Newaukum Adult Salmon and Steelhead Spawner Abundance, 2023-2024

Lea Ronne[1], Katlyn Nielsen[1], Marisa Litz[2], Mike Scharpf[1], Todd Seamons[2], and Andrew Claiborne[2]

Author information:
[1]Washington Department of Fish and Wildlife Region 6 Fish Management, 48 Devonshire Rd, Montesano, WA 98563
[2]Washington Department of Fish and Wildlife, Fish Science Division, 1111 Washington St SE, Olympia WA 98501

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Executive Summary

The Newaukum River basin has served as a critical pilot watershed for monitoring and guiding salmon and steelhead recovery projects within the Chehalis River basin since 2019. This report details findings from the 2023-2024 survey season, focusing on Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*), and steelhead trout (*O. mykiss*).

Census, redd-based escapement surveys were conducted in 2023-2024, similar to previous years, with additional methods implemented for a second year to evaluate the feasibility of refining and improving escapement estimation techniques for Chinook Salmon. In addition to the redd-based estimates, we conducted carcass mark-recapture and trans-generational genetic mark recapture studies to estimate Chinook escapement. The additional carcass recovery efforts needed for these methods allowed us to increase our sample size for genetic run timing evaluation. For Coho Salmon and steelhead trout, a traditional redd-based escapement method, using index and supplemental surveys, was conducted. Major findings for the 2023-2024 season were:

Chinook Salmon (Oncorhynchus tshawytscha)

- **Abundance**: An estimated total of **698** Chinook spawners were observed using the redd-based method, with **383** classified as spring-run and **315** as fall-run based on field identification and an October 15th cutoff date to distinguish spring- from fall-run spawners.
- **Genetic Analysis**: Genetic testing of 96 Chinook carcasses from 2023 identified 6% as genetically spring-run, 21% as heterozygotes, and 73% as fall-run, highlighting the complexity of run-type structure and the presence of genetic hybrids. *Note: Early spring Chinook carcasses are less likely to be recovered, which may affect representation in the genetic dataset.*
- **Run-Type Overlap**: Among carcasses sampled prior to October 15th, genetic results indicated a mix of 45% fall-run, 42% hybrids, and 13% spring-run. These findings suggest that overlap in spawning timing complicates classification based solely on observation date and phenotypic traits.
- **Distribution**: The earliest Chinook spawning occurred in the Pigeon Springs area above the 508 Highway on the South Fork Newaukum. Minimal to no spawning occurred in the last few years before October 15th in the North Fork Newaukum.
- **Life History**: Most Chinook exhibited a sub-yearling ocean-entry life history, migrating to the ocean after one winter in freshwater. Age composition of returning adults was primarily Age-4 (67%) and Age-3 (21%).
- **Challenges**: The October 15th cutoff date for distinguishing spring and fall Chinook redds may overestimate the number of pure spring-run Chinook. Continued development of more nuanced methods, including genetic tools, is needed to improve understanding of population structure and run-type distribution. Additional research is also needed to clarify the role of hybrid individuals in the long-term dynamics of Chinook populations in the Chehalis Basin.

Coho Salmon (Oncorhynchus kisutch)

- **Abundance**: Estimated total of **5,217** spawners, with **3,888** natural origin (NOR) and **1,329** hatchery origin (HOR).

- **Hatchery Influence:** The proportion of hatchery-origin spawners (pHOS) in the Newaukum River basin declined from 53% in 2022 to 25% in 2023—a substantial reduction. Efforts to increase harvest opportunities for hatchery-origin coho could further reduce pHOS and limit hatchery influence on the natural spawning population.
- **Distribution**: Coho Salmon continued to utilize almost all smaller tributaries throughout the basin, emphasizing the importance of small stream restoration efforts to support their spawning and rearing habitat.
- **Life History**: Carcass analysis showed a nearly even sex ratio (52% male, 48% female), with an average fork length of 64.3 cm for females and 66.4 cm for males.

Steelhead Trout (Oncorhynchus mykiss)

- **Abundance**: Estimated total of **1,230** spawners, with **1,045** NOR and **185** HOR, based on the March 15th cutoff date.
- **Distribution**: Spawning occurred mainly in the upper portions of the North Fork and the mid- and upper-South Fork Newaukum River. Steelhead used smaller tributaries, but less frequently than Coho Salmon, and more often while flows were high.
- **Life History**: The predominant freshwater residence time was two years, with most steelhead spending only one year in the ocean before returning to spawn. No repeat spawners were observed in 2024.
- **Challenges**: The March 15th cutoff date for distinguishing NOR from HOR steelhead is imperfect, and better methods for determining hatchery influence are needed.

This year's monitoring results highlight the complexity of salmonid population dynamics in the Newaukum River basin and underscore the need for adaptive habitat restoration strategies. For Chinook Salmon, the presence of heterozygotes and observed shifts in spawn timing point to the importance of protecting and restoring habitats that support both early- and late-spawning fish. Continued refinement of run-type classification methods is also needed to improve population assessments and guide effective management. Coho Salmon's significant use of smaller tributaries emphasizes the value of targeted restoration in these systems, rather than focusing solely on larger mainstem habitats. Steelhead monitoring suggests relatively stable population dynamics in the short term, but also highlights the need to protect key habitats that support diverse life histories. At the same time, data gaps remain regarding run timing and the origin of naturally spawning steelhead and Chinook, reinforcing the need for more accurate and timely monitoring approaches. Overall, ongoing, rigorous monitoring remains essential for guiding effective conservation and restoration strategies in the face of environmental change.

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 to identify means to protect communities and fish from flooding while restoring habitat to support aquatic and semi-aquatic species (http://chehalisbasinstrategy.com/). The Newaukum sub-basin was selected in 2015 by the Chehalis Lead 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 (Ronne et al. 2021) and 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 resulting from 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% (22% average from 2000-2022) to 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, 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 estimates of escapement (i.e., the number of salmon not caught by commercial or recreational fisheries that return to their natal habitat, Johnson et al. 2007).

Starting in 2022, leveraging the existing intensive monitoring infrastructure, we initiated a project funded by the Pacific Salmon Commission (PSC) to compare different Chinook monitoring methods: the limited monitoring by WDFW prior to 2019, the current intensive monitoring, carcass mark-recapture (CMR), and transgenerational genetic mark-recapture (tGMR). The goal of this companion study is to refine and improve escapement estimation techniques for application throughout the Chehalis River basin.

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, and steelhead in the Newaukum River sub-basin during return years 2023-2024, and to determine the abundance of adult spawners above the juvenile fry and smolt traps (Figure 1) as part of the fish in / fish out monitoring program supported by the Chehalis Basin Strategy.

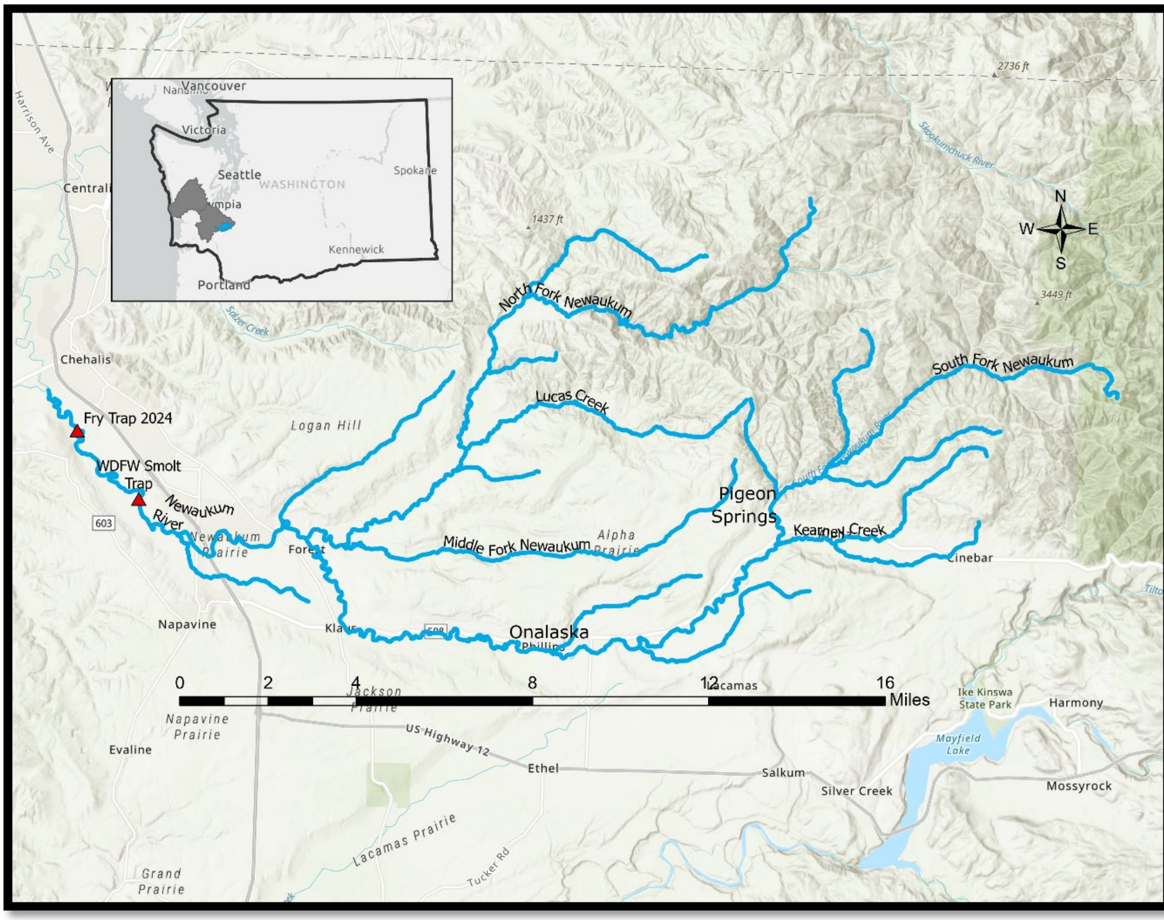

Figure 1. *Overview map of the Newaukum River, sub-basin of the greater Chehalis River basin, showing the juvenile trap sites.*

Methods

Study Design and Area

The study area is 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. Beginning 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 study designs used for this project, a census index for Chinook and an index and supplemental for Coho Salmon and steelhead trout. Both study designs used redd counts to generate spawner estimates based on a fish-per-redd expansion. Census index surveys were designed to cover all the available anadromous spawning areas and occurred approximately every seven days throughout both spring and fall Chinook spawning. Index and supplemental surveys occurred for Coho and steelhead. Coho index surveys covered approximately 70% of the spawning habitat and were conducted weekly, with supplemental surveys occurring on the remaining habitat once or twice during the peak of spawning. Steelhead index surveys were conducted on the majority of spawning habitat (98%) with a 7–14-day rotation and additional supplemental surveys conducted once during the peak of spawning to target potential spawning habitat not surveyed on a regular basis. The ratio of redds visible in an index section during peak spawning to redds observed in that index throughout the entire season was applied to expand supplemental survey observations to account for the entire spawning season.

Additional Chinook spawning escapement methodologies were implemented in 2023 as part of a complementary project to compare the redd-based estimates to other methods such as carcass mark recapture (CMR) and trans-generational genetic mark recapture (tGMR).

Data Collection

Spawning ground surveys were conducted from September 2023 through June 2024, 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, 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) to accurately 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 field run timing (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 to 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 B). 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.

For Coho and steelhead, 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. Six or more scales were taken from each steelhead for ageing.

Surveys for Chinook carcasses were more intensive with surveys happening twice per week. In the South Fork Newaukum, a CMR study was implemented using an open population mark-recapture study design. This design has several assumptions (Seber 1982):

1. ***Equal Catchability***: Each carcass that is present during a sampling event, tagged or untagged, has the same probability of being sampled.
2. ***Equal Persistence***: Each carcass, tagged or untagged, has the same probability of survival (i.e., persisting in the study areas to following sampling period).
3. ***Tag Loss and Recovery***: Tagged carcasses do not lose their marks and all marks are recognized and recorded properly on recovery.
4. ***Instantaneous Sampling***: The samples are instantaneous, (i.e., the time it takes to sample and release the sample is negligible).

Sampling methods were designed to minimize, as much as possible, any violations to these assumptions. Each dead fish was examined for tags placed the previous week and if no tags were present, fish condition was assessed to see if the fish was suitable for tagging (Figure 2).

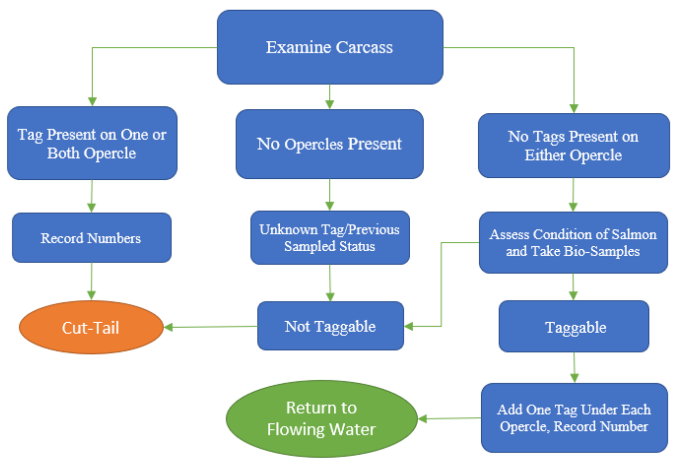

Figure 2. *Chinook Salmon carcass sampling flowchart.*

It was important to examine both opercles for tags and note if a) tags were present, b) no tag was present but opercle was present, or c) if the opercle was missing. If a fish was recovered with one tag present on one opercle but no tag present on the other opercle, it was considered a tag loss on recapture. If the opercle was missing it was not considered a loss on recapture. If the fish was not tagged it was assessed to determine if the carcass was likely to survive until the next survey event.

Carcass condition was rated as follows and only conditions 1-3 were considered taggable:

1. Fresh, clear eyes, red gills, firm flesh, both opercles intact
2. Clear eyes, mostly firm flesh but may have some softening, white gills, both opercles intact
3. Cloudy eyes, flesh softer but intact, both opercles intact
4. Cloudy eyes, flesh very soft
5. Falling apart, skeleton

Carcasses suitable for tagging had one tag stapled under each opercle and were returned to a moving body of water so that they could mix with the remaining populations. Biodata was collected from all Chinook on the first encounter only, including scales for aging and fin clips for genetic run timing analysis and tGMR.

Analysis

Redd Estimates

Estimates of abundance were based on 1) enumerated redds in index reaches, 2) enumerated and expanded redds in supplemental reaches, and 3) redd density expanded for unsurveyed habitat within the survey frame. 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 ≥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, 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 natural 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.

Recovered carcasses of adult Chinook, Coho, 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 (Appendix E). Life history diversity was assessed based on age structure (years in freshwater and the ocean) and summarized for the sampled population. Age data was not collected from Coho in 2023 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.

Carcass Mark Recapture

Carcass tagging data were used to estimate spawner abundance in CMR index reaches. The carcass tagging data were analyzed with a Jolly-Seber (JS) estimator. The formula for the JS estimator is:

$$\widehat{N} = \frac{(M+1)(C+1)}{R+1} - 1$$

M = number of **marked carcasses** (initially tagged)
C = number of **carcasses checked** (i.e., examined for tags in later sampling)
R = number of **recaptured tagged carcasses**
$\widehat{N}$= **estimated population size**

The JS estimator of spawner abundance estimate for each reach was based on the “super population” model (Schwarz et al. 1993) and parameterized in a Bayesian framework. A comprehensive description of this JS model, including summary statistics, fundamental parameters, derived parameters, and likelihoods can be found in Rawding et al. (2014) and Bentley et al. (2018). For this model, spawner escapement is the sum of gross births (i.e., arrival of new carcasses) that enter the system over the study period and includes the estimated number of carcasses present during each sampling period and the carcasses estimated to have entered the system after one sampling period and removed from the system prior to the next sampling period.

Genetic Analysis

Tissue samples from Chinook carcasses in 2023 (n=96) 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-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 sample, pools were sequenced, de-multiplexed, and genotyped by generating a ratio of allele counts. The process has four segments: extraction, library preparation, sequencing, and genotyping. WDFW's Chinook Salmon Gtseq SNP panel has one sex ID marker, 298 nuclear SNP markers, and 33 markers known to be correlated with run timing. The Thompson et al. (2019) SNP markers used in previous analyses are two of the 33 markers. The genotypes of thirteen of the additional markers are 100% correlated with those of the Thompson et al. (2019) markers in Chehalis Chinook Salmon. The genotypes of the additional informative markers were used to infer run-timing of individuals who had missing data at both Thompson et al. (2019) markers. To call run-type using the Thompson et al. (2019) markers, the genotyping results from both SNPs (homozygous spring-run, heterozygous, or homozygous fall-run) were required to agree. Using the additional informative markers, genotypes for at least two of the markers had to be present and had to agree in run-type call.

Scale Analysis

Scale analysis was used to determine age and iteroparity (the ability to spawn more than once). The scale analysis was completed by the WDFW Fish Ageing Lab. 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 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, 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 in the Gilbert/Rich notation is equal to total age. The subscript describes the year of life the fish migrated to sea.

Results

Run Timing All Species

The first spring Chinook redds were observed in early September 2023, equivalent to statistical week (week of the year, SW) 37 (Figure 3, Appendix C). Peak spawning occurred in the beginning of October (SW 41). The first fall Chinook redd was observed in SW 40 overlapping with the spring Chinook peak spawning. Fall Chinook spawning peaked mid-October (SW 42) and continued to spawn four weeks past the peak week to mid-November (SW 46). The first Coho redds were observed at the end of October (SW 42) overlapping with the last four weeks of fall Chinook spawning. Coho in the Newaukum typically have a bimodal spawning pattern with two waves called A and B runs. The A-run spawning normally begins in early December (SW 49) while B-run spawning occurs later in January (SW 4). This was clearly shown in the 2021 and 2020 runs but not as clearly in the 2019 or 2022 run. In 2023, a large A-run peak was seen earlier than normal during SW 46; however, it was protracted and corresponded with a high flow event during SW 49 in the middle of the peak. There was a small B-run peak during SW 5, similar to timing in previous years. The first steelhead were observed spawning in late December in Beaver Creek and at least one of the spawning steelhead was observed to have no adipose fin (HOR). Following this, there was a four-week gap; the next redds observed were in SW 5 and peaked in mid-March (SW 12), one week after the state used date to determine hatchery origin (HOR) steelhead from natural origin (NOR) steelhead. Steelhead continued to spawn for an additional 10 weeks to the end of May 2024 (SW 22).

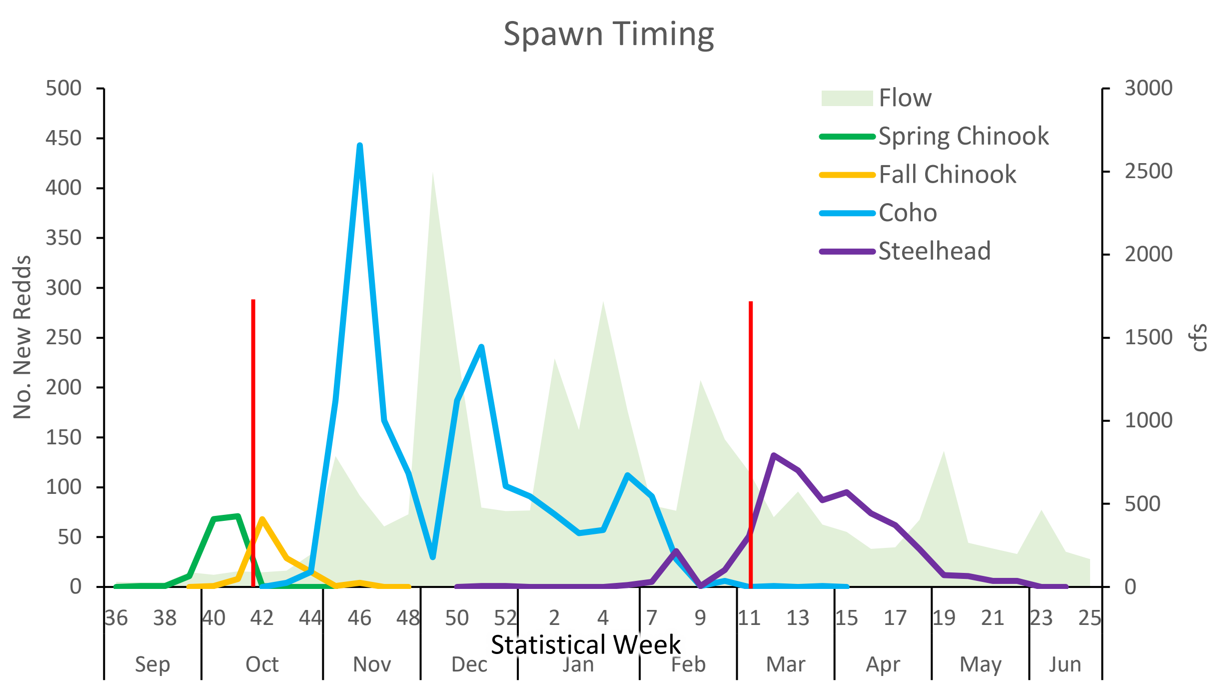

Figure 3. *Run timing for 2023 Pacific Salmon and 2024 steelhead trout in the Newaukum River basin of new redds observed. The red vertical lines show the standard October 15th and March 15th cutoff*

dates that the Washington Department of Fish and Wildlife uses to distinguish spring Chinook from fall Chinook and hatchery-origin from natural-origin steelhead trout for abundance estimates and management purposes. The light green area indicates flow rates in cubic feet/second (cfs).

Chinook Salmon

Run-Type Genetics

Tissue samples from Chinook carcasses were collected in 2023 during spawning ground surveys to determine genetic run type. Carcass surveys were conducted twice a week to increase sample size. Field staff classified carcasses as either 'spring' or 'fall' based on phenotypic characteristics, though these classifications are not used to assign redd origin in the redd-based method. However, they are used in the carcass mark-recapture (CMR) method, so understanding their alignment with genetic results remains important for interpreting that estimate. Of the 131 carcasses encountered, tissue samples were collected from 117, and 96 (92 adults, 4 sub-adults) returned genetic run-type results. Of these, 6% (n=6) were genetically identified as spring, 21% (n=20) as heterozygotes, and 73% (n=70) as fall Chinook. Among field-identified spring Chinook carcasses, only 10% matched the spring genetic designation (Figure 4). Of the 31 carcasses sampled before the October 15th cutoff—used to differentiate spring and fall redds—45% (n=14) were genetically fall-run, 42% (n=13) heterozygotes, and only 13% (n=4) genetically spring-run (Figure 5). All female carcasses collected prior to October 15th were either spent or partially spent, suggesting they likely contributed to redds constructed before their recovery.

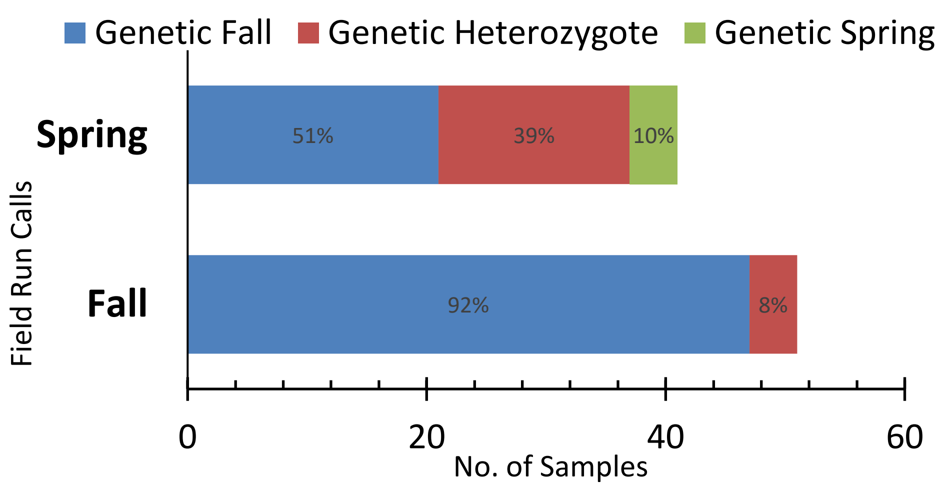

Figure 4. *Successfully genotyped Chinook samples compared to field run calls from the Newaukum River basin, showing sample size and percent composition. Includes sub-adult males.*

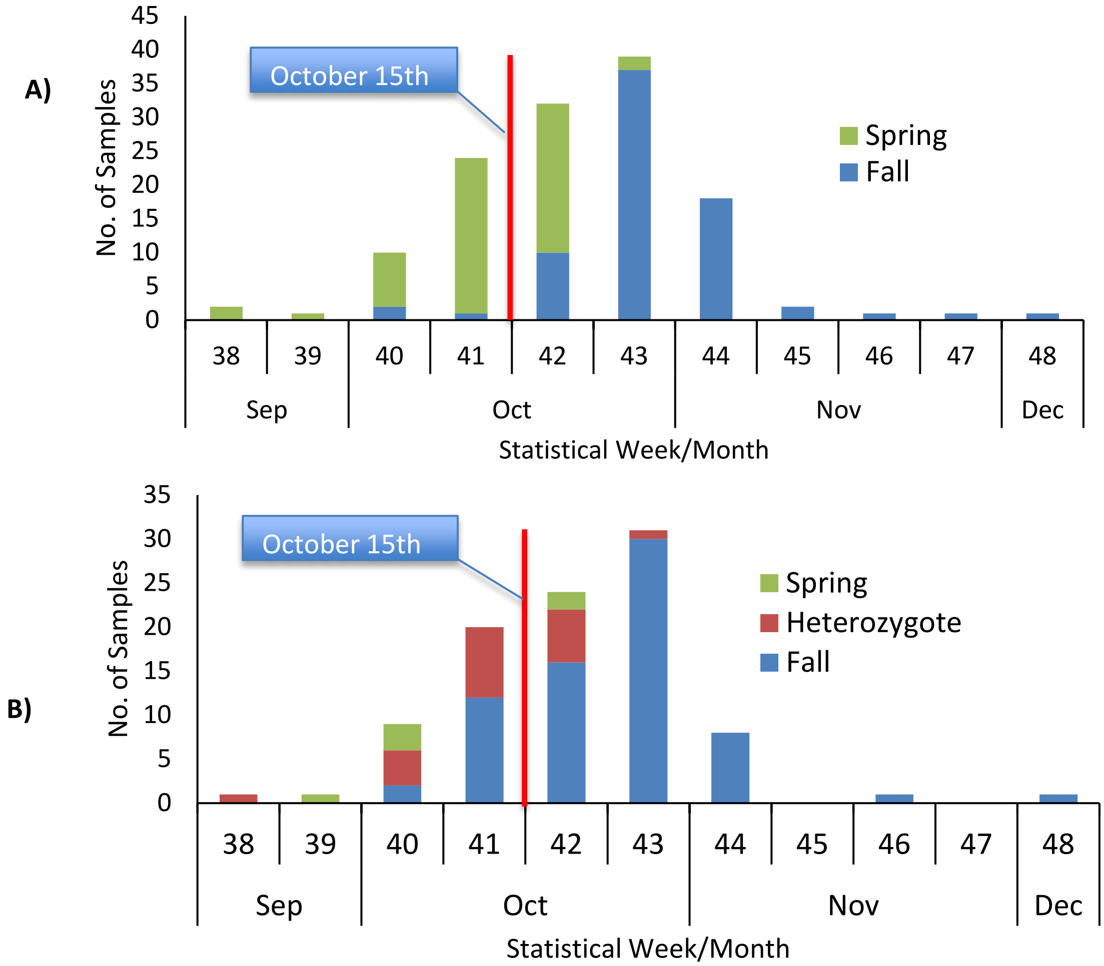

Figure 5. *Carcass run calls by week of year (statistical week) for 2023 Chinook Salmon in the Newaukum sub-basin. A) Run based on field calls. B) Run based on genetic testing. The redd vertical line shows the October 15th date used to differentiate spring from fall Chinook* ***redds*** *when no lives are present on redds.*

Six Chinook carcasses were identified as genetic homozygous spring run-type; four were recovered in the South Fork Newaukum below Onalaska, and two were recovered in the main stem Newaukum (Figure 6). No samples were recovered in the North Fork Newaukum in 2023. By contrast, genetic homozygous fall Chinook and heterozygous Chinook run-types were recovered in the South Fork Newaukum, both above and below Onalaska, in the lower half of the North Fork Newaukum, and in the main stem Newaukum.

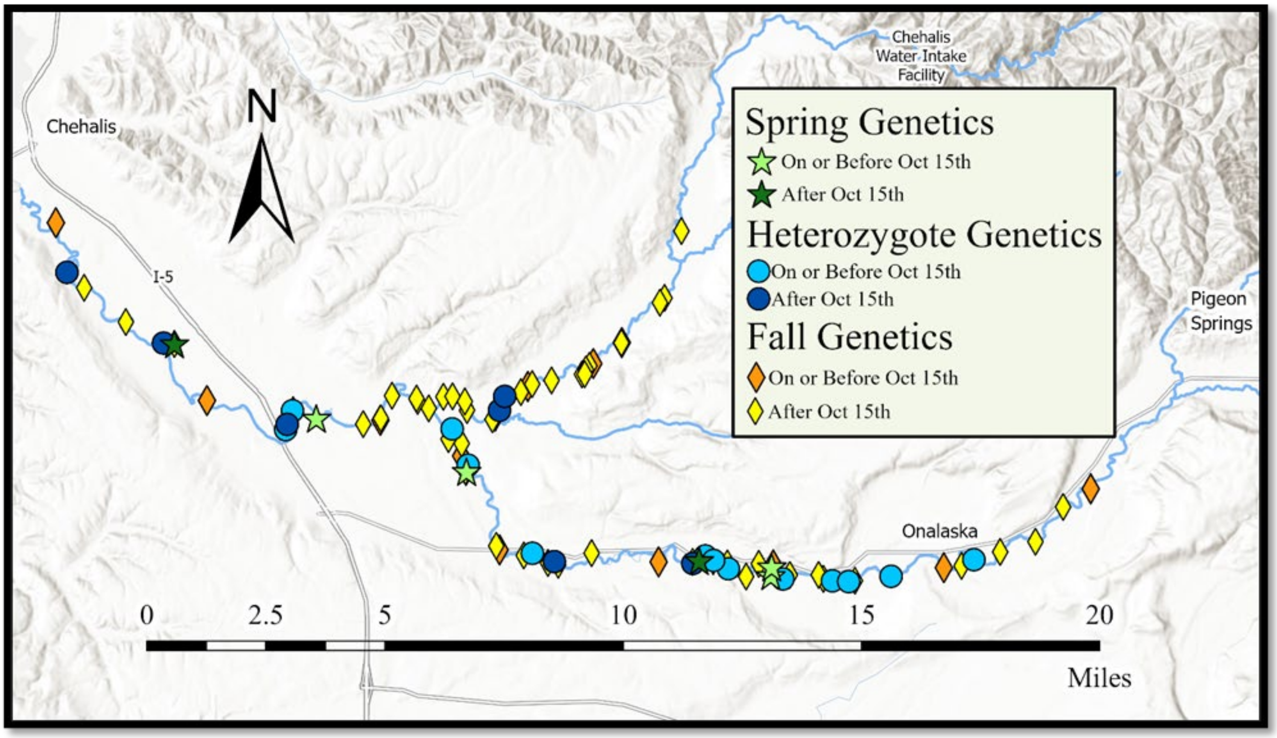

Figure 6. *Location of opportunistic carcass recovery for genotyped Chinook samples collected in 2023 to show temporal and geographic separation of samples collected before and after the October 15th date used as a cut-off for spring Chinook redd determination.*

Abundance

In 2023, multiple methods were used to estimate adult spawner abundance to verify or recalibrate escapements of Chinook in the Newaukum River basin. These methods included redd-based estimates (pre-2019 and current methodologies), a carcass-mark-recapture (CMR) method, and a transgenerational genetic mark-recapture (tGMR) method. Abundance estimates for tGMR are not fully reported in this paper as the work covers a broader scope than just adults. In addition, we explored genetic testing to apportion run-types from the redd-based estimates as a possible alternative to the current October 15th date method.

Redd Based Estimates

The current method of census redd surveys estimated 383 spring Chinook adults and 315 fall Chinook using the October 15th cut-off date between spring and fall Chinook redd construction (Table 1). Total Chinook estimates in 2023 were about 3% higher than 2022 (n=674), which had the lowest escapement since the study commenced in 2019, and 153% less Chinook than 2020 (n=1,763), which was the highest estimate of the time series (2019-2023). Using the genetic proportions of carcasses to separate the redd based Chinook estimates into run-types, we observed a much smaller homozygous spring Chinook run of only 30 adults (compared to 383), a larger homozygous fall Chinook component of 516 adult spawners (compared to 315), and 152 heterozygote adult spawners, which cannot be identified using the redd based methodologies. Using the proportion of run-types based on genetics from carcasses assumes equal rate of capture of all carcasses.

Table 1. *Abundance estimates for 2023 returns from census redd surveys using the current method (October 15th cutoff date and live calls on redds) to determine run-type and run-type proportioned based on the genotyped carcasses. Note: Proportioning based on carcass recovery assumes equal catchability of all carcasses.*

Run-Type	Current Method	Genotype
Spring Chinook	383	30
Fall Chinook	315	516
Heterozygote	-	152
Total Chinook	698	698

Carcass Mark Recapture Estimates

Carcass tagging in 2023 was conducted throughout the Newaukum River basin on all Chinook Salmon. We tagged 67 chinook carcasses and recovered nine tagged carcasses. This generated an estimate of 351 (95% C.I. = 231-952) adult Chinook Salmon, with 162 spring Chinook (95% C.I. = 87-521) and 183 fall Chinook (95% C.I. = 116-517) based on the CMR JS model (Table 2). That estimate was proportioned by the run call prior to any genetic testing. Therefore, the large confidence interval was attributed to the small sample size of tagged and recovered carcasses. The CMR method estimated 58% fewer spring Chinook than the redd survey-based method, 42% fewer fall Chinook, and 50% fewer Chinook overall. However, this method did produce an estimate with known precision, and the 95% C.I. did encompass the redd survey-based escapement estimate.

Table 2. *Adult escapement estimates for spring and fall Chinook from the Newaukum River sub-basin within Grays Harbor, Washington in 2023 using carcass mark-recapture (CMR).*

	NOR	95% CI
Spring Chinook	162	87-521
Fall Chinook	183	116-517
Total	351	231-952

Distribution

The spawning distribution of Chinook was limited to the forks and main stem Newaukum River, similar to years 2019-2021. In 2023, 91% of spring Chinook spawned upstream of the smolt trap and 98% spawned upstream of the fry trap (Table 3). We also estimated that 94% of fall Chinook spawned upstream of the smolt trap and 99% spawned upstream of the fry trap.

Table 3. *Spawning distribution of 2023 Chinook in relation to the juvenile traps collecting the outmigrant smolt and fry. Run differentiation based on redd calls and cutoff date.*

	Upstream %	
	WDFW Smolt Trap	**2023 Fry Trap**
Spring Chinook Salmon	91%	98%
Fall Chinook Salmon	94%	99%

The majority (>50%) of spawning spring Chinook occurred in the South Fork Newaukum (Figure 7) consistent with patterns observed in years prior to 2022. Also, in years prior to 2022, there was an isolated group of spawning spring Chinook that occurred in the Pigeon Springs area of the South Fork Newaukum, upstream of the Highway 508 bridge. This Chinook spawning cluster typically occurs earlier than the rest of the basin. In 2023, although the majority of spawning was in the South Fork Newaukum, we only observed two early redds in that area.

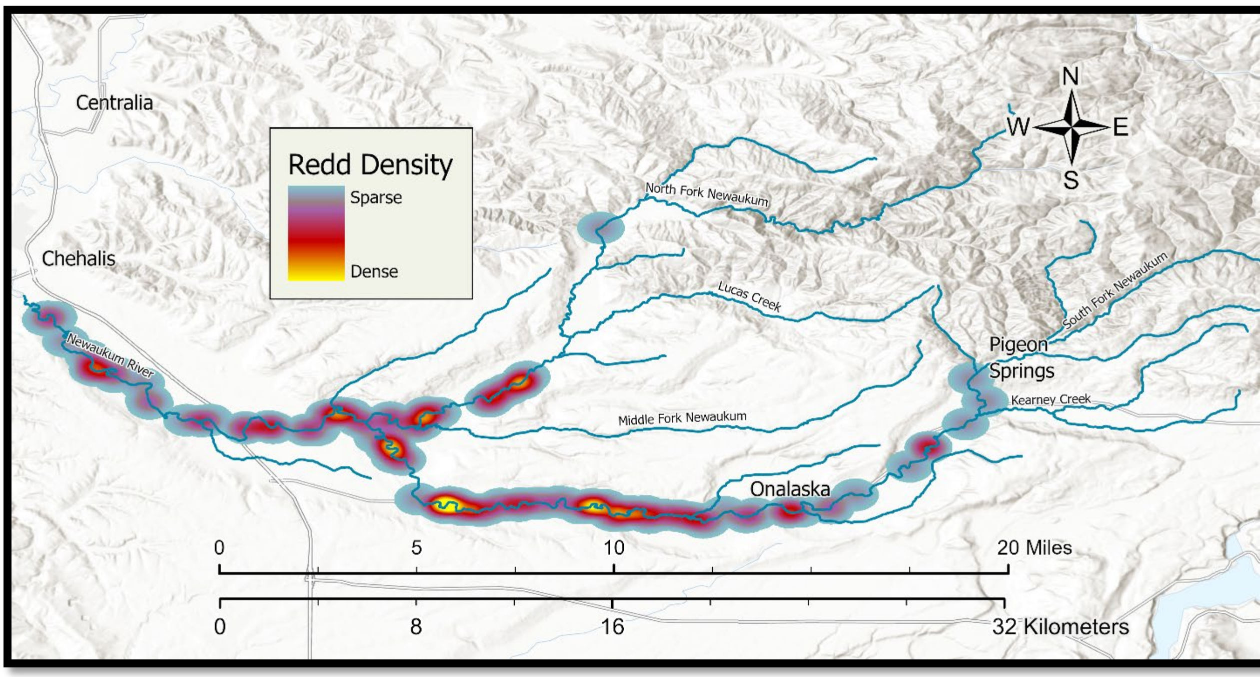

Figure 7. *Density and distribution of 2023 spring Chinook Salmon redds, with high density areas in yellow, for the Newaukum River basin.*

In 2023, fall Chinook exhibited the highest spawner densities in the South Fork, North Fork, and upper mainstem Newaukum River (Figure 8). This spatial distribution was consistent with observations from previous years, with the exception of 2022, when peak spawning density was recorded in the mainstem Newaukum below the I-5 bridge. Notably, redds were observed early in the season in the Pigeon Springs area; however, no carcasses were recovered from this location during subsequent surveys.

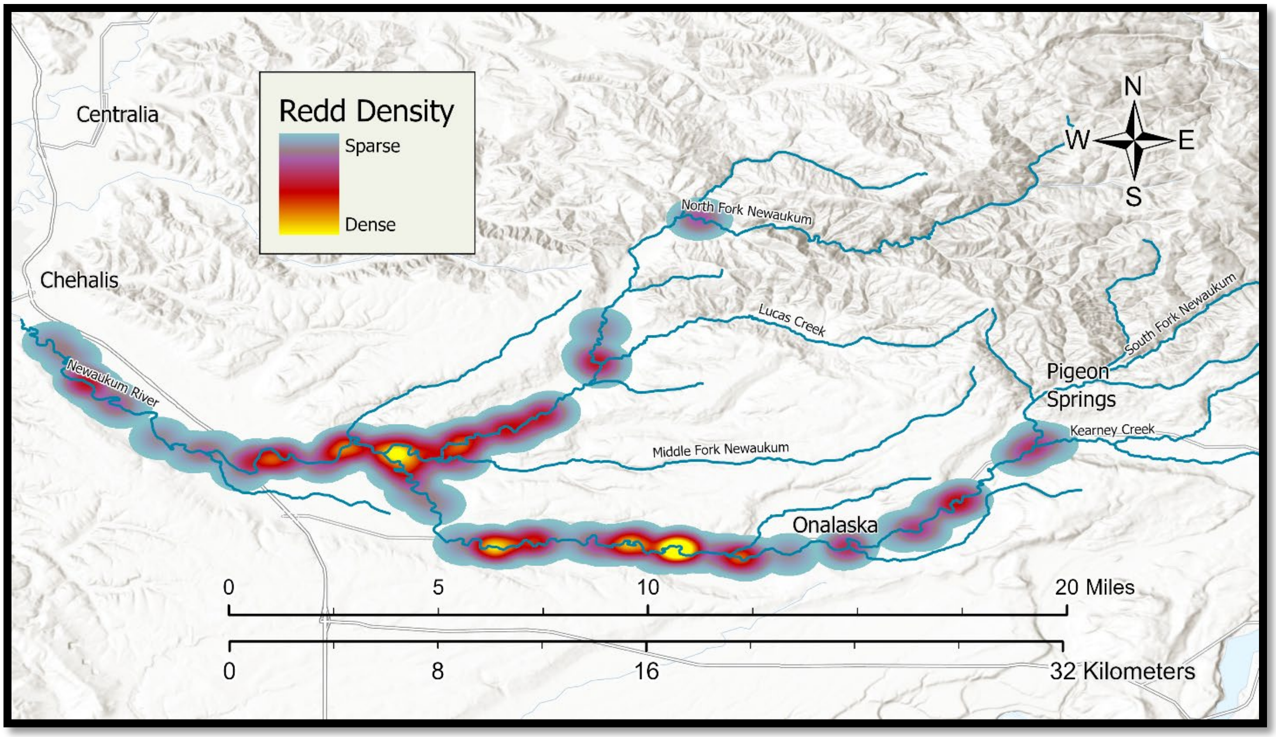

Figure 8. *Density and distribution of 2023 fall Chinook Salmon redds, with high density areas in yellow, for the Newaukum River basin.*

Life History Diversity

All the Chinook carcasses encountered in 2023, where clip status was determined, had an adipose fin present (unmarked, UM), and were considered of natural origin. Of the Chinook carcasses collected that were determined to be fall run-type based on the field run call and where sex was determined, 41% were female (n=24) and 59% were male (n=35, Figure 9). Field run calls of spring Chinook included 57% female (n=25) and 43% male (n=19). When the sex ratio was based on the genetic run-type of the spring run, the sex ratio was 40% female (n=2) and 60% male (n=3). The genetic run-type call for fall Chinook had a sex ratio of 46% female (n=29) and 54% male (n=34) and the heterozygous run call had a ratio of 53% female (n=8) and 47% male (n=7). Also of note was the increase of jacks (sub-adult males) recovered compared to previous years. This increase of sub-adults was also noted in live counts of Chinook Salmon.

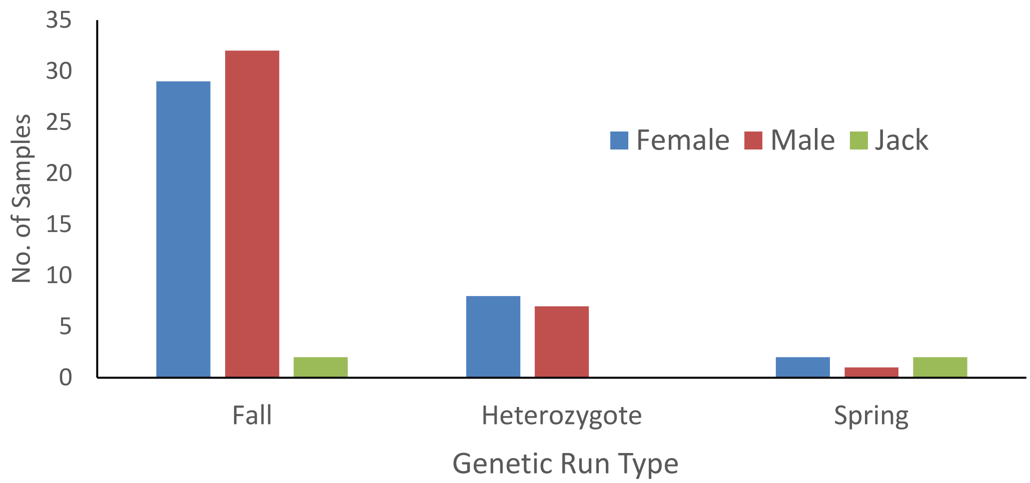

Figure 9. *The sex composition of 2023 Chinook Salmon carcasses using genetic analysis and field calls to determine run-type. Juvenile males (Jacks) displayed separately from adult males.*

Age was determined from scales collected from Chinook carcasses and analyzed based on genetic run type. All scale ages returned with a subscript notation of 1, indicating that the Chinook sampled in 2023 entered the ocean after only one winter in freshwater. This suggests they all followed a sub-yearling life history strategy, rather than remaining in freshwater for a full year as is typical of yearling life histories.

Chinook Salmon sampled in 2023 had an overall scale age composition of 4% Age-2, 21% Age-3, 67% Age-4, and 8% Age-5. When scale age was examined by genetic run type, spring Chinook were composed of 40% Age-2 (n=2), 40% Age-3 (n=2), and 20% Age-5 (n=1). Fall Chinook were predominantly Age-4 (n=41, 68%), with additional representation from Age-3 (n=12, 20%) and Age-5 (n=5, 8%), and a small proportion of Age-2 (n=2, 3%). Heterozygotes were mostly Age-4 (n=14, 74%), with the remainder being Age-3 (n=4, 21%) and Age-5 (n=1, 5%).

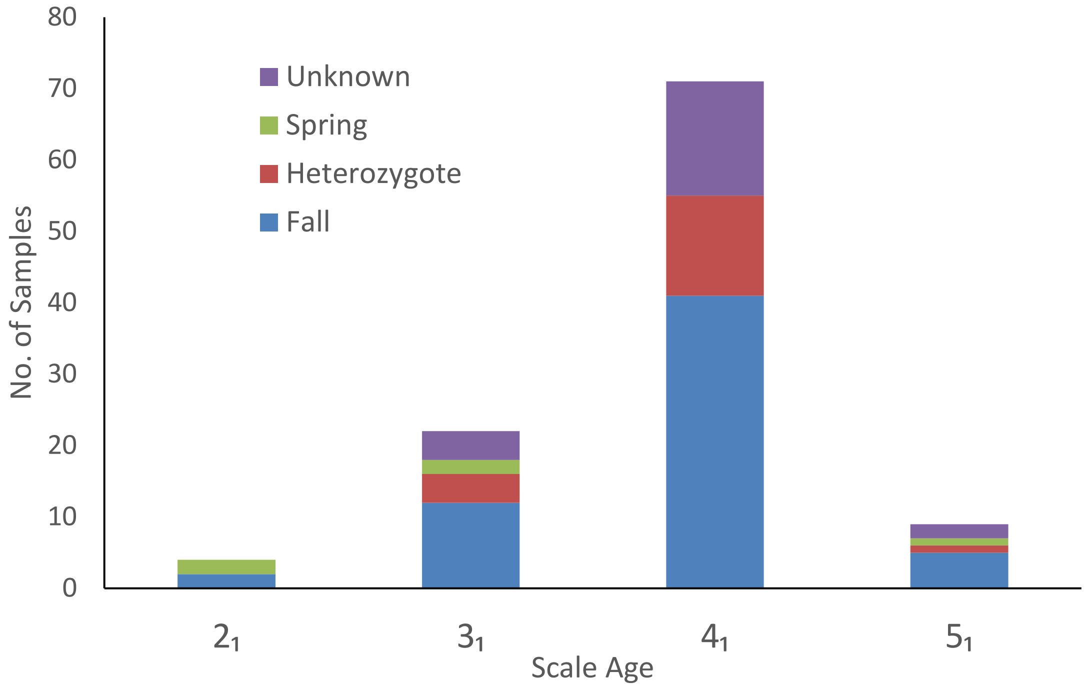

Figure 10. *Age composition from scale analysis of 2023 Chinook Salmon carcasses by genetic run-type. Age is displayed in Gilbert-Rich format where the subscript indicates the year of life migrated to salt water.*

The average length of Chinook Salmon was determined for scale age, sex, and genetic calls (Table 4). Length in Chinook is likely more a function of age and sex than run-type; however, with more data available it may be possible to assess length as a function of run-type, as well as age and sex. Also, with a longer history of data, it might be possible to determine if there is a change in adult length over time, giving an indication of population viability based on size.

Table 4. ***The average length (cm) with standard deviation (SD) of sampled Chinook carcasses calculated for scale age, female and male, and genetic run-type. No SD for categories where only one sample was available and blanks where no samples were available.***

		Scale Age			
		2	**3**	**4**	**5**
Fall	**Female**		71 (n=1)	73.2 (3.4)	75 (9.6)
	Male	42.5 (0.71)	63.4 (3.0)	77.0 (6.4)	
Heterozygote	**Female**			70.25 (2.6)	86(n=1)
	Male		61(n=1)	80.6 (7.2)	
Spring	**Female**		69(n=1)		82(n=1)
	Male	52(n=1)			
Unknown	**Female**			77(n=1)	80(n=1)
	Male		64(n=1)	73.7 (3.2)	88(n=1)

Coho Salmon

Abundance

In the 2023 survey season, we estimated a natural origin (NOR) abundance of 3,888 Coho adult spawners (Table 5). The hatchery origin (HOR) Coho spawner population was less than last year at 1,329 adults, which represented 25% of the total spawning population in the Newaukum River basin.

Table 5. *Newaukum River basin Coho Salmon spawner abundance estimates from 2023 of natural origin (NOR) and hatchery origin (HOR) spawners. All Coho spawned upstream of the smolt trap in 2023.*

2023 Coho Salmon

	Adult Spawners	Upstream of Smolt Trap
NOR	3,888	3,888
HOR	1,329	1,329
Total	**5,217**	**5,217**

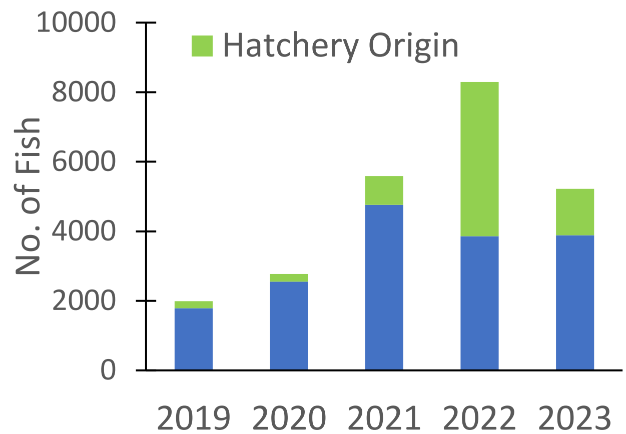

Figure 11. *Newaukum River basin Coho Salmon project time series of spawner abundance estimates from 2019 to 2023 of natural origin (NOR) and hatchery origin (HOR) spawners.*

In 2023, the proportion of hatchery-origin spawners (pHOS) from the Newaukum River basin's sub-basins revealed a decrease of hatchery influence compared to 2022, but higher than 2021 (Figure 11). The upper North Fork Newaukum had a decrease in pHOS from 30% in 2022 to 0% in 2023 (Figure 12). Similarly, Lucas Creek also had a large shift from 50% in 2022 to 0% in 2023; however, the Middle Fork Newaukum had a smaller pHOS shift from 51% in 2022 to 41% in 2023. The lower South Fork and main stem Newaukum maintained similar pHOS values to the previous year, but Kearney Creek increased from 11% in 2022 to 27% in 2023.

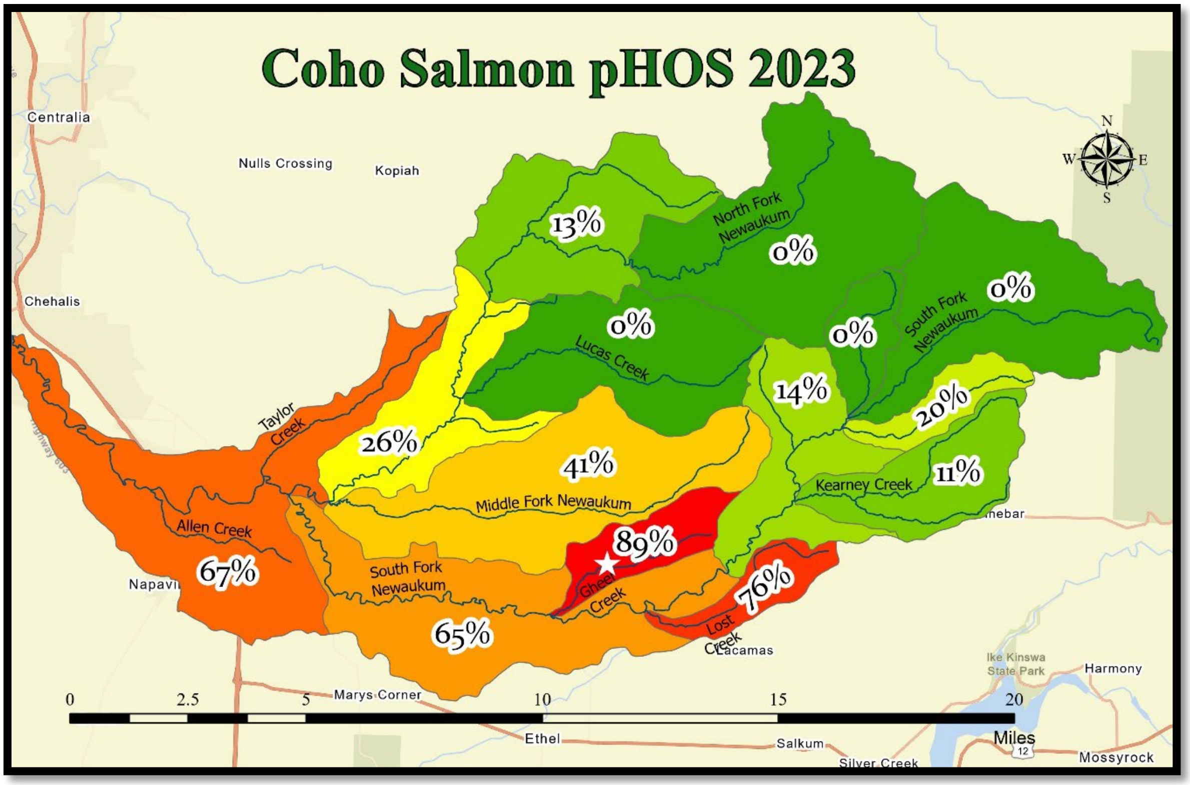

Figure 12. *Percentage of hatchery origin spawners (pHOS) by sub-area of 2023 Coho Salmon in the Newaukum River Basin determined by carcass recovery. The white star is the release location for hatchery Coho Salmon.*

Distribution

In 2023, we explored some smaller tributaries that had not previously been identified as having Coho Salmon spawning habitat. Several of these tributaries were determined to have Coho spawning, including a couple of small Middle Fork Newaukum tributaries and a small tributary off Mitchell Creek, in the North Fork Newaukum area. Coho spawning was concentrated in the Middle and upper North Forks of the Newaukum, Lucas Creek, Kearney Creek and Beaver Creek (Figure 13). Gheer Creek and Lost Creek had some of the highest densities of Coho, but they were primarily composed of hatchery origin spawners. There were “hot spots” spread throughout the upper parts of the basin.

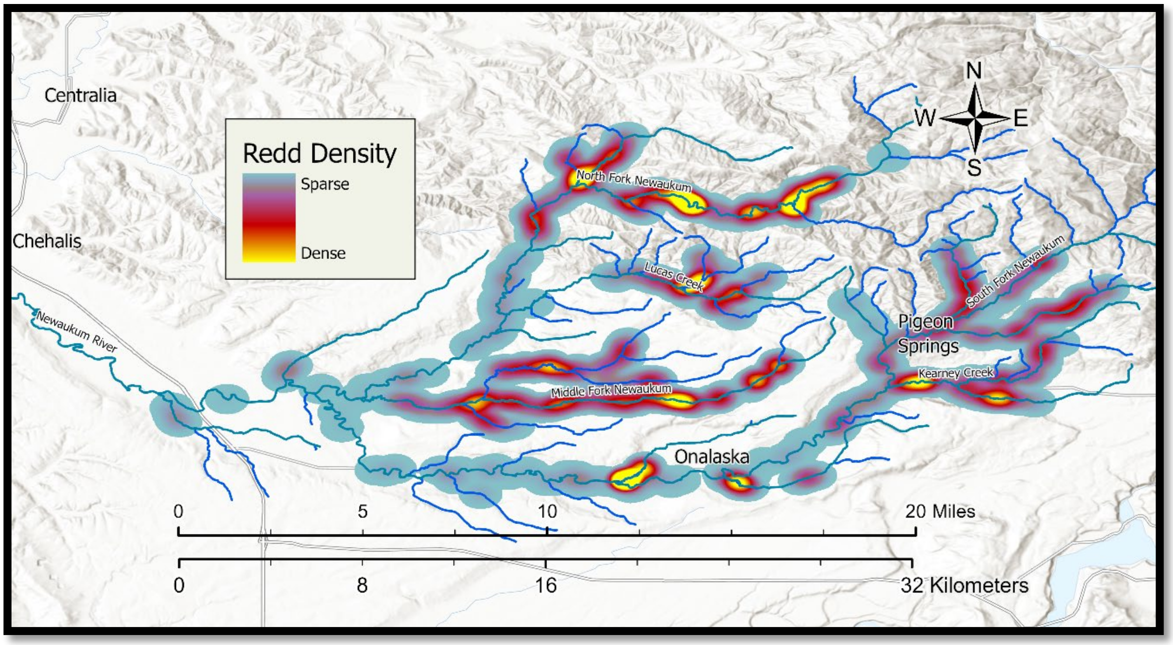

Figure 13. *Density and distribution of 2023 Coho Salmon redds, with high density areas in yellow, for the Newaukum River basin.*

Life History Diversity

Throughout the basin, 135 unmarked (UM) Coho Salmon carcasses were recovered in the 2023-2024 season in the basin outside of Gheer Creek. From the recovered unmarked carcasses, 52% were male with an average fork length of 66.4 cm (SD 8.3) and 48% female with an average fork length of 64.3 cm (SD 5.1, Figure 14).

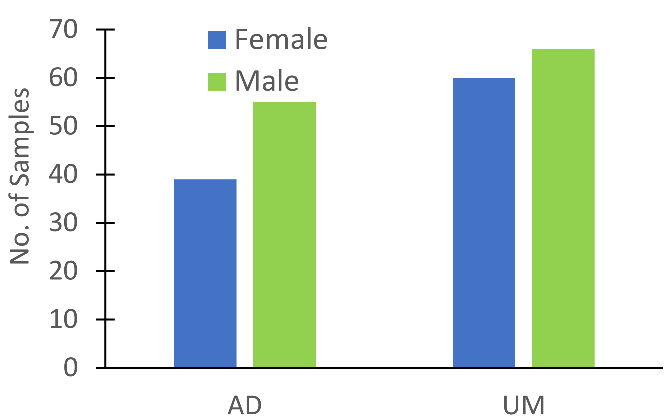

Figure 14. *Clipped status and sex composition of carcass samples collected on Coho Salmon in run year 2023.*

Steelhead Trout

Abundance

Total steelhead trout for 2024 run year was estimated at 1,230 adult spawners. The hatchery portion of steelhead was determined by a cut-off date; any redd created on or before March 15th was considered HOR and any redd created after that date was considered NOR. This method generated an estimate of 185 HOR and 1,045 NOR steelhead trout (Table 6). However, unmarked, or NOR steelhead, were seen spawning prior to this date and adipose clipped, or HOR steelhead were seen spawning after this date. The 2024 estimate is similar to other estimates in the Newaukum from the last 5 years with only the estimate from 2022 coming in about 30% less than the average (Figure 15).

Table 6. *Newaukum River basin steelhead trout spawner abundance estimates from 2024 of natural origin (NOR) and hatchery origin (HOR) spawners. Estimates based on March 15th cut-off date to determine hatchery and natural origin. All steelhead trout spawned upstream of the smolt trap in 2024.*

2024 Steelhead Trout

	Adult Spawners	Upstream of Smolt Trap
Natural Origin	1,045	1,045
Hatchery Origin	185	185
Total	**1,230**	**1,230**

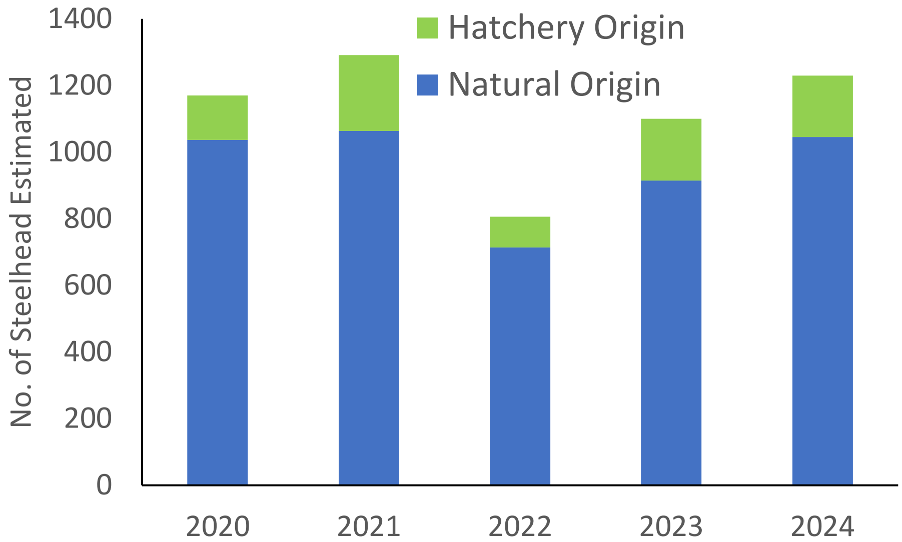

Figure 15. *Newaukum River basin steelhead trout project time series of spawner abundance estimates from 2020 to 2024 of natural origin (NOR) and hatchery origin (HOR) spawners.*

Distribution

Steelhead, like Coho Salmon, rarely utilized the lower Newaukum River basin for spawning habitat during the 2024 run year (Figure 16). Instead, they primarily spawned in the upper portions of both the North Fork and South Fork Newaukum River. However, unlike Coho, steelhead didn’t utilize the smaller tributaries to the forks as much. The highest densities of spawning steelhead occurred in the lower Pigeon Springs area (54 redds mile^{-1}) just above Highway 508 and in a tributary in the upper North Fork Newaukum (40 redds mile^{-1}). The Middle Fork Newaukum, Lucas, and Beaver creeks had low activity in the 2024 steelhead spawning season, which was similar to previous seasons.

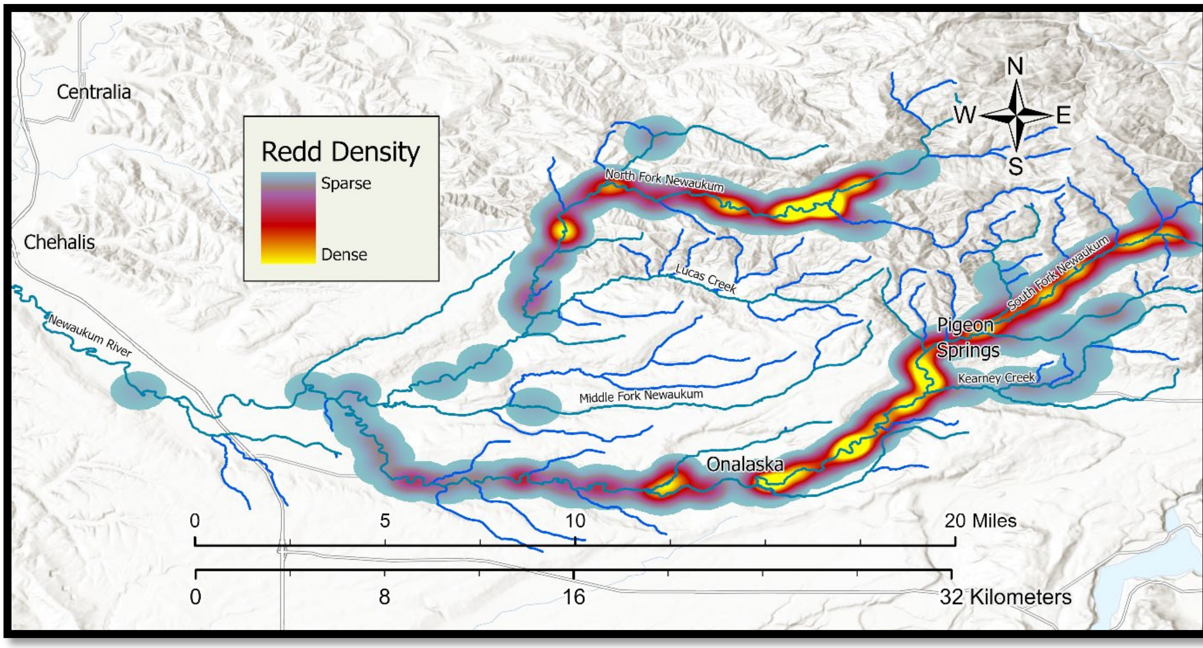

Figure 16. *Density and Distribution of 2024 steelhead trout redds, with high density areas in yellow, for the Newaukum River basin.*

Life History Diversity

The biological sample size of steelhead in 2024 was 57 total samples. Hook and line sampling accounted for 14 of those samples, and the rest were carcasses. Of those samples, 30 had their adipose fins present (UM) and 20 had their adipose fins removed (AD). Of the 20 HOR fish, 15 were from Gheer Creek, where hatchery steelhead are released annually. Two were collected in the South Fork Newaukum just upstream from Gheer Creek, two were collected in the upper extents of basin, and one was collected in the main stem Newaukum River. No hatchery steelhead were recovered in the North Fork Newaukum.

Of the UM, or NOR samples, the majority (56%) were total Age-5 at spawning, 33% were total Age-4, and 11% were total Age-3 (Figure 17, Appendix E). The predominant freshwater age, or time spent in the fresh water prior to heading to the ocean, was 2 years (56%) and the predominant time spent in the salt water prior to returning to spawn was one year (67%). None of the scales that were read showed repeat spawning in 2024. Of the fish sampled where sex could be determined, 33% were determined to be female with an average fork length of 64.4 cm (SD 5.7). The average fork length of the males which composed 67% of the samples, was 73.2 cm (SD 8.5)

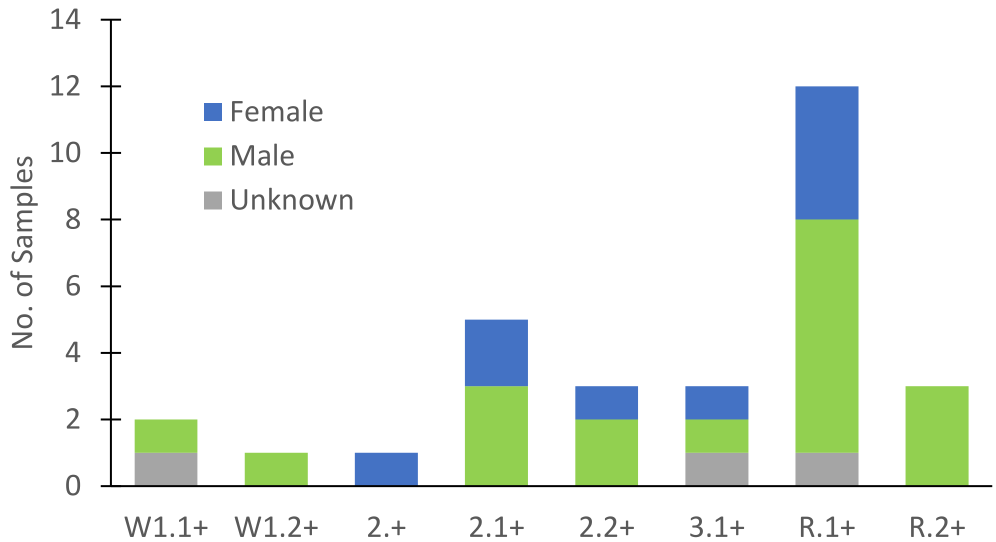

Figure 17. *Ages from scale analysis of 2024 run of steelhead trout with freshwater age on the left of the decimal and saltwater age to the right of decimal. 'R' indicates regenerated, so freshwater age is unknown. Samples included both live hook and line and carcass sampling. Additional explanation of steelhead scale age notation provided in Appendix E.*

Discussion

The Newaukum basin supports populations of spring and fall Chinook, Coho Salmon, and steelhead trout. The intensive adult and juvenile monitoring programs for salmon and steelhead in the Newaukum River basin are crucial for understanding fish response to restoration actions. These monitoring programs provide information that guides the setting of restoration priorities and evaluation of outcomes. By facilitating a systematic science-policy feedback loop, they help ensure that restoration strategies are adaptively managed based on empirical evidence, thereby enhancing their effectiveness and sustainability.

Current fish management practices utilize abundance estimates derived from redd counts, employing an October 15th cutoff date to distinguish between spring and fall Chinook redds. This method generated abundance estimates of 383 spring and 315 fall Chinook adult spawners in 2023. However, based on data collected during this project, particularly genetic evaluations of carcasses, there is increasing evidence of overlapping spawn timing between spring and fall Chinook, suggesting that a fixed cutoff date may not accurately reflect true run composition. Hybrid individuals, which display genetic markers for both spring and fall lineages (i.e., heterozygotes) and are not accounted for in the current redd-based estimation framework, and further complicate accurate run-timing classification. While redd-based methods remain valuable for estimating total Chinook escapement, refinement of run-type differentiation methods is needed to better inform population-specific management.

To refine Chinook escapement estimates, we considered using genetic proportions from recovered carcasses to partition redd count-derived abundance estimates amongst run-types. However, this method assumes equal carcass recovery rates across the entire run, a condition that appears not to have been met for early spring Chinook. In 2023, for example, no carcasses were recovered from areas where the earliest redds were observed, such as Pigeon Springs. It is possible that early spring Chinook carcass recovery is lower due to factors like increased predation or more rapid decomposition, potentially linked to poor body condition prior to spawning. As a result, this method may underestimate the number of true spring Chinook spawners.

We attempted to address this bias by reclassifying redds constructed before October 15th as fall Chinook redds if live spawners exhibited phenotypic characteristics associated with fall-run fish (see Appendix B). Conversely, redds observed after October 15th were classified as spring Chinook if live fish present displayed traits consistent with spring-run individuals. However, it is much more common to observe fall Chinook on redds prior to the cutoff date than it is to observe spring Chinook after, suggesting that the October 15th cutoff may be set later than what is supported by actual spawning behavior. Without this correction, had all pre-October 15th redds been attributed to spring Chinook, the estimate would have been 405 spring and 293 fall Chinook. Genetic analysis showed that only 10% of field-identified spring Chinook carcasses that had spawned prior to the cutoff date were confirmed as genetically homozygous spring-run, further indicating that the October 15th cutoff may overestimate the abundance of true spring-run individuals.

As an interim solution, adjusting the October 15th cutoff date using genetic data may provide a more accurate delineation between spring and fall Chinook spawning activity. Shifting the date earlier could better reflect actual run timing and reduce the overestimation of spring-run abundance observed under the current classification. Although not a comprehensive fix, this approach could improve accuracy until more robust, genetics-based classification methods become feasible. Any date adjustment should account for the lag between spawning and carcass recovery and aim to balance the number of fall Chinook before a cutoff date with spring Chinook after that date. Additionally, because flow and temperature variability can strongly influence spawning behavior, any adjustments to the cutoff date should be based on multiple years of data rather than a single year.

Two alternative escapement methods have been evaluated in the Newaukum with varying success: carcass mark-recapture (CMR) and trans-generational genetic mark-recapture (tGMR). The CMR method produced estimates with known confidence intervals, enabling an assessment of precision, although the intervals were relatively wide. These estimates appeared plausibly accurate, as the confidence intervals encompassed results from other methods. However, CMR has limited effectiveness in the Newaukum due to low fish abundance and broad spatial distribution, which resulted in low capture and recapture rates. It may be better suited in systems like the Skookumchuck River, where spawner concentrations are higher and confined to a single channel. Incorporating genetic data into CMR could substantially improve the accuracy of run-type-specific escapement estimates, although doing so would delay estimate production. Additionally, CMR is resource-intensive and cost-prohibitive for routine application in this system.

The tGMR method uses the proportion of run-types recovered from adult carcasses and juveniles out-migrating the following spring to generate an estimate of escapement needed to produce the juvenile genotypes observed. However, as noted earlier, recovery rate of adults make this approach problematic. Infrastructure to collect genetics in an unbiased way does not exist in the Newaukum Basin. The tGMR method also requires collecting and processing out-migrating juveniles, which is expensive and labor intensive, taking up to a year to produce results. An additional method under development is a spatio-temporal model that utilizes historical information on distribution and abundance to fill gaps caused by poor survey conditions or limited coverage. A similar approach has been developed to estimate escapement of winter steelhead and chum salmon (*O. keta*) in the lower Columbia and shows promise.

Though none of the alternative escapement methods directly or efficiently addresses the issue of assigning a run-type to Chinook salmon, they do contribute to generating robust escapement estimates. However, with increased extreme weather events and changing flow regimes, the reliability of a strict date or location cutoff will continue to shift. It is also crucial to ensure that the focus on spring Chinook does not overshadow the need to manage fall Chinook effectively. Additionally, any modifications to the current estimation methods must be discussed and agreed upon with tribal members who have vested interests in the basin. Another consideration for management is the metrics to which we manage. When these metrics were developed, there was no information on hybridization or its extent and duration. Collaborative efforts with tribal members who have interests in the basin are crucial to ensure the acceptance and success of any revised methodologies. Overall, Chinook abundances in the Newaukum show no immediate signs of improvement and may not recover to historic abundances without intervention.

Coho Salmon continue to utilize a greater proportion of small tributaries in the basin relative to other species. In 2023, the Newaukum River basin observed a natural-origin (NOR) Coho abundance nearly identical to 2022 at 3,888 spawners. Hatchery-origin (HOR) Coho returned at about a third of the 2022 hatchery run, with 1,329 spawners, marking the second highest hatchery return since intensive monitoring began in 2019. Although the program is integrated, the presence of hatchery origin fish on spawning grounds remains notable and may have implication for the genetic diversity and long-term fitness of the natural-origin population. Observations of elevated pHOS levels highlight the importance of continued evaluation of hatchery programs—not only to assess whether they are meeting their stated objectives, but also to determine whether those objectives remain appropriate in the context of current ecological and management conditions. The broad use of small streams by Coho underscores the value of restoration in small tributaries—even those that may go dry in summer months. The Newaukum basin contains numerous opportunities for such projects, which could support Coho life history diversity and population resilience while being less complex and costly than large river restoration efforts.

Steelhead spawning began earlier in 2024 than in previous years but followed a similar pattern to the 2023 run, with the first redds observed in mid-December and peak spawning occurring in mid-March. This timing closely aligns with the state's cutoff date (March 15th) for distinguishing hatchery-origin

(HOR) from natural-origin (NOR) steelhead and may reflect changes in hatchery release strategies or ecological responses to shifting spring flow regimes. Notably, peak spawning has shifted earlier by several weeks in recent years, a trend that warrants further investigation. Improved methods for determining pHOS in steelhead are needed if integrated hatchery programs are to continue. The 2024 run included an estimated 1,230 adult spawners, similar to recent years of intensive monitoring.

Steelhead exhibit complex life histories, including the capacity for repeat spawning, which can enhance population resilience (Schindler et al. 2010). However, no repeat spawners were detected in 2024. Repeat spawners—typically larger and more fecund—play an important role in maintaining population viability (Bowersox et al. 2019; Quinn et al. 2011). Promoting post-spawn survival may be especially important for maintaining this life history trait. In particular, access to high-quality summer holding habitats could support physiological recovery and increase the likelihood of repeat spawning. A more comprehensive understanding of repeat spawning trends would benefit from a larger dataset and comparison with other coastal steelhead populations, particularly in the Chehalis basin, to determine whether repeat spawners are becoming less prevalent across the region.

Effective restoration in the Newaukum River Basin will significantly benefit salmon and steelhead populations by enhancing their spawning and rearing habitats, mitigating the impacts of low flows, and maintaining genetic diversity. Findings from this report can directly inform restoration priorities—for example, the extensive use of small tributaries by Coho underscores the value of restoring these accessible habitats. Similarly, improving summer holding areas—such as cool, deep pools with adequate cover—not only supports post-spawn survival in steelhead, but also benefits spring Chinook during their extended pre-spawn holding period. Enhancing habitat in areas upstream of Onalaska to the Highway 508 bridge may improve conditions for early spring Chinook spawners and aid in the recovery of key life history traits. Adaptive management strategies should consider shifting spawn timing and hydrologic variability to ensure restoration efforts align with critical life stages. Through targeted restoration and monitoring, we can strengthen the resilience and long-term sustainability of these populations amidst ongoing environmental 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.

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%
2022	291	1,350	22%
2023	383	2,175	18%

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	8,175*	4%
2022	383	9,337	4%
2023	315	7,276	4%

*Updated since 2021-2022 report

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%
2022	8,290	52,828	16%
2023	3,888	37,546*	10%

*Preliminary

Steelhead Trout

Escapement of NOR based on March 15th cut-off date.

Year	Newaukum	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	970	6,280	15%
2021	987	5,631	18%
2022	674	5,341	13%
2023	915	6,257	15%
2024	1,045	8,505	12%

* No separate Newaukum estimate reported

Appendix B. 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;	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 15^{th} the redd was recorded as spring run-type unless other fish presence indicates fall Chinook After October 15^{th} the condition of the redd determines run-type If redd was built on/prior to Oct. 15^{th} it was recorded as spring run-type If redd was built after Oct. 15^{th} it was recorded as fall run-type	
Post-overlap		After Oct. 15^{th} 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 C. Dates by statistical week (week of year) for 2023-2024 survey season.

2023

JANUARY

Week #	Su	Mo	Tu	We	Th	Fr	Sa
1	1	2	3	4	5	6	7
2	8	9	10	11	12	13	14
3	15	16	17	18	19	20	21
4	22	23	24	25	26	27	28
5	29	30	31	1	2	3	4
6	5	6	7	8	9	10	11

FEBRUARY

Week #	Su	Mo	Tu	We	Th	Fr	Sa
5	29	30	31	1	2	3	4
6	5	6	7	8	9	10	11
7	12	13	14	15	16	17	18
8	19	20	21	22	23	24	25
9	26	27	28	1	2	3	4
10	5	6	7	8	9	10	11

MARCH

Week #	Su	Mo	Tu	We	Th	Fr	Sa
9	26	27	28	1	2	3	4
10	5	6	7	8	9	10	11
11	12	13	14	15	16	17	18
12	19	20	21	22	23	24	25
13	26	27	28	29	30	31	1
14	2	3	4	5	6	7	8

APRIL

Week #	Su	Mo	Tu	We	Th	Fr	Sa
13	26	27	28	29	30	31	1
14	2	3	4	5	6	7	8
15	9	10	11	12	13	14	15
16	16	17	18	19	20	21	22
17	23	24	25	26	27	28	29
18	30	1	2	3	4	5	6

MAY

Week #	Su	Mo	Tu	We	Th	Fr	Sa
18	30	1	2	3	4	5	6
19	7	8	9	10	11	12	13
20	14	15	16	17	18	19	20
21	21	22	23	24	25	26	27
22	28	29	30	31	1	2	3
23	4	5	6	7	8	9	10

JUNE

Week #	Su	Mo	Tu	We	Th	Fr	Sa
22	28	29	30	31	1	2	3
23	4	5	6	7	8	9	10
24	11	12	13	14	15	16	17
25	18	19	20	21	22	23	24
26	25	26	27	28	29	30	1
27	2	3	4	5	6	7	8

JULY

Week #	Su	Mo	Tu	We	Th	Fr	Sa
26	25	26	27	28	29	30	1
27	2	3	4	5	6	7	8
28	9	10	11	12	13	14	15
29	16	17	18	19	20	21	22
30	23	24	25	26	27	28	29
31	30	31	1	2	3	4	5

AUGUST

Week #	Su	Mo	Tu	We	Th	Fr	Sa
31	30	31	1	2	3	4	5
32	6	7	8	9	10	11	12
33	13	14	15	16	17	18	19
34	20	21	22	23	24	25	26
35	27	28	29	30	31	1	2
36	3	4	5	6	7	8	9

SEPTEMBER

Week #	Su	Mo	Tu	We	Th	Fr	Sa
35	27	28	29	30	31	1	2
36	3	4	5	6	7	8	9
37	10	11	12	13	14	15	16
38	17	18	19	20	21	22	23
39	24	25	26	27	28	29	30
40	1	2	3	4	5	6	7

OCTOBER

Week #	Su	Mo	Tu	We	Th	Fr	Sa
40	1	2	3	4	5	6	7
41	8	9	10	11	12	13	14
42	15	16	17	18	19	20	21
43	22	23	24	25	26	27	28
44	29	30	31	1	2	3	4
45	5	6	7	8	9	10	11

NOVEMBER

Week #	Su	Mo	Tu	We	Th	Fr	Sa
44	29	30	31	1	2	3	4
45	5	6	7	8	9	10	11
46	12	13	14	15	16	17	18
47	19	20	21	22	23	24	25
48	26	27	28	29	30	1	2
49	3	4	5	6	7	8	9

DECEMBER

Week #	Su	Mo	Tu	We	Th	Fr	Sa
48	26	27	28	29	30	1	2
49	3	4	5	6	7	8	9
50	10	11	12	13	14	15	16
51	17	18	19	20	21	22	23
52	24	25	26	27	28	29	30
1	31	1	2	3	4	5	6

2024

JANUARY

Week #	Su	Mo	Tu	We	Th	Fr	Sa
1	31	1	2	3	4	5	6
2	7	8	9	10	11	12	13
3	14	15	16	17	18	19	20
4	21	22	23	24	25	26	27
5	28	29	30	31	1	2	3
6	4	5	6	7	8	9	10

FEBRUARY

Week #	Su	Mo	Tu	We	Th	Fr	Sa
5	28	29	30	31	1	2	3
6	4	5	6	7	8	9	10
7	11	12	13	14	15	16	17
8	18	19	20	21	22	23	24
9	25	26	27	28	29	1	2
10	3	4	5	6	7	8	9

MARCH

Week #	Su	Mo	Tu	We	Th	Fr	Sa
9	25	26	27	28	29	1	2
10	3	4	5	6	7	8	9
11	10	11	12	13	14	15	16
12	17	18	19	20	21	22	23
13	24	25	26	27	28	29	30
14	31	1	2	3	4	5	6

APRIL

Week #	Su	Mo	Tu	We	Th	Fr	Sa
14	31	1	2	3	4	5	6
15	7	8	9	10	11	12	13
16	14	15	16	17	18	19	20
17	21	22	23	24	25	26	27
18	28	29	30	1	2	3	4
19	5	6	7	8	9	10	11

MAY

Week #	Su	Mo	Tu	We	Th	Fr	Sa
18	28	29	30	1	2	3	4
19	5	6	7	8	9	10	11
20	12	13	14	15	16	17	18
21	19	20	21	22	23	24	25
22	26	27	28	29	30	31	1
23	2	3	4	5	6	7	8

JUNE

Week #	Su	Mo	Tu	We	Th	Fr	Sa
22	26	27	28	29	30	31	1
23	2	3	4	5	6	7	8
24	9	10	11	12	13	14	15
25	16	17	18	19	20	21	22
26	23	24	25	26	27	28	29
27	30	1	2	3	4	5	6

JULY

Week #	Su	Mo	Tu	We	Th	Fr	Sa
27	30	1	2	3	4	5	6
28	7	8	9	10	11	12	13
29	14	15	16	17	18	19	20
30	21	22	23	24	25	26	27
31	28	29	30	31	1	2	3
32	4	5	6	7	8	9	10

AUGUST

Week #	Su	Mo	Tu	We	Th	Fr	Sa
31	28	29	30	31	1	2	3
32	4	5	6	7	8	9	10
33	11	12	13	14	15	16	17
34	18	19	20	21	22	23	24
35	25	26	27	28	29	30	31
36	1	2	3	4	5	6	7

SEPTEMBER

Week #	Su	Mo	Tu	We	Th	Fr	Sa
36	1	2	3	4	5	6	7
37	8	9	10	11	12	13	14
38	15	16	17	18	19	20	21
39	22	23	24	25	26	27	28
40	29	30	1	2	3	4	5
41	6	7	8	9	10	11	12

OCTOBER

Week #	Su	Mo	Tu	We	Th	Fr	Sa
40	29	30	1	2	3	4	5
41	6	7	8	9	10	11	12
42	13	14	15	16	17	18	19
43	20	21	22	23	24	25	26
44	27	28	29	30	31	1	2
45	3	4	5	6	7	8	9

NOVEMBER

Week #	Su	Mo	Tu	We	Th	Fr	Sa
44	27	28	29	30	31	1	2
45	3	4	5	6	7	8	9
46	10	11	12	13	14	15	16
47	17	18	19	20	21	22	23
48	24	25	26	27	28	29	30
49	1	2	3	4	5	6	7

DECEMBER

Week #	Su	Mo	Tu	We	Th	Fr	Sa
49	1	2	3	4	5	6	7
50	8	9	10	11	12	13	14
51	15	16	17	18	19	20	21
52	22	23	24	25	26	27	28
53	29	30	31	1	2	3	4
2	5	6	7	8	9	10	11

Appendix D. Carcass Mark Recapture Jolly-Seber Statistics Summary Statistics

dates	ni	mi	Ri	ri	zi	ui
2023-09-21	1	0	0	0	0	1
2023-09-25	1	0	0	0	0	1
2023-10-04	8	0	3	0	0	8
2023-10-10	23	0	14	3	0	23
2023-10-19	35	3	19	4	0	32
2023-10-23	43	4	23	1	0	39
2023-10-30	18	1	4	1	0	17
2023-11-10	3	1	0	0	0	2
2023-11-16	1	0	1	0	0	1
2023-11-22	1	0	0	0	0	1
2023-11-28	1	0	0	0	0	1

m-array

Released	5	14	20	29	33	40	51	57	63	69	Total
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	3	0	0	0	0	0	0	3
19	0	0	0	0	4	0	0	0	0	0	4
23	0	0	0	0	0	1	0	0	0	0	1
4	0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

Appendix E. Winter steelhead age notation

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".