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Green River Juvenile Salmonid Production Evaluation: 2022 Annual Report

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Washington Department of
Fish and Wildlife
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Science Division

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Acknowledgements

Measuring juvenile salmon production from large river systems like the Green River involves a tremendous amount of work. A big thanks goes to Pete Topping, who led this project since it began in 2000. His guidance, support, and knowledge was and continues to be critical to the success of this project. Developing these estimates was possible due to the long hours of trap operation provided by our dedicated scientific technicians: Bob Green, Ashish Katru, and Jessica Hannity.

Several other individuals and agencies contributed to this project. Burr Mosby, the adjacent landowner, provided access to the trap site. Nathanael Overman, WDFW Region 4, provided Chinook spawner survey data.

The juvenile salmonid production study on the Green River was initiated in 2000. This study was funded by the Washington State legislature between 2000 and 2002, by the Washington Salmon Recovery Funding Board (SRFB) between 2002 and 2007, by Tacoma Water between 2008 and 2011 and by the Army Corp of Engineers (USACE), the King County Flood Control District Cooperative Watershed Management Grant Program (WIRA 9), and Tacoma Water between 2013 and 2022.

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Executive Summary

This report provides the 2022 results from the juvenile salmonid monitoring study conducted on the Green River in central Puget Sound, Washington. The primary objective of this study was to estimate the juvenile abundance of natural-origin Chinook salmon in the Green River. Additional objectives were to estimate the number of juvenile migrants and life history characteristics of other salmonid species. Juvenile salmonids were captured in a five-foot screw trap located at river mile 34.5 (55 rkm). Catch was expanded to a total migration estimate using a time-stratified approach that relied on release and recapture of marked fish throughout the outmigration period.

The trap was operated from January 19 through June 27, 2022. During this period, the trap fished 86% of the time. We experienced 8 outages -- three were to avoid large hatchery releases, one to avoid a major windstorm, and four due to the high-water events. We estimated the freshwater production (juvenile abundance) of natural origin subyearling Chinook salmon (Table 1).

Table 1. Catch, freshwater production, fork length (mm), and out-migration timing of natural-origin juvenile salmonids caught in the Green River screw trap in 2022. Data represent freshwater production above the juvenile trap, which is located at river mile 34.5.

Species/Life Stage	Catch	Production (% CV)	Avg FL (± 1 S.D.)	Median Migration Date
Chinook - Subyearling	879	73,413 (24.2%)	54.03 (±19.6)	16-Mar
Chinook - Yearling	3			
Coho - Yearling	1,816 [a]	211,750[a] (64.4%)	118.7 (±14.95)	7-May [b]
Steelhead - Smolt	27		169.72 (±17.66)	18-May [b]
Chum	48,666 [a]		43 (±8.19)	12-Apr [b]
Pink	209,563	9,760,944 (58%)	34.59 (±1.80)	1-Apr

[a] Includes natural-origin and unmarked hatchery-origin fish.
[b] Median catch date- not adjusted for trap efficiency, serves as an index of migration timing.

Chinook salmon spawn above and below the juvenile trap. A basin-wide production estimate was derived by applying estimated survival above the trap to spawning below the trap. Egg-to-migrant survival of Green River Chinook for the 2022 outmigration (2021 brood) was estimated to be 1.35%, yielding a basin-wide production estimate of 78,878 natural-origin juveniles.

Juvenile migrant Chinook in the Green River are predominantly subyearlings. Outmigration timing of natural origin subyearling Chinook was bimodal. The fry (≤45 mm fork length) represented 62.5% of the natural subyearling migrants and peaked in the late February. Parr migrants (>45 mm fork length) represented 37.5% of the total abundance and their migration peaked twice, once in early May and again in mid-June.

We were unable to identify hatchery-origin coho salmon at the trap because only a small portion of the fish released upstream of the trap received CWTs, and none were ad-clipped. Hence, our estimate of 211,750 coho salmon smolts includes an unknown mixture of hatchery-origin and natural-origin fish.

Introduction

This report provides the 2022 results from the juvenile salmonid production evaluation conducted on the Green River in central Puget Sound, Washington. Throughout this report, the number of juvenile migrants will be referred to as "freshwater production" because they are the offspring of naturally spawning salmon and steelhead in the Green River. The Green River study was initiated in 2000 with a focus on freshwater production and survival of Chinook salmon but has also described the abundance and juvenile life history of coho, chum, pink and steelhead in this watershed. Information on Green River Chinook and steelhead contribute to ongoing status evaluations for Puget Sound Chinook and steelhead, both listed as *threatened* under the Endangered Species Act by the National Marine Fisheries Service (NMFS). In addition, freshwater production estimates for all species provide a baseline to evaluate impacts of the Additional Water Storage (AWS) project for Howard Hanson dam. In 2011, 2012 and 2013, the Green River juvenile trap results also contributed to the Genetic Mark Recapture (GMR) program conducted by WDFW Fish Science to validate escapement methodologies in Puget Sound watersheds, including the Green River (Seamons et al. 2012).

Under NMFS Listing Status Decision Framework, listing status of a species under the Endangered Species Act (ESA) will be evaluated based on biological criteria (abundance, productivity, spatial distribution, and diversity) and threats to population viability (i.e., harvest, habitat, hydropower, hatcheries, predation, etc.) (Crawford 2007; McElhany et al. 2000). The Green River supports a demographically independent population of Chinook salmon (Ruckelhaus et al. 2006). Winter-run steelhead in the Green River were designated as a demographically independent population within the Central and South Sound Major Population Group (Myers et al. 2015).

The Green River watershed is distinguished by several factors including canyon geomorphology in a portion of the upper watershed, dikes and development in the lower watershed, regulated flows from Howard Hanson Dam, and large-scale hatchery production. The productivity of salmonid populations, including Chinook salmon, is influenced by the cumulative effect of these natural and human-influenced features. From 2000 to present, a juvenile fish trap has operated in the mainstem Green River (river mile 34.5, rkm 55), approximately a half mile upstream from the mouth of Big Soos Creek. The trap is located upstream of Big Soos Creek to avoid the capture of large numbers of hatchery fish released annually from Soos Creek hatchery. This study has produced a long-term data set on juvenile migrants produced by naturally spawning Chinook salmon as well as other salmonids in the Green River.

The combination of juvenile and spawner abundance data for Green River Chinook salmon allows estimates of brood-specific survival to be partitioned between the freshwater and marine environment. Spawner abundance is currently derived from redd counts obtained by WDFW Region 4 staff. Monitoring freshwater production over a range of spawner abundances should provide a measure of watershed capacity and stock productivity through the spawner-recruit function. This information will be critical to identifying the relative impacts of harvest, habitat, and hatchery stressors on this stock.

Results from the Green River juvenile salmonid production evaluation also provide baseline data useful for assessing impacts of a large-scale water storage project at Howard Hanson reservoir. In the mid-1990s U.S. Army Corps of Engineers and Tacoma Water began planning for the Howard Hanson Dam (HHD) Additional Water Storage (AWS) Project. The project includes raising the reservoir surface elevation to increase water storage for domestic use. The final design for the project was developed between 1999 and 2001. Construction began in 2001 and is finished. The final significant component remaining to complete the project is the construction of the juvenile salmon collection and transport facility in the reservoir above HHD. Juvenile migrant trapping in the Green River was considered important for evaluating the impacts and success of mitigation elements from the AWS project on the abundance, freshwater survival, and migration timing of juvenile Chinook. Currently there are no adult salmon being trapped for transport and release above the dam. Once the juvenile collection facility has been constructed and adult salmon released above the dam, the trapping data will allow us to determine if production increases as fish recolonize the approximately 106 miles of river and stream habitat above the dam.

Objectives

The primary objective of this study was to estimate the abundance of juvenile migrants produced by naturally spawning Chinook salmon in the Green River. Additional objectives were to estimate the number of juvenile migrants produced by other salmonid species and to describe their juvenile life history. This report includes results from the 2022 field season.

Methods

Trap Operation

A floating rotary screw trap (5-ft or 1.5-m diameter) was used to capture juvenile migrants on the Green River (Seiler et al. 2002). The trap was located on the left bank at river mile 34.5 (rkm 55), approximately 3,200 ft (975-m) upstream of the Highway 18 bridge (Figure 1).

In 2022, the trap operated between January 19 and June 27 for a total of 3280.54 of 3836.04 possible hours (86% of the time). Over the course of the season, trapping was suspended 8 times; the duration of outages ranged from 25 to 185 hours. Trapping was suspended temporarily for 25 hours during a large windstorm, for a high-water event that lasted 320.58 hours, and to avoid large hatchery releases for 209.92 hours.

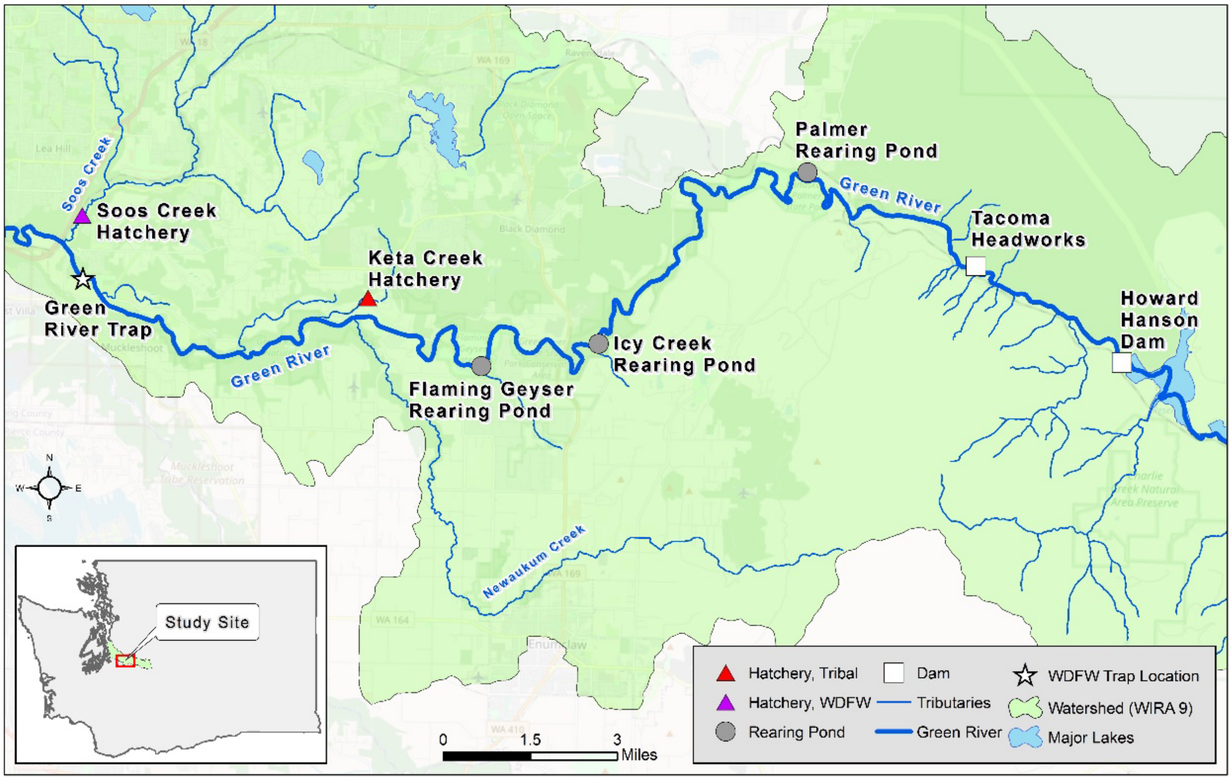

Figure 1. Location of Green River screw trap in relation to existing hatchery release sites and Howard Hanson Dam.

Fish Collection

The trap was checked for fish at dawn and dusk each day and at additional times when required by heavy debris loads or large catches. At the end of each trapping period, all captured fish were sorted by species and mark status (adipose fin clips or coded-wire tags) and then enumerated. Fork length (FL) was measured from a subsample of natural-origin Chinook, coho, chum, and steelhead smolts daily. Subyearling Chinook were length sampled at a rate of approximately 86.6%.

Chinook were enumerated as yearlings and subyearlings. Based on previous years data, yearling Chinook emigrate between February and April and range in size from 76 to 156 mm FL. Subyearling Chinook emigrate between January and July, and range between 34 mm and 121 mm FL. Subyearlings are distinguished from yearling migrants by the body size and date of migration. During the period that yearlings typically migrate, subyearling migrant's average in size between 39 mm and 50 mm FL. For the purpose of analysis, subyearling migrants were further partitioned into "fry" and "parr," two freshwater rearing strategies observed in the Green River as well as other watersheds in Puget Sound (Anderson and Topping 2018; Hall et al. 2018; Zimmerman et al. 2015). Fry migrants were less than 46 mm fork length (FL) and emigrate after minimal to no rearing in freshwater. Parr migrants were longer than 45 mm FL and became the dominant component of the catch by late April. Based on their size, parr migrants have reared in freshwater for some period prior to emigration.

Coho were enumerated as either fry (subyearlings) or smolts (yearlings). Defining characteristics of coho fry are a bright orange-brown color, elongated white anal fin ray, small eye, and small size (under 60 mm FL). Yearling coho are larger in size (approximately 90 to 160 mm FL), with silver sides, black tips on the caudal fin, and large eye compared to the size of the head.

Trout were enumerated by two different age classes: parr and smolt. Parr were trout that were not "smolted" in appearance, typically between 50 and 150mm FL, dark in color (brown with spots on the tail) and caught throughout the trapping season. Smolts were chrome in appearance, larger in size (90 to 225 mm FL) with many spots along the dorsal surface and tail. Smolts were assigned as either steelhead or cutthroat based on mouth size and presence or absence of red coloration on the ventral surface of the gill covers.

Origin was assigned based on the mark status of each species and known marks of hatchery fish released above the trap (Table 2). Hatchery releases above the screw trap in 2022 included Chinook, coho, chum and summer and winter steelhead. Steelhead were assigned to origin based on the presence (natural) or absence (hatchery) of an adipose fin. A group of wild brood hatchery reared steelhead released above the trap were not ad-clipped but were tagged with a blank wire coded wire tag (CWT). Therefore, every unmarked steelhead captured in the trap was electronically scanned for the presence of a CWT. Chum and coho could not be assigned to origin because all hatchery chum and coho released upstream of the trap were unmarked.

In total, 2.07 million ad-clipped hatchery subyearling hatchery Chinook were planted in Palmer Ponds from late February thru March for rearing and acclimation prior to volitional release on June 27-28. Five of these fish were captured at the trap prior to trap removal on June 27.

Table 2. Number of hatchery fish by mark type released above the Green River screw trap in 2022. Fish released below the trap are not included in this table as they do not impact the quality of the freshwater production estimate.

Species/Life Stage	Brood Year	Release Location	Total Released	Ad Marked	Un-marked	CWT Only	Un-tagged	Ad Clipped & CWT
Chinook Subyearling	2021	Palmer Ponds	2,077,568	2,024,355	52,759			
Chinook Yearling	2020	Icy Creek Ponds	310,486	117,985	3,657		539	192,501
Winter Steelhead	2021	Icy Creek Ponds	55,861			55,359	502	
Summer Steelhead	2021	Icy Creek Ponds	56,000	55,362	638			
Chum Subyearling	2021	Keta Creek Hatchery	5,668,037		5,668,037			
Coho Yearling	2020	Keta Creek Hatchery	1,914,360		1,817,845	95,975		

Trap Efficiency Trials

Trap efficiency trials were conducted for subyearling Chinook with both maiden-caught natural origin fish and hatchery-origin fish, Pinks, Coho yearlings, and mixed stock Chum, throughout the season. Hatchery-origin Chinook were used in efficiency trials during periods of low natural-origin Chinook catch, as a means in increase mark-recapture sample size. These fish were anesthetized with tricaine methanesulfonate (MS-222) and marked with either Bismarck Brown dye or a partial caudal fin clip. Small Chinook, Pink, and Chum (January to early-May) were marked with Bismarck Brown dye, whereas the larger Chinook parr and Coho yearlings were marked with a partial caudal fin clip. Fin clipped release groups alternated the fin clip location between upper and lower caudal fin to check for delayed migration of marked fish. After recovery in freshwater for the day, marked fish were released at Neely Bridge, located about a third of a mile upstream of the trap, or 150 yards upstream, at dusk. We did not conduct efficiency trials for steelhead because of low maiden catch.

Freshwater Production Estimate

Freshwater production is the number of juvenile migrants leaving freshwater in a given year. In most cases, freshwater production corresponds to a single brood year of spawners; however, for some species (e.g., steelhead), freshwater production may represent more than one brood year.

Freshwater production was estimated using a single partial-capture trap design (Volkhardt et al. 2007). Data were stratified by time over the outmigration period to accommodate for temporal changes in trap efficiency. The general approach was to estimate (1) missed catch, (2) efficiency strata, (3) time-stratified abundance, (4) extrapolated migration outside the trapping season, and (5) total abundance.

<u>(1) Missed catch</u>. Total catch ($\hat{u}$) was the actual catch (n_i) for period *i* summed with missed catch ($\hat{n}_i$) during periods of trap outages.

Equation 1

$$\hat{u}_i = n_i + \hat{n}_i$$

Missed catch for a given period *i* was estimated as:

Equation 2

$$\hat{n}_i = \overline{R} * T_i$$

where:

$\overline{R}$ = Mean catch rate (fish/hour) from adjacent fished periods, and

T_i = time (hours) during the missed fishing period.

Variance associated with $\hat{u}_i$ was the sum of estimated catch variances for this period. Catch variance was:

Equation 3

$$Var(\hat{u}_i) = Var(\hat{n}_i) = Var(\overline{R}) * T_i^2$$

where:

Equation 4

$$V\left(\overline{R}\right)=\frac{\sum_{i=1}^{i=k}(R_i-\overline{R})^2}{k(k-1)}$$

(2) Efficiency strata. Individual efficiency trials were summed by statistical week to form an efficiency stratum (group). Weekly groups with less than 5 recoveries were grouped with the following week or weeks until a minimum of 5 recoveries were achieved to form the next stratum. (Sokal and Rohlf 1981).

(3) Time-stratified abundance. Abundance for a given stratum *h* ($\hat{U}_h$) was calculated from maiden catch ($\hat{u}_h$), marked fish released (M_h), and marked fish recaptured (m_h). Abundance was estimated with a Bailey estimator (Carlson et al. 1998; Volkhardt et al. 2007).

Equation 5

$$\hat{U}_h=\frac{\hat{u}_h(M_h+1)}{m_h+1}$$

Variance associated with the Bailey estimator was modified to account for variance of the estimated catch during trap outages (derivation in Appendix A):

Equation 6

$$V(\hat{U}_h)=V(\hat{u}_h)\left(\frac{(M_h+1)(M_h m_h+3M_h+2)}{(m_h+1)^2(m_i+2)}\right)+\left(\frac{(M_h+1)(M_h-m_h)\hat{u}_h(\hat{u}_h+m_h+1)}{(m_h+1)^2(m_h+2)}\right)$$

(4) Extrapolated migration. Migration outside the trapping period ($\hat{N}_e$) was estimated based on an assumed number of days (*t*) outside the trapping period that the migration occurred. Extrapolation was used for Chinook salmon (January 1 – July 31) due to their extended outmigration period and the low levels of catch occurring at the beginning and end of the trapping season. Extrapolation was calculated based on the estimated daily migration ($\hat{N}_d$) for the first *k* days of trapping (and the last *k* days of trapping).

Equation 7

$$\hat{N}_e=\frac{\sum_{d=1}^{d=k}\hat{N}_d}{k}*\frac{t}{2}$$

Variance associated with the extrapolated migration was:

Equation 8

$$V(\hat{N}_e) = \frac{\sum_{d=1}^{d=k} (\hat{N}_d - \overline{N})^2}{k(k-1)} * \left(\frac{t}{2}\right)^2$$

(5) Total abundance. Total abundance of juvenile migrants was the sum of in-season stratified estimates and extrapolated estimates.

Equation 9

$$\hat{N}_T = \sum_{h=1}^{h=k} \hat{U}_h + \sum \hat{N}_e$$

Variance was the sum of variances associated with all in-season and extrapolated estimates:

Equation 10

$$V(\hat{N}_T) = \sum_{h=1}^{h=k} V(\hat{U}_h) + \sum V(\hat{N}_e)$$

Confidence intervals were calculated from the variance:

Equation 11

$$\hat{N}_{95\%ci} = \hat{N}_T \pm 1.96\sqrt{V(\hat{N}_T)}$$

Coefficient of variation was:

Equation 12

$$CV = \frac{\sqrt{V(\hat{N}_T)}}{\hat{N}_T}$$

Daily migration estimates were calculated from the daily catch and the trap efficiency for strata *h*:

Equation 13

$$\hat{U}_d = \frac{\hat{u}_{dh}}{e_h}$$

Where:

Equation 14

$$e_h = \frac{\hat{u}_h}{\hat{U}_h}$$

Freshwater Life History Diversity

Juvenile length statistics and median migration dates were summarized for all species. Median migration date was the date that 50% of juvenile migrants were estimated to have passed the trap and was derived from daily migration data. If daily migration estimates were not available for a species (e.g., no production estimate due to low trap efficiency), median catch date was reported as a proxy for median migration date. The use of catch data to estimate migration timing should be viewed with caution as catch numbers have limited meaning without trap efficiency information.

To describe abundance and migration of the two subyearling Chinook strategies, the subyearling Chinook production was divided into fry and parr migrants. For a given statistical week, the proportion of Chinook within each size class (≤ 45 mm FL, > 45 mm FL) was applied to the migration abundance estimate for that week.

Egg-to-Migrant Survival for Subyearling Chinook

Freshwater productivity of subyearling Chinook was estimated as juveniles/female and egg-to-migrant survival. Juvenile migrants were estimated as described above. Female spawners were based on foot, boat, and aerial surveys of Chinook redds conducted by WDFW Region 4 and the Muckleshoot Indian Tribe (Footen et al. 2011). These estimates assume one female per redd (personal communication, Nathanael Overman, WDFW Region 4). Egg-to-migrant survival was the number of juvenile migrants divided by potential egg deposition (P.E.D.). Potential egg deposition was the product of female spawners estimated above the trap site and a Chinook fecundity estimate of 4,500 eggs per female. Fecundity was the long-term average of Chinook fecundity measured at Soos Creek Hatchery (personal communication, Mike Wilson, WDFW Hatchery Division).

Basin-wide Abundance of Subyearling Chinook

A portion of the Chinook spawning occurs below the juvenile trap in the mainstem Green River and in Soos Creek above the hatchery. To make a basin-wide abundance estimate for juvenile migrant Chinook, egg-to-migrant survival above the trap was applied to the estimated number of eggs deposited in the lower river below the trap and Soos creek.

Smolt to adult return rate for Chinook Salmon

To understand patterns of marine survival, we estimated smolt to adult return rate (SAR) for Green River Chinook salmon. This analysis required age data obtained from scale samples, escapement estimates and the hatchery mark rate among Chinook salmon spawning naturally in the Green River. Escapement and hatchery mark rate data were used to estimate the total number of naturally produced adult Chinook salmon returning to the area upstream of the smolt trap (river mile 34.5), including Newaukum Creek. Age data, restricted to samples collected from unmarked fish, were used to allocate adults from each return year to the corresponding brood year. The scale samples were collected from areas both upstream and downstream of the smolt trap, so our approach assumes a common age structure in both locations. For each outmigrant year class, total adult returns were calculated by summing the number of natural-origin adult Chinook salmon returning to the Green River upstream from the screw trap at age-3, age-4, age-5, and age-6. SAR was calculated by dividing the total number of natural-origin adult returns from all age classes by the total natural origin juvenile abundance from above the trap site. Our metric of adult returns was based on escapement to the spawning grounds and does not account for variation in harvest over the years of study. It also does not include natural-origin adult returns captured for hatchery broodstock. For comparison, we report SAR for the non-ad marked CWT Soos Creek hatchery Chinook salmon with data queried from the Regional Mark Information System (RMIS) though brood year 2016.

Results

Subyearling Chinook

The total estimated catch of non-externally marked Chinook ($\hat{u}$ =1,049) included 879 captures in the trap and an estimated missed catch during trap outage periods of 170. The 2022 trapping season experienced 8 trap outages, four due to high-water events (1/20-1/22, 2/27-3/7, 6/6-6/8, and 6/9-6/11), one due to a windstorm (4/4-4/5), and three to avoid large hatchery releases (3/30-4/1, 4/11-4/15, and 4/19-4/21). To estimate the missed catch during these outages, we applied the average hourly catch rates for one day and night period directly before and after the outage. We suspect that downstream fish movement increases during high flow events. Thus, we used the single day before and after the outage because these periods had the highest hourly catch rate and would calculate the largest missed catch estimate. For the outages, we estimated a missed catch of 170 Chinook. (Figure 2, Table 3, Appendix B).

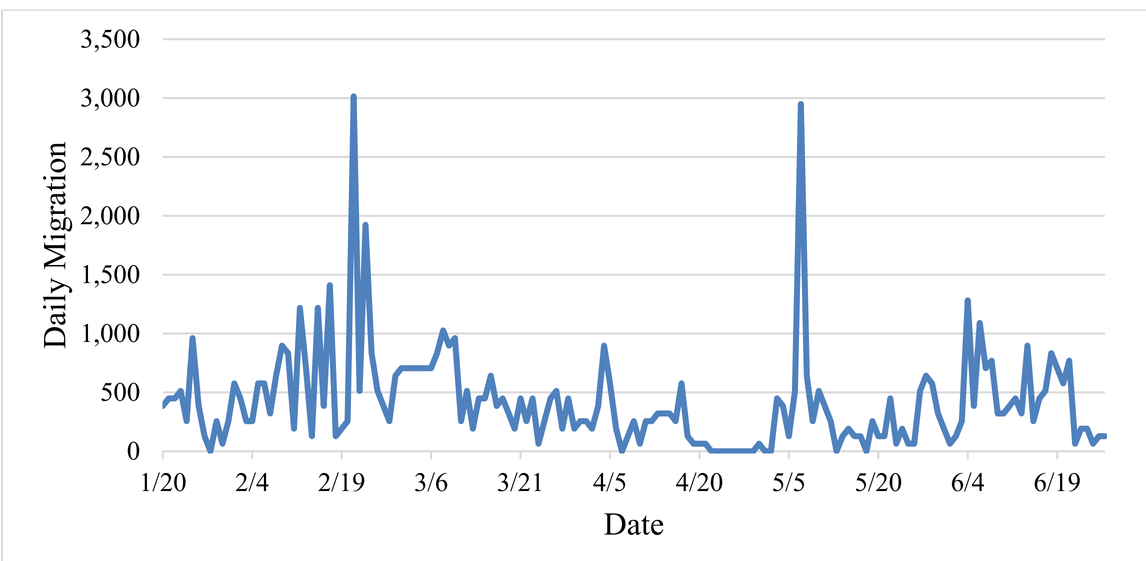

Figure 2. Daily migration of natural-origin subyearling Chinook migrants at the Green River screw trap in 2022.

We released a total of 2,500 natural origin (N-O) and 1,758 hatchery origin (H-O) Chinook salmon within 103 distinct trials to estimate trap efficiency. Release numbers ranged from 1 to 350 fish per trial. These efficiency trial results pooled all trapping weeks into one single strata, plus the pre and post trapping strata (Table 3). We estimated 67,270 unmarked natural-origin subyearling juvenile Chinook salmon during the trapping season plus 3,899 before and 2,244 after the trapping season, for a total of 73,413 (Table 3).

Table 3. Catch, released, and recaptured fish, and estimated abundance of natural origin Chinook migrants at the Green River screw trap in 2022. Release groups were pooled to form one stratum. Missed catch and associated variance were estimated for periods that the trap did not fish.

Strata	Date	Natural Origin Catch			N-O released (H-O released)	N-O Recaps (H-O Recaps)	Total Abundance	
		Actual	Missed	Variance			Estimated	Variance
Pre	1/1-1/19		61				3,899	
1	1/20-6/26	879	170	3.E+08	2,500 (1,758)	14 (24)	67,270	8.34E+06
Post	6/27-7/30		35				2,244	
Season Total	1/1-7/30	879	266					

Freshwater productivity of natural-origin Chinook for brood year 2021 above the trap site was estimated to be 29 juveniles per female, with an egg-to-migrant survival of 1.35%. This calculation was based on the estimated number of natural-origin subyearling Chinook passing the trap ($\hat{N}_T$ = 73,413), 1,209 redds assuming 1 female spawner per redd above the trap site (personal communication, Nathanael Overman, WDFW Region 4), and an estimated P.E.D above the trap site of 5,440,500 eggs.

Basin-wide abundance of subyearling unmarked natural origin Chinook was estimated to be 78,878 migrants. This included 73,413 migrants from above the trap, 1,154 juveniles from the mainstem below the trap, and 4,311 from Soos Creek above the hatchery (Table 4).

We estimated migration timing for natural origin Chinook salmon. The median migration date for natural origin subyearling Chinook was on March 16 (Table 5). Over the entire migration period, we estimated that 67.8% of the natural origin Chinook migrated as fry (≤ 45 mm) and 37.2% migrated as parr (> 45 mm). The fry migration peaked in late February. The parr migration peaked twice, once in early May and again in mid-June. (Table 6, Figure 2).

The seasonal average length of subyearling natural Chinook was 54.03 (19.61 ± 1 S.D.; Appendix C). Excluding the first week, the weekly average lengths of the natural origin subyearling Chinook showed little increase (less than 4mm total increase) during the early portion of the season, (January 23 – April 9). From mid-April thru the end of the trapping season, natural Chinook subyearling average body size increased 4.1 mm per week. The largest size increase occurred between May 8 and May 15 with an increase of 7.1 mm over this one-week period (Figure 3, Appendix C).

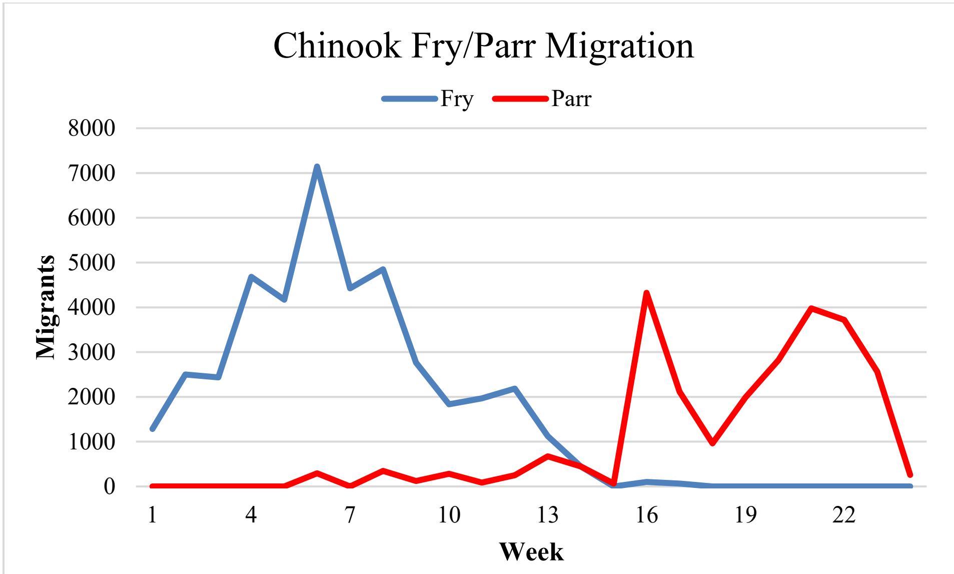

Figure 3. Weekly migration of natural-origin subyearling Chinook migrants at the Green River screw trap in 2022. Subyearling migrants are partitioned into two freshwater rearing strategies fry (≤45 mm FL) and parr (> 45 mm FL) migrants.

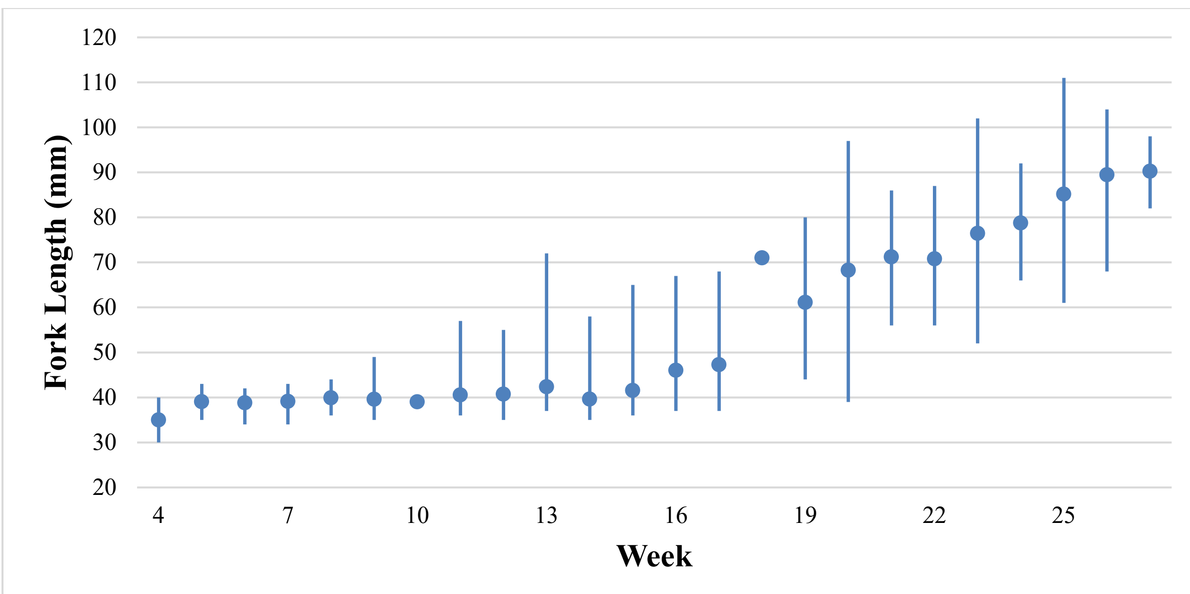

Figure 4. Fork length (mm) of subyearling Chinook migrants of natural origin captured in the Green River screw trap in 2022. Data are mean, minimum, and maximum values.

Table 4. Abundance of juvenile natural origin subyearling migrant Chinook salmon in the Green River. Abundance is partitioned into regions above the juvenile trap site, below the juvenile trap site within the Green River, and above Soos Creek hatchery rack.

Year	Above Trap				Below Trap			Soos creek			Total Production
	Redds	Deposition	Production	Survival	Redds	Deposition	Production	Females	Deposition	Production	
2000	1,835	8,257,500	475,207	5.75%	826	3,717,000	213,908	1,616	7,272,000	275,125	964,240
2001	1,425	6,412,500	809,616	12.63%	936	4,212,000	531,790	1,580	7,110,000		1,341,406
2002	2,167	9,751,500	584,151	5.99%	480	2,160,000	129,392	995	4,477,500		713,543
2003	2,324	10,458,000	449,956	4.30%	2,314	10,413,000	448,020	1,239	5,575,500		897,977
2004	1,793	8,068,500	236,650	2.93%	1,038	4,671,000	137,001	720	3,240,000		373,650
2005	2,738	12,321,000	470,334	3.82%	827	3,721,500	142,062	623	2,803,500		612,397
2006	966	4,347,000	99,796	2.30%	82	369,000	8,471	598	2,691,000		108,267
2007	1,792	8,064,000	127,491	1.58%	883	3,973,500	62,821	313	1,408,500		190,312
2008	1,486	6,687,000	400,763	5.99%	438	1,971,000	118,125	676	3,042,000		518,888
2009	2,107	9,481,500	196,115	2.07%	282	1,269,000	26,248	504	2,268,000		222,362
2010	218	981,000	55,547	5.66%	57	256,500	14,524	759	3,415,500		70,070
2011	706	3,177,000	254,182	8.00%	71	319,500	25,562	461	2,074,500		279,744
2012	333	1,498,500	90,260	6.02%	19	85,500	5,150	190	855,000		95,410
2013	1,127	5,071,500	492,737	9.72%	109	490,500	47,656	682	3,069,000	468,119	1,008,512
2014	774	3,483,000	396,623	11.39%	43	193,500	22,035	149	670,500	101,748	520,406
2015	1,008	4,536,000	396,944	8.75%	84	378,000	33,079	128	576,000	76,037	506,060
2016	1,570	7,065,000	57,214	0.81%	65	378,000	2,369	152	684,000	16,987	76,570
2017	3,516	15,822,000	2,034,861	12.86%	509	2,290,500	294,580	136	612,000	60,493	2,389,934
2018	3,023	13,603,500	315,886	2.32%	320	1,440,000	33,438	No Females released upstream			349,324
2019	2,220	9,990,000	1,008,372	10.09%	537	2,416,500	263,373	100	450,000	49,045	1,320,791
2020	1,140	5,130,000	85,277	1.66%	51	229,500	3,815	86	387,000	6,433	95,525
2021	1,559	7,015,500	203,830	2.91%	161	724,500	21,050	33	148,500	4,315	229,194
2022	1,209	5,440,500	73,413	1.35%	19	85,500	1,154	71	319,500	4,311	78,878

Smolt to adult return rate of Chinook Salmon

Estimating the survival from juvenile outmigration to return as adults will aid recovery efforts by providing information on population dynamics. SAR ranged 10-fold (0.10% - 3.3%) for brood years 2002 through 2017 (Table 7). Natural origin juveniles survived at a higher rate ten out of sixteen years than hatchery origin non-ad marked CWT juveniles released from Soos Creek Hatchery (Figure 5). As data accumulate in future years, we will continue to explore this pattern and the mechanisms that influence SAR rates for both hatchery and natural origin Chinook.

Table 5. Abundance (estimate, 95% confidence interval, coefficient of variation), fork length (average, standard deviation), and median migration date for natural-origin Chinook produced above the Green River juvenile trap, migration years 2000-2022. In trapping year 2014 thru 2018, an unknown number of unmarked hatchery Chinook were present in the length sample.

Migration Year	Abundance				Fork Length		Median Migration Date
	Estimate	Lower C.I.	Upper C.I.	CV	Average	St.Dev.	
2000	475,207	324,315	626,098	16.2	51.40	16.53	13-Mar
2001	809,616	641,195	978,038	10.61	45.00	12.32	16-May
2002	584,151	343,533	824,769	21.02	46.80	12.52	20-Apr
2003	449,956	265,175	634,738	20.98	47.10	12.41	10-Mar
2004	236,650	201,917	271,382	7.49	48.80	16.42	25-Mar
2005	470,334	410,369	530,300	6.5	52.70	18.11	8-Mar
2006	99,796	79,088	120,504	10.59	57.70	21.22	28-May
2007	127,491	107,242	147,740	8.1	69.90	23.47	5-Mar
2008	400,763	361,048	440,477	5.06	54.10	17.16	28-Mar
2009	196,118	171,529	220,706	6.4	54.70	17.49	2-Apr
2010	55,547	39,445	71,648	14.79	67.30	21.43	9-Jun
2011	254,182	225,327	283,037	5.79	51.00	13.29	2-Apr
2012	90,260	68,450	112,069	10.92	63.30	19.35	28-Apr
2013	492,737	420,077	565,397	6.28	48.10	14.41	21-Mar
2014	396,623	231,236	562,010	21.25	61.10	18.66	5-Mar
2015	396,944	290,947	502,941	13.60	45.40	14.60	7-Feb
2016	57,214	43,873	70,556	11.70	63.80	20.92	23-Apr
2017	2,034,861	1,613,904	2,455,817	10.60	53.00	16.99	22-Mar
2018	315,886	192,691	439,081	19.90	58.21	21.8	19-Feb
2019	1,008,372	748,125	1,268,620	9.53	60.89	18.54	12-Mar
2020	85,277	43,034	122,912	29.52	52.29	16.57	12-Feb
2021	184,584	125,563	243,605	15.41	46.37	11.67	3-Mar
2022	67,270	35,423	99,117	24.2	54.03	19.61	16-Mar

Table 6. Abundance of natural origin fry and parr subyearling migrants of Green River Chinook, from above the trap site, migration year 2000 to 2022.

Trapping Year	Fry Migrants			Parr Migrants		
	Migration Interval	Abundance	% of Migration	Migration Interval	Abundance	% of Migration
2000	1/01-4/29	266,481	56.10%	3/11-7/31	208,726	43.90%
2001	1/01-5/20	379,174	46.80%	3/8-7/31	430,442	53.20%
2002	1/01-5/23	357,602	61.20%	3/3-7/31	226,550	38.80%
2003	1/01-5/27	413,358	91.90%	2/16-7/13	36,598	8.10%
2004	1/01-4/29	136,144	57.50%	3/21-7/31	100,506	42.50%
2005	1/01-4/26	391,274	83.20%	2/20-7/31	79,061	16.80%
2006	1/01-5/01	29,946	30.00%	2/18-7/31	69,850	70.00%
2007	1/01-5/07	88,439	69.40%	3/21-7/31	39,053	30.60%
2008	1/01-6/08	251,815	62.80%	3/15-7/31	148,948	37.20%
2009	1/01-5/13	119,406	60.90%	2/6-7/31	76,709	39.10%
2010	1/01-4/20	5,559	10.00%	2/11-7/31	49,988	90.00%
2011	1/01-6/12	128,472	50.50%	2/7-7/31	125,710	49.50%
2012	1/01-5/13	42,133	44.81%	2/27-7/31	48,127	55.19%
2013	1/23-6/2	357,952	72.45%	1/23-7/14	134,785	27.55%
2014	1/01-5/11	319,241	80.49%	2/3-7/31	77,382	19.51%
2015	1/01-5/3	383,580	96.63%	2/2-7/31	13,364	3.37%
2016	1/1-5/8	21,285	37.20%	1/31-7/31	35,929	62.80%
2017	1/1-6/29	1,579,608	77.63%	1/28-7/31	455,253	22.37%
2018	1/1-5/26	274,337	86.85%	2/11-7/31	41,549	13.15%
2019	1/1-6/1	890,063	88.27%	2/9-7/31	118,309	11.73%
2020	1/1-5/16	67,023	78.59%	2/15-7/31	18,254	21.41%
2021	1/1-5/29	166,536	81.70%	2/6-7/31	37,294	18.30%
2022	1/1-5/14	45,862	62.48%	2/20-7/31	27,542	37.52%

Table 7. Smolt to adult return (SAR) for adult Natural Origin Chinook in the Green River, brood years 2002-2017. Juvenile freshwater production and adult return estimates restricted to the area upstream from the smolt trap. Adult returns do not include natural-origin fish encountered in harvest or hatchery broodstock. Does not include age 2 (jack) returns.

Brood Year	Juvenile Freshwater Production	Age 3	Age 4	Age 5	Age 6	Total	Survival to Return
2002	449,956	314	1,341	95	0	1,750	0.39%
2003	236,650	573	718	67	0	1,357	0.57%
2004	470,334	702	3,025	0	0	3,726	0.79%
2005	99,796	152	77	63	0	292	0.29%
2006	127,491	52	633	4	0	689	0.54%
2007	400,763	151	309	107	0	567	0.14%
2008	196,118	57	978	40	0	1,076	0.55%
2009	55,547	408	394	42	0	845	1.52%
2010	254,182	54	493	50	0	597	0.23%
2011	90,260	162	586	64	0	813	0.90%
2012	492,737	244	1314	89	0	1,647	0.33%
2013	396,623	863	949	19	0	1,830	0.46%
2014	396,944	781	784	0	0	1,565	0.39%
2015	57,214	994	864	29	0	1,887	3.30%
2016	2,034,861	422	1520	55	0	1,997	0.10%
2017	315,886	234	362	30	0	626	0.20%

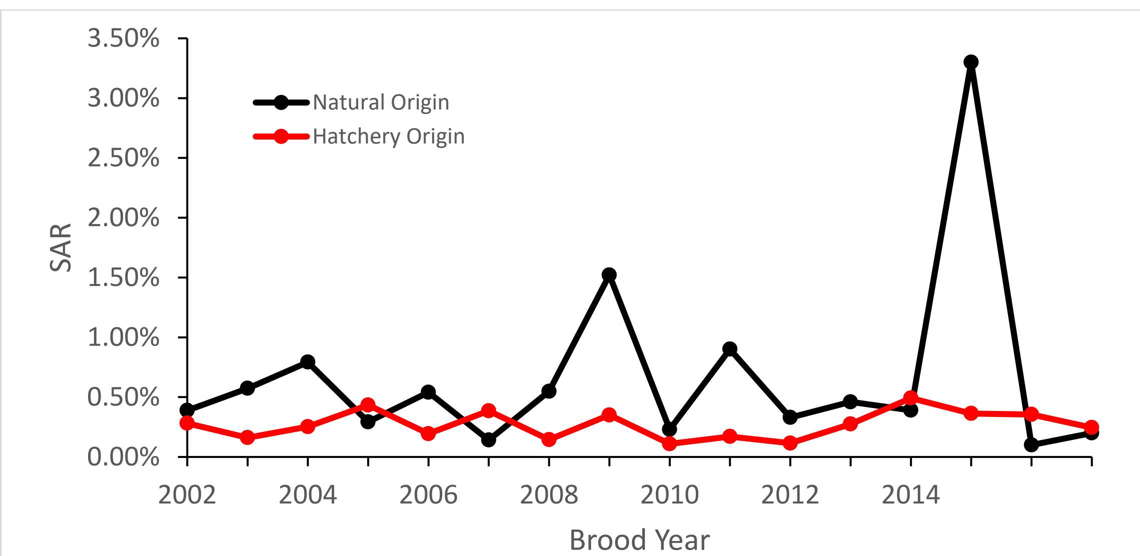

Figure 5. Smolt to adult return rate (SAR) of natural origin vs hatchery origin Chinook from the Green River, brood years 2002-2017. Does not include age 2 (jacks) returns, account for harvest or natural-origin adults captured for hatchery broodstock.

Yearling Chinook

Three natural-origin Chinook yearlings were captured in 2022. In total, 4 hatchery-origin yearling Chinook were captured (1 Ad-marked and 3 Ad-CWT).

Coho Smolts

We could not estimate catch of natural-origin coho smolts because less than 6% of the hatchery smolts released upstream of the screw trap were given CWTs and none were ad-marked. We did, however, estimate a mixed stock for coho smolts. For the season, we caught a total of 1,816 coho smolts, including 1,812 unmarked, and 4 CWT-only. In addition, we estimated 344 coho smolts would have been caught had we fished continually. The first coho was captured on January 26 (Appendix D). Catch remained low and sporadic thru the first two months of trapping averaging less than 2 fish per day. The catch ramped up on April 28 due to a large release of non-externally marked hatchery coho from the Keta Creek Hatchery. Peak daily catch occurred on May 11, with a one day catch of 324 fish. Daily catch declined gradually through May and early June. A coho smolt was captured on June 27, the last day of trap operations.

We released a total of 983 mixed stock coho smolts marked with a caudal clip, within 75 distinct trials to estimate trap efficiency. Release numbers ranged from 1 to 158 fish per trial. The efficiency trials ended up grouping all trials into one single strata at 1.02%. We estimated 211,750 hatchery- plus natural-origin coho smolts to have passed the trap. The CV on this estimate was CV 64.4%, and the lower bound of the 95% confidence interval stretched below zero, emphasizing the uncertainty in the estimate. As mentioned earlier (table 2), over 1.9 million hatchery coho were released above the trap during the fishing season. This nearly tenfold difference, which doesn't account for natural spawning contribution, implies low survival of the hatchery-origin fish from release to trap, and may warrant investigation in the future.

The seasonal average length of coho smolts was 118.7 ± 14.95 mm FL (± 1 S.D). The weekly average size was smaller early in the season prior to the release of the unmarked hatchery coho (Figure 6, Appendix E).

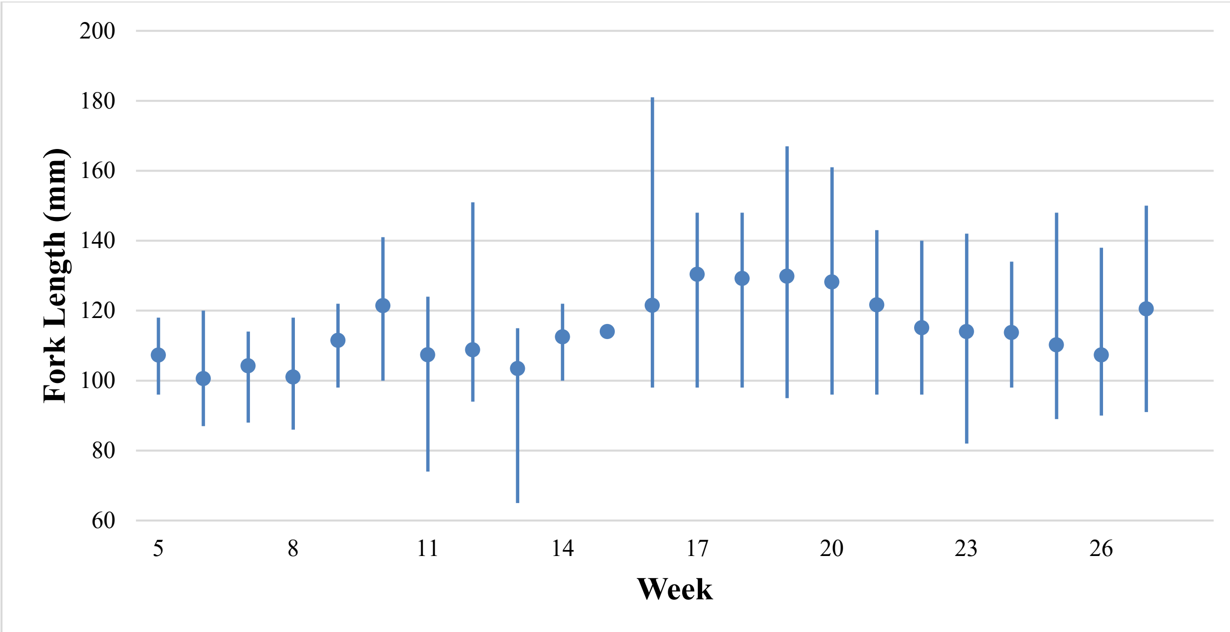

Figure 6. Fork length (mm) of mixed coho captured in the Green River screw trap in 2022. Data are mean, minimum, and maximum values by week.

Steelhead Smolts

The total catch of natural-origin steelhead smolts was 55 with none estimated for periods not fished (Appendix D). In total, 104 (13 ad-only and 91 CWT-only) hatchery steelhead were captured between April 25 and June 18. We did not catch sufficient natural-origin steelhead smolts to estimate trapping efficiency or production. The median catch date for natural origin steelhead smolts was May 18.

Over the season, a total of 54 maiden captured unmarked steelhead were measured (fork length). Individuals ranged from 140 mm to 234 mm and averaged 169.7 mm for the season (Figure 6).

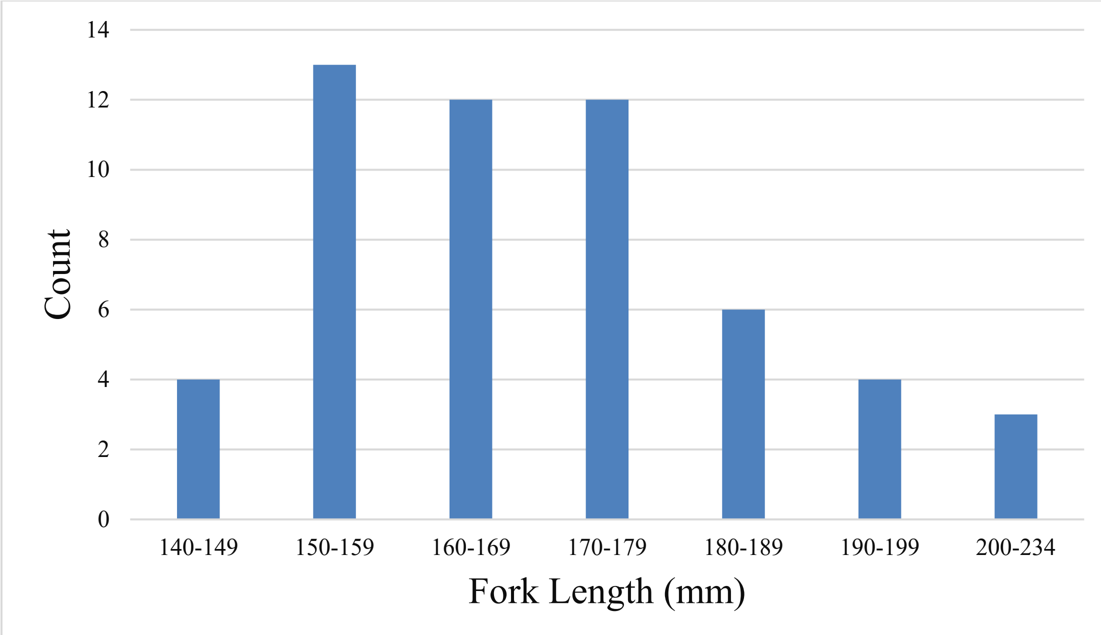

Figure 7. Fork length (mm) of natural-origin steelhead captured in the Green River screw trap in 2022.

Length, weight, and scale samples were collected on 54 natural-origin steelhead smolts captured. Forty-six of the 54 scale samples were readable for age, 6 age 1 fish and 39 age 2 fish, and 1 age 3 fish. (Table 8).

Table 8. Age, average length (mm) and average mass of natural-origin steelhead smolts collected at the Green River juvenile trap, migration years 2011-2022.

Smolt Age	1+			2+			3+			4+		
Year	Avg FL	%	Avg Mass (g)	Avg FL	%	Avg Mass (g)	Avg FL	%	Avg Mass (g)	Avg FL	%	Avg Mass (g)
2011	158.2	26%		180.1	67%		189.9	7%				
2012	158.6	53%		171.7	47%		206.5	1%				
2013	157	40%	39.8	177	59%	56.7	189	1%	78.8			
2014	161.4	61%	27.9	182.2	37%	41.2	211.1	1%	59.7	224	0%	101.3
2015	158.7	59%	40.1	185.8	38%	60.1	190	3%	78.5			
2016	164.6	37%	43.7	170.3	61%	49.8	188.1	2%	77.7	232.5	1%	124.4
2017	163.1	70%	46.4	186.7	29%	66	221	1%	93.4			
2018	157.2	36%	37.2	172.7	73%	50.2	185	1%	60.4			
2019	167.8	71%	45.3	190.3	24%	68.4	185	5%	62.8			
2020	155	13%	na	167	87%	39.7						
2021	162.5	76%	41.4	178.7	24%	51.4						
2022	162.3	13%	46.8	168.7	85%	47.9	204	2%	77.5			

Chum

The total estimated catch of unmarked chum fry ($\hat{u}$ =75,836) included 48,666 captures in the trap and an estimated missed catch of 27,170 fish during trap outage periods (Appendix D). Chum migrants were captured between January 29 and June 26. Captured chum could not be separated into natural- and hatchery-origin because hatchery chum released were unmarked. No production estimate was calculated.

Pink

The total estimated catch of wild pink fry ($\hat{u}$ =282,437) included 209,563 captures in the trap and estimated 72,874 missed catch during trap outage periods (Appendix D). Pink fry were captured from the first day of trapping (1/20/23) until June 24, 2022. The daily migration steadily increased thru the early part of the season and peaked on April 1 with 668,567 fry estimated to have passed the trap in a single day (Figure 8).

Sixty-seven individual efficiency trials were conducted using 15,732 maiden captured pink fry, which were pooled into 7 efficiency strata. We estimated 9,760,948 ± 11,101,798 (95% C.I.) pink fry. The coefficient of variation for this estimate was 58.03%.

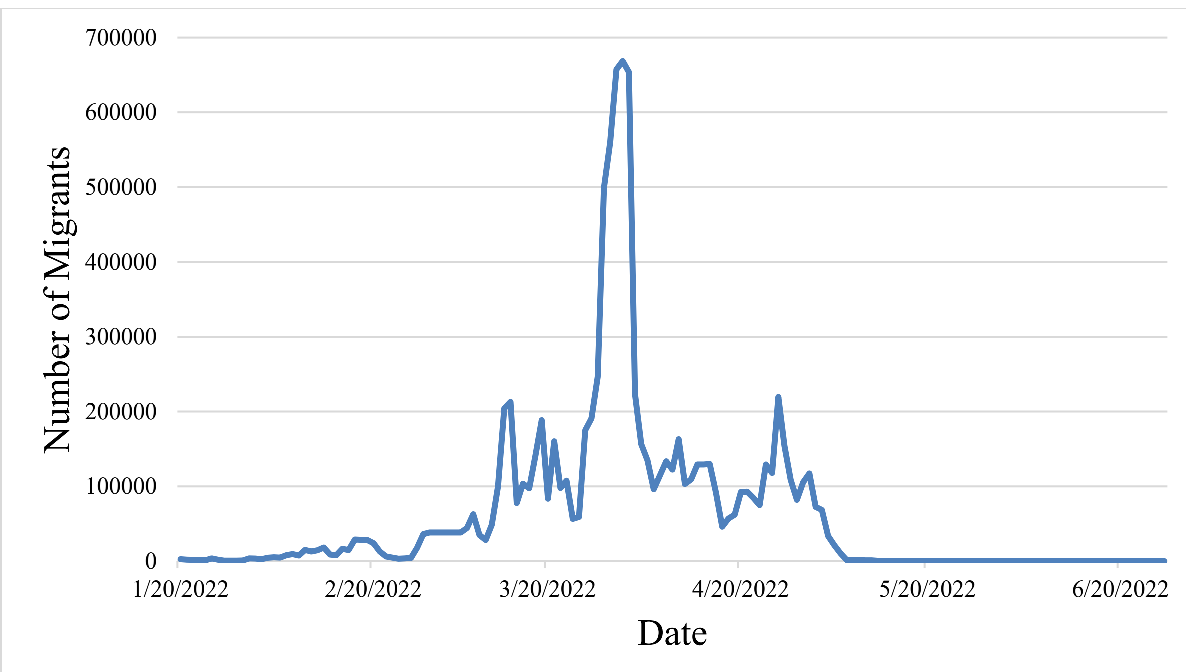

Figure 8. Daily migration of pink fry originating from above the Green River Screw trap in 2022.

Other Species

In addition to species and age classes described above, catch during the trapping season included 112 coho fry, 18 trout parr, 3 cutthroat smolt, and 47 trout fry (Appendix D). Nonsalmonid species captured included sculpin (*Cottus* spp.), three-spine sticklebacks (*Gasterosteus aculeatus*), longnose dace (*Rhynichthys cataractae*), and lamprey ammocoetes.

Discussion and Synthesis

This report provides the freshwater production estimate for natural origin subyearling Chinook salmon emigrating from the Green River in 2022. In addition to abundance estimates, we provide summaries of body length, age, and outmigration timing that describe the duration of time that juvenile salmonids are using freshwater habitat for rearing.

Assumptions for Basin-Wide Chinook Estimate

The basin-wide estimate of Chinook freshwater production relies on three assumptions. The first assumption is that the relative proportion of spawners estimated above and below the Green River juvenile trap is accurate. Redd surveys in 2021 were conducted on a weekly basis throughout the watershed and the relative number of redds observed above and below the trap was not likely to be biased by time or visibility. Therefore, the redd counts above and below the juvenile trap provide a reasonable approach for estimating juvenile production below the trap.

The second assumption is that egg-to-migrant survival of Chinook salmon is comparable above and below the juvenile trap. For estimation purposes, our calculation of egg-to-migrant survival is no different than juveniles per female because the same fecundity is applied to each female spawner. However, differences in watershed geomorphology, land use, spawner distribution and relative reproductive success of natural and hatchery-origin spawners add uncertainty to the assumption that freshwater productivity is comparable above and below the trap. The juvenile production estimated from the mainstem Green River below the trap was 1,154 and 4,311 from Soos Creek; these two locations represented 6.9% of the total production.

Finally, the estimate of natural-origin Chinook production assumes that juvenile fish were correctly identified to species and origin. Hatchery origin Chinook salmon are typically identified by the presence of an adipose-mark or coded-wire tag, and unmarked fish are assumed to be natural origin.

Freshwater Production of Chinook Salmon

The total estimated natural origin production for the entire Green River was 78,878 Chinook salmon, including 73,413 from above trap and 1,154 from the main-stem below the trap and 4,311 from Soos Creek (Table 4).

To estimate missed catch, we used the full day immediately before and after the outage, calculating the hourly catch rates for the day and night time periods separately and applying them to the appropriate periods during the outage. We suspect that fish movement increases during high flow events, and hence we may underestimate abundance during outages caused by high water.

We estimated a total of 27,542 Chinook salmon parr > 45 mm, which was 37.52% of the total migration estimate of 73,413. Parr production, which represents fish that have spent some time rearing in freshwater above the Green River trap, has ranged from 13,364 to 455,253 parr over the 22 years of this study. Parr rearing capacity may fluctuate among years according to biological (competitors, predators, spatial distribution of spawning sites) and environmental conditions (temperature, stream flow). The large parr productions observed in 2001 (430,442) and 2017 (455,253) are very similar and may represent the maximum rearing potential for parr in the Green River above our trap site under the best possible set of conditions. In comparison, fry production, which represents juveniles emigrating from freshwater soon after emergence, has ranged from 6,000 to 1,579,608 fry. Thus, there is much greater fluctuation in fry abundance than parr abundance.

Yearling Chinook migrants appear to be a minor component of the outmigration and in some years undetectable with use of a partial capture screw trap. In 2022, we captured three natural-origin Chinook salmon yearlings.

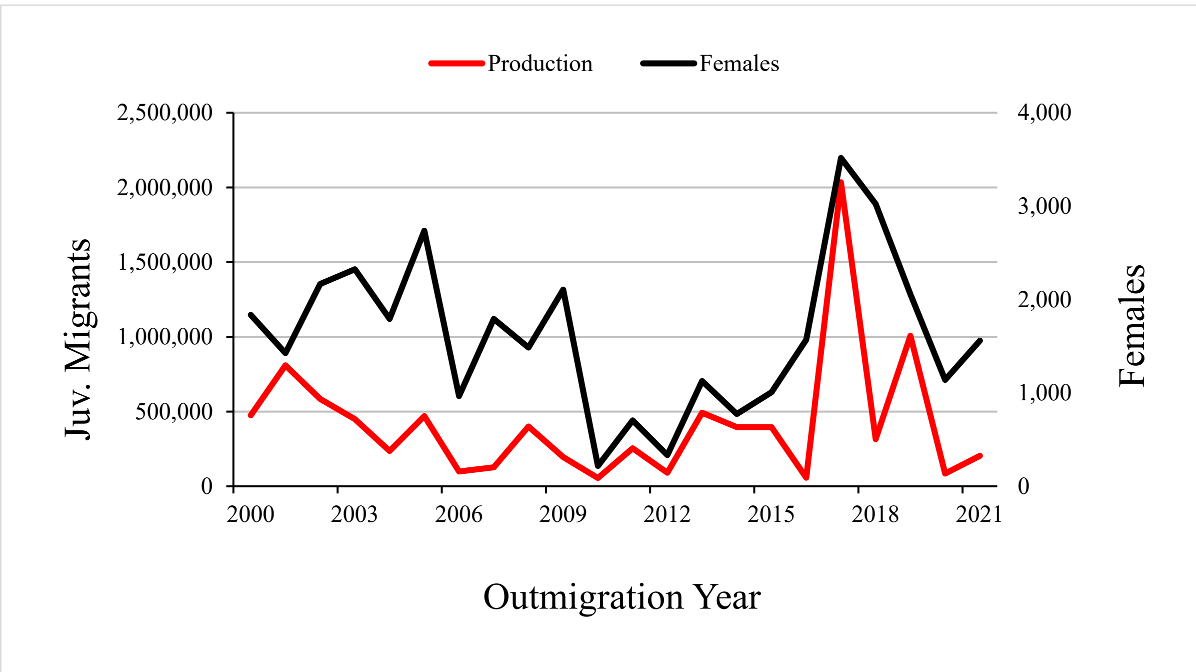

Figure 9. Number of unmarked natural-origin subyearling Chinook (black) passing the Green River trap and the corresponding number of female spawners (Red) above the trap, year 2000-2022.

Freshwater Production of Coho Salmon

The abundance of natural-origin coho salmon produced s above the Green River trap has been estimated for 16 of the 23 years of this study, with two additional years (2019 and 2022) yielding estimates of hatchery- origin plus natural-origin smolt migrants (Table 9). The 2022 estimate of 211,750 included both hatchery-origin and natural-origin smolts. No hatchery origin coho released from Keta Creek Hatchery were ad-marked and very few (<10%) were tagged with a CWT, making positive determination of hatchery origin impossible. With a low proportion of CWT marks in the hatchery release group, scanning trap catch for CWT would be time consuming in the field, and a hatchery-origin abundance estimate resulting from a CWT expansion would be unreliable. We chose not to scan Coho smolts for CWT presence and considered our abundance estimate a mixed hatchery and natural population. Although the estimate of 211,750 hatchery- plus natural-origin coho smolts suggested low survival from the hatchery release of 1.9 million, our abundance estimate had relatively large uncertainty (CV = 64.4%).

The quality of the coho smolt estimates have varied widely among years and trends in these data should be interpreted with caution. In the first two years of the study (2000 and 2001), coho estimates were based on just one or two trap efficiency tests with hatchery fish and no associated variance was calculated. No estimates were generated for trapping years 2004, 2005, 2020, and 2021 because a large percentage of the coho released from the Keta Creek Hatchery (above the trap site) were unmarked, making positive identification of the natural origin coho smolts impossible. In 2019 and 2022 coho smolt estimates were made but included both hatchery and natural origin fish. In trapping year 2008, an abundance estimate was not made because recapture rates were so low that no reliable coho efficiency data were available.

Estimating the freshwater production of species with yearling migrants (i.e., coho and steelhead) has proven to be more challenging than for species with subyearling migrants (i.e., Chinook and pink). In general, larger body size of yearling migrants compared to subyearling migrants increases swimming strength and ability to avoid the trap. Slow water velocity at the trap location tends to reduce trap efficiency for yearling smolts, resulting in few recaptures of marked coho and steelhead smolts and low precision in our abundance estimates. The degree to which water velocity has limited catch has varied by year depending on the channel configuration above the trap. Over the ten consecutive year period between 2009 and 2018, we were able to estimate coho production mainly because of the stability and consistency of the river channel at our trapping location. This location provided a well-defined slot with good water velocities enabling the trap to capture enough coho smolts to generate these estimates. However, starting in 2019, the channel at the trap site widened and became more uniform in depth across the entire channel resulting in slower velocities across the entire river, reducing our capture efficiency.

A second challenge associated with estimating abundance for coho and steelhead smolts is the release of hatchery fish above the trap. In 2022, we were unable to identify hatchery-origin coho salmon at the trap because only a small proportion were marked. However, even when the hatchery-origin fish are externally marked, we often encounter challenges with trap inundation by hatchery-origin fish. Hatchery yearling smolts (Chinook, coho, and steelhead) tend to migrate downstream in large groups resulting in large catches that can overwhelm the live box of the juvenile trap. To accommodate for these catches, the trap is either completely lifted from the water (i.e., not fished) or is operated intermittently during the hatchery migration. Any periods of trap outages due to inundation by hatchery fish requires an estimate of missed catch, which increases the variance and reduces the precision of the annual abundance estimate for natural-origin fish. The release timing of the hatchery fish typically coincides with the peak migration period for the natural origin smolts of the same species. As a result, missed catch estimated during this period is high, as is the corresponding uncertainty (variance) of this catch.

Table 9. Abundance (estimate, 95% confidence interval, coefficient of variation), fork length (average, standard deviation), and median catch or migration date for coho smolts rearing above the Green River juvenile trap, migration years 2000-2022.

Migration Year	Abundance				Fork Length		Migration Timing
	Estimate	Lower C.I.	Upper C.I.	CV	Avg	St.Dev.	Median Date
2000	32,769	---	---	---	115.1	20.37	5/11[a]
2001	55,113	---	---	---	114.3	13.68	5/16[a]
2002	194,393	129,500	259,286	17.00%	99.5	12.76	5/12[a]
2003	207,442	67,404	347,480	34.40%	104.3	12.4	5/8[a]
2004	---	---	---	---	105.8	12.3	5/8[a]
2005	---	---	---	---	106.8	14.93	5/4[a]
2006	31,460	21,143	41,777	16.70%	106.9	16	5/15
2007	22,671	14,735	30,607	17.90%	111.6	11.34	5/7
2008	---	---	---	---	105.1	11.95	5/9[a]
2009	81,079	56,522	105,636	11.90%	103	10.9	5/5
2010	43,763	32,663	54,864	12.90%	115.9	11.21	5/8
2011	62,280	25,495	99,065	30.10%	109.4	11.4	5/7
2012	48,148	24,669	71,627	24.90%	106.1	12.68	5/7
2013	50,642	30,000	71,284	20.80%	103.5	16.75	5/9
2014	106,365	82,645	130,084	11.38%	104	13.13	5/11
2015	42,564	19,108	66,020	28.12%	104.9	11.76	5/2
2016	62,074	43,038	81,109	15.65%	113.8	11.04	4/29
2017	79,491	46,385	112,597	21.25%	111.8	14.6	4/27
2018	57,609	34,616	80,603	20.36%	105.2	10.66	5/7
2019	59,398[b]	12,322	106,474	40.44%	122.5	12.92	4/22
2020	---	---	---	---	109.2	15.19	4/29
2021	---	---	---	---	119.2	14.22	5/6[a]
2022	211,750[b]	1,816[c]	479,137	64.4%	118.7	14.95	5/7[a]

[a] Median catch date. [b] Abundance estimate includes unmarked hatchery coho.

[c] Lower C.I. was below zero, so total caught at trap was used.

Freshwater Production of Steelhead

The abundance of steelhead smolts rearing above the Green River trap has been estimated for only 7 of the 23 years of this study (Table 10). In 2022, natural steelhead smolt production was not estimated. The low maiden catch of 55 steelhead smolts precluded us from estimating trapping efficiency or making a production estimate.

Table 10. Abundance (estimate, 95% confidence interval, coefficient of variation), fork length (average, standard deviation), and median catch or migration date for natural-origin steelhead smolts rearing above the Green River juvenile trap, migration years 2000-2022.

Migration Year	Abundance				Fork Length		Migration Timing
	Estimate	Lower C.I.	Upper C.I.	CV	Average	St.Dev.	Median Date
2000	---	---	---	---	171.5	29.12	5/12[a]
2001	---	---	---	---	176.6	20.2	5/17[a]
2002	---	---	---	---	167.1	19.03	5/19[a]
2003	---	---	---	---	173.8	20.44	4/19[a]
2004	---	---	---	---	148.2	24.33	2/6[a]
2005	---	---	---	---	153.3	19.05	1/25[a]
2006	---	---	---	---	151.1	25.93	5/5[a]
2007	---	---	---	---	157.1	19.8	4/29
2008	---	---	---	---	163.8	23.64	5/15[a]
2009	26,174	10,151	42,198	19.40%	171.4	20.3	5/11
2010	71,710	49,317	94,103	15.90%	178.7	22.87	5/16
2011	---	---	---	---	175.1	18.4	5/8[a]
2012	---	---	---	---	166.1	17.9	5/16[a]
2013	15,339	6,692	23,987	28.76%	169.1	17.73	5/11
2014	31,638	21,901	41,376	15.70%	171.2	18.3	5/5
2015	---	---	---	---	168.7	19	5/8[a]
2016	32,936	8,606	57,266	37.69%	169	16.63	5/18
2017	32,215	15,354	49,077	26.70%	168.2	16.73	5/22
2018	6,025	3,439	8,611	21.90%	168.9	17.13	5/12
2019	---	---	---	---	172	19.08	5/18
2020	---	---	---	---	158.9	18.66	5/2
2021	---	---	---	---	165.8	11.7	5/8[a]
2022	---	---	---	---	169.7	17.66	5/18[a]

[a] Median catch date.

Appendix A

Variance of total unmarked smolt numbers, when the number of unmarked juvenile out-migrants, is estimated

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APPENDIX A.—Variance of total unmarked smolt numbers, when the number of unmarked juvenile out-migrants, is estimated.

The estimator for $\hat{U}_i$ is,

$$\hat{U}_i = \frac{\hat{u}_i\left(M_i+1\right)}{\left(m_i+1\right)}$$

the estimated variance of $\hat{U}_i$, $Var\left(U_i\right)$ is as follows,

$$Var\left(\hat{U}_i\right) = Var\left(\hat{u}_i\right)\left(\frac{\left(M_i+1\right)\left(M_i m_i+3M_i+2\right)}{\left(m_i+1\right)^2\left(m_i+2\right)}\right)+Var\left(\hat{U}_i\middle|E\left(\hat{u}\right)\right)$$

where $$Var\left(\hat{U}_i\middle|E\left(\hat{u}\right)\right)=\frac{\left(M_i+1\right)\left(M_i-m_i\right)E\left(\hat{u}_i\right)\left(E\left(\hat{u}_i\right)+m_i+1\right)}{\left(m_i+1\right)^2\left(m_i+2\right)},$$

$E\left(\hat{u}_i\right)$ = the expected value of $\hat{u}_i$ either in terms of the estimator (equation for $\hat{u}_i$) or just substitute in the estimated value and, $Var\left(\hat{u}_i\right)$ depends on the sampling method used to estimate $\hat{u}_i$.

Derivation:

Ignoring the subscript i for simplicity, the derivation of the variance estimator is based on the following unconditional variance expression,

$$Var\left(\hat{U}\right)=Var\left(E\left(\hat{U}\middle|u\right)\right)+E\left(Var\left(\hat{U}\middle|u\right)\right).$$

The expected value and variance $\hat{U}$ given u is as before, respectively,

$$E\left(\hat{U}_i\middle|u\right)=\frac{u_i\left(M_i+1\right)}{\left(m_i+1\right)} \text{ and,}$$

$$Var\left(\hat{U}\middle|u\right)=\frac{u\left(u+m+1\right)\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}.$$

Substituting in $\hat{u}$ for u gives the following,

$$Var\left(\hat{U}\right) = Var\left(\frac{\hat{u}\left(M+1\right)}{\left(m+1\right)}\right) + E\left[\frac{\left(M+1\right)\left(M-m\right)\hat{u}\left(\hat{u}+m+1\right)}{\left(m+1\right)^2\left(m+2\right)}\right]$$

$$Var\left(\hat{U}\right) = \left(\frac{\left(M+1\right)}{\left(m+1\right)}\right)^2 Var\left(\hat{u}\right) + \frac{\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}\left[E\left(\hat{u}^2\right) + E\left(\hat{u}\right)\left(m+1\right)\right]$$

Note that,

$$E\left(\hat{u}^2\right) = Var\left(\hat{u}\right) + \left(E\hat{u}\right)^2$$

Substituting in this value for $E\left(\hat{u}^2\right)$,

$$Var\left(\hat{U}\right) = \left(\frac{\left(M+1\right)}{\left(m+1\right)}\right)^2 Var\left(\hat{u}\right) + \frac{\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}\left[Var\left(\hat{u}\right) + \left(E\left(\hat{u}\right)\right)^2 + E\left(\hat{u}\right)\left(m+1\right)\right]$$

$$= \left(\frac{\left(M+1\right)}{\left(m+1\right)}\right)^2 Var\left(\hat{u}\right) + \frac{\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}\left[Var\left(\hat{u}\right) + E\left(\hat{u}\right)\left[E\left(\hat{u}\right) + m + 1\right]\right]$$

$$Var\left(\hat{U}\right) = \left(\frac{\left(M+1\right)}{\left(m+1\right)}\right)^2 Var\left(\hat{u}\right) + \frac{\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}Var\left(\hat{u}\right) + \frac{\left(M+1\right)\left(M-m\right)E\left(\hat{u}\right)\left[E\left(\hat{u}\right)+m+1\right]}{\left(m+1\right)^2\left(m+2\right)}$$

$$Var\left(\hat{U}\right) = Var\left(\hat{u}\right)\left(\frac{\left(M+1\right)^2}{\left(m+1\right)^2} + \frac{\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}\right) + \frac{\left(M+1\right)\left(M-m\right)E\left(\hat{u}\right)\left[E\left(\hat{u}\right)+m+1\right]}{\left(m+1\right)^2\left(m+2\right)}$$

$$Var\left(\hat{U}\right) = Var\left(\hat{u}\right)\left(\frac{\left(M+1\right)^2}{\left(m+1\right)^2} + \frac{\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}\right) + Var\left(\hat{U}\middle|E\left(\hat{u}\right)\right)$$

$$Var\left(\hat{U}\right) = \frac{\left(M+1\right)}{\left(m+1\right)^2}Var\left(\hat{u}\right)\left(\frac{\left(M+1\right)\left(m+2\right)}{\left(m+2\right)} + \frac{\left(M-m\right)}{\left(m+2\right)}\right) + Var\left(\hat{U}\middle|E\left(\hat{u}\right)\right)$$

$$Var\left(\hat{U}\right) = \frac{\left(M+1\right)}{\left(m+1\right)^2}Var\left(\hat{u}\right)\left(\frac{Mm + 2M + m + 2 + M - m}{\left(m+2\right)}\right) + Var\left(\hat{U}\middle|E\left(\hat{u}\right)\right)$$

$$Var\left(\hat{U}\right) = Var\left(\hat{u}\right)\left(\frac{\left(M+1\right)\left(Mm + 3M + 2\right)}{\left(m+1\right)^2\left(m+2\right)}\right) + Var\left(\hat{U}\middle|E\left(\hat{u}\right)\right)$$

Appendix B

Daily catch and migration estimate for unmarked natural origin subyearling Chinook in the Green River, 2022

APPENDIX B. — Actual and estimated daily catches and migration for unmarked natural origin subyearling Chinook migrants in the Green River, 2022.

Date	Time Fished		Unmarked Sub-Yearling Chinook Catch		Total	Migration
	Hours In	Hours Out	Actual	Est		
1/1 - 1/19/2022	Pre-Trapping					3899
1/20/2022	26.33		6		6	385
1/21/2022		25.17		7	7	449
1/22/2022		22.16		7	7	449
1/23/2022	25.83		8		8	513
1/24/2022	24.5		4		4	257
1/25/2022	23.67		15		15	962
1/26/2022	24.59		6		6	385
1/27/2022	24.25		2		2	128
1/28/2022	23.75		0		0	0
1/29/2022	23.75		4		4	257
1/30/2022	24.08		1		1	64
1/31/2022	24.17		4		4	257
2/1/2022	24.08		9		9	577
2/2/2022	24.17		7		7	449
2/3/2022	24.17		4		4	257
2/4/2022	23.84		4		4	257
2/5/2022	23.75		9		9	577
2/6/2022	24.08		9		9	577
2/7/2022	23.84		5		5	321
2/8/2022	24.33		10		10	641
2/9/2022	24.17		14		14	898
2/10/2022	23.83		13		13	834
2/11/2022	24.17		3		3	192
2/12/2022	23.66		19		19	1218
2/13/2022	24		11		11	705
2/14/2022	24.17		2		2	128
2/15/2022	24.25		19		19	1218
2/16/2022	24.09		6		6	385
2/17/2022	23.92		22		22	1411

Date	Time Fished		Unmarked Sub-Yearling Chinook Catch		Total	Migration
	Hours In	Hours Out	Actual	Est		
2/18/2022	24		2		2	128
2/19/2022	23.75		3		3	192
2/20/2022	24		4		4	257
2/21/2022	23.83		47		47	3014
2/22/2022	24.17		8		8	513
2/23/2022	24.33		30		30	1924
2/24/2022	23.84		13		13	834
2/25/2022	24		8		8	513
2/26/2022	23.83		6		6	385
2/27/2022	24		4		4	257
2/28/2022		23		10	10	641
3/1/2022		24		11	11	705
3/2/2022		24		11	11	705
3/3/2022		24		11	11	705
3/4/2022		24		11	11	705
3/5/2022		24		11	11	705
3/6/2022		24		11	11	705
3/7/2022	7.5	18	6	7	13	834
3/8/2022	23.67		16		16	1026
3/9/2022	24.67		14		14	898
3/10/2022	23.67		15		15	962
3/11/2022	24.25		4		4	257
3/12/2022	23.42		8		8	513
3/13/2022	24.84		3		3	192
3/14/2022	24		7		7	449
3/15/2022	24		7		7	449
3/16/2022	23.91		10		10	641
3/17/2022	24.08		6		6	385
3/18/2022	24.17		7		7	449
3/19/2022	23.84		5		5	321
3/20/2022	23.92		3		3	192
3/21/2022	37.75		7		7	449
3/22/2022	24		4		4	257
3/23/2022	23.83		7		7	449
3/24/2022	16.83		1		1	64
3/25/2022	23.33		4		4	257
3/26/2022	32		7		7	449
3/27/2022	24.33		8		8	513

Date	Time Fished		Unmarked Sub-Yearling Chinook Catch		Total	Migration
	Hours In	Hours Out	Actual	Est		
3/28/2022	24		3		3	192
3/29/2022	23.92		7		7	449
3/30/2022	16.58	5	2	1	3	192
3/31/2022		24		4	4	257
4/1/2022		25		4	4	257
4/2/2022	25		3		3	192
4/3/2022	24.17		6		6	385
4/4/2022	23.83		14		14	898
4/5/2022		25		9	9	577
4/6/2022	23		3		3	192
4/7/2022	24.25		0		0	0
4/8/2022	24		2		2	128
4/9/2022	24.75		4		4	257
4/10/2022	24.25		1		1	64
4/11/2022	23.25		4		4	257
4/12/2022		21.5		4	4	257
4/13/2022		24		5	5	321
4/14/2022		24		5	5	321
4/15/2022		27		5	5	321
4/16/2022	24		4		4	257
4/17/2022	24.17		9		9	577
4/18/2022	11.25		2		2	128
4/19/2022	12.83	8.42	1	0	1	64
4/20/2022		24		1	1	64
4/21/2022		27		1	1	64
4/22/2022	24		0		0	0
4/23/2022	24.25		0		0	0
4/24/2022	23.75		0		0	0
4/25/2022	35.67		0		0	0
4/26/2022	23.5		0		0	0
4/27/2022	24.25		0		0	0
4/28/2022	24.25		0		0	0
4/29/2022	24		0		0	0
4/30/2022	24.25		1		1	64
5/1/2022	24.25		0		0	0
5/2/2022	23.5		0		0	0
5/3/2022	24		7		7	449
5/4/2022	24		6		6	385

Date	Time Fished		Unmarked Sub-Yearling Chinook Catch		Total	Migration
	Hours In	Hours Out	Actual	Est		
5/5/2022	24		2		2	128
5/6/2022	24.5		8		8	513
5/7/2022	24		46		46	2950
5/8/2022	23.75		10		10	641
5/9/2022	24.08		4		4	257
5/10/2022	23.92		8		8	513
5/11/2022	22.75		6		6	385
5/12/2022	38.17		4		4	257
5/13/2022	24.5		0		0	0
5/14/2022	24		2		2	128
5/15/2022	24		3		3	192
5/16/2022	24		2		2	128
5/17/2022	24.25		2		2	128
5/18/2022	24		0		0	0
5/19/2022	24.08		4		4	257
5/20/2022	23.92		2		2	128
5/21/2022	23.75		2		2	128
5/22/2022	24.25		7		7	449
5/23/2022	23.75		1		1	64
5/24/2022	24.25		3		3	192
5/25/2022	24		1		1	64
5/26/2022	23.75		1		1	64
5/27/2022	24		8		8	513
5/28/2022	24		10		10	641
5/29/2022	24.25		9		9	577
5/30/2022	24.25		5		5	321
5/31/2022	23.5		3		3	192
6/1/2022	24.25		1		1	64
6/2/2022	24.25		2		2	128
6/3/2022	24		4		4	257
6/4/2022	23.75		20		20	1283
6/5/2022	24		6		6	385
6/6/2022	22.75		17		17	1090
6/7/2022		22		11	11	705
6/8/2022		18.25		12	12	770
6/9/2022	31.75		5		5	321
6/10/2022		22		5	5	321
6/11/2022		26		6	6	385

Date	Time Fished		Unmarked Sub-Yearling Chinook Catch		Total	Migration
	Hours In	Hours Out	Actual	Est		
6/12/2022	24.5		7		7	449
6/13/2022	24.25		5		5	321
6/14/2022	24.5		14		14	898
6/15/2022	24.25		4		4	257
6/16/2022	24		7		7	449
6/17/2022	24		8		8	513
6/18/2022	23		13		13	834
6/19/2022	24.17		11		11	705
6/20/2022	23.33		9		9	577
6/21/2022	25		12		12	770
6/22/2022	24.25		1		1	64
6/23/2022	24		3		3	192
6/24/2022	24		3		3	192
6/25/2022	23.75		1		1	64
6/26/2022	24.17		2		2	128
6/27/2022	10.83		2		2	128
6/28 - 7/31/2022	Post-Trapping					2244
Total	**3280.54**	**555.50**	**879**	**170**	**1049**	**73413**

Appendix C

Fork length of natural origin subyearling Chinook in the Green River, 2022

APPENDIX C.─ Weekly mean fork length (mm), standard deviation (St. Dev.) range, and sample size of non-externally marked subyearling Chinook caught in the Green River screw trap in 2022.

Week		Average FL	St. Dev.	Range		Number		Percent Sampled
Begin	End			Min	Max	Sampled	Catch	
1/18/2022	1/22/2022	35.00	3.46	30	40	6	20	30.00%
1/23/2022	1/29/2022	39.04	2.28	35	43	28	39	71.79%
1/30/2022	2/5/2022	38.78	1.96	34	42	37	38	97.37%
2/6/2022	2/12/2022	39.13	1.76	34	43	62	73	84.93%
2/13/2022	2/19/2022	39.89	2.10	36	44	47	65	72.31%
2/20/2022	2/26/2022	39.59	2.53	35	49	76	116	65.52%
2/27/2022	3/5/2022	39.00	1.00	38	40	3	69	4.35%
3/6/2022	3/12/2022	40.55	3.47	36	57	60	81	74.07%
3/13/2022	3/19/2022	40.72	3.59	35	55	47	45	104.44%
3/20/2022	3/26/2022	42.37	7.32	37	72	30	33	90.91%
3/27/2022	4/2/2022	39.63	4.63	35	58	24	32	75.00%
4/3/2022	4/9/2022	41.52	6.55	36	65	29	38	76.32%
4/10/2022	4/16/2022	46.00	12.57	37	67	8	28	28.57%
4/17/2022	4/23/2022	47.25	9.85	37	68	12	14	85.71%
4/24/2022	4/30/2022	71.00		71	71	1	1	100.00%
5/1/2022	5/7/2022	61.11	9.47	44	80	44	69	63.77%
5/8/2022	5/14/2022	68.24	11.24	39	97	34	34	100.00%
5/15/2022	5/21/2022	71.21	9.42	56	86	14	15	93.33%
5/22/2022	5/28/2022	70.77	7.63	56	87	31	31	100.00%
5/29/2022	6/4/2022	76.43	11.09	52	102	44	44	100.00%
6/5/2022	6/11/2022	78.74	7.25	66	92	23	62	37.10%
6/12/2022	6/18/2022	85.16	9.36	61	111	56	58	96.55%
6/19/2022	6/25/2022	89.46	6.91	68	104	40	40	100.00%
6/26/2022	7/2/2022	90.25	6.55	82	98	4	4	100.00%
Season Total		**54.03**	**19.61**	**30**	**111**	**760**	**1049**	**72.45%**

Appendix D

Daily estimated catch of coho, and chum salmon, steelhead and cutthroat trout in the Green River, 2021

APPENDIX D.— Daily estimated catches of coho, chum and pink salmon and steelhead and cutthroat trout caught in the Green River screw trap in 2022. Catch represents actual and estimated catch for a given day. Time in and out reflect time fished (in) and not fished (out) on a given day.

Date	Time Fished		Trout	Chum	Pink	Coho		Steelhead	Cutt
			Parr	Fry	Fry	Smolt	Fry	Smolt	Smolt
	Hours In	Hours Out	Nat	Mixed	Nat	Mixed	Nat	Nat	Nat
1/20/2022	26.33			0	34	0			
1/21/2022		25.17		0	27	0			
1/22/2022		22.16		0	24	0			
1/23/2022	25.83			0	22	0			
1/24/2022	24.5			0	16	0			1
1/25/2022	23.67			0	50	0	1		
1/26/2022	24.59		1	0	28	1	2		
1/27/2022	24.25		1	0	8	1	3		
1/28/2022	23.75		1	0	10	2			
1/29/2022	23.75			1	8	2			
1/30/2022	24.08			0	13	6			
1/31/2022	24.17			2	49	0	1		
2/1/2022	24.08			1	47	1	1		
2/2/2022	24.17			0	36	0		1	
2/3/2022	24.17			0	61	2			
2/4/2022	23.84		1	3	70	1	2		
2/5/2022	23.75			1	66	2			
2/6/2022	24.08			10	108	0			
2/7/2022	23.84			6	128	0			
2/8/2022	24.33			2	104	2			
2/9/2022	24.17			3	206	0			
2/10/2022	23.83			9	176	0	2		
2/11/2022	24.17		1	1	200	1	1		
2/12/2022	23.66			9	248	2			
2/13/2022	24			5	120	0			
2/14/2022	24.17			6	109	1			
2/15/2022	24.25			23	226	1	1		
2/16/2022	24.09			13	203	1			
2/17/2022	23.92			39	395	0			
2/18/2022	24			8	390	1			
2/19/2022	23.75			27	385	5	1		
2/20/2022	24			78	774	0			
Date	Time Fished		Trout	Chum	Pink	Coho		Steelhead	Cutt
			Parr	Fry	Fry	Smolt	Fry	Smolt	Smolt

	Hours In	Hours Out	Nat	Mixed	Nat	Mixed	Nat	Nat	Nat
2/21/2022	23.83		1	37	413	0			
2/22/2022	24.17		1	13	201	1			
2/23/2022	24.33			27	150	1			
2/24/2022	23.84			39	104	0			
2/25/2022	24			29	118	4			
2/26/2022	23.83			26	138	4			
2/27/2022	24			140	252	5		1	
2/28/2022		23		113	514	36			
3/1/2022		24		120	546	38			
3/2/2022		24		120	546	38			
3/3/2022		24		120	546	38			
3/4/2022		24		120	546	38			
3/5/2022		24		120	546	38			
3/6/2022		24		120	546	38			
3/7/2022	7.5	18		132	631	43			
3/8/2022	23.67		2	101	893	70	2	1	1
3/9/2022	24.67		4	53	498	154	3	1	
3/10/2022	23.67		1	109	403	19			
3/11/2022	24.25			125	690	31			
3/12/2022	23.42			276	1425	17			
3/13/2022	24.84			401	2904	6			
3/14/2022	24			236	3028	0			
3/15/2022	24		1	250	1105	8			
3/16/2022	23.91			276	1475	3	1		
3/17/2022	24.08			388	1387	4			
3/18/2022	24.17			259	2012	1	9		
3/19/2022	23.84		1	597	2683	2	2		
3/20/2022	23.92			1065	2342	0	3		
3/21/2022	37.75			1182	4492	6	8		
3/22/2022	24		1	598	2739	5	1		
3/23/2022	23.83			745	3019	1	7		
3/24/2022	16.83			358	1586	2	2		
3/25/2022	23.33			241	1656	3	6		
3/26/2022	32			601	4908	0	4		
3/27/2022	24.33			860	2656	2	5		
3/28/2022	24			778	3427	0	1		
3/29/2022	23.92			536	6942	1	5		
3/30/2022	16.58	5		1191	7793	0	5		
Date	Time Fished		Trout	Chum	Pink	Coho		Steelhead	Cutt
			Parr	Fry	Fry	Smolt	Fry	Smolt	Smolt

	Hours In	Hours Out	Nat	Mixed	Nat	Mixed	Nat	Nat	Nat
3/31/2022		24		1324	9144	1			
4/1/2022		25		1341	9300	1			
4/2/2022	25			1330	9094	1	2		
4/3/2022	24.17		1	1696	13425	0	3		
4/4/2022	23.83			2101	9408	0	3		
4/5/2022		25		1380	8099	0			
4/6/2022	23			508	5781	0			
4/7/2022	24.25			3347	6894	0			
4/8/2022	24			885	8030	0			
4/9/2022	24.75			4351	7354	1	1		
4/10/2022	24.25			908	9806	2	3		
4/11/2022	23.25			2858	6197	0			
4/12/2022		21.5		4244	6572	1			
4/13/2022		24		4959	7765	1			
4/14/2022		24		4959	7765	1			
4/15/2022		27		5104	7812	1			
4/16/2022	24			5075	5505	1	1		
4/17/2022	24.17			2943	2772	1	1		
4/18/2022	11.25			518	3427	0	1		
4/19/2022	12.83	8.42		1757	3735	0	1		
4/20/2022		24		1353	5560	4			
4/21/2022		27		1382	5588	4			
4/22/2022	24			423	5085	6			
4/23/2022	24.25			358	4508	11			
4/24/2022	23.75			237	4508	10			
4/25/2022	35.67			103	4115	6			
4/26/2022	23.5			2765	7662	17			
4/27/2022	24.25			743	5383	13			
4/28/2022	24.25			217	3797	35			
4/29/2022	24			397	2863	19			
4/30/2022	24.25			74	3685	20	1		
5/1/2022	24.25			755	4096	12			
5/2/2022	23.5			515	2533	5			
5/3/2022	24			892	2389	37	2		
5/4/2022	24			187	1171	30			
5/5/2022	24			91	737	40			
5/6/2022	24.5			212	362	52	1		1
5/7/2022	24			188	45	257	1		
Date	Time Fished		Trout	Chum	Pink	Coho		Steelhead	Cutt
			Parr	Fry	Fry	Smolt	Fry	Smolt	Smolt

	Hours In	Hours Out	Nat	Mixed	Nat	Mixed	Nat	Nat	Nat
5/8/2022	23.75			41	46	54		1	
5/9/2022	24.08			21	56	17	1		
5/10/2022	23.92			110	38	45	1	6	
5/11/2022	22.75			180	36	324	1	10	
5/12/2022	38.17			66	16	33			
5/13/2022	24.5			62	12	30		2	
5/14/2022	24			9	17	21			
5/15/2022	24			3	14	8			
5/16/2022	24			8	11	4			
5/17/2022	24.25			8	3	39		3	
5/18/2022	24			2	4	17	2	2	
5/19/2022	24.08			11	3	16			
5/20/2022	23.92			6	2	14		1	
5/21/2022	23.75			4	1	9		4	
5/22/2022	24.25			12	0	14		2	
5/23/2022	23.75			0	1	4		1	
5/24/2022	24.25			3	0	11			
5/25/2022	24			11	0	2			
5/26/2022	23.75			5	0	19			
5/27/2022	24			12	0	10		1	
5/28/2022	24			3	0	18	1	5	
5/29/2022	24.25			1	1	10	1	1	
5/30/2022	24.25			1	0	12			
5/31/2022	23.5			5	0	8	1	1	
6/1/2022	24.25			2	0	7		1	
6/2/2022	24.25			1	1	9	1		
6/3/2022	24			1	0	8			
6/4/2022	23.75			1	1	20		5	
6/5/2022	24			2	0	7		1	
6/6/2022	22.75			2	0	12		1	
6/7/2022		22		1	0	8			
6/8/2022		18.25		1	0	9			
6/9/2022	31.75			0	0	2			
6/10/2022		22		0	0	3			
6/11/2022		26		0	0	3			
6/12/2022	24.5			0	0	6	1		
6/13/2022	24.25			1	0	4			
6/14/2022	24.5			0	0	3		2	
Date	Time Fished		Trout	Chum	Pink	Coho		Steelhead	Cutt
			Parr	Fry	Fry	Smolt	Fry	Smolt	Smolt

	Hours In	Hours Out	Nat	Mixed	Nat	Mixed	Nat	Nat	Nat
6/15/2022	24.25			0	0	2			
6/16/2022	24			1	0	3			
6/17/2022	24			1	0	9		1	
6/18/2022	23			2	0	9			
6/19/2022	24.17			1	0	6			
6/20/2022	23.33			1	0	3	1		
6/21/2022	25			2	0	2			
6/22/2022	24.25			0	0	2	1		
6/23/2022	24			1	0	1			
6/24/2022	24			1	1	1			
6/25/2022	23.75			0	0	1			
6/26/2022	24.17			1	0	1			
6/27/2022	10.83			0	0	1			
Total	**5280.54**	**555.50**	**18**	**75836**	**282437**	**2160**	**112**	**55**	**3**

Appendix E

Fork lengths of mixed-origin coho smolts in the Green River, 2022

APPENDIX E.─Mean fork length (mm), standard deviation (St.Dev.), range, and sample size of mixed-origin coho smolts in the Green River in 2022.

Week	Dates		Sample Results				
	Start	End	Average	Std Dev	Min	Max	Count
5	1/23/2022	1/29/2022	107.29	8.14	96	118	7
6	1/30/2022	2/5/2022	100.56	11.19	87	120	9
7	2/6/2022	2/12/2022	104.20	9.71	88	114	5
8	2/13/2022	2/19/2022	101.00	11.64	86	118	10
9	2/20/2022	2/26/2022	111.50	8.45	98	122	10
10	2/27/2022	3/5/2022	121.40	15.32	100	141	5
11	3/6/2022	3/12/2022	107.35	10.73	74	124	55
12	3/13/2022	3/19/2022	108.79	11.55	94	151	29
13	3/20/2022	3/26/2022	103.43	12.76	65	115	14
14	3/27/2022	4/2/2022	112.50	9.71	100	122	4
15	4/3/2022	4/9/2022	114.00	NA	114	114	1
16	4/10/2022	4/16/2022	121.50	39.77	98	181	4
17	4/17/2022	4/23/2022	130.35	12.74	98	148	17
18	4/24/2022	4/30/2022	129.19	8.75	98	148	67
19	5/1/2022	5/7/2022	129.83	12.94	95	167	90
20	5/8/2022	5/14/2022	128.20	12.38	96	161	71
21	5/15/2022	5/21/2022	121.64	9.74	96	143	56
22	5/22/2022	5/28/2022	115.11	9.71	96	140	53
23	5/29/2022	6/4/2022	114.02	11.98	82	142	59
24	6/5/2022	6/11/2022	113.73	10.36	98	134	22
25	6/12/2022	6/18/2022	110.21	13.30	89	148	38
26	6/19/2022	6/25/2022	107.31	13.54	90	138	16
27	6/26/2022	7/2/2022	120.50	41.72	91	150	2

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