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Newaukum Adult Salmon and Steelhead Spawner Abundance, 2021-22

by Lea Ronne, Nick VanBuskirk, Marisa Litz, Mike Scharpf, Todd Seamons and Andrew Claiborne

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Executive Summary

The Newaukum River basin was selected as a “pilot watershed” in 2015 by Chehalis Lead Entity to help guide and monitor salmon recovery projects in the Chehalis River basin with the goal of assessing limiting factors, data gaps, and restoration targets (http://www.chehalisleadentity.org/our-work/). Since then, both an adult and juvenile monitoring program have been implemented in the basin, allowing for adult and juvenile in-stream production estimates. This report covers the 2021-2022 survey season 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*).

A census redd (salmon nest) survey was conducted for all salmonids for the 2021-2022 season in the Newaukum basin (total escapement for Chinook and Coho Salmon in the 2021 run year and steelhead escapement in 2022 run year). However, due to the high flows and broad distribution of Coho Salmon in small creeks and tributaries with many private landowners, we were unable to completely survey all spawning habitat. 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. Major findings for the 2021-2022 season were:

- Spring Chinook adult abundance of 545 spawners in 2021 was less than the 20-year average.
- Fall Chinook abundance in 2021 was 423 adult spawners, less than half of the previous year’s abundance (1,063 spawners) and the 20-year average (995 spawners). Also of note is the fall Chinook abundance estimate was less than that of spring Chinook.
- Genetic analysis of run timing markers of opportunistically collected salmon carcasses showed hybridization between fall and spring run types; 23% of the samples came back as heterozygotes with the majority of those from downstream of Onalaska on the South Fork Newaukum.
- Spring and fall Chinook spawning distribution overlapped spatially and temporally however, there appears to be some separation between early Spring Chinook spawners in the upper South Fork above Onalaska. The fall Chinook spawners that reach these upper reaches appear to do so after most of spring Chinook have spawned. This is observed in both the redd timing information combined with live observation and the genetic testing from carcasses sampled.
- Both fall and spring Chinook distribution and spawning were greatly reduced in the North Fork Newaukum when compared to the previous year’s distribution. Likely, a combination of lower run size and reduced flows during migration and spawning.
- Coho Salmon nearly doubled in escapement when compared to 2020 and was the most abundant salmonid species in the Newaukum basin with 5,594 spawners.
- Hatchery Coho Salmon spawning in the Newaukum Basin quadrupled to 833 spawners in 2021 from around 200 spawners in the previous two years.
- Steelhead spawner abundance was 766 adults, 15% lower than the 20-year average.
- Steelhead were mostly distributed in the upper North and South forks of the Newaukum River with few spawning in the lower parts of the forks or the Middle Fork Newaukum. Only one steelhead redd was observed in the main stem Newaukum River below the confluence of the North and South forks.

On average (run years 2000 to 2020), the Newaukum River contributed between 18% and 45% of the Chehalis River spring Chinook spawning population, yet both Newaukum River and Chehalis River basin populations have declined since 2000. In 2021, the Newaukum contributed 21% to the overall spring Chinook total spawner abundance, yet this was lower than the average (28%) for the time series indicating that Newaukum River spring Chinook contribution is still below the long-term average. Through long term monitoring of the Newaukum River, our program will generate a time series of species distribution, spawner abundance, life history diversity, and other population-level metrics (e.g., productivity) that will be valuable as restoration projects are implemented throughout the 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 means 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 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 adult salmon returning to their freshwater spawning habitat and juvenile production occurring at the watershed scale (West et al. 2020; Olson et al. 2021) 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 environmental change. The Newaukum sub-basin was selected, in part, because it supports a spawning population of spring Chinook Salmon (*Oncorhynchus tshawytscha*) that has contributed anywhere from 18% to 45% (28% average from 2000-2021) of the total Chehalis River basin spring Chinook Salmon abundance (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.

This monitoring effort focuses on Spring and fall Chinook Salmon (*O. tshawytscha*), hereafter referred to as Chinook, Coho Salmon (*O. kisutch*), and winter-run steelhead trout (*O. mykiss*), hereafter referred to as steelhead. The framework for this study, which includes intensive monitoring of abundance, distribution, and run timing of adult salmonids, began in the Newaukum sub-basin in September 2019. Prior to this, limited monitoring occurred to produce abundance estimates used by fish managers. Throughout time, surveys based on redd (i.e., salmon nest) counts and live counts have been used to generate an estimate of an escapement (i.e., the number of salmon not caught by commercial or recreational fisheries that return to their natal habitat, Johnson et al. 2007). Surveys were conducted from September 2021 to June 2022 throughout the known distribution of each species, with additional effort 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 since at least 2000 (Appendix B).

Objectives

The overall goal of this monitoring project was to describe the abundance, spawn timing, spatial distribution, and life history diversity of adult spring and fall Chinook, Coho Salmon, and steelhead in the Newaukum River sub-basin during return years 2021/2022, and to determine the abundance of adult spawners above the juvenile smolt trap located at river mile 5.8 (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 supplemental surveys during the peak of spawning to document activity on any potential spawning habitat not surveyed on a weekly basis;
- Increase steelhead biological sample size from carcass recovery efforts using catch-and-release hook and line sampling;
- 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.

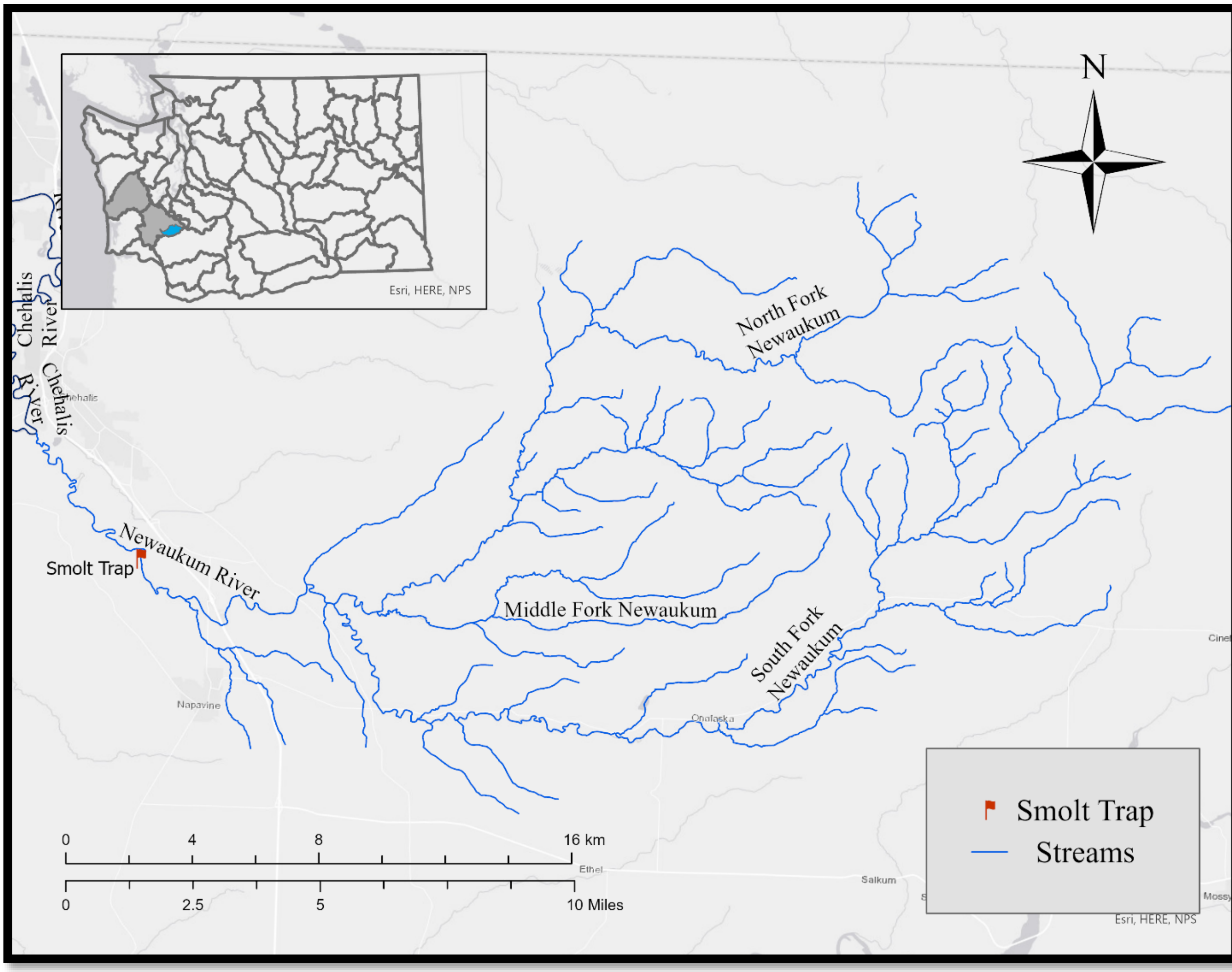

Figure 1. Overview map of the Newaukum River sub-basin of the greater Chehalis River basin, showing the juvenile smolt trap site.

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 occurred when spawning activity peaked for each species and covered as much potential spawning habitat as possible in areas that were not surveyed on a weekly basis. The ratio of redds visible in an index during peak to how many were observed in that index throughout the entire season was applied to expand supplemental survey observations to account for the entire spawning season.

Data Collection

Spawning ground surveys were conducted from September 2021 through June 2022, covering the spawn timing for each species of salmon and steelhead. Surveys comprised of 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 material (e.g., scales for ageing and tissue for genetics). Each redd was flagged, numbered, and georeferenced. Since spatial and temporal overlap in spawning activity occurs between fall Chinook and Coho Salmon, and between Coho Salmon 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 order to assign a species to each redd. 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. Fin clips were taken from both field-determined spring and fall Chinook carcasses for genetic run timing analysis. In addition, otoliths were taken for a separate study on spring Chinook otolith microchemistry, although results from that study were not available at the time of writing. Catch-and release via hook and line sampling of live steelhead was used to supplement biological samples from carcasses.

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, expressed in redds per mile (redds mile^{-1}), expansion for unsurveyed habitat where spawning may have occurred. 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 index 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 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 (Orelle 1976), which is the standard expansion used by WDFW for stock assessment in western Washington. For Coho Salmon, 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 was 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 assumed a 1:1 ratio of male to female steelhead. The redd based estimation methodology is based on multiple assumptions, including:

Assumption 1: species assignments for redds are correct;
Assumption 2: survey reaches are representative of spatial and temporal spawning distribution;
Assumption 3: true redds are accurately distinguished from natural scour and test digs;
Assumption 4: the 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 either 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 gets sourced from integrated broodstock 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 Salmon, and both live and dead (carcasses) steelhead were used to determine the ratio of hatchery- to natural-origin fish (HOR:NOR) based on the adipose fin and CWT status or scale morphology. 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 was collected from Coho Salmon in 2021 as part of a life history study for another project even though typically all Coho Salmon are 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 Salmon by either index or supplemental surveys. For unsurveyed reaches, we expanded the redd count using the nearest applicable redds mile^{-1} density or used an average density value obtained from multiple similar streams. Anecdotal reports from landowners of Coho Salmon spawning in small ephemeral streams in 2021 not previously considered spawning habitat, was unable to be evaluated but we believe that there is a likelihood some Coho Salmon spawning activity is unaccounted for in this report.

Genetic Analysis

Tissue samples from opportunistically sampled spring and fall Chinook Salmon carcasses were tested for genetic run timing using methods outlined in Thompson et al. (2019). Briefly, genomic DNA was isolated from fish tissue with Machery-Nagle silica based column extraction kits following the manufacturers protocol for animal tissues. Chinook salmon-specific single nucleotide polymorphisms (SNPs) were genotyped using a cost-effective method based on a custom amplicon sequencing called Genotyping in Thousands (GTseq) (Campbell et al. 2015). For each individual, pools were sequenced, de-multiplexed, and genotyped by generating a ratio of allele counts. The process had four segments:

extraction, library preparation, sequencing, and genotyping. SNP markers used to infer adult run timing phenotype were those of Thompson et al. (2019). These markers were included in the GTseq SNP panel with a sex ID marker and 298 additional loci. To call run-type, the genotyping results from both SNPs (homozygous spring-run, heterozygous, or homozygous fall-run) were required to agree.

Scale Analysis

Scale analysis was used to determine age and iteroparity. The scale analysis was completed by the WDFW Fish Ageing Lab each spawn year for run reconstruction and co-management purposes. Scales were mounted on gummed scale cards in the field. Acetate impressions were made of each card using a heated hydraulic press and viewed using a digital microscope camera (e.g. Leica S9i ©). Alternating zones of tightly and widely spaced circuli, termed annuli, were identified and indicated the number of winters or years a fish has lived. For steelhead trout, iteroparity was also identified based on scars present when a scale resorbs during a previous spawning migration then regrows leaving a scar that is discernable. For steelhead, age was designated using the European age notation described in Koo (1962) and adapted for winter steelhead (WDFW 1978, Scott and Gill 2008). Numbers to the left of the decimal point represent years spent in freshwater and "." indicates the initial seaward migration. Numbers to the right of the decimal point indicate years at sea and the "+" is used to represent the annulus that occur(s) as the fish migrate back to freshwater. A "S" denotes a spawn scar. For Chinook and coho salmon, age was recorded using Gilbert/Rich notation (Gilbert and Rich 1927, Groot and Margolis 1991). Gilbert/Rich notation consists of two numbers where the second number is a subscript (e.g. 5_2). The first number describes the total years of life between when a fish was deposited in gravel as an egg and capture. The subscript describes the year of life the fish migrated to sea. The first number in the Gilbert/Rich notation is equal to total age.

Results

Abundance

During the 2021-2022 survey season, the estimated spawner abundance of spring Chinook was 545 adults, fall Chinook was 423 adults, Coho Salmon was 5,594 adults, and steelhead was 766 adults (Table 1). For the 2021 run year, there was no evidence of hatchery origin (HOR) spring or fall Chinook found in the Newaukum River basin. By contrast, both 2021 Coho Salmon and 2022 steelhead had HOR spawners present, contributing 15% and 7% HOR rate, respectively. For Coho Salmon 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 (494 fish mile^{-1}) and percentage of HOR Coho Salmon (96%) on the spawning grounds. In all, there were 332 adult Coho Salmon estimated to have spawned in the 0.7 miles of Gheer Creek downstream of the adult trap. 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 7% HOR determined by visual observations of carcasses and live counts.

Table 1. Abundance estimates for 2021 returns of spring Chinook Salmon, fall Chinook Salmon, Coho Salmon, and 2022 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 for hatchery origin (HOR) 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	545	**545**	45	500
Fall Chinook Salmon	0	423	**423**	58	365
Coho Salmon	839	4,755	**5,594**	0	5,594
Steelhead*	52	714	**766**	0	766
Steelhead**	92	674	**766**	0	766

* 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 early September 2021, equivalent to statistical week (week of the year, SW) 37 (Figure 2, Appendix D). Peak spawning occurred in the beginning of October (SW 40). The first fall Chinook redd was observed in SW 41 overlapping with the later spring Chinook spawning. Fall Chinook spawning peaked mid-October (SW 42) but fall Chinook continued to spawn for four weeks past the peak week to mid-November (SW 46). The first Coho Salmon redds were observed at the end of October (SW 44) while fall Chinook were still spawning. Coho Salmon had bimodal spawning peaks; the first occurred at the beginning of December (SW 49) and the second six weeks later at the end of January (SW 5). Middle Fork Newaukum Coho Salmon timing was three weeks earlier than the rest of the Newaukum River basin for the first spawning peak but showed the same timing for the second peak (Figure 3). Spawn timing for steelhead began at the beginning of February 2022 (SW 7) and peaked early-April (SW 14). Steelhead continued to spawn for an additional eight weeks into June 2022 (SW 23).

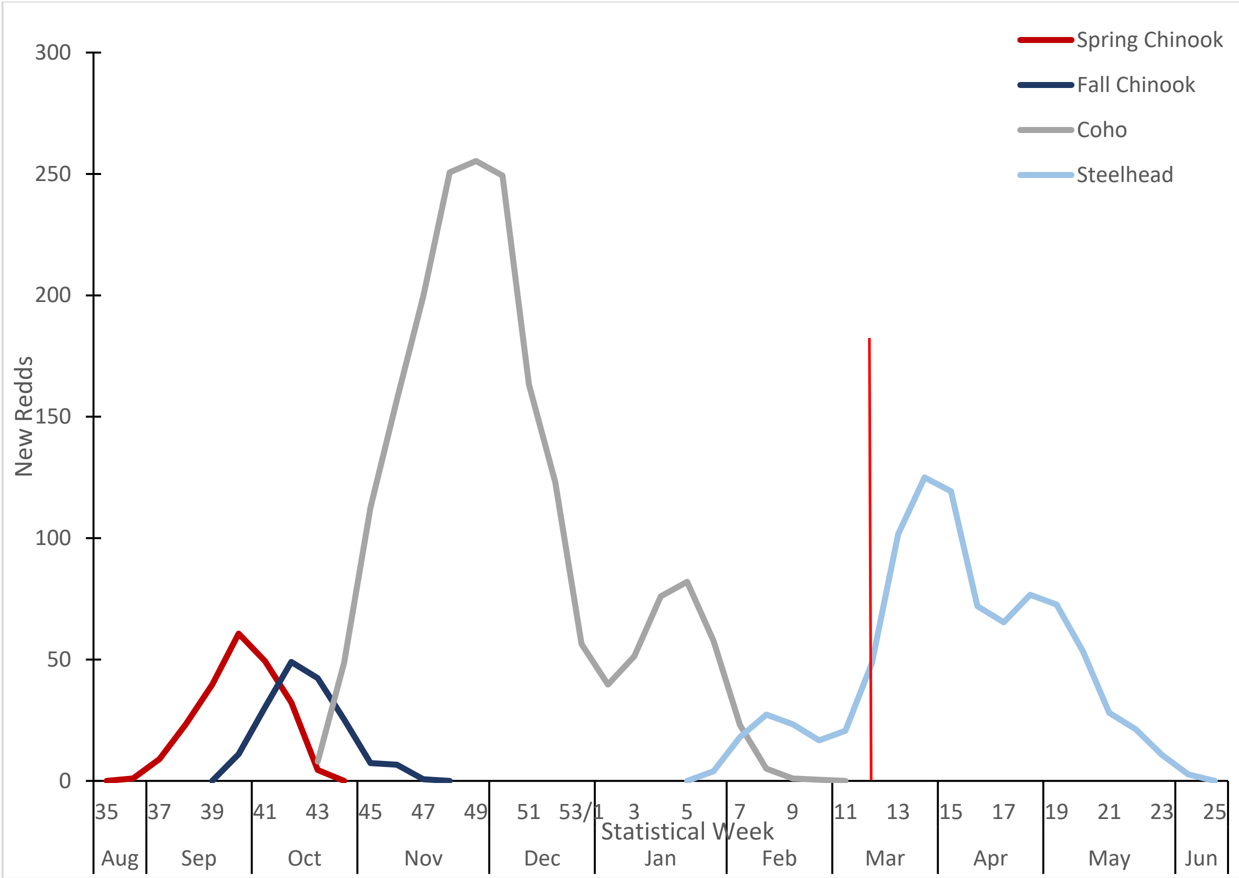

Figure 2. Run timing for 2021 Pacific Salmon and 2022 steelhead trout in the Newaukum River basin based on a three-week rolling average of new redds observed. The red vertical line shows the standard March 15th cutoff date that the Washington Department of Fish and Wildlife uses for distinguishing hatchery origin from natural origin steelhead trout.

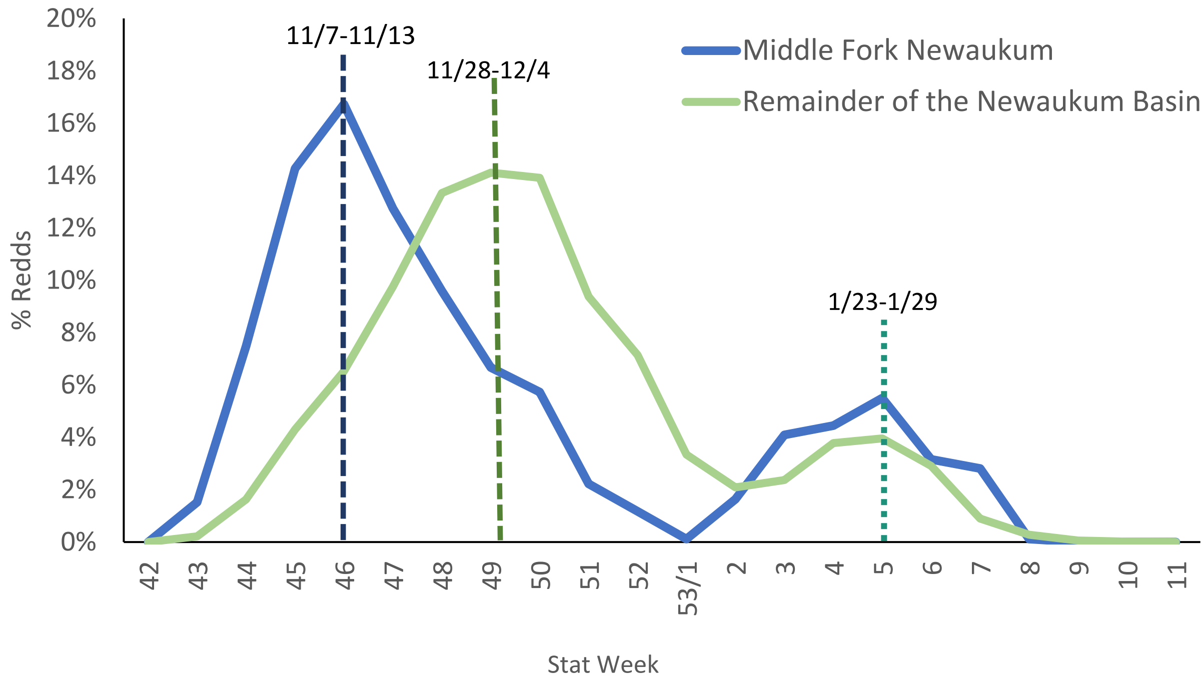

Figure 3. Middle Fork Newaukum 2021 Coho Salmon spawn timing when compared to the spawn timing for the remainder of the basin. Shows an earlier peak spawn timing for Middle Fork Newaukum's early Coho Salmon (A run) but the similar spawn timing for the later (B run) Coho Salmon. The vertical dotted lines are the dates of peak spawning in each area and run.

Life History Diversity

Adult salmon and steelhead life history diversity metrics included age and sex composition, length data, and origin status (hatchery or natural). All spring and fall Chinook carcasses encountered, where clip status could be determined, had an adipose fin present (unmarked, UM) and were considered of natural origin. Of the spring Chinook carcasses collected where sex was determined, 52% were female (n=13) and 48% were male (n=12). Age was determined from scales collected and spring Chinook came back with 32% scale age 3 (n=7), 59% scale age 4 (n=13), and 9% scale age 5 (n=2, Figure 4). The average lengths (cm ± SD) of female and male spring Chinook recovered were 71.6 ± 3.0 and 76.3 ± 6.2, respectively.

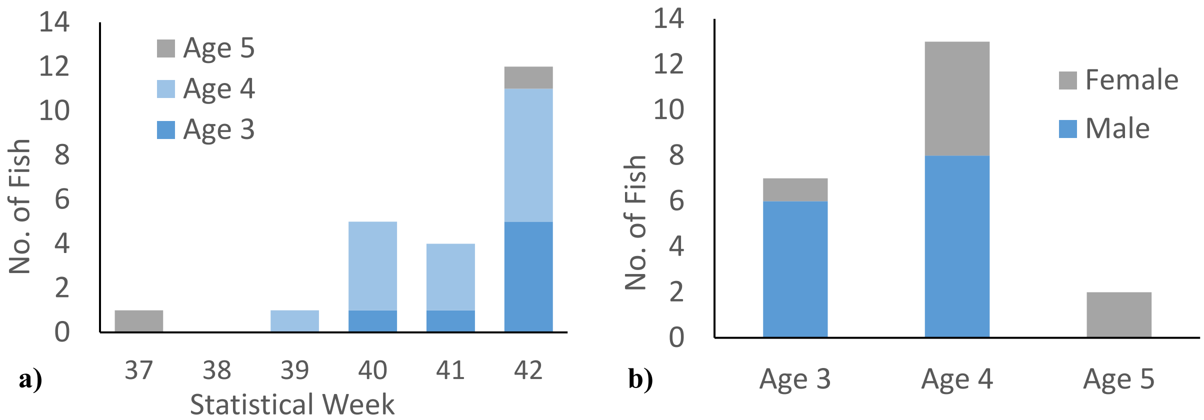

Figure 4. Total age from scale analysis for 2021 spring Chinook Salmon carcasses recovered in the Newaukum River basin a) by week of the year (Appendix D), b) by sex.

Fall Chinook had 41% female (n=27) to 59% male (n=39) of the samples collected in 2021, and no jacks were recovered. The average fork lengths (cm ± SD) of female and male fall Chinook recovered were 76.8 ± 5.0 and 77.4 ± 9.0, respectively. For fall Chinook carcasses sampled in 2021, 20% were scale age 3 (n=10) and 80% were scale age 4 (n=39, Figure 5). None of the fall Chinook carcasses recovered in 2021 were adipose clipped (AD), indicating they were all of natural origin.

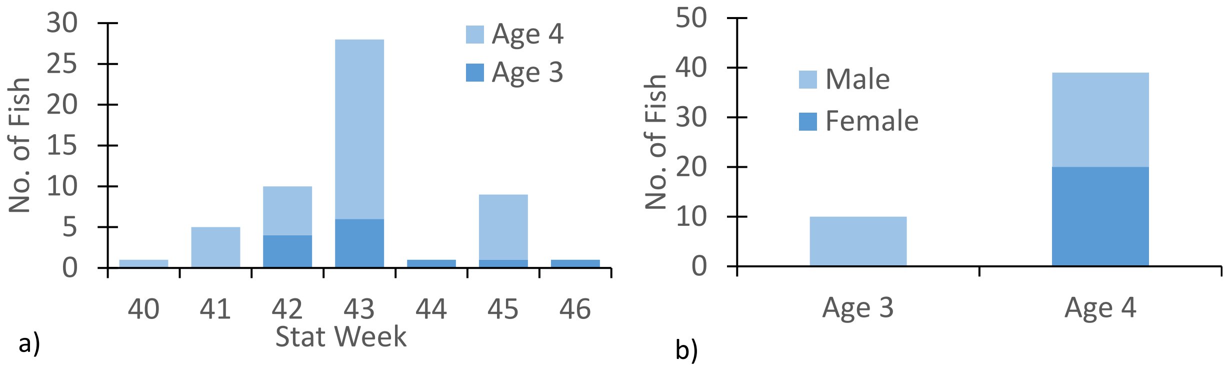

Figure 5. Total age from scale analysis for 2021 fall Chinook Salmon carcasses recovered in the Newaukum River basin a) by week of the year (Appendix D) b) by sex.

Throughout the basin, 220 unmarked Coho Salmon carcasses were recovered in the 2021-2022 season. Scales were taken for age analysis and except for two fish, all coho were assigned to ocean age 3. Of the remaining two samples, one was assigned as a two-year-old and the other was a four-year-old. Overall, the sex ratio determined for UM Coho Salmon was 45% female and 55% male. The average fork lengths (cm ± SD) of recovered unmarked female and male Coho Salmon were 64.6 ± 4.7 and 68.0 ± 7.3, respectively. In the Newaukum basin, hatchery Coho Salmon, and to a lesser extent steelhead, are reared and released into Gheer Creek by aquaculture students attending the Onalaska High School. Coho Salmon hatchery origin spawners (HOS) were found throughout the Newaukum River basin (Figure 6) As expected, Gheer Creek had the highest pHOS at 96% hatchery spawners. The North Fork and upper South

Fork Newaukum had under 2% pHOS. Hatchery Coho Salmon were also found spawning in the Middle Fork Newaukum (11.6%), Lost Creek (75%), and the lower mainstem tributaries (67% pHOS). As a result, we generated estimates and applied these differing pHOS rates for each sub-area separately.

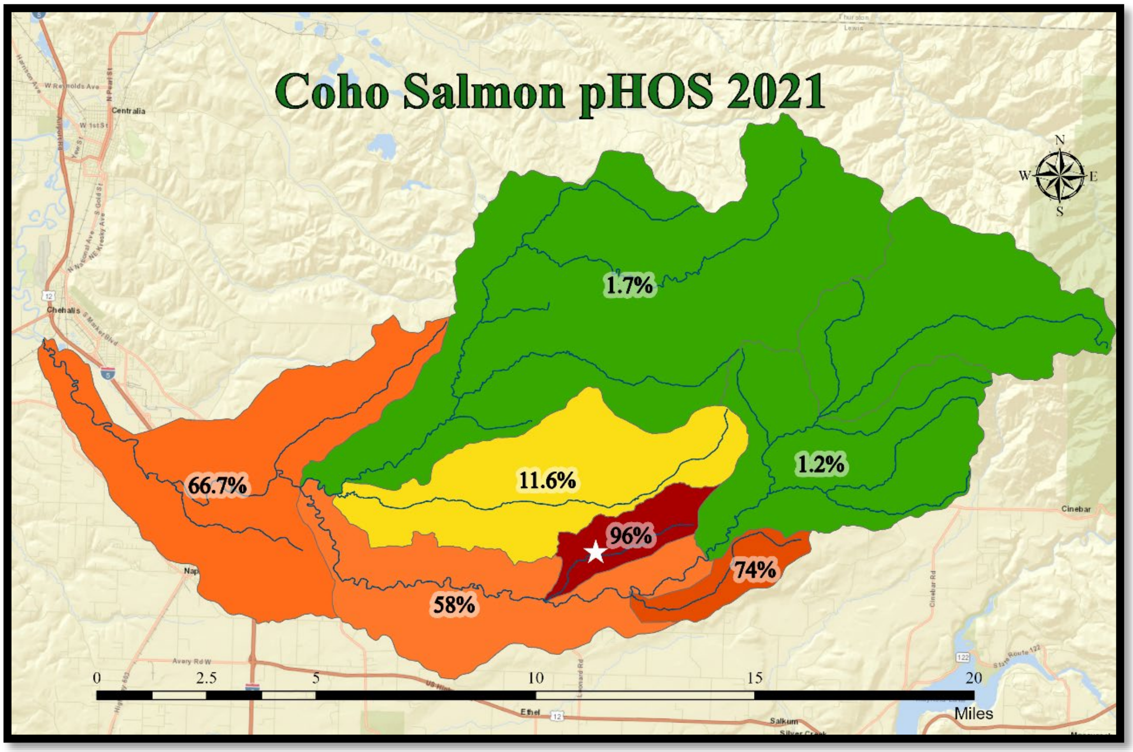

Figure 6. Percentage of hatchery origin spawners (pHOS) by sub-area of 2021 Coho Salmon in the Newaukum River Basin determined by carcass recovery. The white star is release location for hatchery Coho Salmon. Note: spawner density is higher in the upper basin where pHOS is lower.

In an effort to increase steelhead biological samples for sex, age, and origin, hook and line live sampling was implemented for the 2022 return year. Of the 49 samples taken from carcasses and live steelhead, via hook and line sampling, four were adipose clipped. Of those four, one was found in Gheer Creek (100% HOR), two were found in the lower South Fork Newaukum (7% HOR) downstream of Gheer Creek, and one was found in the upper North Fork Newaukum (5% HOR). Of the adipose intact or natural origin (NOR) samples, the most common age seen was age 2.1+ for a total age of four at spawning (Figure 7, Appendix E). Two of the samples came back as repeat spawners. Of the NOR sampled steelhead, 31% were (n=14) female with an average fork length (cm ± SD) of 68.3 cm ± 8.3 and 69% male (n=31) with an average fork length of 68.6 cm ± 7.8.

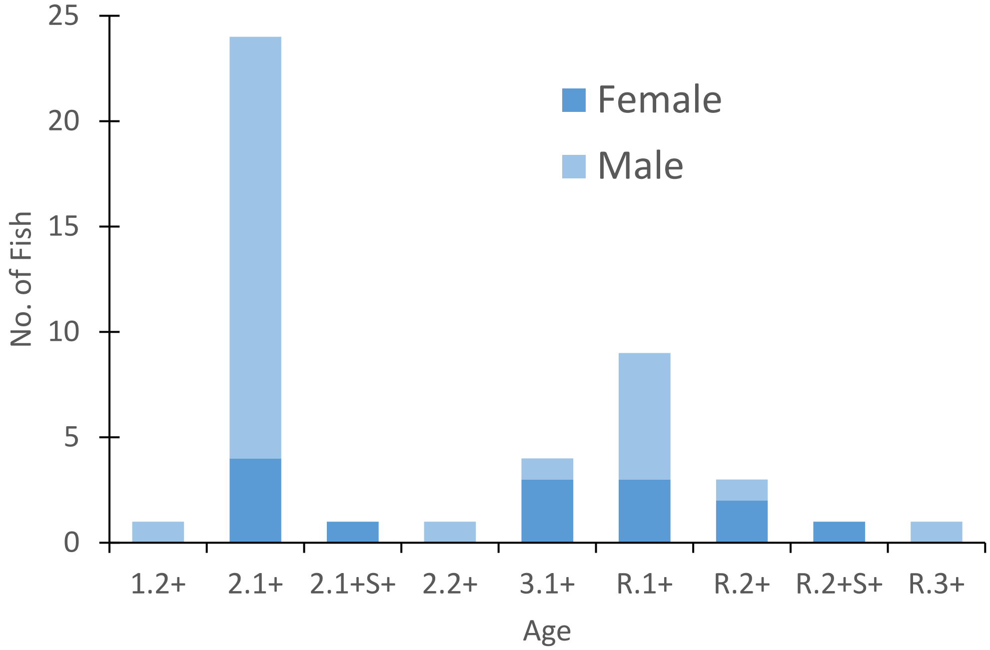

Figure 7. Age from scale analysis of 2022 steelhead trout with freshwater age on the left of the decimal and saltwater age to the right of decimal. 'R' indicates regenerated, so freshwater age is unknown, and 'S' indicates multiple spawns. Samples include both live hook and line and carcass sampling. Additional explanation of scale age notation in Appendix E.

Distribution

The spawning distribution of spring Chinook adults in 2021 was isolated to the forks and main stem Newaukum River, similar to the 2019 and 2020. Though Spring Chinook Salmon did spawn in the North Fork and main stem Newaukum River, the majority of spawning (70%) took place in the South Fork Newaukum River (Figure 8). The highest density spawning areas (10.1-15 redds mile^{-1}) occurred on the South Fork Newaukum River from lower Highway 508 bridge up to Onalaska, and Kearney Creek to the upper Highway 508 bridge. Some streams like Middle Fork Newaukum, Kearney Creek, and Lucas Creek 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 the highest density (9 redds mile^{-1}) on the South Fork Newaukum River between Guerrier and Gish roads (Figure 9). The main stem Newaukum also had some of the highest density areas in 2021 with 8.6 redds mile^{-1} around where I-5 crosses the river. North Fork Newaukum had much lower densities than both South Fork and main stem Newaukum with only 18% of the run spawning in the North Fork. The highest fall Chinook density in the North Fork Newaukum was just upstream of Centralia Alpha Road with 8 redds mile^{-1}. Unlike in the previous year, fall Chinook did not utilize Lucas Creek, Kearney Creek, or Middle Fork Newaukum to spawn in 2021. Likely due to both low flows and low abundance.

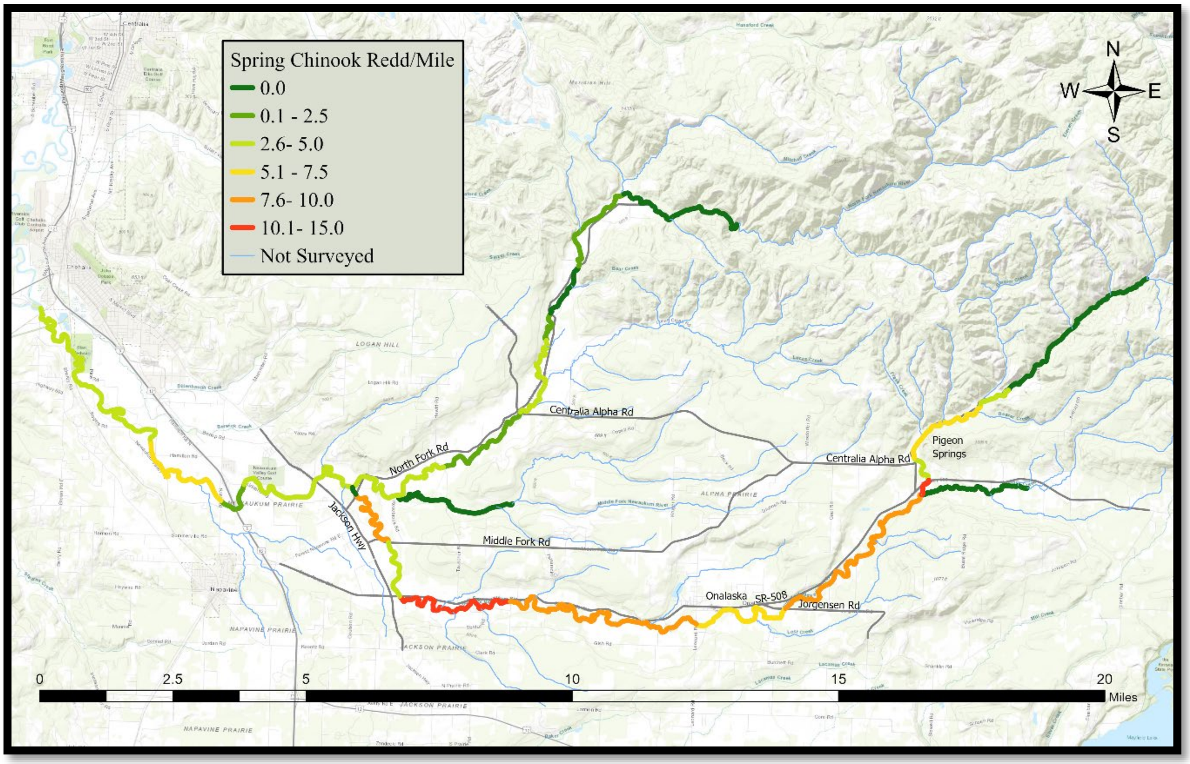

Figure 8. Distribution of 2021 spring Chinook Salmon, shown as redds mile^{-1}, for the Newaukum River basin. "Not Surveyed" sections indicate areas where presence was not expected.

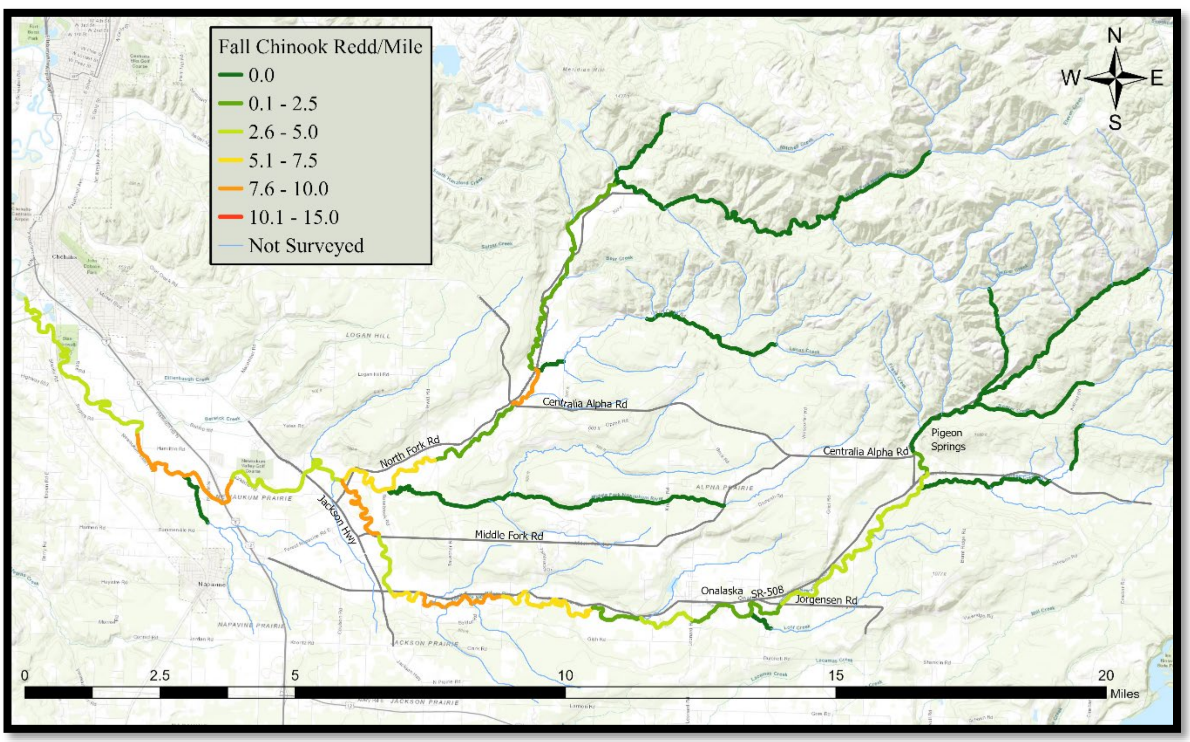

Figure 9. Distribution of 2021 fall Chinook Salmon, shown as redds mile^{-1}, for the Newaukum River basin. "Not Surveyed" sections can indicate areas where presence was possible, but field staff were unable access.

Coho Salmon primarily spawned in the forks and tributaries of the Newaukum basin in 2021 with no spawning recorded in the main stem (Figure 10). Not unexpectedly, the highest spawning density (>200 redds mile^{-1}) occurred in Gheer Creek and was associated with 96% hatchery return. Lower Lost Creek also had densities in the 200 redds mile^{-1} range and had 74% hatchery return. Many of the tributaries had areas of density greater than 50 redds mile^{-1} including Mitchell, Bernier, Lucas, Kearney and Door creeks. The North Fork Newaukum also had an area of high density over 50 redds mile^{-1} just below the water intake for the city of Chehalis. There were anecdotal reports from landowners of Coho Salmon spawning in ephemeral rivulets near their houses which were previously not expected to have Coho presence. We were unable to check all of these areas, so density and distribution of Coho Salmon is likely underestimated for 2021.

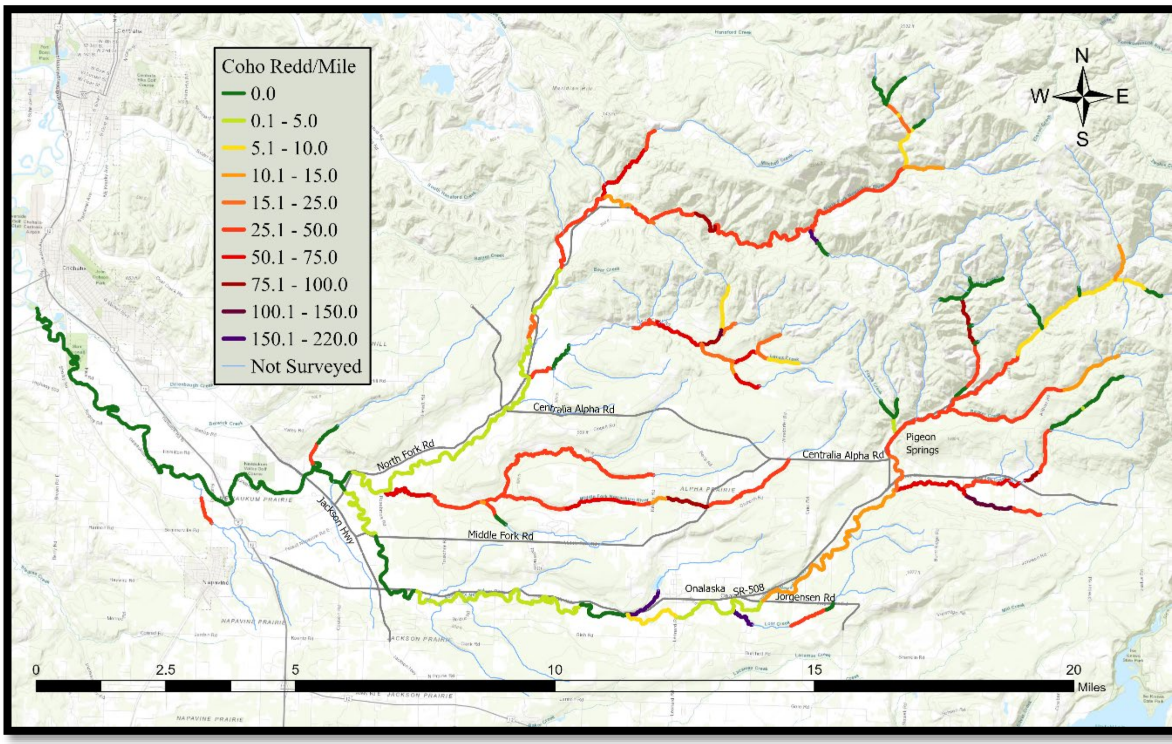

Figure 10. Distribution of 2021 Coho Salmon, shown as redds mile^{-1}, for the Newaukum River basin. "Not Surveyed" sections can indicate areas where presence was not expected or where presence was possible, but field staff were unable access.

Steelhead, like Coho Salmon, barely utilized the lower Newaukum River basin for spawning habitat in 2022 run year (Figure 11). Instead, steelhead utilized the upper extents of both the North Fork and South Fork Newaukum River. The highest densities (35 redds mile^{-1}) occurred in the South Fork Newaukum around the Pigeon Springs Area. Although spawning occurred in the Middle Fork Newaukum and other tributaries all of the tributaries had lower densities (≥10 redds mile^{-1}) when compared to the North and South forks of Newaukum River.

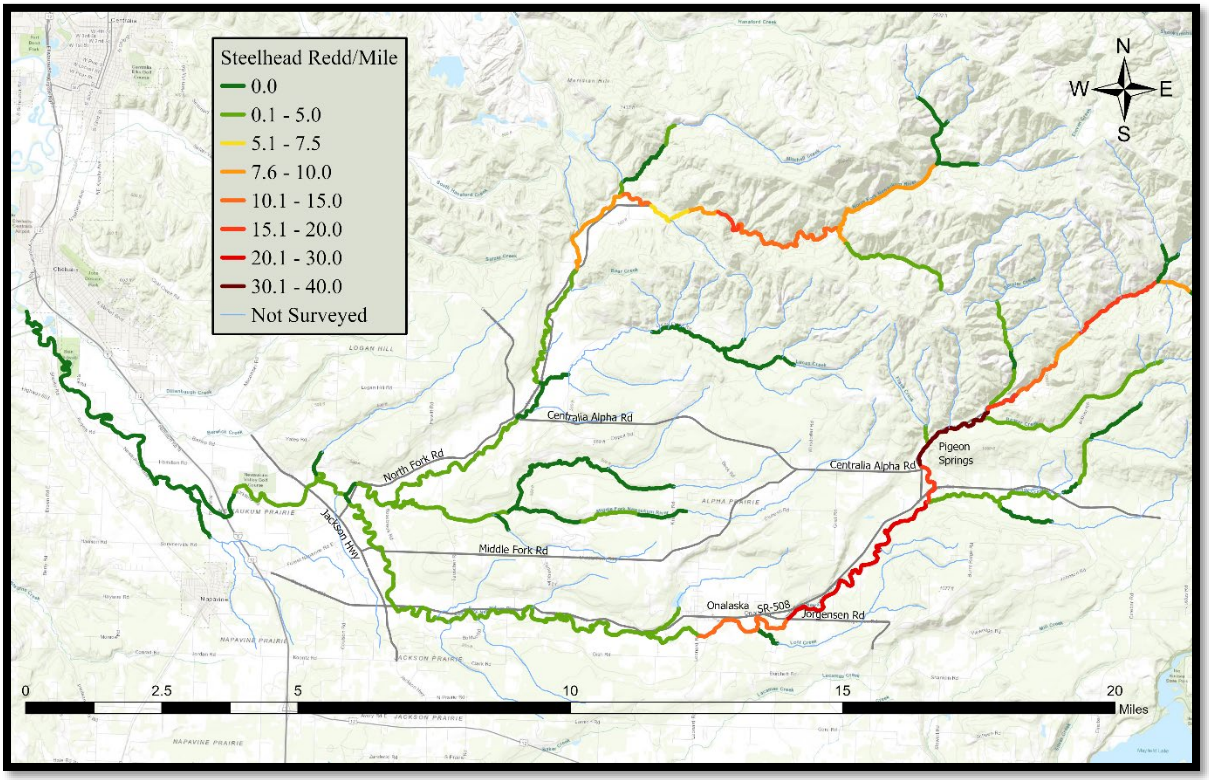

Figure 11. Distribution of 2022 steelhead, shown as redds mile^{-1}, for the Newaukum River basin. “Not Surveyed” sections can indicate areas where presence was not expected or where presence was possible, but field staff were unable access.

Run Type Genetics

Tissue samples from Chinook Salmon carcasses were collected in 2021 in an opportunistic manner during redd spawning ground surveys to determine genetic run timing and validate field calls. Of the 89 samples submitted for run timing determination, only 73 were successfully genotyped for fall or spring run types on both markers. Heterozygosity (both spring and fall markers) showed up in 23% (n=17) of the samples. The heterozygote samples were collected around the October 15th date between October 7th and October 21st (Figure 12). The earliest genotyped fall Chinook carcass that was not a pre-spawn mortality was collected on October 6th, one week before October 15th, the cut-off date for spring Chinook redd calls, and the latest spring Chinook carcass was collected October 18th. Of the fall and spring genotyped samples, ten came back different from the original field calls. Six genotyped spring Chinook were assigned fall Chinook in the field and four genotyped fall Chinook were mistaken as spring Chinook in the field. All of these incongruent calls occurred between October 7th – October 18th. Of the heterozygote genotypes, the field calls were 60% fall Chinook and 40% spring Chinook. It should be noted that the accuracy of the run-type field calls did not translate to the accuracy of the escapement estimates.

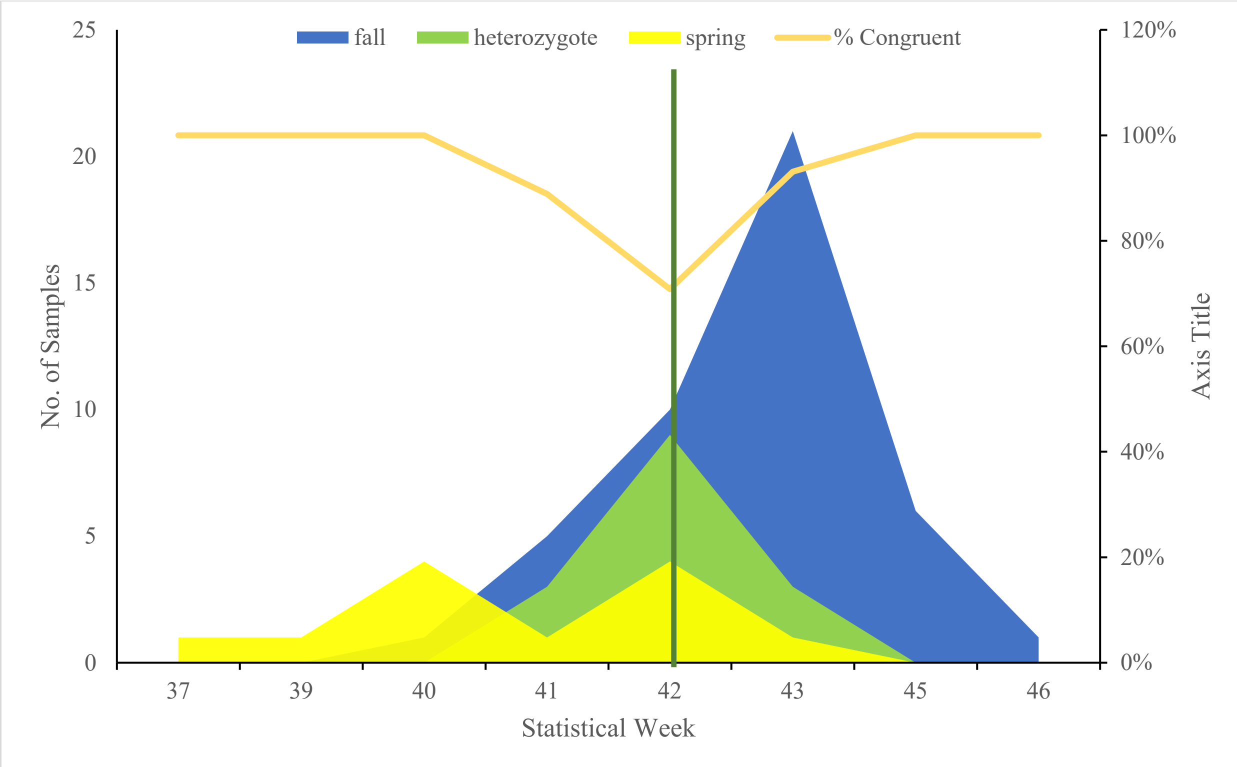

Figure 12. Genotyped run calls for 2021 Chinook Salmon in the Newaukum sub-basin. The horizontal line indicates the percentage of field assignments that were congruent with the genotype. The green vertical line shows the October 15th date used to differentiate spring from fall Chinook. No samples were recovered during statistical weeks 38 or 44.

The majority (83%) of genotyped spring Chinook were recovered in the South Fork Newaukum River but only half of those were in the upper South Fork Newaukum upstream of Onalaska. There were also single recoveries of spring Chinook in each of the North Fork Newaukum River and the main stem Newaukum River that were genotyped (Figure 13). The majority of heterozygote genotypes were recovered from the South Fork Newaukum River. One heterozygote was recovered in the North Fork and

18% in the main stem Newaukum River. The samples genotyped as fall Chinook had the broadest distribution and occurred in all areas where Chinook redds were observed.

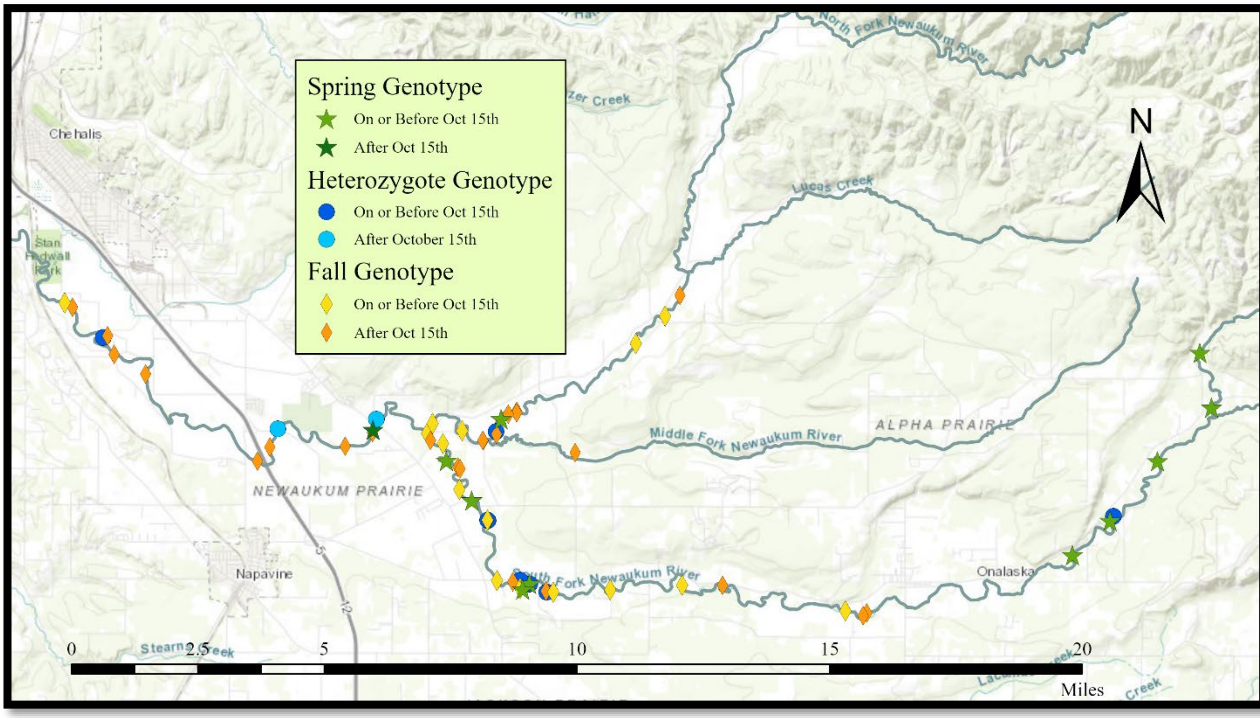

Figure 13. Location of opportunistic carcass recovery for genotyped Chinook samples collected in 2021 to show temporal and geographic separation of samples collected before and after the October 15th date used as a cut-off for spring Chinook spawning.

Discussion

Adult monitoring of salmon and steelhead in the Newaukum River basin, in conjunction with the juvenile monitoring program, is providing valuable information on population viability and the effects of habitat restoration on salmon and steelhead productivity. The Newaukum basin supports populations of spring and fall Chinook, Coho Salmon, and steelhead. On average (2000-2021) the Newaukum River contributes 28% of spring Chinook production to the Chehalis basin total. However, this value has varied annually from 18% to 45% (Appendix A). The contribution of spring Chinook from the Newaukum River in 2021 (21%) was below the average contribution for the 2000-2021 series but average for the three years of this intensive study (2019-2021). 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 (2000-2001 to 2021-2022 run years), fall Chinook, Coho Salmon, and steelhead from the Newaukum River contributed an average of 8%, 9%, and 11%, respectively, to the total Chehalis River spawner population. Overall, the percent contribution of Newaukum fall Chinook to the Chehalis River basin appears to be decreasing slightly over time with 2021 being the lowest contribution since 2000 at only 4%. In contrast, the percent contribution of Newaukum Coho Salmon to the Chehalis basin appears to be remaining relatively steady. Over the last two decades, Newaukum River steelhead decreased slightly over time in both abundance and relative contribution to the Chehalis River total. In the 2022 run year, steelhead trout in the Newaukum sub-basin contributed 13% to the Chehalis basin totals which is slightly more than the average contribution of 11%. Nevertheless, the overall steelhead abundance trend in the Chehalis River has declined over the time series. It should be noted that the new intensive monitoring methodology is different from the methodology employed in the rest of the Chehalis basin, and what was used in the Newaukum River prior to the 2019-2020 survey season. Trends and historical information will be useful in evaluating population-level responses to restoration projects and climate change.

Overall, the 2021 spring Chinook estimate in the Newaukum sub-basin was down by about 20% from the previous year. The North Fork Newaukum only contributed 11% to the Newaukum Basin spring Chinook estimate in 2021. Although North Fork Newaukum typically contributes less than the South Fork Newaukum, 2021’s contribution may have been affected by a record-breaking heatwave, one of the most extreme weather events ever recorded globally (Thompson et al. 2022). Surveyors observed around 20 dead spring Chinook in the North Fork Newaukum during this heat wave and three in the South Fork Newaukum. The total loss of spring Chinook during the summer heat wave is unknown. Recovery of spring Chinook carcasses is difficult due to intense predation and degradation and there are no regular surveys for monitoring during the summer period.

The earliest Chinook redds occur in the South Fork Newaukum above Jorgensen Road at the beginning of September. Towards the end of September, spawning transitioned to lower in the basin on the South Fork and the main stem Newaukum. However, all the live fish observed on redds during this period were consistent with the characteristics of spring Chinook (Appendix C). The first with fall Chinook characteristics appeared at the beginning of October in the lower main stem Newaukum, although the majority of fish on redds at this time still had spring Chinook characteristics. By mid-October, Chinook were observed with fall characteristics as far as Jorgensen Road. Also, at the beginning of October the first redds occurred in the North Fork Newaukum River.

The observed spatiotemporal overlap of spring and fall Chinook was confirmed with genetic run-timing analysis of carcasses collected during redd surveys in 2021. However, this opportunistic method of collecting data may be problematic for drawing conclusions about spawning location based on carcass recovery location and date. Nonetheless, there appears to be some indication that more hybridization is occurring in the main stem Newaukum and lower South Fork Newaukum as opposed to upper South Fork or North Fork Newaukum based on these results. The use of the entire main stem, including the lower section, by spring Chinook for spawning, may also indicate that some fish migrated into the Newaukum from the main stem Chehalis River just prior to spawning. The confluence of the Newaukum and Chehalis rivers has previously been identified as an area of thermal refugia (Liedtke et al. 2017) Additional effort would be needed to determine holding patterns of spring Chinook to confirm this. More work, including directed efforts to collect carcass samples, 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).

Field calls of spring and fall Chinook salmon generally agreed with the genetic results (homozygous spring and homozygous fall run-types) except during the week before and after October 15th. During this time, genotyped spring Chinook were called fall Chinook in the field (n=4) and genotyped fall chinook were called spring Chinook (n=6). It should be noted that the accuracy of the run-type field assignments did not translate to the accuracy of the escapement estimates. Run-type field calls on carcasses recovered were not applied to the escapement estimates based on redds observed before or after October 15th. Redds were only called fall Chinook before that date if there was Chinook female on the redd that had characteristics of a fall, not a spring migrant (see Appendix C). Another limitation with opportunistic carcass sampling used for genotyping is that samples are not necessarily representative of population run-timing, run size, or distribution. Quantifying the relationship between genotype and phenotype at the population level will require a much more intensive study with higher levels of carcass recovery and consideration for heterozygous run-types (spring and fall hybrids). There is currently a collaborative effort with Coast Salmon Partnership, West Fork Environmental, Quinault Tribe, and

Chehalis Tribe to quantify the relative abundance of juvenile Chinook run production using genetic data collected from fry and rotary screw traps in the Newaukum River basin. However, this will not definitively determine the expression of the genes (i.e. the timing of migration as adults).

Coho Salmon were the most abundant species spawning in the Newaukum River basin in 2021 and spawner abundance was twice what it was in 2020 and almost three times that of 2019. The 2021 estimate was about 25% higher than the 20-year average. It should be noted that in 2021 frequent high flows during the spawning season created opportunities for salmon to enter normally unused tributaries and ephemeral streams. This was indicated by anecdotal evidence from local landowners who saw live Coho Salmon in tributaries on their properties. These streams were small and had minimal to no spawning habitat available, making it impossible to verify how much, if any, spawning may have occurred in these areas. In addition to the increase in possible available habitat, frequent high flows also reduced the visibility and may have negatively biased the number of redds observed. This suggests that the escapement estimate generated in 2021 is likely an underestimate but by how much remains uncertain.

The highest densities of Coho Salmon were found in Gheer Creek with 216 redds mile^{-1} and a pHOS of 96%. Lost Creek also had high densities (200 redds mile^{-1}) of spawning and pHOS of 74%. Lost Creek is the next tributary just upstream of Gheer Creek. The high density spawning where there were fewer hatchery strays was closer to 100 redds mile^{-1} and included Door Creek, parts of upper Middle Fork Newaukum, and parts of upper North Fork Newaukum. The combined hatchery Coho Salmon stray rate for the entire Newaukum River basin was 15% pHOS, the highest recorded since intensive monitoring began in 2019. There are likely several reasons for this increase in hatchery straying, improved ocean conditions contributing to better survival, possible decrease in in-river harvest due to early fishery closures related to steelhead conservation concerns, and a change in hatchery coho release methods. Since 2019 releases, Coho Salmon smolts within the Carlisle Lake net pens have been pumped out and released directly into Gheer Creek as opposed to being release into the lake. Additionally, limited trapping of the adults upon return likely encouraged straying into other parts of the basin.

Newaukum River steelhead trout typically spawn in the upper portions of the basin. Nearly 90% spawned in the upper half of the North and South Forks of the Newaukum. There was very little spawning of steelhead in the main stem Newaukum and no spawning downstream of I-5. The hatchery component of the steelhead run 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 7% pHOS 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 based on early run timing for some hatchery stocks. 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 moved to integrated hatchery steelhead programs, which makes use of NOR broodstock, thus creating hatchery origin steelhead with spawn timing more similar to NOR steelhead as opposed to earlier timed Chambers stock. However, to remain consistent with the rest of the Chehalis River basin, HOR and NOR proportions and associated abundances were and will continue to be reported using both observational-based (live and dead sampling) and date-based methodologies.

Steelhead have complex life histories with the potential for repeat spawning; these diverse life histories can improve resilience of a population (Schindler et al. 2010). On average between 10 and 15 percent of coastal Chehalis basin steelhead each year are repeat spawners. Two repeat spawners out of forty-five samples (4.4%) were recorded in 2022 data set. This was less than the previous year (2021) of five repeat spawners or 12.5% of samples recovered, but more than the 2020 data where no repeat spawners were identified. This could have resulted from a few years of more favorable ocean conditions for marine survival (Nickelson 1986). Repeat spawning is important for population viability as older steelhead are generally larger and have increased fecundity compared to smaller and younger steelhead (Bowersox et al. 2019; Quinn et al. 2011). A closer examination quantifying interannual variation in repeat spawners would benefit from a broader dataset and comparison to other coastal steelhead populations.

As intensive adult monitoring continues in the Newaukum River basin, future work will continue to focus on generating unbiased estimates of spring and fall Chinook, Coho Salmon, and steelhead spawner abundance and evaluating distribution, run timing, and life history diversity. A continued effort to cover the spawning habitat on a weekly basis for all species will help to produce accurate estimates. However, it may be necessary to consider new methodologies for Coho Salmon due to their broad distribution. As additional years of information with differing flow and abundance regimes are added to the time series, understanding interannual variability in spatial distribution throughout the basin will be refined. Combining adult spawning estimates with juvenile smolt production estimates will also inform adult to smolt (freshwater) production and smolt to adult (ocean) survival, providing valuable information on limiting stages throughout the life cycle. The adult to smolt estimates for the Newaukum fish-in fish-out study showed 46.3 smolts-per-spawner for the 2021 Chinook brood year (Olson et al. 2023 in press). For the 2019 and 2020 Chinook brood years smolts-per-spawner values were 139.9 and 97.5, respectively. This decrease over the first three years of the fish-in fish-out study may be due to reduced fecundity of adults or survival to smolt age. Additional information provided by this work will improve the ability to detect changes in salmon and steelhead productivity and population viability as a result of restoration actions and climate change.

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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%
2020	700	2,828	25%
2021	545	2,578	21%

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	11,129	8%
2020	1063	15,934	7%
2021	423	9,591	4%

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	7%
2020	2,770	20,675	13%
2021	5,594	58,059*	10%

*Preliminary

d) Steelhead Trout

For 2020 and 2021 steelhead trout in the Newaukum, both the observational (includes both HOR and NOR) and the date derived (NOR only) methods are shown. Prior to 2020, only the date-based method was available and when comparing to the rest of the basin, therefore the date-based method is shown 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	6,280	15%
2021	1,214	987	5,631	18%
2022	766	674	5,350	13%

* No separate Newaukum estimate reported

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

		2021-2022	**2020-2021**	**2019-2020**	**Pre-2019**
Spring Chinook	Index	44.2	44.2	47.8	5.5
	Supplemental	6.6	4.4	0.8	36.5
		50.8	**48.6**	**48.6**	**42.0**
Fall Chinook	Index	52.8	51.4	53.0	5.5
	Supplemental	19.0	19.9	18.3	42.1
		71.8	**71.3**	**71.3**	**47.6**
Coho Salmon	Index	74.9	73.2	72.9	4.0
	Supplemental	27.8	26.7	18.0	33.6
		101.9	**99.9**	**90.9**	**37.6**
Steelhead	Index	74.5	74.7	77.2	10.1
	Supplemental	15.3	11.6	10.3	28.3
		89.8	**86.3**	**87.5**	**38.4**

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

		Spring Chinook	Fall Chinook
Overlap			
	Fish[a]	Grey, olive, or black/dark in color; Dull and/or dusky appearance, not bright and shiny colors; Low energy level, lethargic, exhibiting an unwillingness to be spooked off of redds (for females) or into quick currents; [b] Fungus present on fish and edges of snout, and fins showing wear; Have a soft caudal peduncle	Red, green, or purple in color; Bright, shiny colors, vivid High energy level, spooking easily and powering through riffles and low water areas, exhibiting a frantic behavior when spooked or scared No or minimal amounts of fungus and/or wear Have a firm caudal peduncle
	Redds	Presence of a spring 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	Presence of a fall Chinook female;
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 2021-2022 survey season.

From Date	To Date	Statistical Week	From Date	To Date	Statistical Week
8/29/2021	9/4/2021	36	1/30/2022	2/5/2022	6
9/5/2021	9/11/2021	37	2/6/2022	2/12/2022	7
9/12/2021	9/18/2021	38	2/13/2022	2/19/2022	8
9/19/2021	9/25/2021	39	2/20/2022	2/26/2022	9
9/26/2021	10/2/2021	40	2/27/2022	3/5/2022	10
10/3/2021	10/9/2021	41	3/6/2022	3/12/2022	11
10/10/2021	10/16/2021	42	3/13/2022	3/19/2022	12
10/17/2021	10/23/2021	43	3/20/2022	3/26/2022	13
10/24/2021	10/30/2021	44	3/27/2022	4/2/2022	14
10/31/2021	11/6/2021	45	4/3/2022	4/9/2022	15
11/7/2021	11/13/2021	46	4/10/2022	4/16/2022	16
11/14/2021	11/20/2021	47	4/17/2022	4/23/2022	17
11/21/2021	11/27/2021	48	4/24/2022	4/30/2022	18
11/28/2021	12/4/2021	49	5/1/2022	5/7/2022	19
12/5/2021	12/11/2021	50	5/8/2022	5/14/2022	20
12/12/2021	12/18/2021	51	5/15/2022	5/21/2022	21
12/19/2021	12/25/2021	52	5/22/2022	5/28/2022	22
12/26/2021	1/1/2022	53/1	5/29/2022	6/4/2022	23
1/2/2022	1/8/2022	2	6/5/2022	6/11/2022	24
1/9/2022	1/15/2022	3	6/12/2022	6/18/2022	25
1/16/2022	1/22/2022	4	6/19/2022	6/25/2022	26
1/23/2022	1/29/2022	5	6/26/2022	7/2/2022	27

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".