Tulalip Tribes Natural Resources Department Report

SNOQUALMIE RIVER JUVENILE SALMON OUT-MIGRATION STUDY PROGRESS REPORT

February – June 2024

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INTRODUCTION

Due to considerable declines in salmon populations, fisheries managers and stakeholders have been working collaboratively to restore salmon runs in the Snohomish watershed. In 1994, a partnership of 41 organizations formed the Snohomish Basin Salmon Recovery Forum (the Forum) in order to implement a watershed scale, scientifically-based, adaptive management strategy to better inform salmon recovery. The Snoqualmie sub-basin is managed by a partnership of local tribes and municipalities called the Snoqualmie Watershed Forum.

In 2005, the Forum adopted the *Snohomish River Basin Salmon Conservation Plan* in order to coordinate fisheries management on a watershed scale. To inform this planning with the best available science, it is necessary to gather and analyze data on Chinook and Coho Salmon abundance, productivity, survival, escapement, spatial structure, and life-history diversity within the Snohomish system (Snohomish Basin Salmonid Recovery Technical Committee, 2005). Information about the trends and inter-annual variability in these populations are critical to inform salmon recovery efforts, provide basic information on the productivity and capacity of the system, and lead to significant improvements in harvest management modeling and run forecasting. Additionally, the monitoring of production and survival along with other physical, chemical, and biological conditions provides a means to evaluate habitat restoration effectiveness, recovery actions, habitat conditions, and potential ecological trajectories in the basin**.**

In 1999, the National Marine Fisheries Service (NMFS) listed the Puget Sound Chinook Salmon *Oncorhynchus tshawytscha* as threatened under the federal Endangered Species Act (ESA). This listing included Chinook Salmon from the Snohomish River basin, which includes sub-populations from the Skykomish and Snoqualmie Rivers. Decreases in many runs of Puget Sound Coho Salmon *Oncorhynchus kisutch* have also resulted in their designation as a species of concern under the ESA. This report focuses on Chinook and Coho Salmon because recovery efforts targeted at these species will help other federally listed salmonid stocks in the watershed.

A key method for monitoring Snohomish River salmon populations has been the operation of rotary screw traps in the Skykomish and Snoqualmie rivers. Over the last 22 years, these projects have sampled juvenile Chinook and Coho Salmon as they emigrate to the Puget Sound. The goals of these trapping efforts are to estimate Chinook and Coho Salmon natural production, migration patterns, and freshwater survival. These goals are accomplished through the direct quantification of juvenile salmon emigrations, evaluation of trap efficiency, and assessment of influential environmental attributes. The Tulalip Tribes' trapping project has been classified as a project of high priority by the Forum because it is necessary for stock assessment, population monitoring and run forecasting (Snohomish Basin Salmonid Recovery Technical Committee, 2005).

SNOQUALMIE RIVER TRAPPING SITE

The current trap site is located on the Snoqualmie River 32 miles upriver from the ocean and 12 miles up from the confluence with the Skykomish River (Figure 1). It is on the Flooded Riveranch in Duvall, WA in a section of the channel that flows north (Figure 2). The river at this point has a wetted width of ~142 ft., a bankfull width of ~210 ft., a maximum bankfull depth of ~23.5 ft., and a summer low-flow depth of ~5 ft. The water surface velocity is ~3-4 ft./sec., the summer low flow discharge is ~847 cubic feet per second (CFS), and the mean annual discharge is ~3,800 CFS. The channel gradient is <1% and the substrate is principally sand and silt with some gravel and cobble on the western side of the channel. The land use adjacent to the trap is principally agriculture with riparian vegetation limited to the banks (e.g. <30 ft.). The riparian zone principally consists of grass, shrubs, and a few scattered trees. At the immediate trap site, the left bank is composed of a steep slope vegetated with mixed deciduous trees and an understory of blackberry and salmonberry (leading to West Snoqualmie Valley Rd NE). The right bank is steeply cut and leads to an active horse and cattle pasture. Riparian vegetation on the right bank is principally Japanese Knotweed, Himalayan Blackberry with an occasional Red Alder and Cottonwood. In 2003, a previous landowner had a fence built around the pasture on the right bank creating a buffer zone of ~50 ft. between the pasture and the river bank. This buffer was planted with an assortment of native riparian vegetation (Kubo et al. 2013).

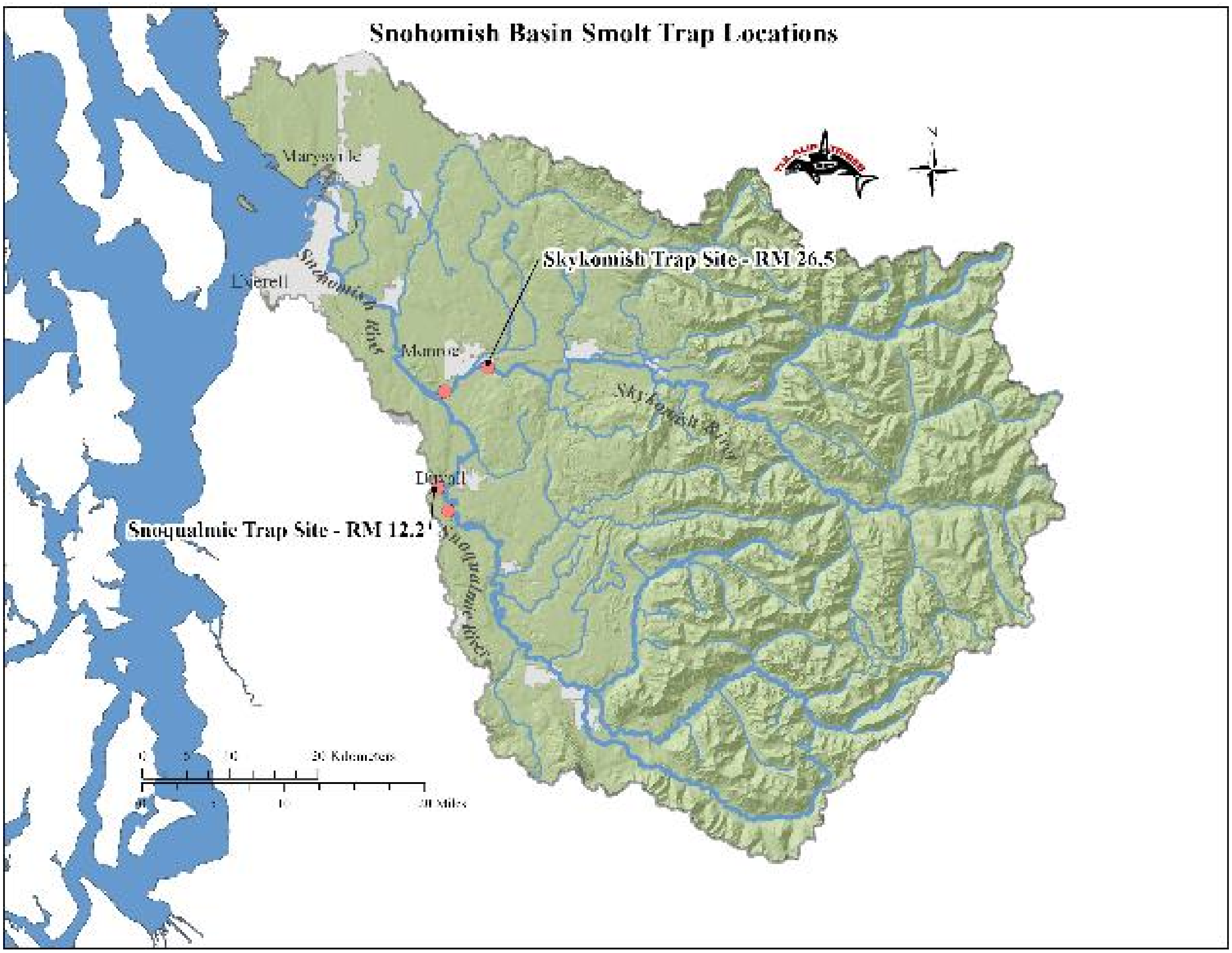

Figure 1: Map of the Snohomish watershed with the locations of the trap sites on the Skykomish and Snoqualmie Rivers.

Figure 2. Aerial photograph of the trap site at river mile 12.2 on the Snoqualmie River in Duvall, WA. The yellow X indicates the approximate trap fishing position.

SUMMARY OF SAMPLING OPERATIONS

The Snoqualmie River rotary screw trap operates during the juvenile salmon outmigration season, from February through June. Sampling is conducted on 4–5 weeknights and 1–2 weekdays each week, stratified by Julian week (JW) to allow more accurate year-to-year comparisons. In 2024, trapping occurred from February 13 to May 31 (JW 7–JW 22; Table 1). Sampling usually spans Julian week 7 to Julian week 25, though this timing can vary. High flows at the end of May prevented sampling into June, resulting in an earlier-than-usual end to the season. Overall, the trap operated for 928 hours—above the average effort of 870 hours (Table 2). A total of 198 salmonid mortalities occurred during trapping and handling, including one Chum Salmon, and 197 Pink Salmon. A detailed summary of the season's catch is available in Appendix A.

Catch numbers for the 2024 season were well below average for Chinook but only slightly below for Coho Salmon. The number of sub-yearling Chinook Salmon caught was 32% of the project average, while unmarked yearling Coho Salmon reached 87% of the project average (Table 2). While this season's catch was below average for Coho it is an improvement in catch since 2018. Unmarked Steelhead had a slightly higher catch rate since 2020 but was low for the project average. Marked Steelhead catch rates were well below the project average this season. Catch per unit effort calculations and production estimates confirm these low numbers, suggesting poor conditions for fish prior to and/or during outmigration.

Table 1. Julian weeks and corresponding dates for the 2024 sampling season

Start Week	End Week	Julian Week
1/2/2024	1/8/2024	1
1/9/2024	1/15/2024	2
1/16/2024	1/22/2024	3
1/23/2024	1/29/2024	4
1/30/2024	2/5/2024	5
2/6/2024	2/12/2024	6
2/13/2024	2/19/2024	7
2/20/2024	2/26/2024	8
2/27/2024	3/4/2024	9
3/5/2024	3/11/2024	10
3/12/2024	3/18/2024	11
3/19/2024	3/25/2024	12
3/26/2024	4/1/2024	13
4/2/2024	4/8/2024	14
4/9/2024	4/15/2024	15
4/16/2024	4/22/2024	16
4/23/2024	4/29/2024	17
4/30/2024	5/6/2024	18
5/7/2024	5/13/2024	19
5/14/2024	5/20/2024	20
5/21/2024	5/27/2024	21
5/28/2024	6/3/2024	22
6/4/2024	6/10/2024	23
6/11/2024	6/17/2024	24
6/18/2024	6/24/2024	25
6/25/2024	7/1/2024	26

CATCH PER UNIT OF EFFORT (CPUE)

Catch data are converted to catch per unit effort (CPUE), which represents the number of fish caught per hour. CPUE can be averaged over a given period by dividing the total catch by the number of hours fished during that time. This standardization facilitates easier comparisons of catch rates both within and across years. In 2024, CPUE data for unmarked Chinook Salmon sub-yearlings reveal two prominent peaks at Julian weeks 18 and 21, with a smaller peak observed during Julian weeks 12–13 (Figure 3). Notably, the peak CPUE for sub-yearling Chinook Salmon in 2024 occurred later and was less pronounced compared to the typical out-migration period, which usually spans Julian weeks 11–17. For yearling Coho Salmon, the out-migration peak was observed between Julian weeks 17 and 21. This timing aligns closely with patterns seen in previous years of the trapping project (Kubo et al. 2013).

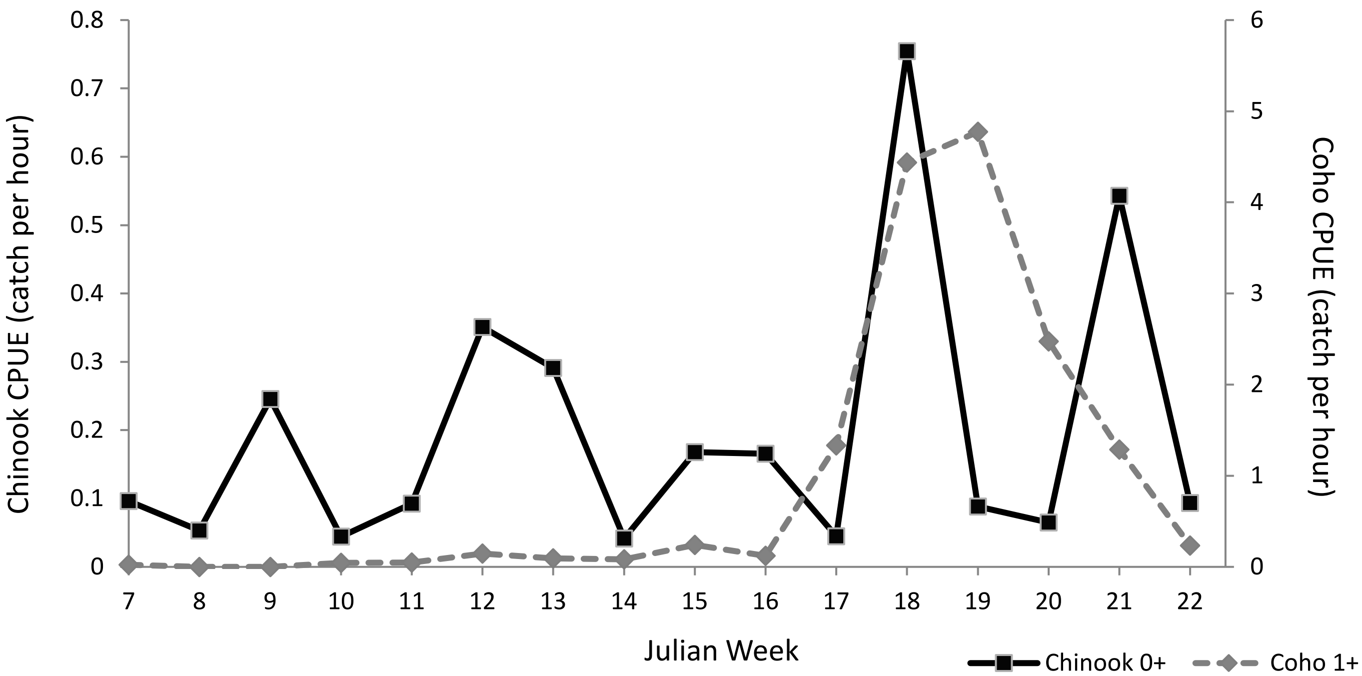

Figure 3. Sub-yearling (0+) Chinook Salmon and yearling (1+) Coho Salmon CPUE by Julian week at the Snoqualmie River trap, 2024.

The average annual salmonid CPUE on the Snoqualmie trap has varied throughout the project due to changing sampling conditions and the strength of each year's out-migrant cohort. This season, saw significantly lower catch rates, with CPUE well below the project average for Chinook and slightly below average for Coho. While the yearling Coho catch and CPUE reached about 78% of the project average, the Chinook catch was substantially lower, at just 30% of average, marking a considerable decline compared to years since 2017. While yearling Coho was still below the project average, this season's CPUE was considerably higher than CPUE from the last five years.

Table 2. Annual sampling effort, catch totals, and catch CPUE (fish per hour) for sub-yearling Chinook and yearling Coho Salmon at the Snoqualmie River rotary screw trap 2001-2024.

Year	Effort (Hours)	0+ Chinook	1+ Coho	Chinook CPUE	Coho CPUE
2001	509	619	553	1.22	1.09
2002	712	584	1751	0.82	2.46
2003	946	887	1305	0.94	1.38
2004	1056	610	1127	0.58	1.07
2005	1006	672	1187	0.67	1.18
2006	1011	794	2031	0.79	2.01
2007	510	153	615	0.30	1.21
2008	318	275	587	0.87	1.85
2009	633	269	765	0.43	1.21
2010	1123	668	1149	0.60	1.02
2011	573	282	1662	0.49	2.90
2012	847	377	1384	0.44	1.63
2013	1218	623	1718	0.51	1.41
2014	805	293	1097	0.36	1.36
2015	1017	89	678	0.09	0.67
2016	1112	50	809	0.04	0.73

2017	1131	1517	925	1.34	0.82
2018	1117	1587	1517	1.42	1.36
2019	818	667	612	0.82	0.75
2020*	159	13	1		
2021	764	582	563	0.76	0.74
2022	913	179	473	0.20	0.52
2023	949	619	313	0.65	0.33
2024	928	174	897	0.19	0.97
Average	**870**	**547**	**1031**	**0.63**	**1.25**

[a] = Trapping cancelled due to Covid-19

Yearling Coho Salmon catch rates exhibit variability influenced by river conditions and the size of the annual out-migrant cohort. Nevertheless, there is a concerning long-term trend of declining total annual catch and CPUE (catch-per-unit-effort) averages at the Snoqualmie trap (Table 2). Over the past five years, yearling Coho Salmon CPUE has declined, with project lows recorded in the 2022 and 2023 seasons. Notably, the 2023 season marked the lowest CPUE since Tulalip began operating the screw trap. This past season, Coho catch rates were higher than in recent years, but slightly below the project average.

For sub-yearling Chinook, CPUE showed a declining trend from 2001 to 2016, reaching a project low of approximately 0.55 fish per hour (Figure 4, Table 2). Between 2017 and 2021, CPUE rebounded significantly, exceeding prior years, only to fall well below average again in 2022. In 2023, CPUE surged to 103% of the project average, but this season's catch rates and CPUE have once again dropped sharply, falling significantly below average (Figure 4). This recent decline is particularly concerning and may be partially attributed to severe flooding in December 2023, which likely disrupted habitat conditions and out-migration success.

While CPUE is a useful tool for identifying trends, production estimates offer a more comprehensive assessment of overall abundance, as they incorporate trap efficiency and account for credible intervals.

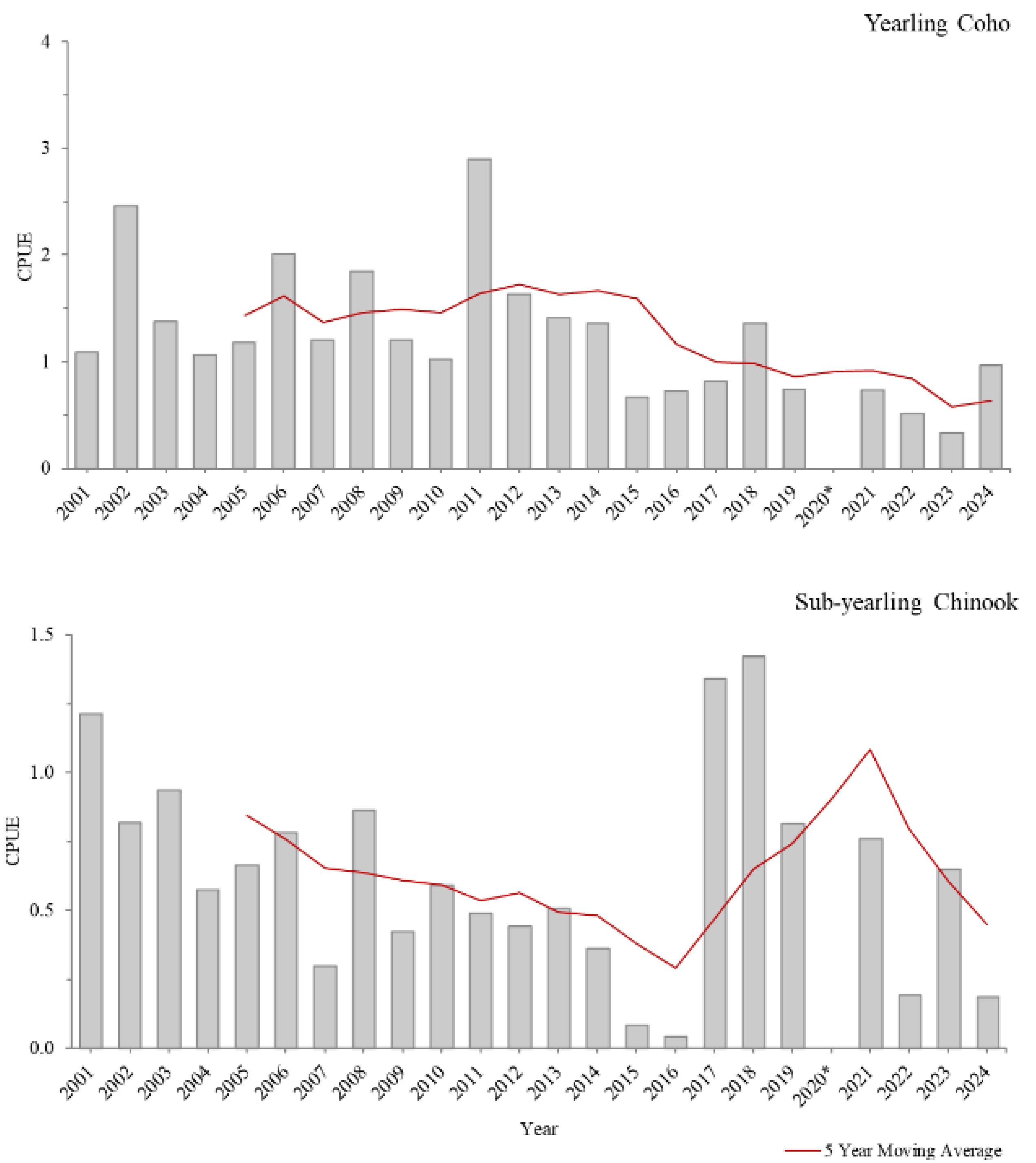

Figure 4. Natural-origin sub-yearling Chinook and yearling Coho Salmon CPUE time series at the Snoqualmie trap by year; 2001-2024. Sampling was ended early in 2020 due to Covid-19.

PRODUCTION ESTIMATES

Production in this report refers to the abundance of out-migrating salmon at the trap site. Our traps catch around one to three percent of the emigrating salmon and this proportion is known as trap efficiency. In order to estimate the total number of fish passing the trap, we use the efficiency to expand the catch. Trap efficiency is estimated using mark-recapture efficiency trials where marked fish are released upstream of the trap weekly and those recaptured are tallied (see details in the efficiency section of this report).

Our database was cleaned and this season's data has been uploaded into SQL. Over the coming year, we will clean and upload previous years' data. We transitioned to a new production estimate model, a Bayesian time-stratified Petersen estimator that relies on a hierarchical, semi-parametric model with penalized spline (P-spline) smoothing to estimate production during sampled and un-sampled strata. Posterior distributions are modelled in Just Another Gibbs Sampler (JAGS) software using Markov chain Monte Carlo (MCMC) simulations. Studies have shown Bayesian inference models to be the best fit when trap efficiencies are too variable to pool, when there are strata with minimal efficiency data, and when there are trap outages (Schwarz et al. 2009, Bonner and Schwarz 2011, Oldemeyer et al. 2018). This model also provides statistically robust imputations of production and efficiency during un-sampled periods.

Our trap efficiency values tend to exhibit too much heterogeneity to apply a pooled Petersen estimator. Pooling efficiencies would introduce bias given the variability in efficiency test values. Time-stratified Petersen estimators assume homogeneity within each stratum, so efficiency testing must be conducted consistently to avoid bias. Simple Petersen estimators can be a decent option when efficiency testing is done regularly throughout the season, but due to constraints around river size and hatchery releases, this would be highly challenging on the Snoqualmie River. Simple Petersen estimates do not account for variance in efficiency testing, so it is likely that these models are underestimating uncertainty. Comparisons of mark-recapture estimators have shown that Bayesian inference models provide a higher level of precision compared to pooled or stratified Petersen estimates and also give more accurate estimates of uncertainty (Bonner and Schwarz 2011, Oldemeyer et al. 2018).

Production estimates are modeled using the Bayesian Time-Stratified Population Analysis System (BT-SPAS) R package, version 2021.11.02 (available at www.github.com/cschwarz-stat-sfu-ca/BTSPAS). We use the diagonal model with three chains, iterations are set at 200,000, burn in period is 100,000 and 6,000 iterations are saved, which makes the thin rate 50. Bayesian inference allows us to use credible intervals, so we report a 95% credible interval, which means that actual production has a 95% probability of being within the interval. This provides an easily understandable measure of uncertainty. For our point estimates, we use the median values of the posterior distribution since the distributions are log-normal with asymmetric tails. Our 95% credible interval is bounded by the 2.5th and 97.5th percentiles. Model convergence and mixing is checked using trace plots and by checking the autocorrelation. Brooks-Rubin-Gelman statistic values are calculated and kept under 1.1. If the model does not converge sufficiently, we increase the iterations and burn-in period. Goodness of fit is checked using deviance information criterion as well as Freeman-Tukey and deviance statistic plots. Splines are split using the "jump after" function whenever catch numbers jump up or down rapidly and if it improves the fit.

Each Julian week is stratified into day and night periods, defined by sunrise and sunset times in Duvall, WA. This diurnal stratification is used because catch rates suggest differences in migration behavior and/or trap efficiency between day and night periods. Since we do not sample continuously, we must expand the trap catch to estimate the total number of fish that would have been caught for each Julian week and diel stratum. Daytime catch is expanded into unsampled daytime strata and nighttime catch is expanded into unsampled nighttime strata. This expansion is done by dividing the catch by the proportion of the week sampled with the following formula:

$$\hat{C}_{ix} = n_{ix} / f_{ix} \qquad (1)$$

where

$\hat{C}_{ix}$ = estimated catch for diel stratum x during week i

n_{ix} = catch for diel stratum x during week *i*
f_{ix} = proportion of diel stratum fished during week *i*.

This expansion assumes that catch rates are similar during sampled and unsampled periods. In order to avoid violating this assumption, we reject some sampling events that are less than four hours if they occur during a time that could bias catch rates. For example, if a sampling event was only three hours long and occurred immediately before sunset, we would reject it because the catch rate is likely higher around sunset than the rest of the day. Occasionally, we don't reject these short effort events when recent surveys balance out the times sampled. Also, weeks with low effort are rejected since it is less likely that catch rates remained the same throughout the entire week. It is important to separate day and night strata before making this expansion, but once the expansion is done, catch during the two diel strata are summed so that a total catch for each week can be input into the production model. With our previous model, we were able to calculate the variance in this expansion, but we currently are not able to incorporate it into our credible interval estimate. We think that with our dataset, it is more important to account for the variance in efficiency testing than the variance in this expansion since the efficiency testing is a much larger source of variance.

The coefficient of variation (CV) is calculated by dividing the posterior standard deviation by the mean. Since the posterior standard deviation is drawn from a probability density, CV in BT-SPAS is a direct measure of uncertainty in the parameter value, rather the more commonly used classical inference CV, which is a measure of the variance in estimate values if the experiment were repeated many times. This Bayesian version of CV provides a more intuitive metric for interpreting uncertainty.

Natural-Origin Sub-Yearling Chinook Salmon

Based on our data and findings from other Puget Sound trapping studies, we assume that the sub-yearling Chinook Salmon emigration begins in Julian week 1 and concludes by week 30 (Conrad and MacKay 2000; Seiler et al. 2002; Lisi 2019; Topping and Anderson 2021b). Although we do not sample during the very start and end of the migration period, the BT-SPAS package is capable of inferring production for these unsampled weeks. To improve MCMC convergence and ensure our estimates taper to zero at the season's boundaries, we input catch values of one for Julian weeks 1 and 30, as well as for some adjacent unsampled weeks (Carl Schwarz, personal communication).

Table 3. Natural-origin sub-yearling Chinook Salmon production estimates in the Snoqualmie River, 2001-2024.

Migration Year	Production Estimate	2.5% Credible Interval	97.5% Credible Interval	Coefficient of Variation (CV)
2001[a]	177,711			
2002[a]	127,298			
2003[a]	143,296			
2004	90,991	39,058	209,056	0.47
2005	92,382	55,223	161,648	0.30
2006	131,345	73,788	224,840	0.29
2007	39,157	26,679	59,463	0.21
2008[b]				
2009	45,090	24,717	99,747	0.43
2010	136,961	79,396	263,764	0.34
2011	75,453	44,265	134,453	0.29
2012	45,093	32,935	61,285	0.16
2013	185,552	129,271	263,720	0.18

2014	113,636	81,435	160,672	0.18
2015	18,322	14,798	23,081	0.12
2016	14,043	7,670	28,821	0.35
2017	515,311	400,949	684,023	0.14
2018	348,002	268,881	482,088	0.15
2019	156,010	113,813	233,437	0.23
2020[c]				
2021	79,111	45,978	187,488	0.43
2022	75,049	41,333	161,474	0.40
2023	101,268	61,217	178,240	0.30
2024	45,586	31,168	84,464	0.34
Average	**125,303**	**82,767**	**194,830**	**0.28**
a = No efficiencies, used simple Petersen estimate with five-year mean of efficiencies				
b = Trap repairs				
c = Covid-19 shut down				

In 2024, we estimate that approximately 45,586 natural-origin sub-yearling Chinook Salmon migrated past our trap site on the Snoqualmie River. This figure is significantly below the long-term project average of 125,303, representing just 36% of the typical annual migration. This is a reasonable estimate, as both catch and CPUE (catch-per-unit-effort) were 32% and 30% of the project average, respectively (Table 3). The discrepancy likely arises from the production model's reliance on weekly efficiency estimates throughout the season rather than assuming a constant CPUE. The coefficient of variation (CV), which measures the uncertainty of the estimate, is 0.34 for 2024. This is higher than the project average, indicating less confidence in this year's model estimates compared to previous years.

Before 2017, production estimates showed a gradual long-term decline, reaching a project low in 2016 (Figure 5, Table 3). This was followed by a record peak in 2017, the highest estimated emigration on record, and then a gentle downward trend from 2017 to 2022, with average estimates and no major fluctuations. Last year’s production estimates showed a slight increase in production. This season, however, we observed a sharp decline, resulting in our lowest recorded out-migration since 2016 (Figure 5). In 2024, production peaked in Julian week 18, with the majority of out-migration occurring between julian weeks 12 and 21 (Figure 6).

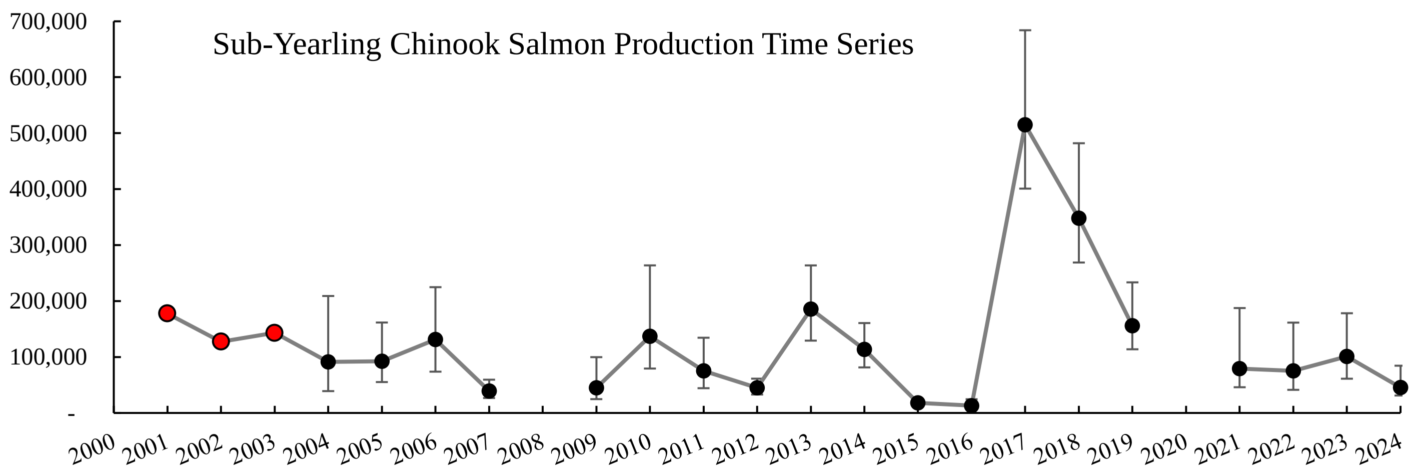

Figure 5. Natural-origin sub-yearling Chinook Salmon production estimates for the Snoqualmie River, 2001-2024. Red dots indicate years that used simple Petersen estimates with five-year means of efficiencies due to a lack of efficiency testing. Error bars represent the 95% credible interval range. Data is missing for 2020 due to Covid-19.

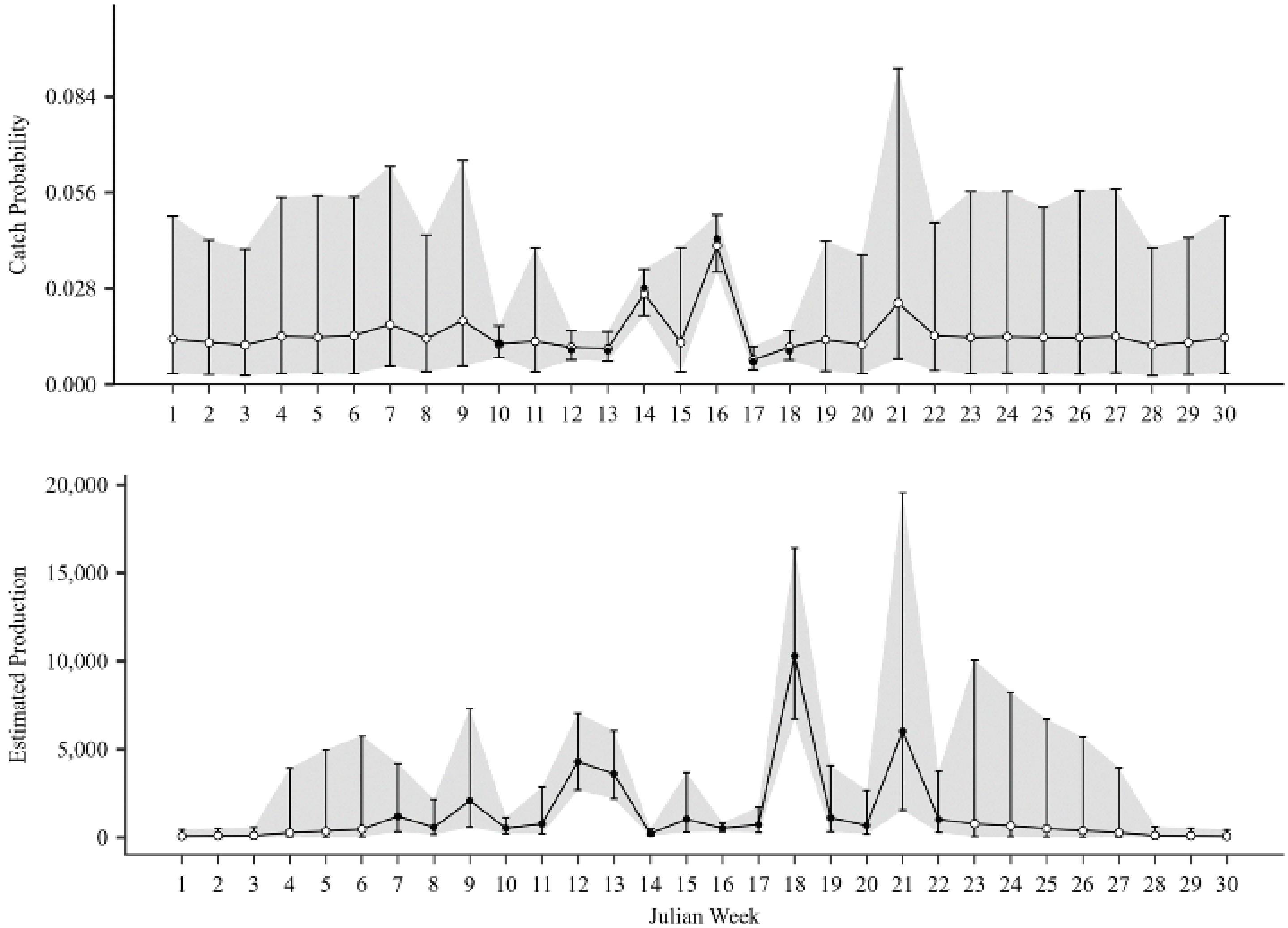

Figure 6. Natural-origin sub-yearling Chinook Salmon efficiency (i.e. catch probability, top panel) and production estimates (bottom panel) by Julian week in the Snoqualmie River, 2024. Shaded areas represent the credible intervals. In the catch probability plot, closed circles represent actual efficiency tests values, while open circle values represent modeled ones. In the production estimate plot, open circles represent unsampled weeks and closed circles represent sampled weeks.

Natural-Origin Yearling Coho Salmon

For yearling Coho Salmon, emigration is assumed to begin in Julian week 7 and conclude by Julian week 26, with no migration expected in Julian week 6 or Julian week 27. In 2024, we estimate that approximately 184,038 natural-origin yearling Coho Salmon migrated past our trap site on the Skykomish River (Table 4, Figure 7). While this estimate represents a decrease from the previous year, it is likely more accurate, as last year's higher production estimate included significant uncertainty (Figure 7).

Yearling Coho production has remained relatively stable throughout the project's duration, with some year-to-year fluctuations (Figure 7). The coefficient of variation (CV)—a measure of estimate uncertainty, where lower values indicate greater confidence—is similar to the project’s long-term average for 2024 and a marked improvement over last season. However, the slightly elevated CV this year likely stems from uncertainty caused by having only one efficiency test, conducted in Julian week 20. This single test was also applied to Julian week 19 to meet the BT-SPAS model’s requirement for at least two efficiency measurements. The low number of efficiency tests puts a large caveat on these production estimates and indicates that the credible interval is likely larger than estimated. A simple Petersen estimate was also run with an efficiency of 1.04% (efficiency from julian week 20) and a production estimate of 172,861 was determined. This estimate is slightly lower than what was predicted from the BT-SPAS model but within the credible interval.

The peak of natural-origin Coho Salmon out-migration in 2024 occurred between Julian weeks 17 and 21, consistent with patterns observed in previous years (Figure 8).

Table 4. Natural-origin yearling Coho Salmon production estimates in the Snoqualmie River, 2001-2024.

Migration Year	Production Estimate	2.5% Credible Interval	97.5% Credible Interval	Coefficient of Variation (CV)
2001[a]	142,125			
2002	1,110,452	522,317	2,660,610	0.48
2003	404,132	266,255	634,378	0.24
2004	600,252	289,540	1,424,038	0.45
2005[a]	171,946			
2006	393,938	263,620	611,858	0.22
2007	62,329	46,197	89,366	0.18
2008[a]	361,383			
2009	274,187	170,606	521,329	0.47
2010	360,277	197,518	691,719	0.34
2011	734,889	494,744	1,135,904	0.22
2012	722,478	443,303	1,273,062	0.29
2013	511,735	385,433	735,163	0.17
2014	363,874	261,890	514,558	0.18
2015	180,367	139,988	239,550	0.14
2016	245,399	163,396	379,315	0.22
2017[a]	238,528			
2018	162,748	104,579	261,171	0.25
2019	245,866	158,173	416,729	0.26
2020[b]				
2021	236,981	180,414	330,147	0.18
2022	359,582	236,660	601,188	0.25
2023	242,667	95,429	684,991	0.57
2024	184,038	126,112	343,201	0.28
Average	**361,312**	**239,272**	**713,067**	**0.28**

a = Insufficienct efficiencies, used simple Petersen with five-year mean of efficiencies

b = Covid-19 shut down

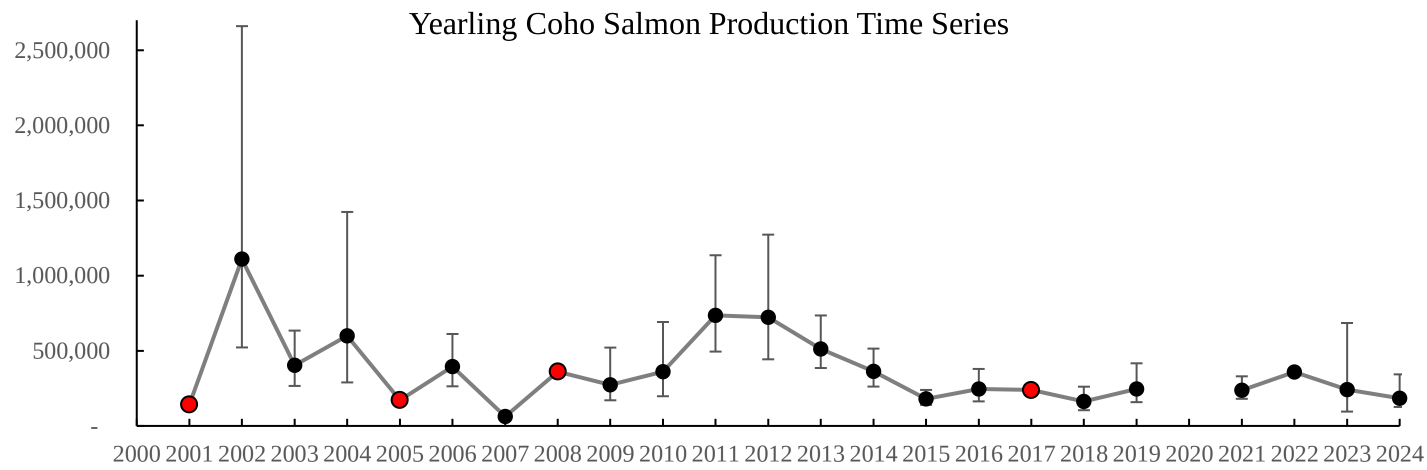

Figure 7. Natural-origin yearling Coho Salmon production estimates for the Snoqualmie River, 2001-2024. Red dots indicate years that used simple Petersen estimates with five-year means of efficiencies due to a lack of efficiency testing. Error bars represent the 95% credible interval range.

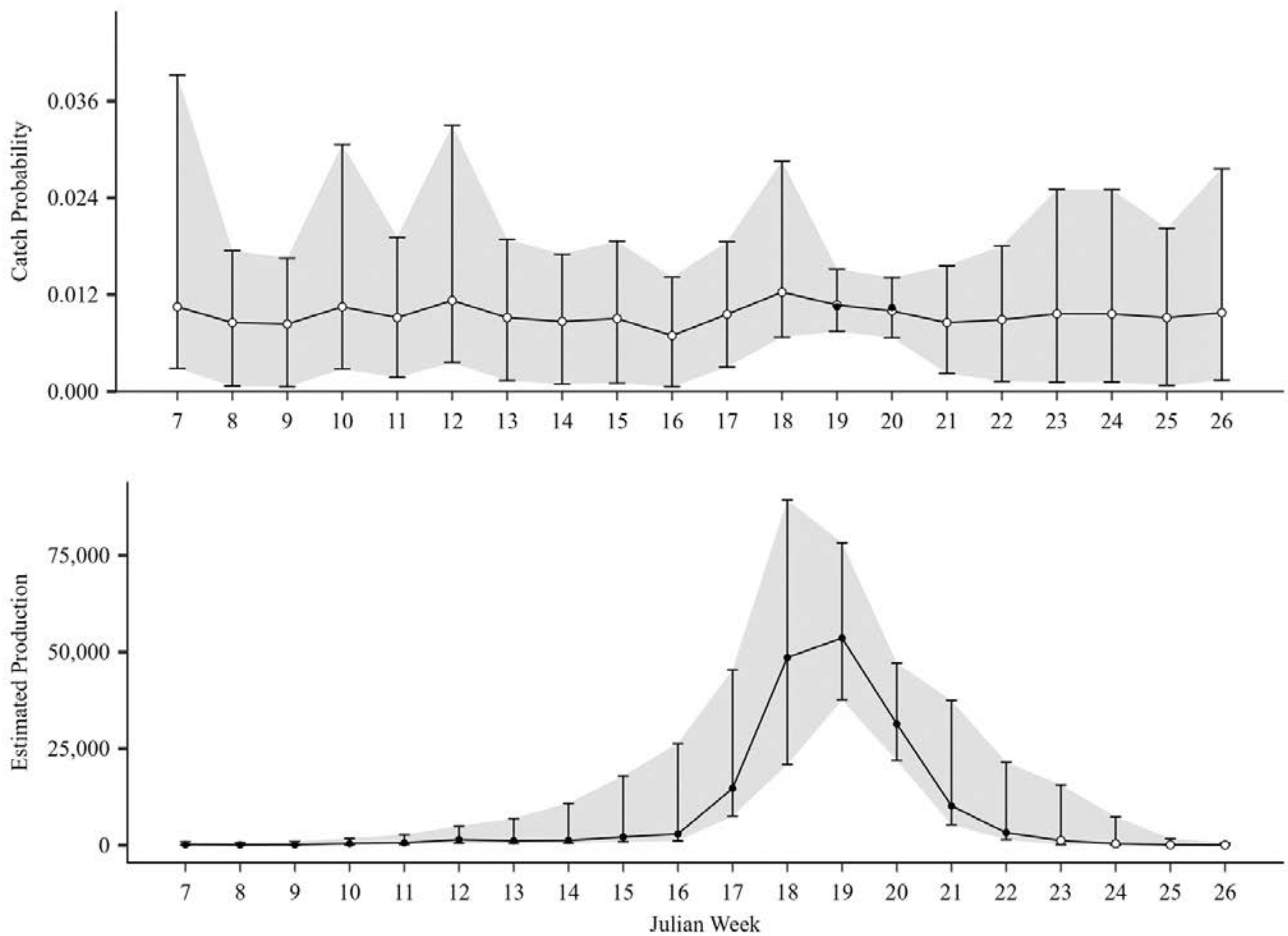

Figure 8. Natural-origin yearling Coho Salmon efficiency (i.e. catch probability, top panel) and production estimates (bottom panel) by Julian week in the Snoqualmie River, 2024. Shaded areas represent the credible intervals. In the catch probability plot, closed circles represent actual efficiency tests values, while open circle values were modeled. In the production estimate plot, open circles represent unsampled weeks and closed circles represent sampled weeks.

EFFICIENCY TESTING AND RESULTS

During the 2024 season, trapping equipment was inspected and monitored frequently and the trap was found to be in full operational condition with almost no escape paths detected and no major equipment malfunctions. Efficiency releases were conducted weekly throughout the duration of the sampling season while hatchery Chinook and Coho Salmon were available. In May, high river flows disrupted our efficiency releases. During these tests, groups of hatchery-origin juvenile salmon were collected from Wallace River Hatchery, marked and released approximately one mile upstream of the trap site.

The trap was operating at an average efficiency rate of 1.53% for Chinook Salmon sub-yearlings. The single test for Coho yearlings had an efficiency of 1.04% during the 2024 sampling season (Table 4). Efficiency tests were rejected if the efficiency was less than 0.3% for Coho Salmon or less than 0.4% for Chinook Salmon. Tests that fall below this threshold are deemed not representative of the actual trap efficiency; no tests fell below the threshold this season. Yearling Coho typically have less efficiency than sub-yearling Chinook due to their larger size and ability to avoid the screw trap.

Table 4. Efficiency release dates and re-capture percentages at the Snoqualmie trap site; 2023.

Species	Date	Released	Captured	Efficiency
0+ Chinook	3/6/2024	1923	23	1.20%
0+ Chinook	3/12/2024	1812	6	**0.33%**
0+ Chinook	3/20/2024	1997	20	1.00%
0+ Chinook	3/26/2024	1941	19	0.98%
0+ Chinook	4/3/2024	2023	57	2.82%
0+ Chinook	4/17/2024	2122	90	4.24%
0+ Chinook	4/23/2024	1974	13	0.66%
0+ Chinook	5/1/2024	2047	20	0.98%
1+ Coho	5/15/2024	1922	20	1.04%
	2024 Average Chinook Efficiency			**1.53%**
	2024 Average Coho Efficiency			**1.04%**

red = Efficiency too low (Coho <0.3; Chinook <0.4) for production modelling.

GENETIC MONITORING

Along with estimating natural production, the rotary screw trap provides an efficient way to gather genetic samples from juvenile salmonids and monitor the run timing of hatchery-origin fish. We take small fin clips from natural-origin Chinook Salmon and steelhead (*Oncorhynchus mykiss*). The steelhead samples are used to monitor the proportion of effective hatchery contribution (PEHC) in natural-origin steelhead. This research is conducted by Bethany Craig, Joseph Anderson, Ken Warheit and Todd Seamons from the Washington Department of Fish and Wildlife.

The Chinook Salmon genetic samples are used for genetic monitoring by the Tulalip Tribes' stock assessment program. These samples are genotyped to estimate relative productivity and gene flow between hatchery and natural-origin fish and to compare genetic estimates to demographic-based estimates of the proportion of hatchery-origin fish spawning naturally ($pHOS_{G,D}$) and proportion of natural influence ($PNI_{G,D}$) estimates. Additionally, Chinook spawners from 19 spawning cohorts across the basin are genotyped to assess population structure, run timing markers, effective population size and the effective number of breeders by origin, time, and location.

DISCUSSION

This year's fishing effort of 928 hours was above the project average of 870 (Table 2) even with the shortened sampling season due to high flows. It is likely that cancelations due to flooding caused us to miss the final pulse of out-migrating fish, but our new production model provides more robust imputation for these unsampled periods. The shortage of Coho Salmon efficiency tests contributed to somewhat higher uncertainty in our Coho Salmon production estimate. In previous years, Coho efficiency was very poor but our efficiency for this season was well above the average. Our next goal will be to increase the number of tests that are conducted. Aside from the aforementioned scheduling difficulties, all trapping equipment including the trap itself, the boat, and all associated supplies were in full working order and operated as expected for the 2024 trapping season.

Chinook Salmon natural production estimates have shown no clear trend over the past two decades, and escapement numbers remain significantly below recovery targets (Snohomish County 2019). This year marked a near-record low in Chinook out-migration, accompanied by a sharp decline in abundance compared to previous years. Variability in abundance and cohort strength is a natural occurrence in fish populations, especially during early life stages when high mortality rates are common. However, it is critical to determine whether these recent declines are exacerbated by human activities or natural phenomena.

One potential contributing factor to this decline is the impact of high flows in early winter could have contributed to significant red scour and egg mortality. High-magnitude or prolonged flood events can scour redds, leading to reduced egg survival (Zimmerman et al. 2015; Montgomery et al. 1996). Winter floods are especially harmful to fall spawners as their eggs are incubating in the streambed during this time. In snowmelt basins, fall spawners could also be at high risk as climate warming increases the quantity of rainfall and the frequency and magnitude of winter floods (Goode et al. 2013). In December 2023, the Snoqualmie River experienced a major flood event, with flow rates reaching approximately 30,000 CFS. This event likely had a significant impact on fish populations, including a decrease in the number of sub-yearling Chinook captured in the screw trap. It is hypothesized that many young Chinook were swept downstream during this high-flow event. The lack of suitable refuge habitat for juvenile fish under such conditions further amplifies mortality risks.

While high-flow events like this are unavoidable, improving river habitats is a critical step toward mitigating their effects. Recent studies have highlighted the effectiveness of restoration strategies such as floodplain reconnection, barrier removal, bank armor removal, wood augmentation, estuary restoration, and shade restoration in boosting salmonid productivity in the Snohomish Basin (Beechie et al. 2023). Enhancing juvenile rearing habitats could significantly aid in the recovery of threatened salmon and steelhead populations in the Skykomish River.

In contrast, natural-origin yearling Coho Salmon production in 2024 was slightly below average, but it did not experience the sharp decline observed in sub-yearling Chinook. Long-term monitoring of Coho Salmon out-migrations indicates that natural production has remained relatively stable, despite a slight downward trend in recent years. While the 2023 production estimate was higher than this year's, it also carried greater uncertainty. However, other metrics, such as total catch and CPUE, suggest an increase in yearling Coho abundance in the Snoqualmie River, offering a more reliable perspective on population trends.

For the 2024 season, our primary goal was to enhance consistency in release sites and increase the number of fishes released to reduce variability in the efficiency rates. While we succeeded in improving consistency for efficiency releases, further improvements in our Coho release methods are needed. It is important to highlight that the Snoqualmie River experienced unusually high flows toward the end of the season, which led to the cancellation of several Coho releases. Additionally, high mortality during yearling Coho releases remains a significant concern, directly affecting our efficiency rates. Looking ahead, our objective for the upcoming year is to maintain consistent sub-yearling Chinook releases while increasing the number of Coho releases to reduce uncertainty in yearling Coho production.

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APPENDIX A: SUMMARY OF 2024 SNOQUALMIE RIVER TRAP CATCH AND MORTALITIES

	Chinook		Coho		Chum	Pink	Steelhead		Cutthrout Trout	Total Salmonid Catch	Lamprey	Dace spp.	Sculpin spp.	Sunfish spp.	Stickleback	Mountain Whitefish	Peamouth	Bass
	Unmarked		Unmarked				Unmarked	Marked										
	0+	1+	0+	1+	0+	0+	Smolts	Smolts										
February																		
Catch	14	1	1	1	1	3789	0	0	0	3807	44	2	4	0	0	1	4	0
Mortalities	0	0	0	0	0	12	0	0	0	12	0	0	0	0	0	0	0	0
March																		
Catch	52	0	155	22	231	23774	1	0	3	24238	87	6	5	1	0	4	0	0
Mortalities	0	0	0	0	0	67	0	0	0	67	0	0	0	0	0	0	0	0
April																		
Catch	69	7	410	267	97	22330	10	9	4	23203	65	9	4	5	50	0	0	1
Mortalities	0	0	0	0	1	116	0	0	0	117	0	0	0	0	0	0	0	0
May																		
Catch	38	2	237	607	0	79	11	4	5	983	90	21	5	17	28	1	1	5
Mortalities	1*	0	0	0	0	2	0	0	0	3	0	0	0	0	0	0	0	0
Total																		
Catch	173	10	803	897	329	49972	22	13	12	52231	286	38	18	23	78	6	5	6
Mortalities	1*	0	0	0	1	197	0	0	0	199	0	0	0	0	0	0	0	0
% Mortalities	0.58	0	0	0	0.30	0.39	0	0	0	0.38	0	0	0	0	0	0	0	0

*intentional take