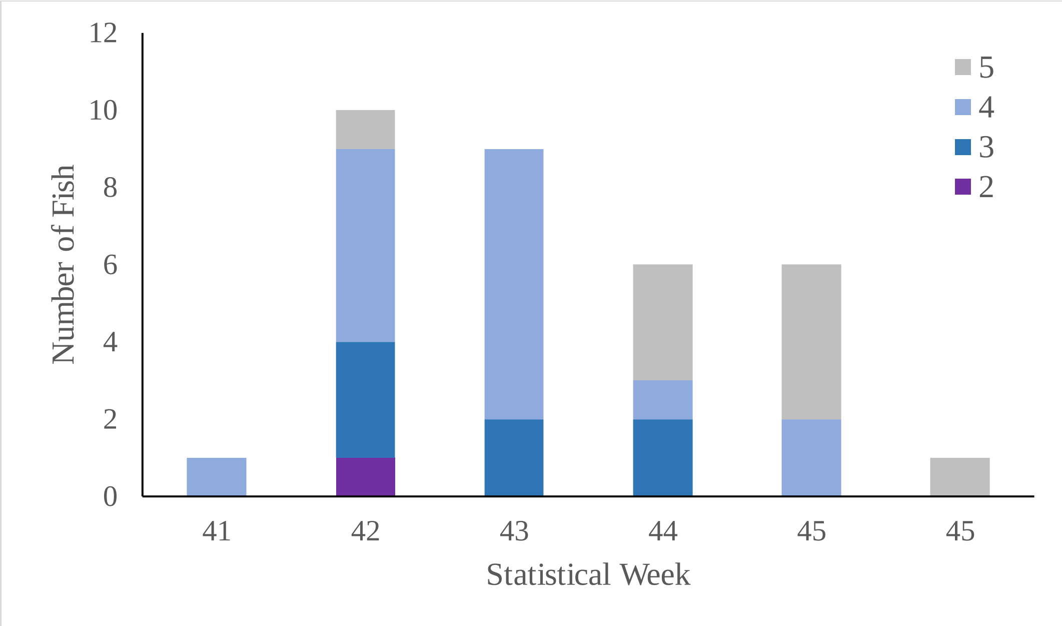

Figure 3. Total age from scale analysis for 2019 fall Chinook Salmon carcasses recovered in the Newaukum River basin by week of the year (Appendix D).

Throughout the basin, 53 coho carcasses were recovered in the 2019-2020 season. No scales were taken for age analysis and all adult coho were assumed to be ocean age 3. We did record two coho jacks (male, age 2 with FL <47 cm) in the basin (one marked, AD and the other UM). Overall, the sex ratio determined for UM coho was 58% female and 42% male (Figure 4). The average lengths (cm ± SD) of recovered female and male coho were 68.1 ± 5.6 and 72.2 ± 7.5, respectively. Verified presence of hatchery origin (HOR) coho was discovered in both the South Fork and Middle Fork Newaukum; however, the HOR coho in Middle Fork was a jack and therefore not used to calculate the adult HOR contribution. No hatchery presence was observed in the North Fork or other tributaries except Gheer Creek, a small tributary in the South Fork Newaukum River. Outside of Gheer Creek, the South Fork Newaukum River basin had 88% confirmed NOR (n=22) and 12% HOR (n=3) adult coho in 2019. By contrast, Gheer Creek had 92% HOR (n=55) and 8% NOR (n=5) coho carcasses recovered in 2019. Hatchery coho and to a lesser extent, steelhead in the Newaukum basin, are reared and released into Gheer Creek by aquaculture students attending the Onalaska High School. As a result, coho escapement in Gheer Creek in 2019 was calculated separately from the rest of the basin to account for the disproportionate amount of hatchery fish in this stream relative to the rest of the Newaukum watershed. The Middle Fork and North Fork had zero HOR adult coho represented in sampled fish (n=18).

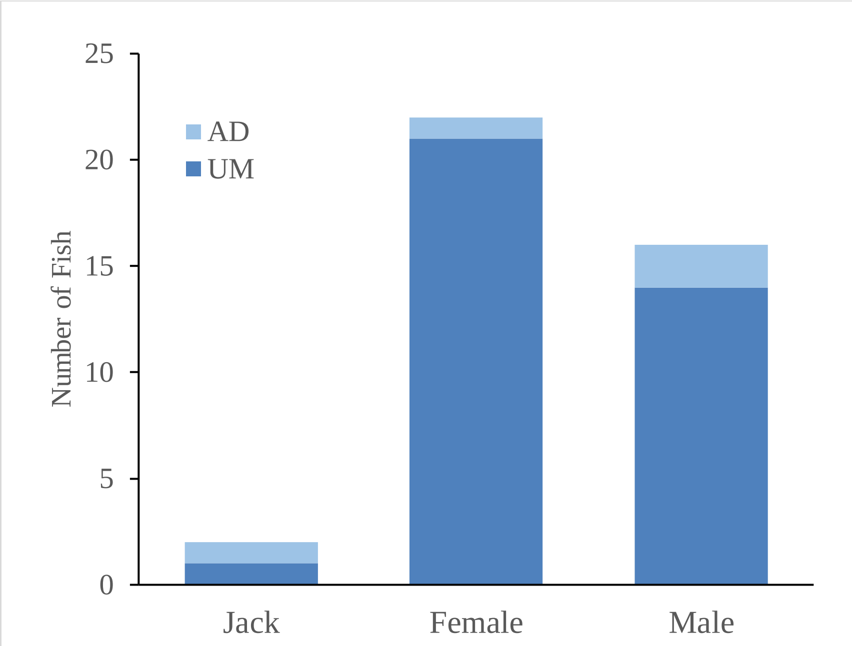

Figure 4. Relative contribution of hatchery/natural origin (HOR/NOR) by male, female, and jack for 2019 Coho Salmon in the Newaukum River Basin.

In an effort to increase steelhead biological samples for sex, age, and origin, hook and line live sampling was implemented for the 2020 return year. Of the 37 samples collected, 27 were from live steelhead. The majority (n=19) of steelhead spent two years in freshwater and one in saltwater (2.1+, Appendix E) for a total age of four at spawning (Figure 5). None of the samples collected indicated any repeat spawners. Of the steelhead carcasses recovered, 24% were (n=8) female with an average (± standard deviation SD) fork length of 65.4 cm ± 2.4 SD and 76% male (n=26) with an average (± SD) fork length of 70.4 cm ± 8.2 SD. All but one of the 37 samples were examined for an adipose mark. Two were adipose clipped (AD) indicating a 6% HOR rate and 94% NOR rate for steelhead in the Newaukum River basin.

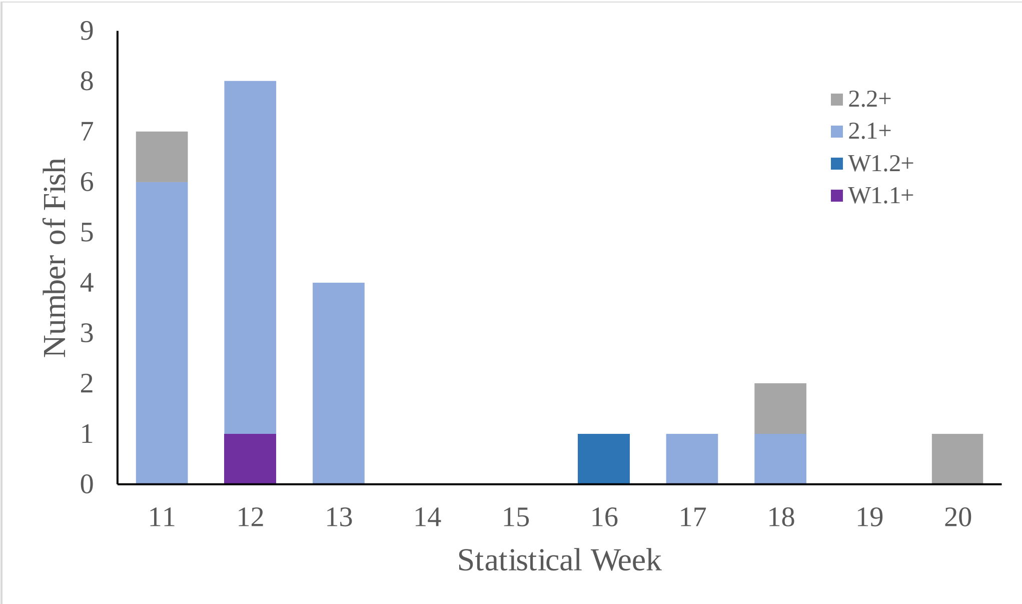

Figure 5. Age from scale analysis of 2020 steelhead trout shown by week number (Appendix D) collected. Samples include both live hook and line sampling and carcass sampling.

Distribution

The spawning distribution of spring Chinook adults in 2019 was isolated to the forks and main stem Newaukum River (Figure 6). Spring Chinook Salmon were evenly distributed (approximately 2 redds mile^{-1}) throughout the South Fork and main stem Newaukum with slightly higher density (6 redds mile^{-1}) where Newaukum parallels Pigeon Springs Rd. The smaller creeks were not surveyed on a weekly basis during the spring Chinook spawning period as flows were too low for spring Chinook to access any potential spawning habitat. Fall Chinook had higher average density (10 redds mile^{-1}) in the lower basin compared to the upper basin but did spawn in the Pigeon Springs area (density = 1 redds mile^{-1}) where spring Chinook Salmon had the highest density (Figure 7). Fall Chinook also spawned in the Middle Fork Newaukum and larger tributaries of Kearney and Lucas creeks as flows increased in October 2019. The highest average spawning density (15 redds mile^{-1}) occurred on the South Fork Newaukum from Leonard Rd (Onalaska) downstream to Jackson Highway. Other high-density areas (>11 redds mile^{-1}) were on the main stem Newaukum near I-5, North Fork Newaukum near Middle Fork Newaukum, and also near Lucas Creek.

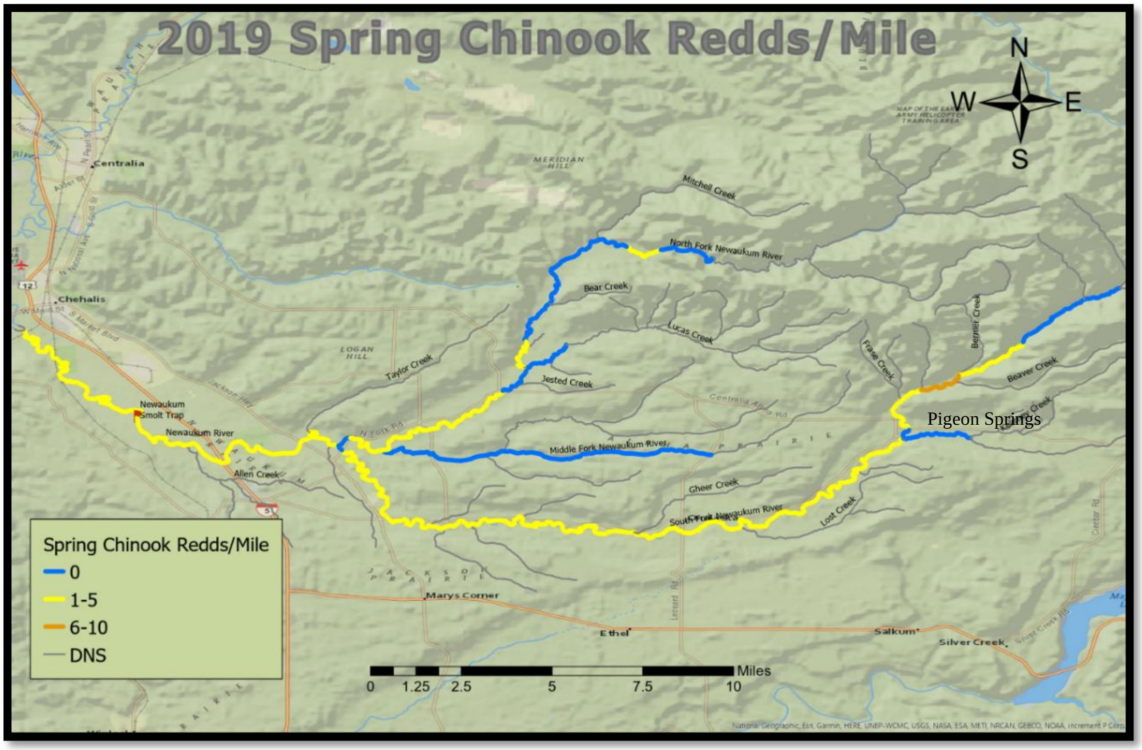

Figure 6. Distribution of 2019 spring Chinook Salmon, shown as redds mile^{-1}, for the Newaukum River basin.

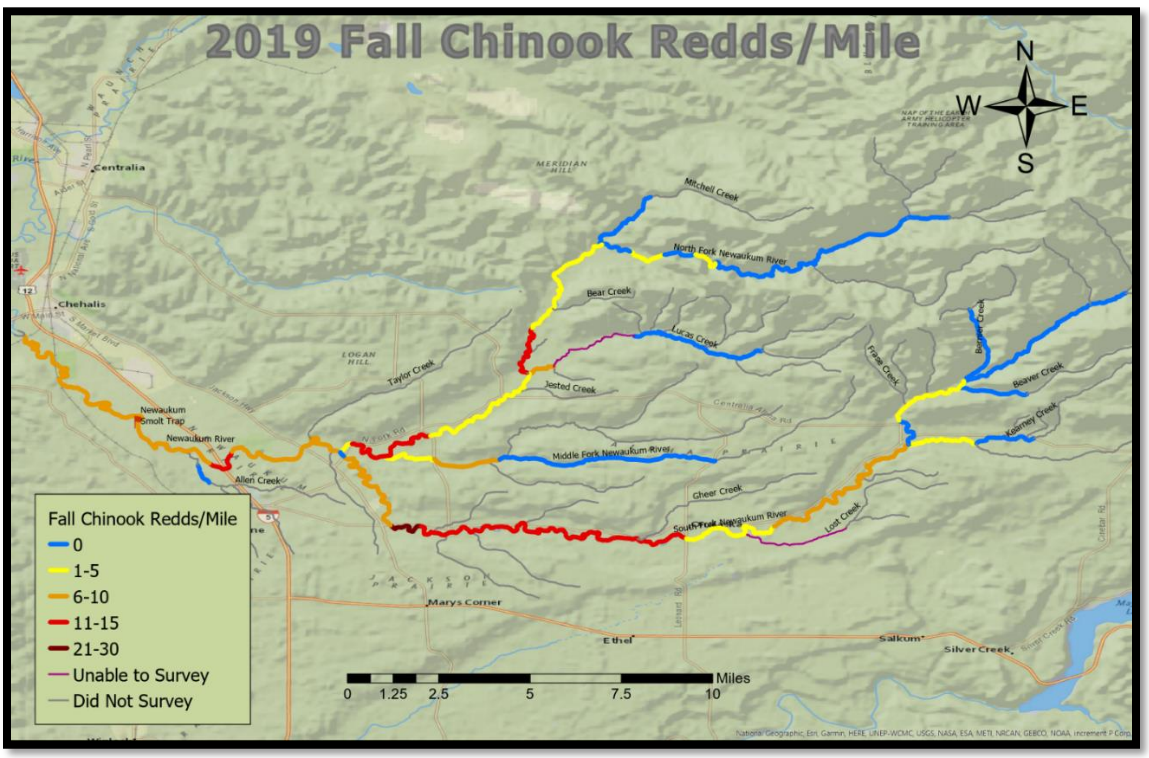

Figure 7. Distribution of 2019 fall Chinook Salmon, shown as redds mile^{-1}, for the Newaukum River basin. “Unable to Survey” sections indicate areas where presence was possible, but field staff were unable to access.

Coho primarily spawned in the forks and tributaries of the Newaukum basin in 2019 with minimal spawning in the main stem (Figure 8). Not unexpectedly, the highest spawning density (> 50 redds mile^{-1}) occurred in Gheer Creek and was associated with hatchery returns. Other high densities (> 30 redds mile^{-1}) occurred in the Middle Fork and North Fork Newaukum as well as Kearney Creek. The South Fork Newaukum had coho spawning throughout the system with the highest density (28 redds mile^{-1}) being in the Pigeon Springs area. There were two tributaries, Lost Creek and Door Creek, that were unable to be surveyed, but likely had spawning based on historical information. Other tributaries that may have some potential for coho spawning, but were unable to be surveyed in 2019, included Jested Creek, upper Allen Creek, and several un-named creeks, although they were unlikely to have high numbers of spawning based on stream type, size, and historical information.

Steelhead, like coho, did not spawn much in the main stem Newaukum River in 2020 (Figure 9). Steelhead utilized the upper extents of both the North Fork and South Fork Newaukum River with >30 redds mile^{-1} in some areas. Although spawning occurred in the Middle Fork Newaukum as well as Kearney, Bernier, and Beaver creeks, it was lower in density (<5 redds mile^{-1}). We were unable to survey in Lost, Door, and a section of Lucas creeks. While spawning was possible in these locations, based on historical knowledge and production from similar streams that year, it is unlikely those streams added much to the steelhead population in the Newaukum River basin during the 2020 return year.

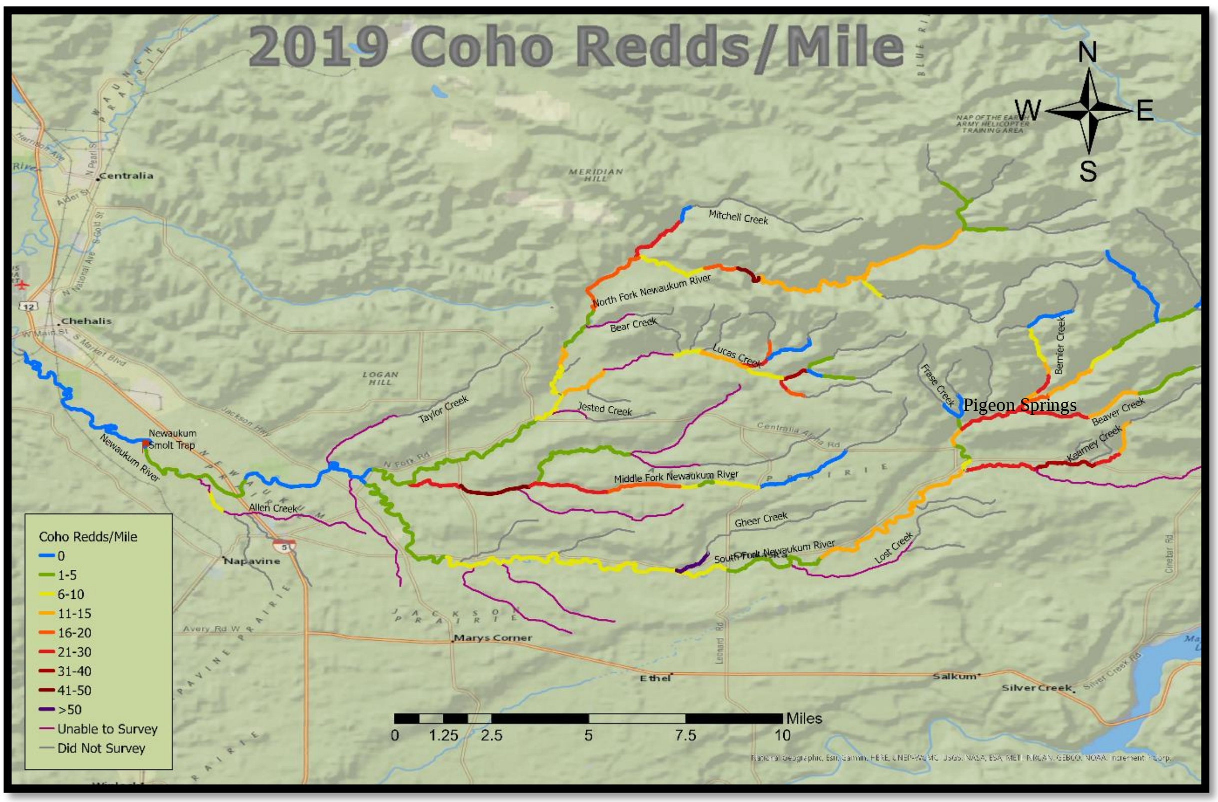

Figure 8. Distribution of 2019 Coho Salmon, shown as redds mile^{-1}, for the Newaukum River basin. "Unable to Survey" sections indicate areas where presence was possible, but field staff were unable to access.

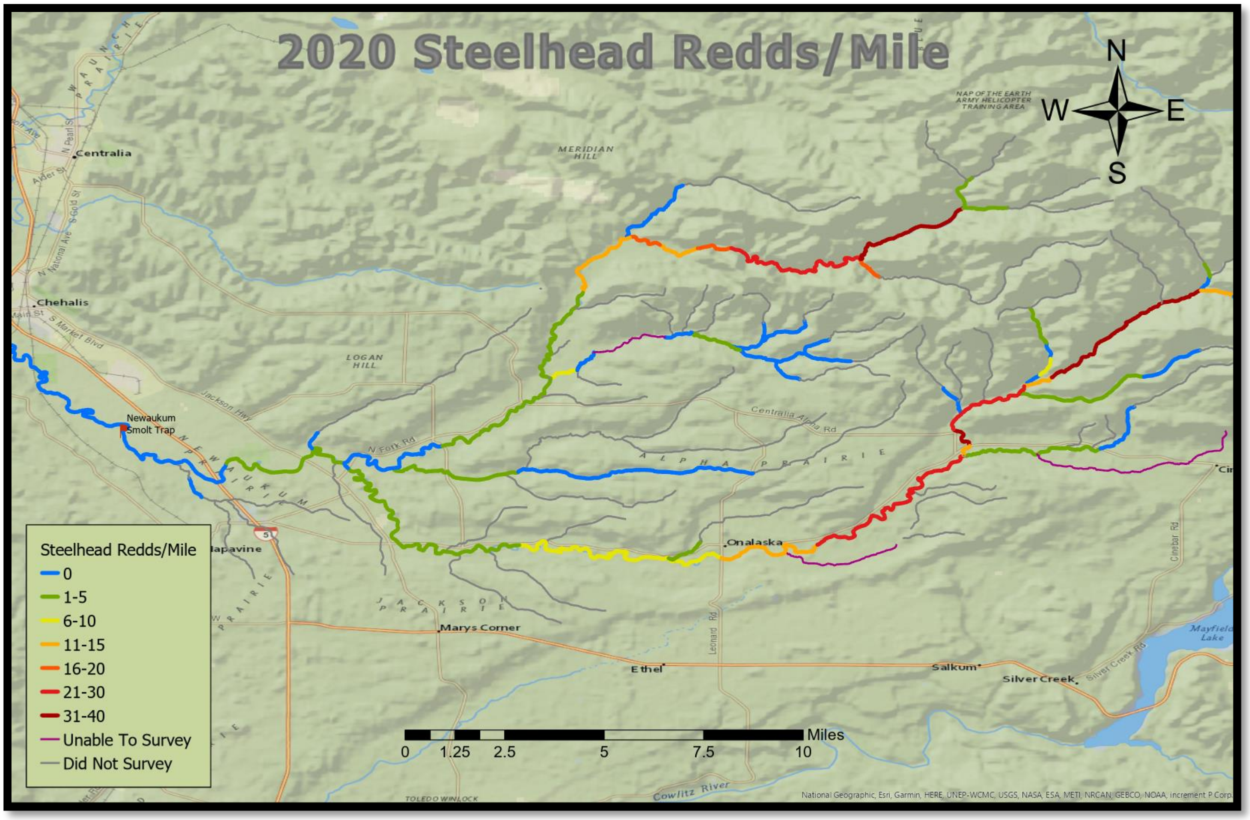

Figure 9. Distribution of 2020 steelhead, shown as redds $mile^{-1}$, for the Newaukum River basin. "Unable to Survey" sections indicate areas where presence was possible, but field staff were unable access.

Discussion

Adult monitoring of salmon and steelhead in the Newaukum River basin, in conjunction with the juvenile monitoring program, will provide valuable information on population viability and the effects of habitat restoration on salmon and steelhead productivity. Our results will also provide information on the population level response to climate change in the Newaukum basin. The Newaukum basin supports populations of spring and fall Chinook, coho, and steelhead. On average (2000-2019) the Newaukum River contributes 29% of spring Chinook production to the Chehalis basin. However, this value has varied annually from 18% to 45% (Appendix A). The contribution of spring Chinook from the Newaukum River in 2019 (18%) was the lowest of the time series. However, this may be due to an increase in the accuracy of the Newaukum basin estimate due to additional survey effort, although there has been an overall decreasing trend in the contribution of spring Chinook from the Newaukum River to the Chehalis basin total over the last 20 years. Simultaneously, there has been a decreasing trend in overall abundance of spring Chinook in the Newaukum River and throughout the Chehalis River basin over the last 20 years.

Historically (2000-2019), fall Chinook, coho, and steelhead from the Newaukum River contributed an average of 9%, 9%, and 11%, respectively, to the total Chehalis River population. Overall, the percent contribution of Newaukum fall Chinook to the Chehalis River basin appears to be decreasing slightly over time. In contrast, the contribution of Newaukum coho to the Chehalis basin appears to be increasing while the overall trend of abundance in the Chehalis River basin is decreasing (2000-2019). Over the last three decades (return years 2000-2020), Newaukum River steelhead decreased slightly over time in both abundance and relative contribution to the Chehalis River total. The overall steelhead abundance trend in the Chehalis River populations also declined over this period. For the 2019 runs of fall Chinook, the Newaukum contributed 8% to the Chehalis population. Newaukum River 2019 coho contributed 8% and 2020 steelhead contributed 17% to the Chehalis population. It should be noted that the new intensive monitoring methodology is different from the rest of the basin, and the methods employed in the Newaukum River prior to the 2019-2020 survey season due to survey coverage. Trends and historical information will be useful in establishing a baseline for response to restoration projects and climate change.

During this first year of the adult monitoring project in the Newaukum River basin, we were able to survey nearly the full spawning distribution of spring and fall Chinook using weekly indexes. Two tributaries that may have had fall Chinook spawning, but we were unable survey, were lower Lost Creek and a section of Lucas Creek between RM 0.5 and 2.6. It is possible that these streams contributed a few redds that were unaccounted for, potentially making our 2019 fall Chinook estimate slightly low.

Interestingly, spring Chinook spawned throughout the main stem and South Fork Newaukum but had very little presence in the North Fork Newaukum. There was a slightly higher density (6 redds mile^{-1}) of spring Chinook higher up in South Fork Newaukum, Pigeon Springs Area, than fall Chinook (1.3 redds mile^{-1}). Fall Chinook spawned before October 15th and overlapped both spatially and temporally with spring Chinook, indicating that hybridization is likely occurring in the Newaukum River. The use of the entire main stem, including the lower few miles, by spring Chinook for spawning, may also indicate that some moved into the Newaukum from the main stem Chehalis River just prior to spawning. Additional effort would be needed to determine holding patterns of spring Chinook to confirm this. More work is also needed to develop a more comprehensive and accurate picture of spring versus fall Chinook run-timing and the degree of hybridization of genetic run-types in the basin (Thompson et al. 2019). To begin to address this data gap, samples were collected from five spring Chinook carcasses in 2019 and continued collection of DNA and otolith samples are planned for future surveys in the Newaukum River basin.

Coho were the most abundant species spawning in the Newaukum River basin in 2019 and utilized many of the smaller tributaries including the Middle Fork Newaukum that had limited use by other species. In the pilot year of the study in 2019, the majority of coho distribution was covered, but we still need to obtain landowner permission to access some areas in order to have a complete census count. For the tributaries that were not surveyed in 2019, redd density was estimated utilizing the nearest applicable stream or by averaging multiple similar streams. This was done for all unsurveyed streams (n=10) where stock assessment estimates were historically generated. In addition, it was determined that hatchery coho in the Newaukum basin had the highest densities (> 50 redds mile^{-1}) in Gheer Creek where juveniles are released by the Onalaska High School hatchery program. However, it remains unclear how much hatchery strays contribute to juvenile production.

In 2020, steelhead was the second most abundant adult salmonid in the Newaukum basin. The majority of spawning distribution for steelhead was surveyed on a weekly basis and unlike other species, most (75%) steelhead spawned in the upper North and South Forks. The hatchery component of steelhead was determined using two separate methods. The first method used the ratio of marked to unmarked steelhead encountered (carcasses and live hook and line samples), which estimated a 6% HOR rate. The second method used March 15th as a cutoff date for HOR spawners (a method employed by WDFW Chehalis stock assessment biologists), which estimated a 12% HOR rate. As noted in previous studies in the upper Chehalis River (Ashcraft et al. 2017; Ronne et al. 2018; 2020), the latter methodology may be problematic as the Chehalis River basin has moved to integrated HOR steelhead programs, which makes use of NOR broodstock, thus creating hatchery origin steelhead with spawn timing similar to NOR steelhead. During steelhead surveys in 2020, NOR steelhead were observed spawning before March 15th

and pre-spawned HOR steelhead were encountered after March 15th. However, to remain consistent with the rest of the Chehalis River basin, HOR and NOR proportions and associated abundance will continue to be reported using both observational-based (live and dead sampling) and date-based methodologies. It should be noted that due to COVID-19 restrictions related to essential workers and social distancing in spring 2020, live sampling of steelhead concluded earlier than anticipated. There was also no sampling lower in the basin. This could have affected the ratio of marked to unmarked steelhead as relative proportions may vary throughout the basin and season. Missing the later spawning period in 2020 could have biased the estimate for HOR steelhead upward. However, by not sampling in the lower basin, it is possible that this may have biased the estimate for HOR steelhead downward. Future efforts will attempt to eliminate these potential biases.

Steelhead have complicated life histories with the potential for repeat spawning; these diverse life histories can improve resilience of a population (Schindler et al. 2010). The first year of data from the Newaukum indicates limited life history diversity of spawning steelhead with no repeat spawners identified. A link between younger/smaller spawners and reduced fecundity has been observed (Bowersox et al. 2019 and Quinn et al. 2011) and can have implications not only for the population, but for sport and broodstock harvest. A closer examination of this diversity would benefit from a broader dataset and comparison to the greater Chehalis River basin and other coastal populations. Further attention will be directed at collecting samples to fill out this dataset in the Newaukum River basin.

As intensive adult monitoring continues in the Newaukum River basin, the focus will remain on generating precise and unbiased estimates of spring and fall Chinook, coho, and steelhead distribution, run timing, life history diversity, and abundance. A continued effort will be made to cover the spawning habitat on a weekly basis for all species to produce accurate estimates. As additional years of information with differing flow and abundance regimes get added to the time series, understanding of spatial distribution in the basin will be refined. Combining adult spawning estimates with juvenile smolt production estimates will also inform adult to smolt (freshwater) survival and smolt to adult (ocean) survival. This will improve the ability to detect changes to salmon and steelhead population viability as a result of restoration actions and climate change.

References

Aquatic Species Enhancement Plan Technical Committee. 2014. Aquatic Species Enhancement Plan Data Gaps Report: Prepared for the Chehalis Basin Work Group, 154 p., http://chehalisbasinstrategy.com/publications/.

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

Bowersox, B., M. P. Corsi, J. L. McCormick, T. Copeland, M. R. Campbell. 2019. Examining Life History Shifts and Genetic Composition in a Hatchery Steelhead Population, with Implications for Fishery and Ocean Selection. Transactions of the American Fisheries Society 148:1056–1068

Burner, C. J. 1951. Characteristics of spawning nests of Columbia River salmon. U.S. Fish and Wildlife Service, Fisheries Bulletin 61:97–110

Freymond, Bill. 1982. Steelhead Spawning Escapement in Boldt Case Area Rivers – 1982. Washington State Game Department.

Gallagher, S. P., P. K. Hann, D. R. Johnson. 2007. Redd Counts. California Department of Fish and Wildlife.

Johnson, D.H., B.M. Shrier, J.S. O'Neal, J. A. Knutsen, X. Augerot, T.A. O'Neil, and T.N. Pearsons. 2007. Salmonid Field Protocols Handbook techniques for assessing status and trends in salmon and trout populations. American Fisheries Society.

Quinn, T. P., T. R. Seamons, L. A. Vøllestad, and E. Duffy. 2011. Effects of growth and reproductive history on the egg size–fecundity trade-off in steelhead. Transactions of the American Fisheries Society 140:45–51

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

Ronne L., N. Vanbuskirk, M. Litz. 2020. Spawner Abundance and Distribution of Salmon and steelhead in the Upper Chehalis River, 2019 and Synthesis of 2013-2019, FPT 20-06 Washington Department of Fish and Wildlife, Olympia, Washington.

Seamons, T. R., C. Holt, L. Ronne, A. Edwards, and M. Scharpf. 2020. Population genetic analysis of Chehalis River watershed coho salmon (*Oncorhynchus kisutch*). FPT 20-02. Washington Department of Fish and Wildlife, Olympia, Washington.

Schindler, D. E., R. Hilborn, B. Chasco, C. P. Boatright, T. P. Quinn, L. A. Rogers, and M. S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. Nature 465:609–612.

Thompson,T.Q., M.R. Bellinger, S.M. O'Rourke, D.J. Prince, A.E. Stevenson, A.T. Rodrigues, M.R. Sloat, C.F. Speller, D.Y. Yang, V.L. Butler, M.A. Banks and M.R. Miller. 2019. Anthropogenic habitat alteration leads to rapid loss of adaptive variation and restoration potential in wild salmon populations. Proceedings of the National Academy of Sciences of the United States of America.

USFWS (U.S. Fish and Wildlife Service) & WGD (Washington Game Department). 1980. Steelhead Progress Report. Cooperative Agreement #14-16-0001-5776 FS/6345 IFC, Washington, D.C.

Weitkamp, L. A., and coauthors. 1995. Status review of coho salmon from Washington, Oregon, and California. U.S. Dept. Commer., NMFS-NWFSC-24.

West, D., J. Winkowski, and M. Litz. 2020. Newaukum River Smolt Production, 2019, FPA 20-04. Washington Department of Fish and Wildlife, Olympia, Washington.

Appendices

Appendix A. Escapement estimates for available data with contribution of Newaukum populations to the Chehalis River basin. Total escapement does not include Humptulips

a) Spring Chinook Salmon

Escapement Year	Newaukum River	Total Escapement	% of Total
2000	566	3135	18%
2001	1,218	2,860	43%
2002	815	2,598	31%
2003	396	1,904	21%
2004	1,041	5,034	21%
2005	595	2,130	28%
2006	850	2,481	34%
2007	293	652	45%
2008	298	996	30%
2009	303	1,123	27%
2010	760	3,495	22%
2011	743	2,563	29%
2012	283	878	32%
2013	1,021	2,459	42%
2014	315	1,583	20%
2015	465	1,824	25%
2016	277	926	30%
2017	525	1,405	38%
2018	125	495	25%
2019	175	983	18%

b) **Fall Chinook Salmon**

Year	Newaukum River	Total Escapement	% of Total
2000	684	7,892	9%
2001	571	7,902	7%
2002	893	9,691	9%
2003	2,287	16,111	14%
2004	1,697	26,320	6%
2005	1,608	13,367	12%
2006	951	12,545	8%
2007	924	10,750	9%
2008	1,222	12,079	10%
2009	580	6,857	8%
2010	538	11,158	5%
2011	836	16,292	5%
2012	901	9,778	9%
2013	811	10,158	8%
2014	592	8,590	7%
2015	612	13,226	5%
2016	1,007	7,117	14%
2017	862	9,594	9%
2018	1,399	14,801	9%
2019	858	11,118	8%

c) Coho Salmon

Estimates shown are total spawners, includes hatchery origin (HOR) and natural origin (NOR).

Year	Newaukum Basin	Total Escapement	% of Total
2000	4,186	32,679	13%
2001	4,459	61,916	7%
2002	6,346	87,776	7%
2003	7,162	75,309	10%
2004	2,813	45,482	6%
2005	1,893	30,857	6%
2006	2,161	15,922	14%
2007	2,097	22,698	9%
2008	2,654	31,643	8%
2009	5,545	65,517	8%
2010	7,444	87,959	8%
2011	4,977	58,093	9%
2012	5,442	63,523	9%
2013	4,466	52,133	9%
2014	7,916	92,402	9%
2015	1,661	19,386	9%
2016	3,821	31,730	12%
2017	2,876	22,691	13%
2018	5,186	45,649	11%
2019	1,988	26,969*	8%

*Preliminary

d) Steelhead Trout

For 2020 steelhead trout in the Newaukum, both the observational (includes both HOR and NOR) and the date derived (NOR only) method are shown. Prior to 2020 only the date derived method is available and when comparing to the rest of the basin, the date derived method is used for consistency.

Newaukum Basin

Year	Observational Method	Date Method	**Total Escapement**	**% of Total**
2000	-	1,644	11,679	14%
2001	-	1,124	9,802	11%
2002	-	734	10,440	7%
2003	-	930	8,424	11%
2004	-	1,712	15,825	11%
2005	-	1,062	9,059	12%
2006	-	1,348	10,418	13%
2007	-	988	7,602	13%
2008	-	632	6,493	10%
2009	-	*	6,956	
2010	-	673	6,765	10%
2011	-	364	6,090	6%
2012	-	415	7,592	5%
2013	-	1,225	9,776	13%
2014	-	772	6,944	11%
2015	-	1,570	10,568	15%
2016	-	833	8,824	9%
2017	-	325	4,618	7%
2018	-	464	6,840	7%
2019	-	492	6,130	8%
2020	1,103	970	6,283**	15%

* No separate Newaukum estimate reported
** Preliminary data

Appendix B. Survey miles covered pre and post implementation of intensive monitoring in 2019-2020. Index indicates weekly surveys. Supplemental indicates surveys done once during peak spawning.

		2019-2020	**Pre-2019**
Spring Chinook	Index	47.8	5.5
	Supplemental	0.8	36.5
		48.6	**42.0**
Fall Chinook	Index	53.0	5.5
	Supplemental	18.3	42.1
		71.3	**47.6**
Coho	Index	72.9	4.0
	Supplemental	18.0	33.6
		90.9	**37.6**
Steelhead	Index	77.2	10.1
	Supplemental	10.3	28.3
		87.5	**38.4**

Appendix C. Description of spring-run Chinook vs. fall-run Chinook characteristics used to distinguish between run-type during their overlapping spawning period around October 15th.

	Spring Chinook	Fall Chinook
Overlap		
Fish[a]	Grey, olive, or black/dark in color;	Red, green, or purple in color;
	Dull and/or dusky appearance, not bright and shiny colors;	Bright, shiny colors, vivid
	Low energy level, lethargic, exhibiting an unwillingness to be spooked off of redds (for females) or into quick currents; [b]	High energy level, spooking easily and powering through riffles and low water areas, exhibiting a frantic behavior when spooked or scared
	Fungus present on fish and edges of snout, and fins showing wear;	No or minimal amounts of fungus and/or wear
	Have a soft caudal peduncle	Have a firm caudal peduncle
Redds	Presence of a spring Chinook female;	Presence of a fall Chinook female;
	If no female presence: Before/on October 15th the redd was recorded as spring-run type unless other fish presence indicates fall Chinook After October 15th the condition of the redd determines run type If redd was built on/prior to Oct. 15th it was recorded as spring-run type If redd was built after Oct. 15th it was recorded as fall-run type	
Post-overlap	After Oct. 15th live fish and redds are fall-run type unless the observation is different from the rest of the observations in the survey	

[a]: For live fish – justify decision with 3 of the 4 characteristics; for carcasses – justify decision with 2 of the 3 characteristics

[b]: Energy level and behavior of fish on a redd was used to clarify run type on live fish and associated redds only

Appendix D. Dates by statistical week (week of year) for 2019-2020 survey season.

From Date	To Date	Statistical Week	From Date	To Date	Statistical Week
9/1/2019	9/7/2019	36	2/2/2020	2/8/2020	6
9/8/2019	9/14/2019	37	2/9/2020	2/15/2020	7
9/15/2019	9/21/2019	38	2/16/2020	2/22/2020	8
9/22/2019	9/28/2019	39	2/23/2020	2/29/2020	9
9/29/2019	10/5/2019	40	3/1/2020	3/7/2020	10
10/6/2019	10/12/2019	41	3/8/2020	3/14/2020	11
10/13/2019	10/19/2019	42	3/15/2020	3/21/2020	12
10/20/2019	10/26/2019	43	3/22/2020	3/28/2020	13
10/27/2019	11/2/2019	44	3/29/2020	4/4/2020	14
11/3/2019	11/9/2019	45	4/5/2020	4/11/2020	15
11/10/2019	11/16/2019	46	4/12/2020	4/18/2020	16
11/17/2019	11/23/2019	47	4/19/2020	4/25/2020	17
11/24/2019	11/30/2019	48	4/26/2020	5/2/2020	18
12/1/2019	12/7/2019	49	5/3/2020	5/9/2020	19
12/8/2019	12/14/2019	50	5/10/2020	5/16/2020	20
12/15/2019	12/21/2019	51	5/17/2020	5/23/2020	21
12/22/2019	12/28/2019	52	5/24/2020	5/30/2020	22
12/29/2019	1/4/2020	53/1	5/31/2020	6/6/2020	23
1/5/2020	1/11/2020	2	6/7/2020	6/13/2020	24
1/12/2020	1/18/2020	3	6/14/2020	6/20/2020	25
1/19/2020	1/25/2020	4	6/21/2020	6/27/2020	26
1/26/2020	2/1/2020	5			

Appendix E. Winter steelhead age notation key provided by Andrew Claiborne, WDFW scale lab.

Age (European)	Freshwater Winters	Saltwater Winters	Total Age at Spawning	Spawning Count	Notation Notes
1.1+	1	1	3	0	
1.1+S+	1	1	4	1	
1.1+S+S+	1	1	5	2	
1.2+	1	2	4	0	
2.+	2	0	3	0	
2.+S+	2	0	4	1	
2.1+	2	1	4	0	
2.1+S+	2	1	5	1	
2.1+S+S+	2	1	6	2	
2.2+	2	2	5	0	
2.2+S+	2	2	6	1	
2.3+	2	3	6	0	
3.+	3	0	4	0	
3.1+	3	1	5	0	
3.1+S+	3	1	6	1	
3.1+S+S+	3	1	7	2	
3.2+	3	2	6	0	
3.2+S+	3	2	7	1	
3.3+	3	3	7	0	
4.+	4	0	5	0	
4.1+	4	1	6	0	
R					Regenerated Scale
R.1+		1		0	Regenerated in FW
R.1+S+		1		1	Regenerated in FW
R.1+S+S+		1		2	Regenerated in FW
R.2+		2		0	Regenerated in FW
R.2+S+		2		1	Regenerated in FW
R.3+		3		0	Regenerated in FW
W1.+	1	0	2	0	
W1.1+	1	1	3	0	
W1.1+S+	1	1	4	1	
W1.2+	1	2	4	0	
W1.2+S+	1	2	5	1	
W1.3+	1	3	5	0	

In the European age notation, the number of freshwater annuli (winters) precedes the decimal.

In the European age notation, the number of saltwater annuli (winters) follows the decimal.

"W" before freshwater age-1 indicates wild pattern.

Fish designated freshwater age 1 with no "W" are hatchery fish

"+" denotes winter from summer run.

To determine brood year for Winter SH using European Notation, subtract the total age at spawning from the spawn year.

Total age at spawning = add numbers left and right of decimal, any spawn checks (a single "S"= 1 year), and one additional year.

Note that total age at spawning cannot be determined when scale is regenerated "R".