

Tulalip Tribes Natural Resources Department Report

SKYKOMISH RIVER JUVENILE SALMON OUT-MIGRATION STUDY PROGRESS REPORT

February – June 2023

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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).

SKYKOMISH RIVER TRAPPING SITE

The current trap site is located 26.5 miles upriver from the ocean on the Skykomish River and six miles up from the confluence with the Snoqualmie River (Figure 1). It is in the tail-out of a wide pool/run as it transitions into a riffle, confined by two gravel point bars (Figure 2). The wetted width of the Skykomish River at this point is ~325 ft. during the spring out-migration period and the channel's bank full width is ~490 ft. The channel's maximum depth at the site is ~5 ft. at summer low-flow level and approaches ~18.5 ft. at bank full depth. The channel gradient is < 1% and the substrate is mostly gravel and cobble. When fishing; the trap is positioned in the thalweg, near the center of the river (Figure 2). Land use adjacent to the current project site is principally agricultural with relatively intact riparian vegetation. Existing riparian vegetation is primarily cottonwood and alder with some planted cedar and spruce. At the immediate trapping site, the river right is composed of a gravel bar adjacent to a cottonwood stand. The left bank is just downstream of a rip-rapped bank with planted riparian vegetation integrated into a cottonwood stand and a larger cottonwood grove downstream on the inside bend. This land is being purchased by the Tulalip Tribes for future stream restoration.

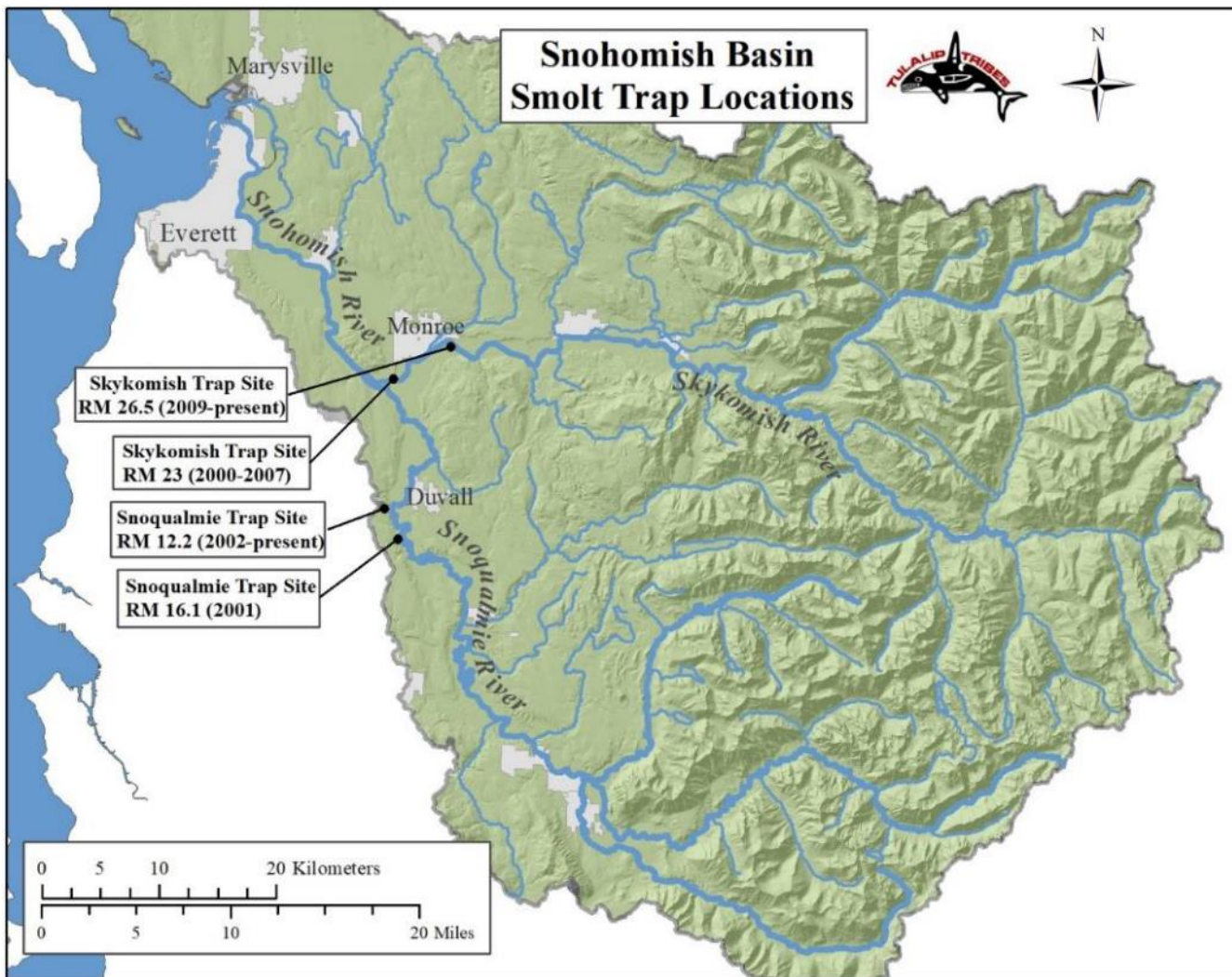


Figure 1: Map of the Snohomish watershed with the locations of the trap sites on the Skykomish and Snoqualmie Rivers.



Figure 2: Aerial photograph of the trap site at river mile 26.5 on the Skykomish River. The yellow X indicates the approximate trap fishing position.

SUMMARY OF SAMPLING OPERATIONS

The Skykomish River rotary screw trap is operated during the juvenile salmon outmigration from February through June. Sampling occurs on four to five weeknights and one or two weekdays per week. Sampling dates are stratified by Julian week (JW) in order to more accurately compare results from year to year. Table 1 shows the Julian weeks that were sampled in 2023 and the corresponding dates. In 2023, trapping was conducted from February 21st to June 22nd (JW 8- JW 25). Normally, sampling occurs from JW 7 to JW 25 with some variability in timing. In 2023, the trap was operated for 901 hours, which is above the average effort of 827 hours (Table 2). Of those hours, 529 were fished at night, representing 59% of the total trapping effort. Sampling had to be cancelled on Julian weeks 18 and 20 due to safety hazards caused by large flood events.

A detailed summary of catch numbers by month can be found in Appendix A. During the sampling season, a total of 85,154 salmonids were captured. Captured unmarked Chinook Salmon included 3,496 sub-yearlings (0+) and 73 yearlings (1+). The number of 0+ Chinook Salmon caught at the Skykomish River trap in 2023 was well above the project average of 1,988 (Table 2). Captured unmarked Coho Salmon included 593 sub-yearlings and 2,924 yearlings. The number of unmarked 1+ Coho Salmon caught in 2023 (2,924) was only 88% of the project average (3,341). During the trapping and handling process a total of 10 salmonid mortalities were reported. The 10 mortalities included three unmarked 0+ Chinook Salmon, one unmarked 0+ Coho Salmon, five Chum Salmon and one unmarked steelhead smolt. Mortality as a percentage of the total sub-yearling Chinook Salmon catch was 0.09% (Appendix A).

Table 1. Julian weeks and corresponding dates for 2023 sampling season.

Julian Week	From	To
8	2/19/2023	2/25/2023
9	2/26/2023	3/4/2023
10	3/5/2023	3/11/2023
11	3/12/2023	3/18/2023
12	3/19/2023	3/25/2023
13	3/26/2023	4/1/2023
14	4/2/2023	4/8/2023
15	4/9/2023	4/15/2023
16	4/16/2023	4/22/2023
17	4/23/2023	4/29/2023
18	4/30/2023	5/6/2023
19	5/7/2023	5/13/2023
20	5/14/2023	5/20/2023
21	5/21/2023	5/27/2023
22	5/28/2023	6/3/2023
23	6/4/2023	6/10/2023
24	6/11/2023	6/17/2023
25	6/18/2023	6/24/2023

CATCH PER UNIT OF EFFORT (CPUE)

Catch data are converted to catch per unit effort (CPUE) for quick analyses dealing with run-timing and migration size. This allows for easier comparison of catch both within and between years. CPUE represents the number of fishes caught per hour and can be averaged for a period by dividing the catch by the number of hours fished for that period. CPUE for 0+ Chinook Salmon demonstrated a peak in JW 13 (Figure 3). The peak CPUE for sub-yearling Chinook Salmon in 2023 was consistent with the usual emigration period between JW 11 and JW 17. The timing of the yearling Coho Salmon out-migration is more consistent from year to year, generally occurring from JW 17 to JW 21 and the peak CPUE in 2023 was during this time frame (Kubo et al. 2013).

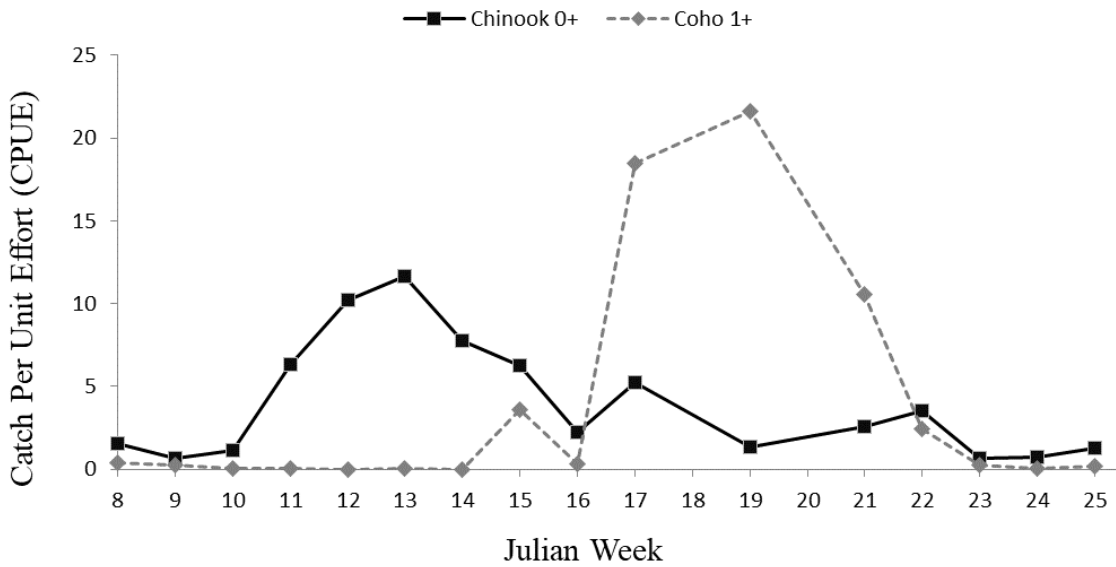


Figure 3. Natural-origin sub-yearling (0+) Chinook Salmon and yearling (1+) Coho Salmon CPUE by Julian week at the Skykomish River trap, 2023.

Average annual salmonid CPUE on the Skykomish trap has exhibited variability throughout the duration of the project due to fluctuating sampling conditions and the strength of a given year’s out-migrant cohort. Average annual CPUE for sub-yearling Chinook Salmon in 2023 was well above the project average and significantly higher than all years since 2019 (Table 2, Figure 4 and 5). CPUE for yearling Coho Salmon in 2023 was below average but higher than last year and well above the average catch since the trap was moved in 2009 (1,976).

Table 2. Annual sampling effort, catch totals, and catch CPUE (fish per hour) for unmarked sub-yearling Chinook and yearling Coho Salmon at the Skykomish River rotary screw trap 2000-2023.

Year	Effort (Hours)	0+ Chinook	1+ Coho	Chinook CPUE	Coho CPUE
2000	309	1287	5972	4.17	19.36
2001	889	1770	4790	1.99	5.39
2002	672	1082	8779	1.61	13.07
2003	992	3267	7427	3.29	7.49
2004	1071	939	10608	0.88	9.90
2005	994	1704	2661	1.71	2.68
2006	1114	3075	6210	2.76	5.57
2007	447	1368	763	3.06	1.71
2009	688	1654	1409	2.41	2.05
2010	974	2288	1245	2.35	1.28
2011	734	753	1796	1.03	2.45
2012	1016	1283	2992	1.26	2.95
2013	1194	2452	4443	2.05	3.72
2014	880	1392	2612	1.58	2.97
2015	1079	1433	1577	1.33	1.46
2016	1032	563	2137	0.55	2.07
2017	843	3961	2154	4.70	2.55
2018	836	4453	1583	5.33	1.89
2019	986	4076	1699	4.14	1.72
2020	151 ^a	38	11	0.25	0.07
2021	287	1739	181	6.06	0.63
2022	925	1652	2879	1.79	3.11
2023	901	3496	2924	3.88	3.25
Average	827	1988	3341	2.53	4.23

^a = Trapping shut down due to Covid-19

It appears that 0+ Chinook CPUE was on a downward trend from 2001-2016 when it reached the project lows at approximately 0.55 fish per hour (Figure 4, Table 2). From 2017 to 2019 CPUE increased well above previous years, to then decline in 2022 to below average levels. In 2023, CPUE increased to 3.9 fish per hour and well above the project average. Although CPUE can be used for trend detection, production estimates are better suited for this since they represent overall abundance by incorporating trap efficiency and include credible intervals.

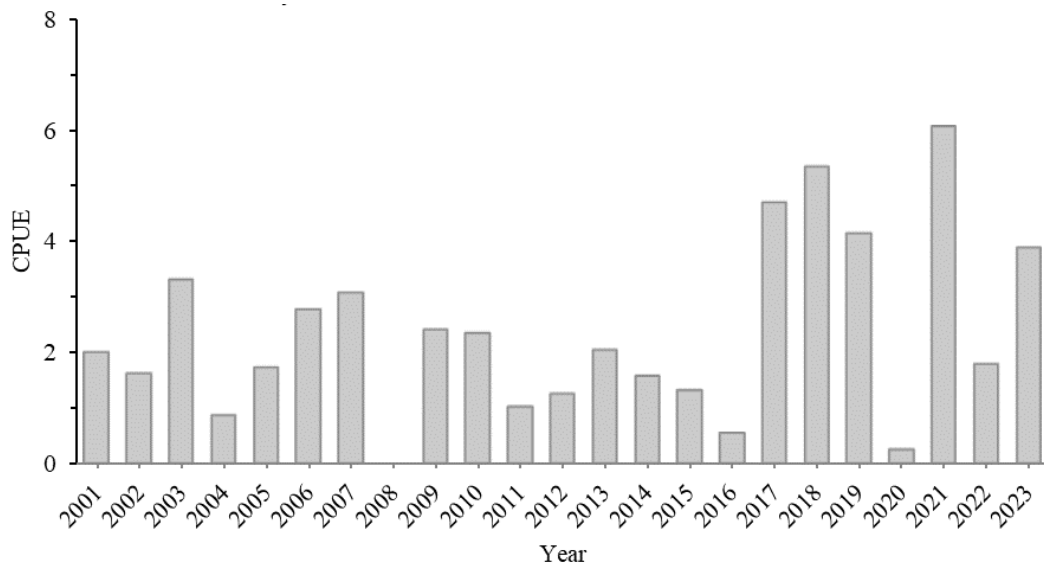


Figure 4. Natural-origin sub-yearling Chinook Salmon CPUE time series at the Skykomish trap by year; 2001-2023. The years 2008, 2020 and 2021 are not included due to missing or limited sampling seasons.

Yearling Coho Salmon catch rates were in a downtrend until 2010, when the lowest documented average CPUE of 1.28 occurred (Table 2, Figure 5). In 2009, the trap was moved upstream from River mile (RM) 23 to its current location at RM 26.5. This relocation excluded the Woods Creek drainage from sampling, likely causing a catch decline, particularly for Coho following 2009 due to decreasing drainage area sampled. Woods Creek is known to have high Coho Salmon spawning activity but little Chinook Salmon spawning. The overall decline in Coho Salmon catch rates is also related to a decline in the Coho Salmon escapement in the latter half of the 2000s (Pacific Fishery Management Council 2019). Following relocation in 2009, catch rates have remained fairly consistent both in total catch and CPUE.

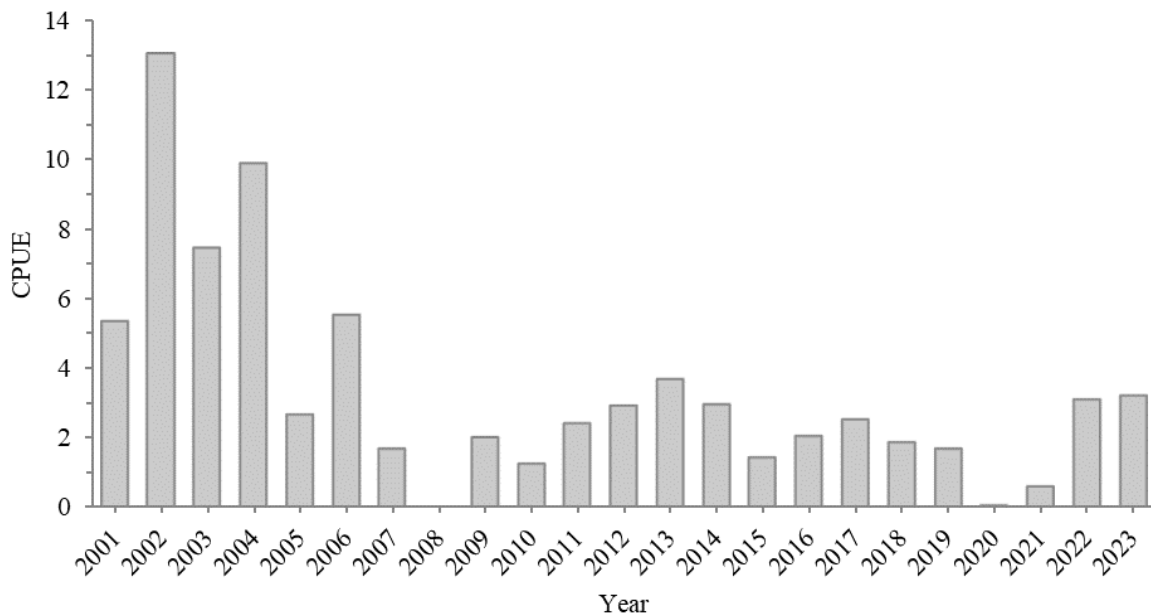


Figure 5. Natural-origin yearling Coho Salmon CPUE time series at the Skykomish trap by year; River mile 23: 2000-2007; River mile 26.5: 2009-2019. The years 2008, 2020 and 2021 are not included due to missing or limited sampling seasons.

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 fishes 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 the number that are recaptured are tallied (see details in the efficiency section of this report).

Last year, we transitioned to a new production estimate model in order to update our statistical methods. Jonah Keith cleaned the database and coded our data processing in order to recalculate all previous estimates. We now use 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 Skykomish 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 doesn't 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 Monroe, 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 don't 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:

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

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 aren't 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 was 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 as well as those of other Puget Sound trapping efforts, we assume that the beginning and end of the sub-yearling Chinook Salmon emigration are Julian weeks 1 and 30, respectively (Conrad and MacKay 2000; Seiler et al. 2002; Lisi 2019; Topping and Anderson 2021b). Although we don't sample during the very beginning and end of the migration, the BT-SPAS package is able to impute production during these times with known certainty. In order to improve MCMC convergence and force our estimates to zero at the ends of the season, we enter catch values of one for Julian weeks one and 30 as well as for some of the adjacent un-sampled weeks (Carl Schwarz, personal communication).

In 2023, we estimate that approximately 432,124 natural-origin sub-yearling Chinook Salmon emigrated past our trap site on the Skykomish River. This production estimate is above the project average of 404,685 (Table 3).

Table 3. Natural-origin sub-yearling Chinook Salmon production estimates in the Skykomish River, 2001-2023.

Migration Year	Production Estimate	2.5% Credible Interval	97.5% Credible Interval	Coefficient of Variation (CV)
2001	375,060	261,643	638,483	0.26
2002	405,924	307,717	552,788	0.15
2003	636,143	452,850	942,176	0.19
2004	248,020	165,738	363,986	0.20
2005	296,236	202,722	482,705	0.24
2006	510,128	302,321	827,053	0.25
2007	364,439	213,834	750,146	0.44
2008	a			
2009	252,074	151,590	503,704	0.37
2010	560,966	350,573	1,127,872	0.39
2011	241,483	154,529	386,676	0.25
2012	155,966	121,638	250,867	0.21
2013	530,655	366,065	803,224	0.21
2014	255,309	203,401	338,638	0.13
2015	157,208	134,528	187,572	0.08
2016	151,339	121,230	199,080	0.14
2017	996,899	724,979	1,514,165	0.20
2018	686,634	524,215	1,002,894	0.18
2019	553,375	441,194	728,195	0.13
2020	b			
2021	399,128	265,730	654,917	0.24
2022	289,279	225,750	390,241	0.15
2023	432,124	356,859	565,876	0.12
Average	404,685	288,053	629,108	0.22

a = Trap repairs/ moved trap site

b = Covid-19 shut down

Previous to 2017, production estimates were on a gradual long-term decline, reaching the project low in 2016 (Figure 6, Table 3). This was followed by a peak in 2017, the largest estimated emigration on record, and a downward trend from 2017 to 2022. Fortunately, 2023 production estimates are similar to 2021 and an increase from last year. In 2023, production appears to have peaked on JW 15, with most of the outmigration occurring between JWs 11 and 15 (Figure 7).

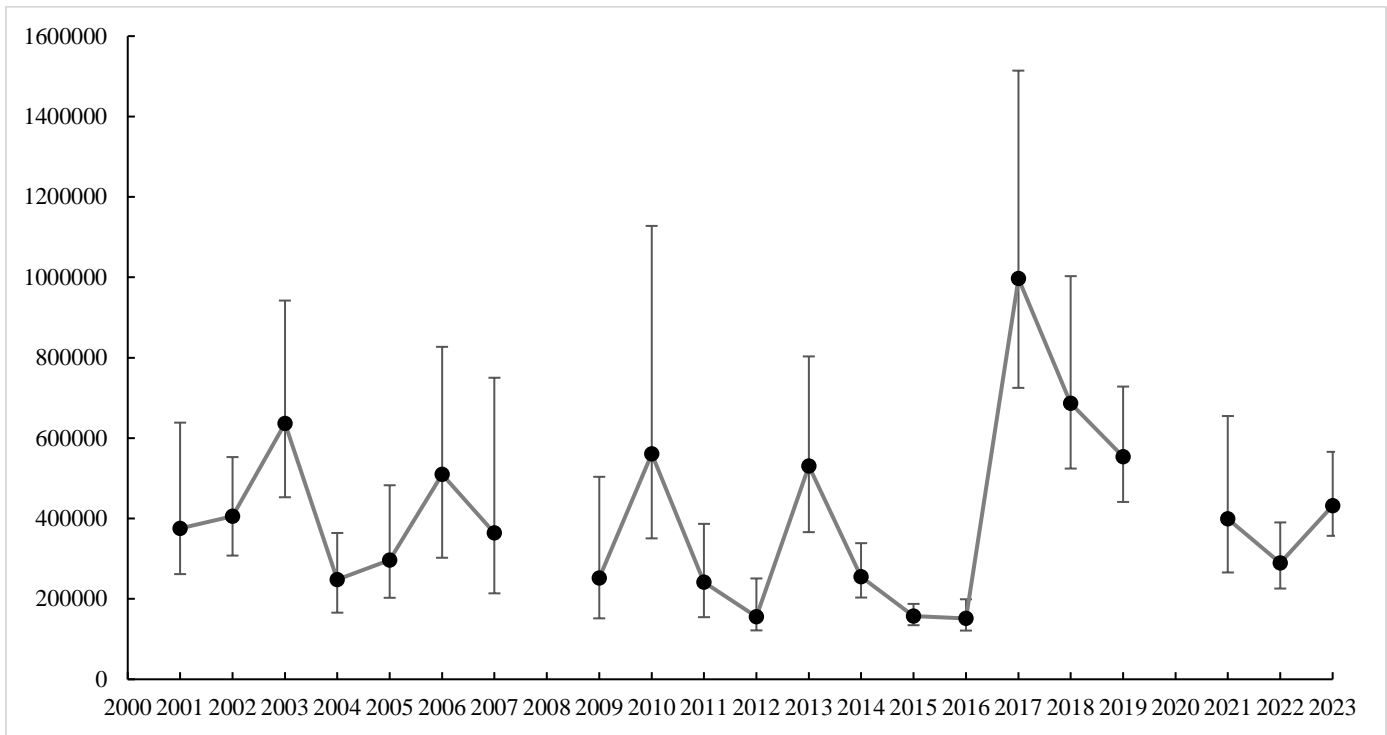


Figure 6. Natural-origin sub-yearling Chinook Salmon production estimates for the Skykomish River, 2001-2023. Error bars represent the 95% credible interval range.

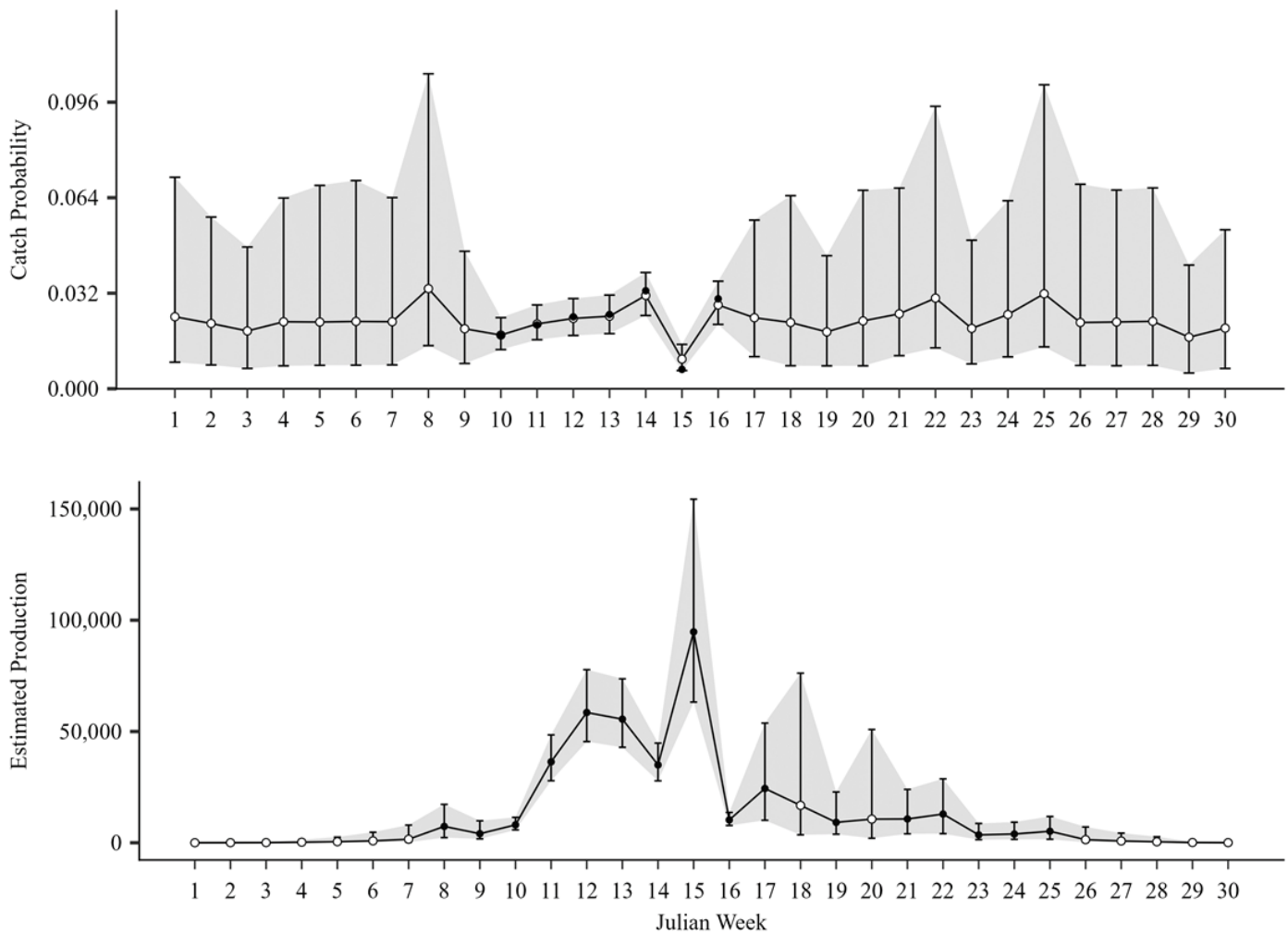


Figure 7. Natural-origin sub-yearling Chinook Salmon efficiency (i.e. catch probability, top panel) and production estimates (bottom panel) by Julian week in the Skykomish River, 2023. Shaded areas represent the credible intervals. In the catch probability plot, closed circles represent actual efficiency tests values, while open circle values were modeled. In the production estimate plot, open circles represent unsampled weeks and closed circles represent sampled weeks.

Natural-Origin Yearling Coho Salmon

For yearling Coho Salmon, we assume that the emigration begins during JW 7 and ends during JW 26. We consider Coho Salmon migration in JW 6 and 27 to be zero. In 2023, we estimate that approximately 876,537 natural-origin yearling Coho Salmon emigrated past our trap site on the Skykomish River. This production estimate is above the project average of 844,877, but much higher than the average since the trap was moved upstream in 2009 (594,115) (Table 4, Figure 8). It appears that yearling Coho production has been gradually declining over the course of the project with some variability from year to year (Figure 8).

Table 4. Natural-origin yearling Coho Salmon production estimates in the Skykomish River, 2001-2022.

Migration Year	Production Estimate	2.5% Credible Interval	97.5% Credible Interval	Coefficient of Variation (CV)
2001	1,115,611	646,091	2,378,896	0.44
2002	1,935,526	1,298,266	2,998,647	0.22
2003	1,354,132	877,320	2,166,201	0.23
2004	2,571,352	1,468,705	4,511,959	0.29
2005	568,995	287,081	1,275,233	0.44
2006	1,361,263	816,160	2,432,828	0.31
2007	118,470	63,669	222,453	0.33
2008	a			
2009	349,263	243,846	544,168	0.22
2010	772624 ^b			
2011	405,037	294,504	577,755	0.18
2012	573,537	402,180	821,050	0.18
2013	801,396	634,454	1,031,667	0.13
2014	1,072,216	761,702	1,664,305	0.21
2015	232,056	167,879	377,597	0.23
2016	461,968	368,178	601,446	0.13
2017	564303 ^b			
2018	611,173	428,699	921,904	0.20
2019	332,160	271,065	417,316	0.11
2020	c			
2021	d			
2022	819,926	539,698	1,463,905	0.29
2023	876,537	446,146	1,696,272	0.45
Average (2009-2023)	594,115	414,396	919,762	0.21

a = Trap repairs/ moved to new site

b = Insufficient efficiency tests, used simple Petersen with five-year mean of efficiency test

c = Covid-19 shut down

d = Sampling stopped due to LWD jam above trap

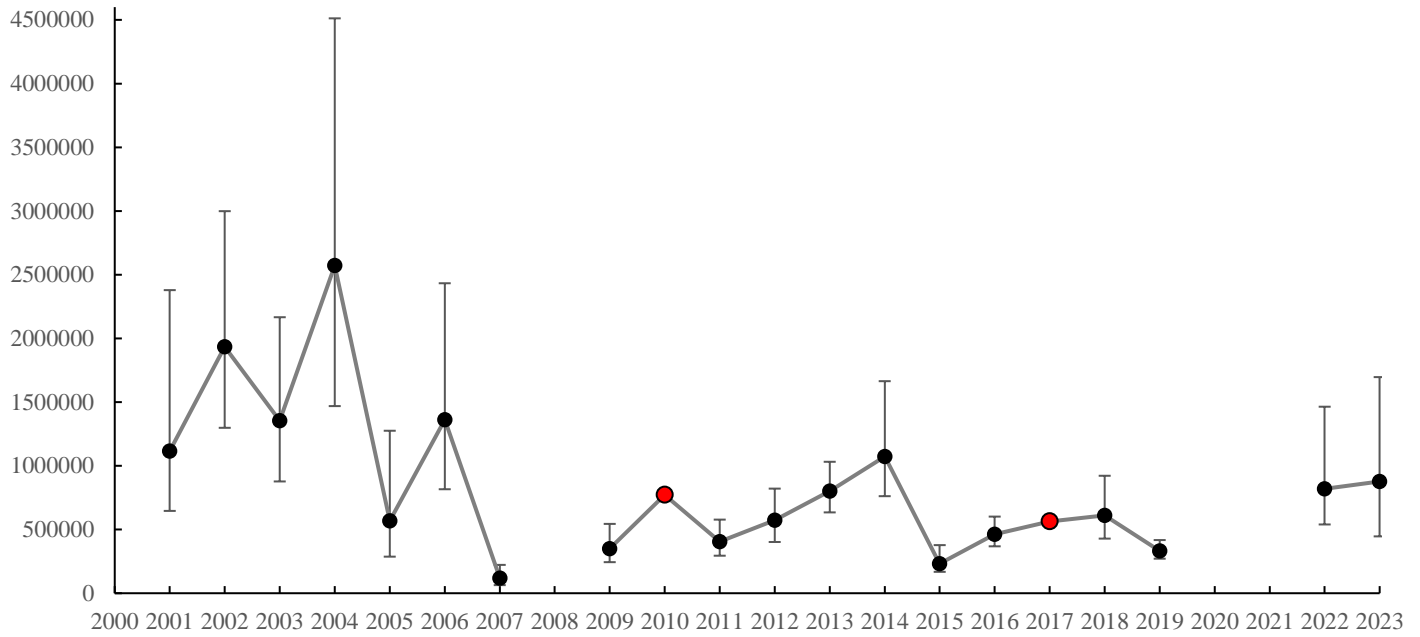


Figure 8. Natural-origin yearling Coho Salmon production estimates for the Skykomish River, 2001-2023. Red dots indicate years that used simple Petersen estimates with five-year means of efficiencies due to a lack of efficiency testing. Error bars represent the 95% credible interval range.

The 2023 credible interval range for yearling Coho Salmon was wider than last year and most recent years. This was due to uncertainty caused by only having two efficiency tests along with having two unsampled weeks. The natural-origin Coho Salmon outmigration happened mostly between JWs 17 and 19, which is consistent with all other years that have been monitored (Figure 9). Unfortunately, the trap was not fished during JWs 18 and 20 which appears to be during peak outmigration.

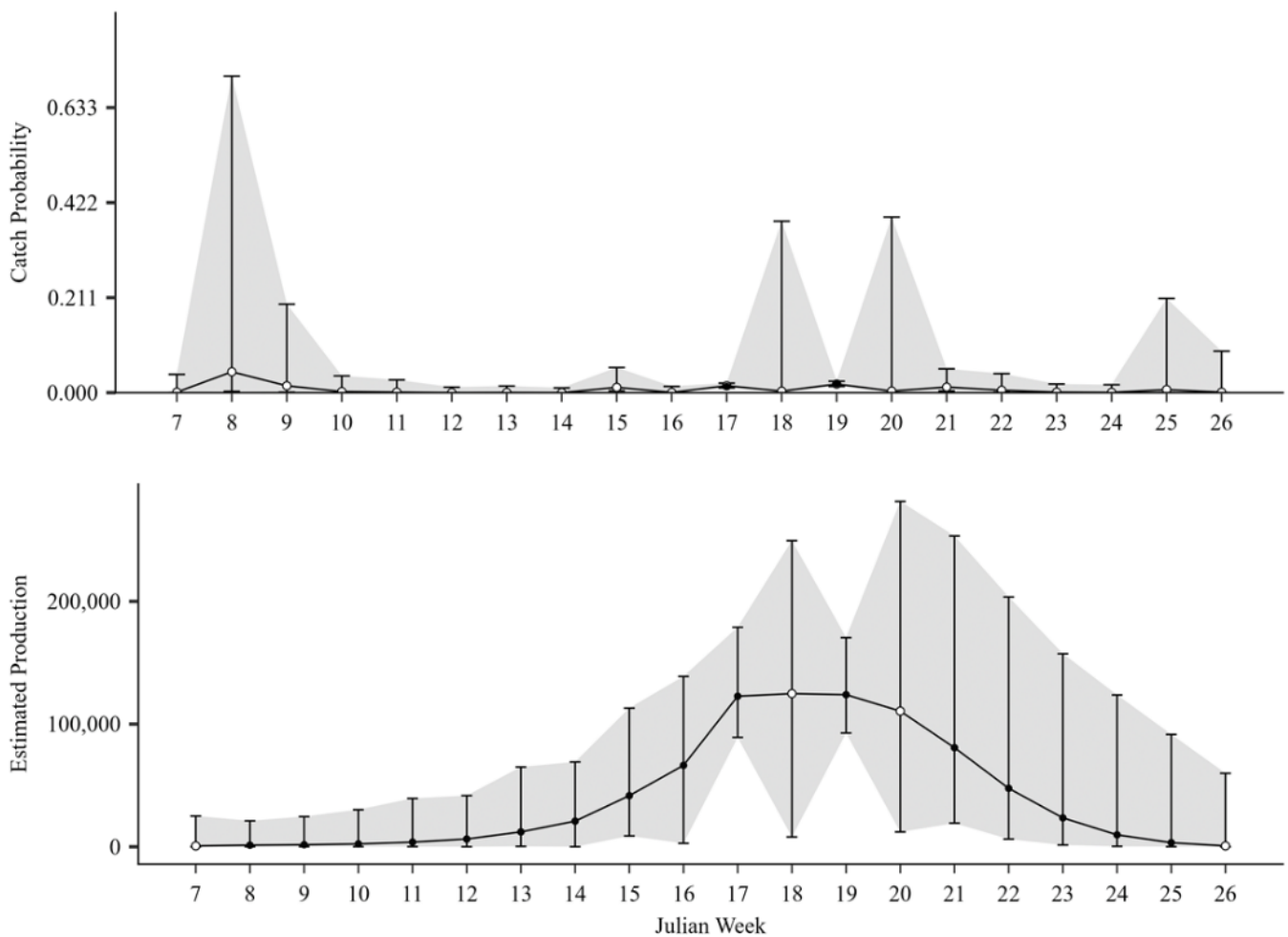


Figure 9. Natural-origin yearling Coho Salmon efficiency (i.e. catch probability, top panel) and production estimates (bottom panel) by Julian week in the Skykomish River, 2023. Shaded areas represent the credible intervals. In the catch probability plot, closed circles represent actual efficiency tests 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 2023 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. 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 release site was inconsistent during the 2023 season and was considered random compared to previous years. The trap was operating at an average efficiency rate of 2.25% for Chinook Salmon sub-yearlings and 0.56% for Coho Salmon yearlings during the 2023 sampling season (Table 4). A total of 14 trap efficiency tests were conducted throughout the 2022 sampling season; seven for Chinook Salmon and seven for Coho Salmon (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. The total number of acceptable efficiency tests were seven for Chinook and two for Coho. A

time series of percent efficiency shows that efficiency tests conducted with only yearling Coho in the later portion of the trap season have significantly less efficiency than earlier tests (Figure 11).

Table 4. Efficiency Release dates, species, and capture percentages for the Skykomish River smolt trap, 2023.

Species	Date	Released	Captured	Efficiency
0+ Chinook	3/8/2023	1959	35	1.79%
0+ Chinook	3/14/2023	2104	45	2.14%
0+ Chinook	3/22/2023	2034	49	2.41%
0+ Chinook	3/28/2023	2050	51	2.49%
0+ Chinook	4/5/2023	2041	67	3.28%
0+ Chinook	4/11/2023	2002	13	0.65%
0+ Chinook	4/19/2023	1825	55	3.01%
1+ Coho	4/25/2023	1920	26	1.35%
1+ Coho	5/9/2023	2027	41	2.02%
1+ Coho	5/23/2023	1938	5	0.26%
1+ Coho	5/31/2023	2021	3	0.15%
1+ Coho	6/6/2023	1978	3	0.15%
1+ Coho	6/14/2023	1935	0	0.00%
1+ Coho	6/21/2023	1810	0	0.00%
2023 Average Chinook Efficiency				2.25%
2023 Average Coho Efficiency				0.56%

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

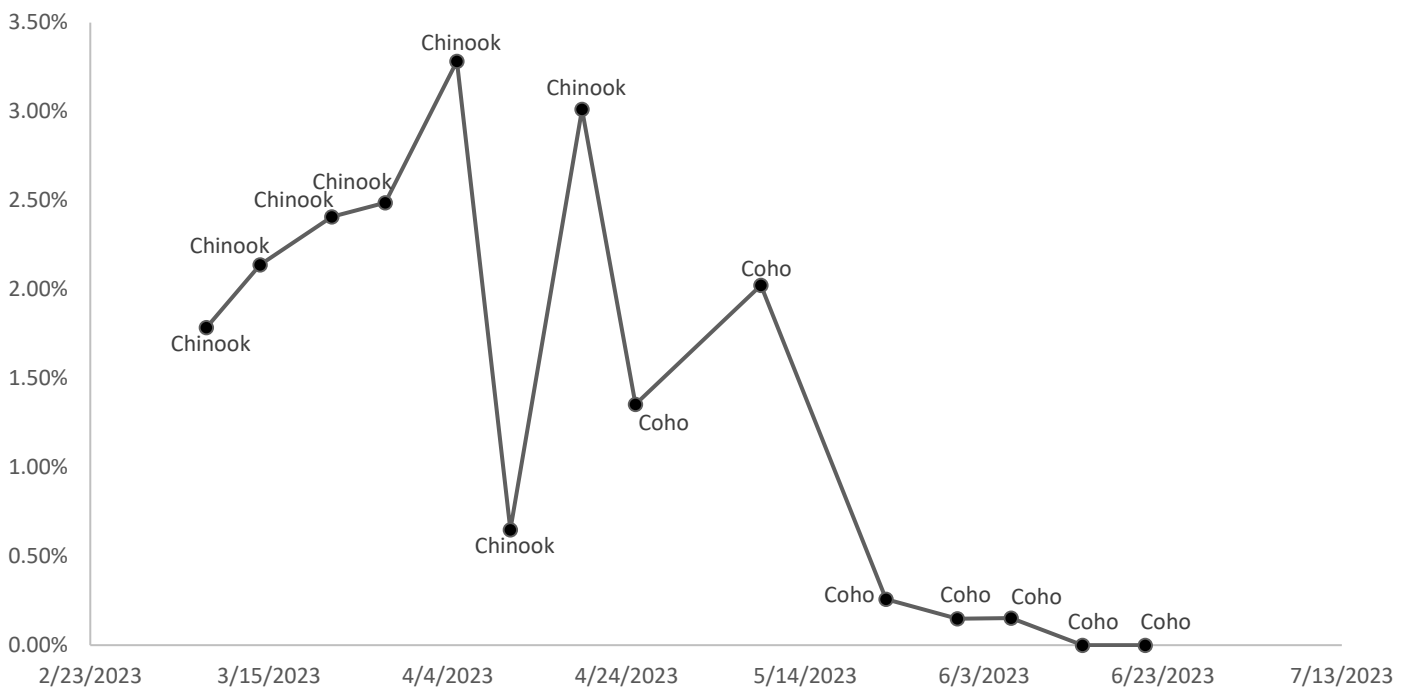


Figure 10: Time series of efficiency release dates and re-capture percentages for Chinook and Coho at the Snoqualmie trap site; 2023.

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 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 901 hours was above the project average of 827 (Table 2) even though we had to cancel trapping due to large flood events. Julian weeks 18 and 20 were cancelled for safety issues caused by these high flows. It is likely that cancellations due to flooding caused us to miss pulses of out-migrating fish, but our new production model provides more robust imputation for these unsampled periods. These cancellations and shortage of Coho Salmon efficiency tests contributed to somewhat higher uncertainty in our Coho Salmon production estimate. 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 most of the 2023 trapping season. There was an incident at the end of the season when boat engine failure delayed checking the live box on several occasions and a trap cone door failure caused the crew to end the trapping season slightly early. As of December 2023, this failure has been repaired and should not be an issue on the upcoming season.

Natural-origin sub-yearling Chinook Salmon production estimates were well above average this year and our CPUE was comparable to the high rates encountered from 2017-2019. This is encouraging after finding very low production estimates for the 2022 season. Chinook Salmon natural production estimates have not shown a clear trend over the last twenty years, but escapement estimates still remain far below recovery goals (Snohomish County 2019).

We estimate that natural-origin yearling Coho Salmon production was about average in 2023 and much higher than the average since the trap was moved. There was a fairly high degree of uncertainty in this year's Coho Salmon estimate. Ensuring consistent efficiency testing in the future should make our credible intervals narrower. Our reported estimates appear to align well with Coho Salmon escapement estimates in the Snohomish basin, when adjusted for brood year (Pacific Fishery Management Council 2019; Snohomish County 2019).

Natural-origin yearling Chinook Salmon out-migrations have been abnormally low in recent years. This is cause for concern since diminished life-history diversity can lower the resilience of Chinook Salmon stocks. The decline in stream-type Chinook Salmon may be an indicator that freshwater juvenile rearing habitat could be improved. Recent research has shown that floodplain reconnection, barrier removal, bank armor removal,

wood augmentation, estuary restoration and shade restoration could greatly improve salmonid productivity in the Snohomish Basin (Beechie et al. 2023). Improvements in juvenile salmon rearing habitat would greatly contribute to the recovery of endangered salmon and steelhead populations in the Skykomish River.

The biggest difficulty in the 2023 trap season was the poor efficiency tests that severely impacted our ability to estimate production of outmigrants. Inconsistent efficiency releases during the 2023 season likely impacted our ability to determine the true efficiency of the smolt trap. The goal for the 2024 season is to improve our consistency in release sites and the number of fish released. While sub-yearling Chinook releases had several acceptable efficiencies, yearling Coho releases were significantly lower than previous years and resulted in high uncertainty production estimates. These poor efficiencies could be because of the size difference between sub-yearling Chinook and yearling Coho (i.e. larger fish have more success in avoiding capture). It is also important to note that the Skykomish River typically has lower flows later in the season which negatively impacts the screw trap's catching efficiency. High mortality during yearling Coho releases has also been a concern that could be impacting our efficiency rates. Our poor efficiencies for yearling Coho are likely influenced by all of these factors and should be considered while planning and executing the screw trap sampling program.

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APPENDIX A: SUMMARY OF 2023 SKYKOMISH RIVER TRAP CATCH AND MORTALITIES

February

	Chinook Salmon				Coho Salmon			Chum Salmon	Pink Salmon	Steelhead		Total Salmonid Catch	Lamprey	Dace Spp.	Sculpin Spp.	Sunfish Spp.	Stickleback
	Unmarked		Marked		Unmarked	Marked				Unmarked Smolts	Marked Smolts						
	0+	1+	0+	1+		0+	1+	1+	0+			0+					
Day (32.3 hours of effort)																	
Catch	50	0	0	86	1	13	0	195	0	0	0	345	0	3	1	0	0
Mortalities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Night (41.6 hours of effort)																	
Catch	48	0	0	439	0	20	0	637	1	0	0	1145	0	5	13	0	0
Mortalities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Total (73.9 hours of effort)																	
Catch	98	0	0	525	1	33	0	832	1	0	0	1490	0	8	14	0	0
Mortalities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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March

	Chinook Salmon				Coho Salmon			Chum Salmon	Pink Salmon	Steelhead		Total Salmonid Catch	Lamprey	Dace Spp.	Sculpin Spp.	Sunfish Spp.	Stickleback
	Unmarked		Marked		Unmarked	Marked		0+	0+	Unmarked Smolts	Marked Smolts						
	0+	1+	0+	1+		0+	1+										
Day (88.1 hours of effort)																	
Catch	31	0	0	2	1	0	0	520	1	0	0	555	0	0	1	0	1
Mortalities	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0
Night (179.3 hours of effort)																	
Catch	1562	1	0	416	5	11	0	36110	6	2	0	38113	4	22	12	1	1
Mortalities	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
Monthly Total (267.4 hours of effort)																	
Catch	1593	1	0	418	6	11	0	36630	7	2	0	38668	4	22	13	1	2
Mortalities	0	0	0	0	0	0	0	5	0	0	0	5	0	0	0	0	0

APPENDIX A: SUMMARY OF 2023 SKYKOMISH RIVER TRAP CATCH AND MORTALITIES

April

	Chinook Salmon				Coho Salmon			Chum Salmon	Pink Salmon	Steelhead		Total Salmonid Catch	Lamprey	Dace Spp.	Sculpin Spp.	Sunfish Spp.	Stickleback
	Unmarked		Marked		Unmarked	Marked		0+	0+	Unmarked Smolts	Marked Smolts						
	0+	1+	0+	1+		0+	1+										
Day (96.3 hours of effort)																	
Catch	106	0	0	1	10	9	0	1313	6	0	0	1445	1	7	0	0	0
Mortalities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Night (136.3 hours of effort)																	
Catch	1105	25	0	14	185	1252	0	31379	4	53	161	34178	4	203	11	1	0
Mortalities	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Monthly Total (232.9 hours of effort)																	
Catch	1211	25	0	15	195	1261	0	32692	10	53	161	35623	5	210	11	1	0
Mortalities	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0

May

APPENDIX A: SUMMARY OF 2023 SKYKOMISH RIVER TRAP CATCH AND MORTALITIES

	Chinook Salmon				Coho Salmon			Chum Salmon	Pink Salmon	Steelhead		Total Salmonid Catch	Lamprey	Dace Spp.	Sculpin Spp.	Sunfish Spp.	Stickleback
	Unmarked		Marked		Unmarked	Marked	Marked	0+	0+	Unmarked Smolts	Marked Smolts						
	0+	1+	0+	1+													
Day (52.5 hours of effort)																	
Catch	19	0	22	1	32	28	1	89	0	0	2	194	0	3	1	0	0
Mortalities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Night (77.5 hours of effort)																	
Catch	321	3	69	1071	278	1478	104	2679	0	20	38	6061	5	9	8	0	0
Mortalities	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Monthly Total (130 hours of effort)																	
Catch	340	3	91	1072	310	1506	105	2768	0	20	40	6255	5	12	9	0	0
Mortalities	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0

APPENDIX A: SUMMARY OF 2023 SKYKOMISH RIVER TRAP CATCH AND MORTALITIES

June

	Chinook Salmon				Coho Salmon			Chum Salmon	Pink Salmon	Steelhead		Total Salmonid Catch	Lamprey	Dace Spp.	Sculpin Spp.	Sunfish Spp.	Stickleback
	Unmarked		Marked		Unmarked	Marked				Unmarked Smolts	Marked Smolts						
	0+	1+	0+	1+		0+	1+										
Day (103 hours of effort)																	
Catch	12	0	31	3	9	1	0	3	0	0	0	59	1	1	1	0	0
Mortalities	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Night (94 hours of effort)																	
Catch	242	44	2378	190	72	112	0	14	0	3	4	3059	2	6	3	0	0
Mortalities	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Monthly Total (197 hours of effort)																	
Catch	254	44	2409	193	81	113	0	17	0	3	4	3118	3	7	4	0	0
Mortalities	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0

Totals (900.8 total hours of effort)

	Chinook Salmon				Coho Salmon			Chum Salmon	Pink Salmon	Steelhead		Total Salmonid Catch	Lamprey	Dace Spp.	Sculpin Spp.	Sunfish Spp.	Stickleback
	Unmarked		Marked		Unmarked	Marked				Unmarked Smolts	Marked Smolts						
	0+	1+	0+	1+		0+	1+										
Catch	3496	73	2500	2223	593	2924	105	72939	18	78	205	85154	17	259	51	2	2
Mortalities	3	0	0	0	1	0	0	5	0	1	0	10	0	0	0	0	0
% Mortalities % of Total Catch	0.09	0.00	0.00	0.00	0.17	0.00	0.00	0.01	0.00	1.28	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Catch	4.09	0.09	2.92	2.60	0.69	3.42	0.12	85.32	0.02	0.09	0.24	99.61	0.02	0.30	0.06	0.00	0.00

APPENDIX A: SUMMARY OF 2023 SKYKOMISH RIVER TRAP CATCH AND MORTALITIES
