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Green River Juvenile Salmonid Production Evaluation: 2020 Annual Report

by Peter C. Topping, and
Joseph H. Anderson

Washington Department of Fish and Wildlife
Fish Program
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. Developing these estimates was possible due to the long hours of trap operation provided by our dedicated scientific technicians: Bob Green, Jayson Gallatin and Tom Mathews. Logistical support was provided by Wild Salmon Production Evaluation Unit biologist Josh Weinheimer.

Several other individuals and agencies contributed to this project. Burr Mosby, the adjacent landowner, provided access to the trap site. Mike Wilson, manager of the WDFW Soos Creek hatchery, provided logistical support and a secure staging site near the trap. Aaron Bosworth and 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 2020.

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Executive Summary

This report provides the 2020 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 16 through June 22, 2020. During this period, the trap fished 72% of the time. We experienced several prolonged outages, two early in the season due to a prolonged high water event in late January thru the first half of February and a third outage in March and the first half of April due to field work restrictions associated with Covid-19. We suspect that large numbers of juvenile salmonids moved downstream (possibly involuntarily) during the prolonged high-water event, especially young of the year fry. We estimated the freshwater production (juvenile abundance) of natural origin subyearling Chinook and wild pink 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 2020. Data represent freshwater production above the juvenile trap, which is located at river mile 34.5.

Species/Life Stage	Catch	Production (% CV)	Avg Fork Length (± 1 S.D.)	Median Migration Date
Chinook – Subyrlg	582	85,277 (24.56%)	52.29 (±16.57)	13-Feb
Chinook – Yrlg	1			
Coho – Yrlg	642[a]		109.2 (±15.19)	29-Apr [b]
Steelhead – Smolt	10		158.90 (±18.66)	2-May [b]
Pink	61,985	3,580,237 (31.17%)	33.61 (±18.66)	30-Mar
Chum	13,350 [a]			23-Apr [b]

[a] This figure includes natural-origin and unmarked hatchery-origin fish.
[b] This catch is median catch date which is not adjusted for trap efficiency and therefore 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 2020 outmigration (2019 brood) was estimated to be 1.66%, yielding a basin-wide production estimate of 95,525 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 79% of the natural subyearling migrants and peaked in the early February. Parr migrants (>45 mm fork length) represented 21% of the total abundance and their migration peaked two times, once in mid-February and again in early June.

Introduction

This report provides the 2020 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, 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 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 pool 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 2020 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 2020, the trap operated between January 16 and June 22 for a total of 2,693.58 of 3,783.50 possible hours (71% of the time). Over the course of the season, trapping was suspended 9 times; the duration of outages ranged from 4.50 to 509.75 hours. Trapping was suspended twice for high water for a total of 503 hours in late January and the first half of February, once for Covid-19 for 509.75 hours in late March and first half of April, twice for trap movement, three times late in the season to avoid interactions with rafters and once for staffing issues.

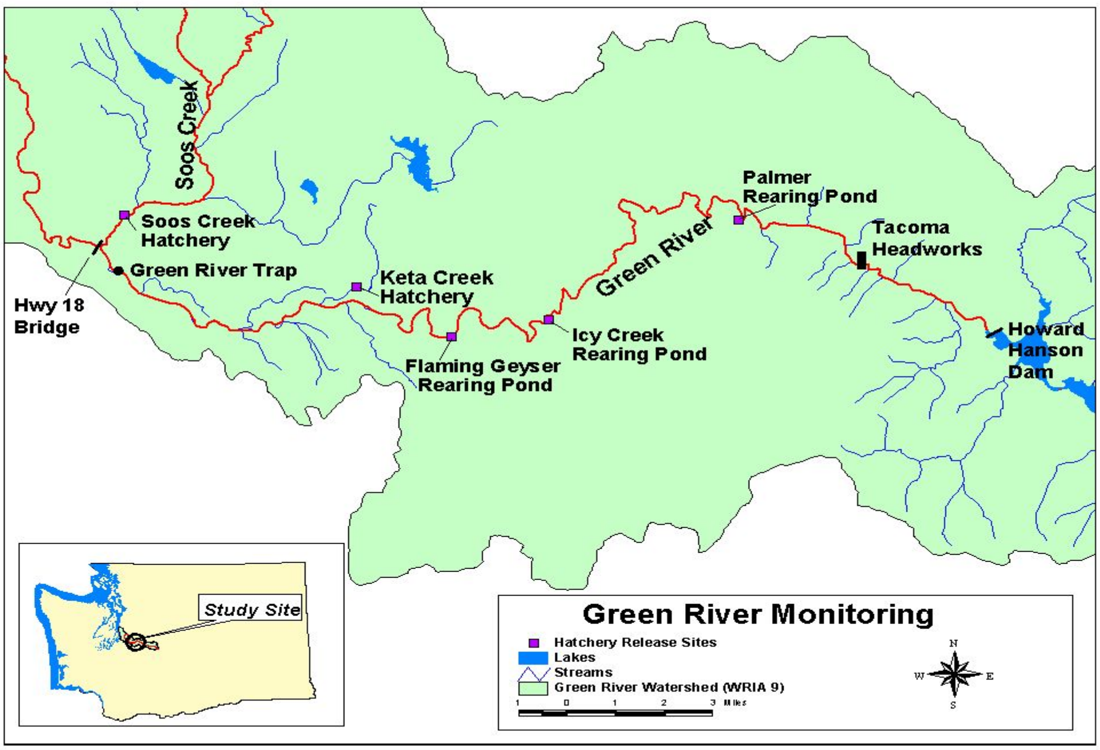

Figure 1. Location of Green River screw trap in relation to existing hatchery release sites and Howard Hanson Dam.

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 and steelhead smolts daily. Subyearling Chinook were length sampled at a rate of approximately 70%.

Chinook were enumerated as subyearlings and yearlings. 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 or smolts (yearlings). Defining characteristics of coho fry were a bright orange-brown color, elongated white anal fin ray, small eye and small size (under 60 mm FL). Yearling coho were 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 2020 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 where unmarked.

In total, 2 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 July 1st after the trap was removed from fishing. Over the previous two years of trapping, we have observed fish reared at Palmer Ponds escaping the hatchery facility, beginning shortly after planting. In 2020, we captured a few ad-clipped fry after they were planted into Palmer Ponds with the first one captured on April 21 a month after planting. In total, we caught only 39 ad-marked fry for the entire season, suggesting that the fish leakage from the pond had been greatly reduced.

Table 2. Number of hatchery fish by mark type released above the Green River screw trap in 2020. Fish released below the trap are not included in this table as they do not impact the quality of the freshwater production estimate.

Species	Brood Year	Release Location	Ad-clip + CWT	CWT only	Ad-Clip only	Externally unmarked
Chinook – Subyrlg	2019	Palmer Pond	196,399	4,564	1,767,233	34,308
Chinook – Yrlg	2018	Icy Creek	200,766	2,426	90,825	1,056
Coho – Yrlg	2018	Keta Creek		52,314		901,287
Chum - Subyrlg	2019	Keta Creek				6,176,797
Summer steelhead	2019	Icy Creek			49,517	144
Winter steelhead	2019	Icy Creek		66,824		

Trap Efficiency Trials

Trap efficiency trials were conducted for subyearling Chinook and pink salmon with maiden-caught fish of natural origin throughout the season. Captured fish were anesthetized with tricaine methanesulfonate (MS-222) and marked with either Bismarck Brown dye or a partial caudal fin clip. Small Chinook (January to early-May) and all the pink salmon were marked with Bismarck Brown dye, whereas the larger Chinook parr were marked with a partial caudal fin clip. Release groups alternated the fin clip position 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 at dusk. We have used this same release location throughout the many years of this project.

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.

(1) Missed catch. 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 strata (group). Weekly groups with less than 5 recoveries were grouped with the follow week or weeks until a minimum of 5 recoveries were achieved to form the next strata. (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 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 2015. The 2015 hatchery brood SAR reported in this document does not include 5 year old adult returns due to the data not being available online when this report was completed.

Results

Subyearling Chinook

The total estimated catch of non-externally marked Chinook ($\hat{u}$ = 1,484) included 582 captures in the trap and an estimated missed catch during trap outage periods of 902. The 2020 trapping season experienced two of the longest trap outage periods in the 21 years of this project. To estimate the missed catch during both the high flow outage, (1/23-2/17) and the Covid-19 outage (3/25-4/15) we applied the average hourly catch rates for just 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 this outage we estimated a missed catch of 857 Chinook. For the Covid-19 outage we used this same approach because the catch before and after the outage was extremely low and consistent. Using more days in the average hourly catch rate estimate would have make little to no difference in the estimated catch. For this outage we estimated a missed catch of just 42 Chinook or 2 fish per day. (Figure 2, Table 3, Appendix B).

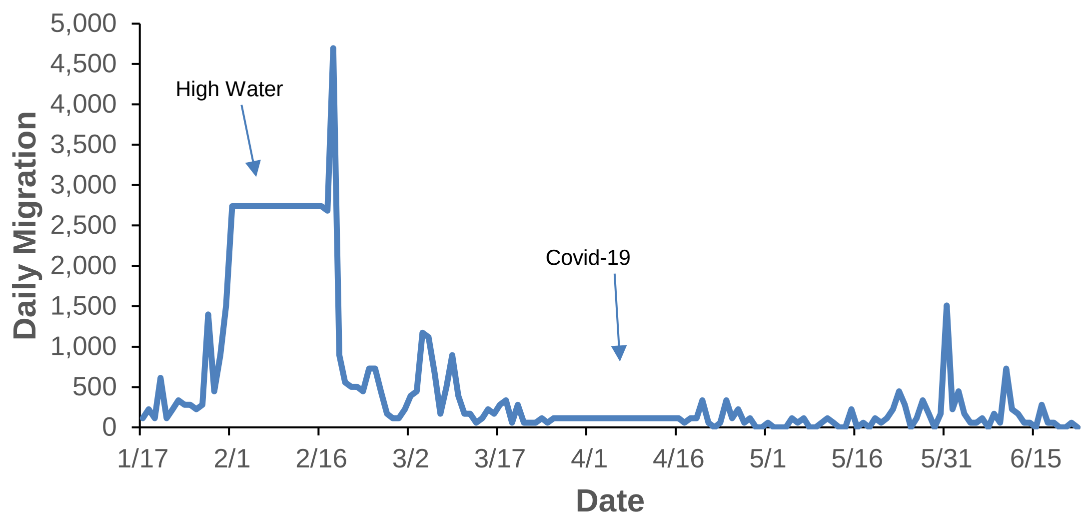

Figure 2. Daily migration of natural-origin subyearling Chinook migrants at the Green River screw trap in 2020.

We released a total of 1,900 Chinook salmon within 56 distinct trials to estimate trap efficiency. Release numbers ranging from 1 to 250 fish per trial and were performed with both maiden captured natural origin fish and ad-marked hatchery origin fish obtained from the Soos Creek hatchery. All the efficiency trials were combined to form a single efficiency for the season (Table 3). We estimated 82,973 unmarked natural origin subyearling juvenile Chinook salmon during the trapping season.

We estimated natural-origin subyearling Chinook from spawning and rearing locations upstream of the trapping site. The trapping season of January 16 through June 22 encompassed most of the natural-origin subyearling Chinook migration; we estimated 82,973 Chinook salmon during the trapping season, plus 1,879 before and 425 after the trapping season for a total of 85,277 (Table 3).

Table 3. Catch, marked and recaptured fish, and estimated abundance of natural origin Chinook migrants at the Green River screw trap in 2020. Release groups were pooled to form a single stratum. Missed catch and associated variance were estimated for periods that the trap did not fish.

Strata	Date	Natural origin catch			Marked	Recap	Total Abundance	
		Actual	Missed	Variance			Estimated	Variance
Before	1/1-1/23						1,879	7.49E+05
	1/20-6/22	582	902	1.48E+03	1,900	33	82,973	4.15E+08
After	6/23-7/31						425	2.18E+08
Season Total		582	902	1.48E+03	1,900	33	85,277	6.34E+08

Freshwater productivity of natural-origin Chinook for brood year 2019 above the trap site was estimated to be 75 juveniles per female, with an egg-to-migrant survival of 1.66%. This calculation was based on the estimated number of natural origin subyearling Chinook passing the trap ($\hat{N}_T$ = 85,277), 1,140 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 5,130,000 eggs.

Basin-wide abundance of subyearling unmarked natural origin Chinook was estimated to be 95,525 migrants. This included 85,277 migrants from above the trap and 3,815 juveniles from the mainstem below the trap and 6,433 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 February 13 (Table 5). Over the entire migration period, we estimated that 78.59% of the natural origin Chinook migrated as fry (≤ 45 mm) and 21.41% migrated as parr (> 45 mm). The fry migration peaked in the second week of February. The parr migration peaked twice, once at the same time as the fry in mid-February and again in the first week of June. (Table 6, Figure 2).

The seasonal average length of subyearling natural Chinook was 52.29 (16.57 ± 1 S.D.; Appendix C). The weekly average lengths of the natural origin subyearling Chinook showed little increase (approximately 4 mm) during the early portion of the season, (January 17 – April 12). From mid-April thru the end of the trapping season, natural Chinook subyearling average body size increased 3.3 mm per week. The largest size increase occurred between May 10 and May 23 with an increase of 13 mm over this two-week period (Figure 3, Appendix C).

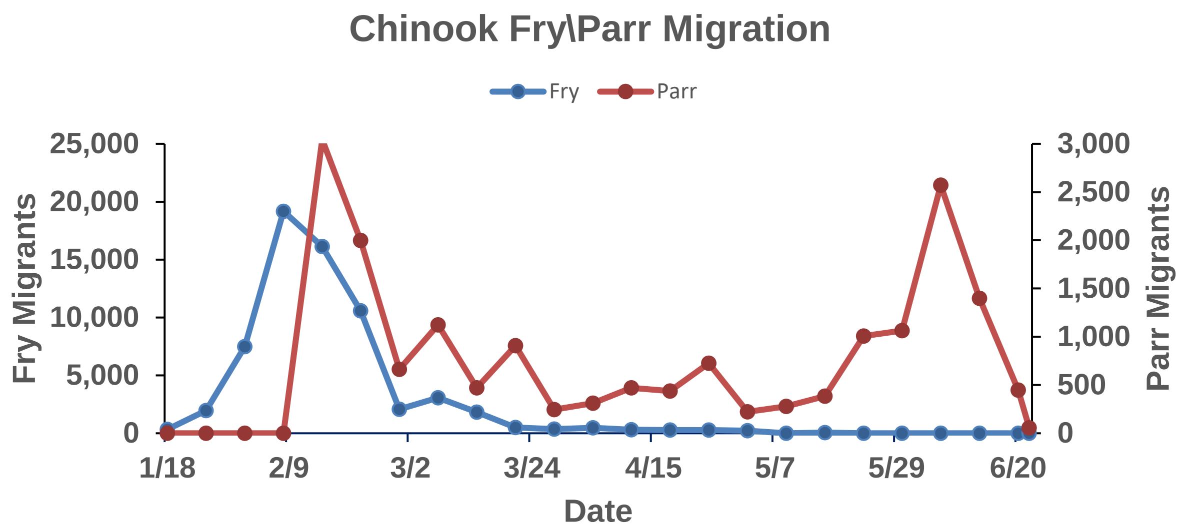

Figure 3. Weekly migration of natural-origin subyearling Chinook migrants at the Green River screw trap in 2020. Subyearling migrants are partitioned into two freshwater rearing strategies fry (≤45 mm FL) and parr (> 45 mm FL) migrants.

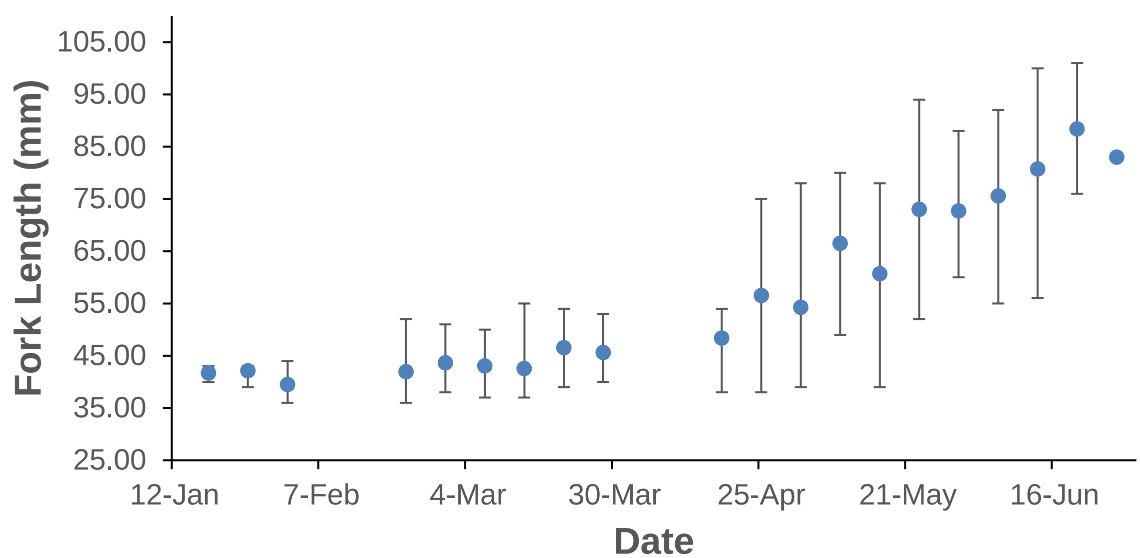

Figure 4. Fork length (mm) of subyearling Chinook migrants of natural origin captured in the Green River screw trap in 2020. Data are mean, minimum, and maximum values.

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. Note that the methods for estimating production from Big Soos Creek have changed over the years (see text of results for details)

Trap	Above Trap				Below Trap			Soos Crk			Total Green
Year	Redds	Deposition	Production	Survival	Redds	Deposition	Production	Females	Deposition	Production	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

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 (0.14% - 3.3%) for brood years 2002 through 2015 (Table 7). At the time of this publication, the 5 year old hatchery returns for the 2015 brood were not accessible through the RMIS database. Therefore, the 2015 hatchery brood SAR is likely bias low. Natural origin juveniles survived at a higher rate ten out of thirteen years than hatchery origin non-ad marked CWT juveniles released from Soos Creek Hatchery (Figure 4). 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, except for trapping year 2014 thru 2018 when an unknown number of unmarked hatchery Chinook were present in the length sample, migration years 2000-2020.

	Abundance				Fork Length		Migration Timing
Migration Year	Estimate	Lower C.I.	Upper C.I.	CV	Average	St.Dev.	Median Date
2000	475,207	324,315	626,098	16.2	51.4	16.53	13-Mar
2001	809,616	641,195	978,038	10.61	45	12.32	16-May
2002	584,151	343,533	824,769	21.02	46.8	12.52	20-Apr
2003	449,956	265,175	634,738	20.98	47.1	12.41	10-Mar
2004	236,650	201,917	271,382	7.49	48.8	16.42	25-Mar
2005	470,334	410,369	530,300	6.5	52.7	18.11	8-Mar
2006	99,796	79,088	120,504	10.59	57.7	21.22	28-May
2007	127,491	107,242	147,740	8.1	69.9	23.47	5-Mar
2008	400,763	361,048	440,477	5.06	54.1	17.16	28-Mar
2009	196,118	171,529	220,706	6.4	54.7	17.49	2-Apr
2010	55,547	39,445	71,648	14.79	67.3	21.43	9-Jun
2011	254,182	225,327	283,037	5.79	51	13.29	2-Apr
2012	90,260	68,450	112,069	10.92	63.3	19.35	28-Apr
2013	492,737	420,077	565,397	6.28	48.1	14.41	21-Mar
2014	396,623	231,236	562,010	21.25	61.1	18.66	5-Mar
2015	396,944	290,947	502,941	13.60	45.4	14.60	7-Feb
2016	57,214	43,873	70,556	11.70	63.8	20.92	23-Apr
2017	2,034,861	1,613,904	2,455,817	10.60	53.0	16.99	22-Mar
2018	315,886	192,691	439,081	19.90	58.2	21.8	19-Feb
2019	1,008,372	748,125	1,268,620	9.53	61	18.54	12-Mar
2020	85,277	43,034	122,912	29.52	52.29	16.57	12-Feb

Table 6. Abundance of natural origin fry and parr subyearling migrants of Green River Chinook, from above the trap site, migration year 2000 to 2020.

Trapping	Fry Migrants			Parr Migrants		
Year	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%

Table 7. Smolt to adult return (SAR) for adult Chinook in the Green River, brood years 2002-2015. 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%

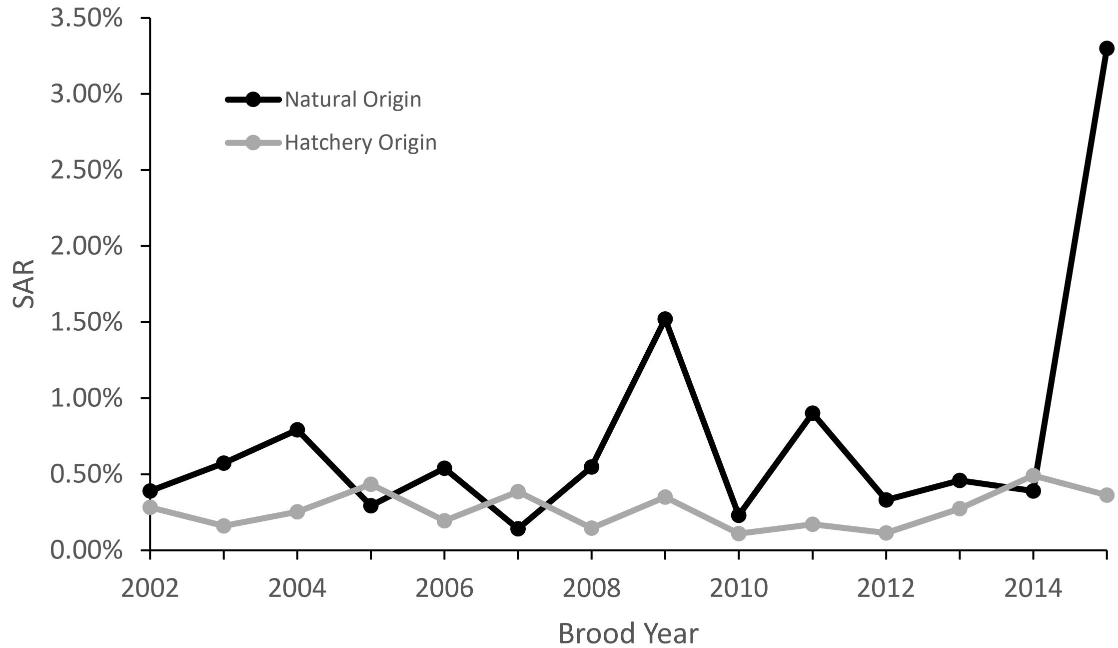

Figure 5. Smolt to adult return rate (SAR) of natural origin vs hatchery origin Chinook from the Green River, brood years 2002-2015. Does not include age 2 (jacks) returns, account for harvest or natural-origin adults captured for hatchery broodstock. The 2015 hatchery brood does not include 5 year old returns and is likely biased low.

Yearling Chinook

One natural-origin Chinook yearling was captured. In total, 11 hatchery-origin yearling Chinook were captured (3 Ad-mark and 8 Ad-CWT).

Coho Smolts

We could not estimate catch of natural-origin coho smolts because all the hatchery smolts released upstream of the screw trap were unmarked. For the season, we caught a total of 642 coho smolts, including 610 unmarked and 32 individuals with Coded Wire Tagged only. In addition, we estimated 120 unmarked fish would have been caught had we fished continually. The first coho was captured on January 16th, the first day of trapping (Appendix D). Catch remained low and sporadic thru the first two full month of trapping averaging less than 2 fish per day. The catch ramped up on April 28th with the release of over 900,000 non-externally marked hatchery coho. Peak daily catch occurred on April 29 with a one day catch of 77 fish. Daily catch declined gradually through May and early June. The last coho smolt was captured on June 17, 2020. No production estimate was made for natural origin coho smolts because of the large number of unmarked hatchery coho.

The seasonal average length of coho smolts was 109.23 ± 15.19 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 5, Appendix E).

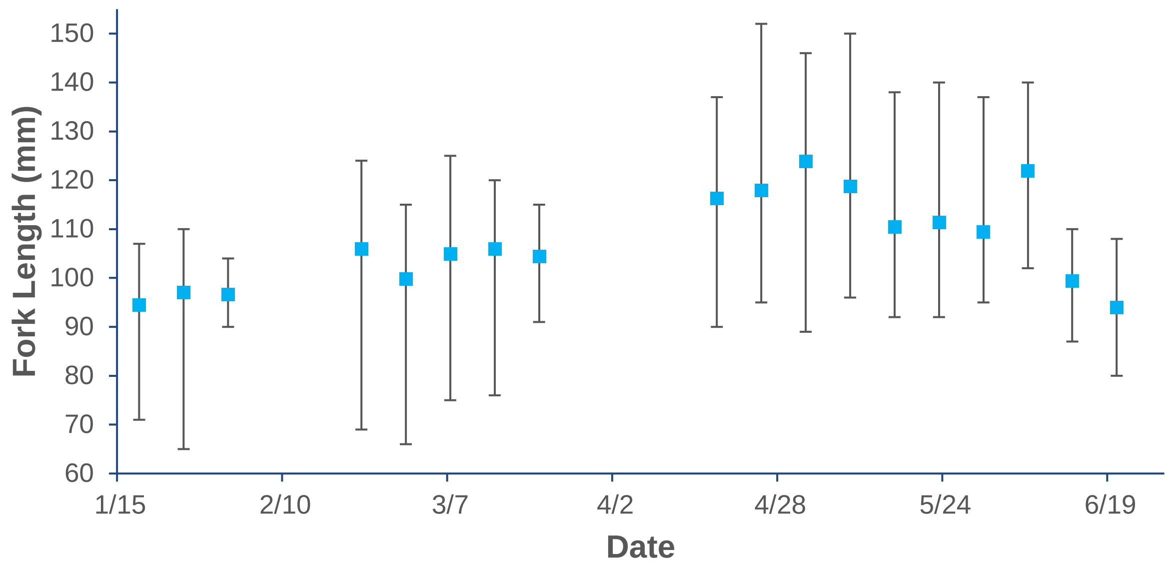

Figure 6. Fork length (mm) of mixed coho captured in the Green River screw trap in 2020. Data are mean, minimum, and maximum values by week.

Steelhead Smolts

The total catch of natural-origin steelhead smolts was 10 with none estimated for periods not fished (Appendix D). In total, 126 (104 Ad-only and 22 CWT-only) hatchery steelhead were captured between April 17 and June 14. We did not catch enough natural origin steelhead smolts to estimate trapping efficiency or production.

The median catch date for natural origin steelhead smolts was May 2nd.

Over the season, a total of 10 maiden captured unmarked steelhead were measured (fork length). Individuals ranged from 130 mm to 187 mm and averaged 158.9 mm for the season (Figure 6).

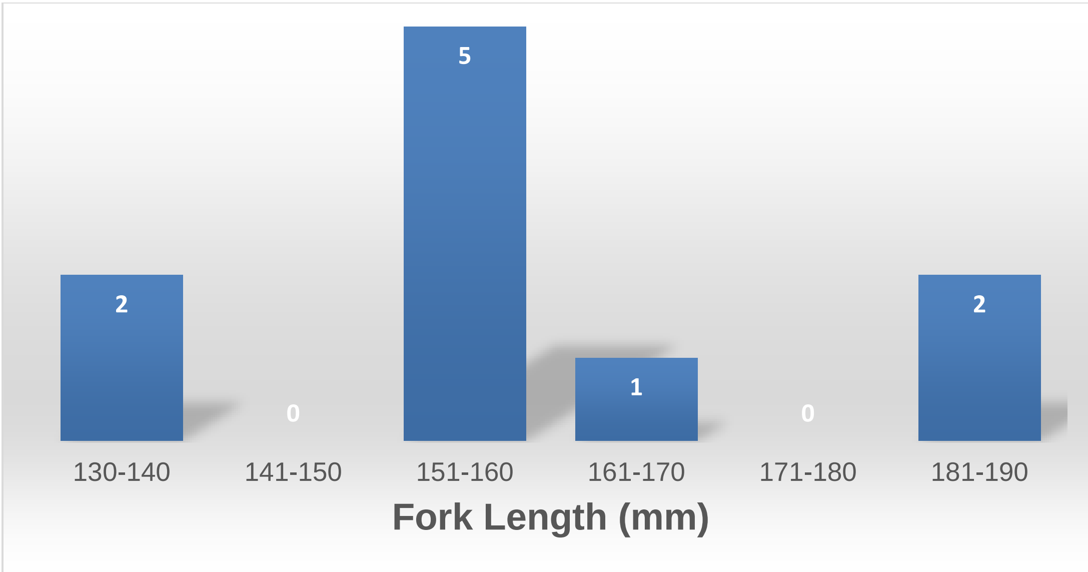

Figure 7. Fork length (mm) of natural-origin steelhead captured in the Green River screw trap in 2020.

Length and DNA samples were collected on all 10 natural-origin steelhead smolts captured. Mass was measured for eight individuals were weighed and 8 of the 10 scale samples were readable for age. (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 2011-2020.

Smolt	1+			2+			3+			4+		
Age Year	Ave FL	%	Ave mass (g)	Ave FL	%	Ave mass (g)	Ave FL	%	Ave mass (g)	Ave FL	%	Ave 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	189.0	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	190.0	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	221.0	1%	93.4			
2018	157.2	36%	37.2	172.7	73%	50.2	185.0	1%	60.4			
2019	167.8	71%	45.3	190.3	24%	68.4	185.00	5%	62.8			
2020	155.0	13%	na	167.0	87%	39.7						

Chum

The total estimated catch of unmarked chum fry ($\hat{u}$ =20,374) included 13,354 captures in the trap and 7,020 missed catch estimated for trap outage periods (Appendix D). Chum migrants were captured between February 2 and June 10, 2020. Captured chum could not be separated into natural and hatchery origin because chum released from Keta Creek hatchery were unmarked. No production estimate was calculated.

Pink

The total estimated catch of wild pink fry ($\hat{u}$ =118,958) included 61,985 captures in the trap and and estimated 56,973 missed catch during trap outage periods (Appendix D). Pink fry were captured from the beginning of trapping until May 21, 2020. The daily migration steadily increased thru the early part of the season and peaked on the night of April 19 with over 150,400 fry estimated to have passed the trap in a single night (Figure 7).

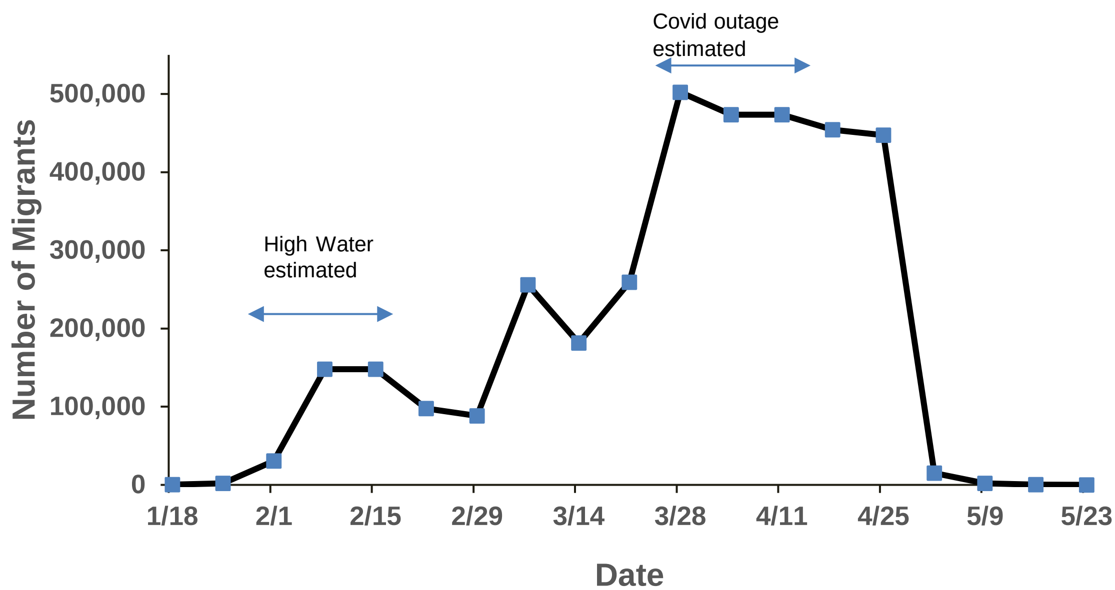

Figure 8. Weekly migration of pink fry originating from above the Green River Screw trap in 2020. Data are number of juvenile pink migrants by week.

Thirty-five individual efficiency trials were conducted using 7,549 maiden captured pink fry, which were pooled into three efficiency strata. We estimated 3,580,237 ± 2,187,596 (95% C.I.) pink fry. The coefficient of variation for this estimate was 31.17%.

Other Species

In addition to species and age classes described above, catch during the trapping season included 110 coho fry, 8 trout parr, one cutthroat smolt, and 307 trout fry (Appendix D). Non-salmonid 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 2020. 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 two 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 2019 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 3,815 and 6,433 from Soos Creek and represented 10.7% of the total production.

Identification of Species and Origin

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. However, in 2014 and continuing thru 2018, the primary hatchery mark strategy for the Palmer Pond release was an internal thermal otolith mark, with a goal of 100% marking of approximately one million fish. In 2019, an additional two million Ad-mark only subyearling Chinook were reared and released from Palmer Ponds. None of the 2014-2018 Palmer Pond releases were ad-marked; only in 2014 did a portion of the release receive CWT. In 2020, virtually all the subyearling Chinook fry planted in Palmer Ponds for acclimation were adipose-marked (ad-marked). The fish were transported from Soos Creek hatchery and planted in Palmer Ponds in March and we did not catch a single ad marked fish in our trap until April 21st , and for the season only 39 ad-marked and 7 ad-marked CWT hatchery fish were captured in the trap. Assuming similar capture efficiency as the natural origin Chinook we would only estimate a total of about 2,600 hatchery fish migrated past the trap during the trapping season. The Palmer Pond subyearling Chinook release started on July 1st after the end of the trapping season.

Freshwater Production of Chinook Salmon

The total estimated natural origin production for the entire Green River was 95,525 Chinook salmon, including 85,277 from above trap and 3,815 from the main-stem below the trap and 6,433 from Soos Creek (Table 4). We feel the highwater event that occurred between January 24 and February 17 greatly impacted the juvenile salmonids in the Green River. The flows at the Auburn gauge were over 4,000 CFS for 25 consecutive days with flows over 8,000 CFS for 7 days and flows crested over 10,000 CFS on January 27th. Over the twenty-year project history, we have observed the negative impacts caused by high flows to juvenile salmon survival and production. High flow events that occurs during egg incubation and inter-gravel rearing significantly reduce survival. Flows of this magnitude scour redds and wash newly emerged fry downstream. This was the highest flow with the longest duration event of any flows we have experienced on this project and contributed to the extremely low catch of all species of juvenile salmon.

Interruptions in trap operation due to the high flow event and Covid-19 presented significant challenges to estimating abundance. The flow event occurred just as the Chinook fry migration was beginning, with a daily average catch of just 4 fry from the start of the season. The catch on the first day back in fishing at the end of the high water outage was substantially higher at 84 fry captured. The daily catch subsided quickly with just 21 captured the second day and by the fourth day of fishing after the outage, the daily catch averaged less than 10 per day. This catch suggests that peak migration occurred during the outage period. 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. By using the single full day before and after the outage, periods that had the highest hourly catch rate during this portion of the season, we aimed to estimate a relatively large missed catch during the outage. We believe this approach still underestimates the number of juvenile Chinook that passed the trap during this event. Furthermore, in late March and the first half of April the trap was not fished due to Covid work restrictions, The daily catch before and after this outage was very low averaging less than 2 fish per day, so we used just the catch from the day before and the first day after the outage to estimate the missed catch. We feel this is a good estimate of the missed catch during this outage period, with catch so low there was little scope for error.

We feel we likely underestimated the number of juvenile Chinook to pass the trap for the entire season. We expect that fish movement increased significantly during the high flow even in January and February, as it was of sufficient magnitude to mobilize river gravels, suggesting small fry with limited swimming strength also would have been pushed downstream. However, it is possible that the high flow event significantly reduced survival, and perhaps fish flushed downstream during this period were no longer alive. The high flow event was of large magnitude, long duration and occurred when the fry were very fragile, just emerging or still in the gravel. A more conservative approach would exclude the estimated migration during the flood. The number of Chinook estimated during that flood event was 47,916 and represented 56% of the total estimated migrants from above the trap for the year.

We estimated a total of 18,254 Chinook salmon parr > 45 mm, which was 21.41% of the total migration estimate of 85,277. 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 twenty one 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 2020, we captured one natural origin yearlings.

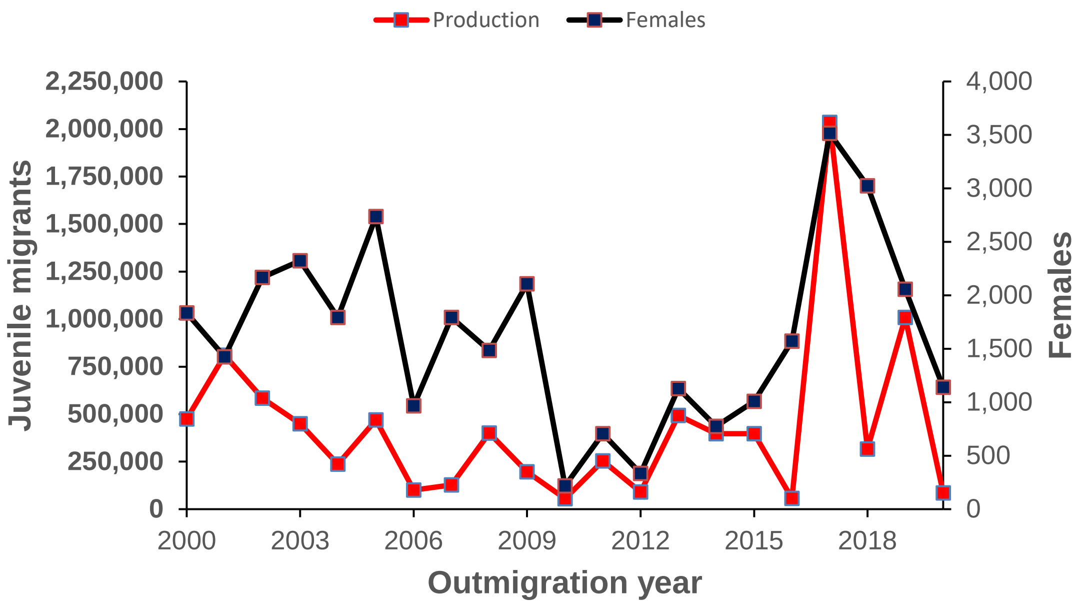

Figure 9. Number of unmarked natural origin subyearling Chinook migrants (black line) passing the Green River juvenile trap and the corresponding number of female spawners (Red line) above the juvenile trap, outmigration year 2000-2020.

Freshwater Production of Coho Salmon

Freshwater production of coho smolts above the Green River trap has been estimated for 15 of the 21 years of this study (Table 9). The 2020 freshwater production was not estimated because none of the hatchery origin coho released from Keta Creek Hatchery were externally marked, making positive identification unreliable.

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, 2019 and 2020 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 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. In 2019 and 2020, 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. We encounter challenges with natural origin abundance estimation even when the hatchery origin fish are externally marked. 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. 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 natural-origin coho smolts rearing above the Green River juvenile trap, migration years 2000-2020.

	Abundance				Fork Length		Migration Timing
Migration Year	Estimate	Lower C.I.	Upper C.I.	CV	Average	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	5/1[b]
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	14.60	4/27
2018	57,609	34,616	80,603	20.36%	105.2	10.66	5/7
2019	59,398	12,322	106,474	40.44%	122.5	12.92	4/22
2020	---	---	---	---	109.2	15.19	4/29

a Median catch date.

b Abundance estimate includes unmarked hatchery coho.

Freshwater Production of Steelhead

The abundance of steelhead smolts rearing above the Green River trap has been estimated for only 7 of the 21 years of this study (Table 10). In 2020, natural steelhead smolt production was not estimated. The low maiden catch of 10 steelhead smolts precluded us from estimating trapping efficiency or making a production estimate. Scale samples were collected from all 10 smolts captured, 8 samples were readable (1 age one, and 7 age two). (Table 8).

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 2000-2020.

	Abundance				Fork Length		Timing
Migration Year	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	2/06[a]
2005	---	---	---	---	153.3	19.05	1/25[a]
2006	---	---	---	---	151.1	25.93	5/05[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	5/08[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	19.00	5/08[a]
2016	32,936	8,606	57,266	37.69%	169.0	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	---	---	---	---	172.0	19.08	5/18
2020	---	---	---	---	158.9	18.66	5/2

a Median catch date

Appendix A

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

Author: Kristen Ryding, WDFW Biometrician

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,

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

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

$E\left(\hat{u}_i\right)$ = 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,

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

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

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

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

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 $E\left(\hat{u}^2\right)$,

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

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

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

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

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

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

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

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

Appendix B

Daily catch and migration estimate for unmarked natural origin subyearling Chinook in the Green River, 2020

APPENDIX B. — Actual and estimated daily catches and migration for unmarked natural origin subyearling Chinook migrants in the Green River, 2020.

Date	Time Fished Hours		Unmarked Sub-yearling Chinook Catch			Migration
	In	Out	Actual	Est	Total	
1/1-1/16	Pre-Trapping					1,879
1/17/2020	26.50		2		2	112
1/18/2020	24.25		4		4	224
1/19/2020	23.75		2		2	112
1/20/2020	24.17		11		11	615
1/21/2020	25.83		2		2	112
1/22/2020	20.00		4		4	224
1/23/2020		28.00		6	6	335
1/24/2020		24.00		5	5	280
1/25/2020		24.00		5	5	280
1/26/2020		17.00		4	4	224
1/27/2020	29.00		5		5	280
1/28/2020	24.00		25		25	1,398
1/29/2020	23.50		8		8	447
1/30/2020	24.50		16		16	895
1/31/2020	14.50	11.00	20	7	27	1,510
2/1/2020		24.00		49	49	2,740
2/2/2020		24.00		49	49	2,740
2/3/2020		24.00		49	49	2,740
2/4/2020		24.00		49	49	2,740
2/5/2020		24.00		49	49	2,740
2/6/2020		24.00		49	49	2,740
2/7/2020		24.00		49	49	2,740
2/8/2020		24.00		49	49	2,740
2/9/2020		24.00		49	49	2,740
2/10/2020		24.00		49	49	2,740
2/11/2020		24.00		49	49	2,740
2/12/2020		24.00		49	49	2,740
2/13/2020		24.00		49	49	2,740
2/14/2020		24.00		49	49	2,740
2/15/2020		24.00		49	49	2,740
2/16/2020		24.00		49	49	2,740
2/17/2020	8.00	15.00	2	46	48	2,684
2/18/2020	23.50		84		84	4,697

Table continued next page

APPENDIX B.─ continued.

Date	Time Fished Hours In	Out	Unmarked Sub-yearling Chinook Catch Actual	Est	Total	Migration
2/19/2020	24.17		16		16	895
2/20/2020	24.33		10		10	559
2/21/2020	24.00		9		9	503
2/22/2020	24.00		9		9	503
2/23/2020	24.00		8		8	447
2/24/2020	24.25		13		13	727
2/25/2020	23.75		13		13	727
2/26/2020	24.00		8		8	447
2/27/2020	19.75	4.25	3		3	168
2/28/2020	23.00		2		2	112
2/29/2020	25.00		2		2	112
3/1/2020	24.00		4		4	224
3/2/2020	24.00		7		7	391
3/3/2020	23.50		8		8	447
3/4/2020	24.00		21		21	1,174
3/5/2020	24.00		20		20	1,118
3/6/2020	24.00		12		12	671
3/7/2020	24.50		3		3	168
3/8/2020	24.50		9		9	503
3/9/2020	24.50		16		16	895
3/10/2020	23.25		7		7	391
3/11/2020	23.75		3		3	168
3/12/2020	24.25		3		3	168
3/13/2020	24.00		1		1	56
3/14/2020	24.75		2		2	112
3/15/2020	24.00		4		4	224
3/16/2020	24.00		3		3	168
3/17/2020	23.50		5		5	280
3/18/2020	24.25		6		6	335
3/19/2020	24.00		1		1	56
3/20/2020	23.75		5		5	280
3/21/2020	24.75		1		1	56
3/22/2020	23.75		1		1	56
3/23/2020	24.00		1		1	56
3/24/2020	24.25		2		2	112

Table continued next page

APPENDIX B.— continued.

Date	Time Fished Hours In	Time Fished Hours Out	Unmarked Sub-yearling Chinook Catch Actual	Unmarked Sub-yearling Chinook Catch Est	Total	Migration
3/25/2020	13.25	10.50	1	0	1	56
3/26/2020		24.00		2	2	112
3/27/2020		24.00		2	2	112
3/28/2020		24.00		2	2	112
3/29/2020		24.00		2	2	112
3/30/2020		24.00		2	2	112
3/31/2020		24.00		2	2	112
4/1/2020		24.00		2	2	112
4/2/2020		24.00		2	2	112
4/3/2020		24.00		2	2	112
4/4/2020		24.00		2	2	112
4/5/2020		24.00		2	2	112
4/6/2020		24.00		2	2	112
4/7/2020		24.00		2	2	112
4/8/2020		24.00		2	2	112
4/9/2020		24.00		2	2	112
4/10/2020		24.00		2	2	112
4/11/2020		24.00		2	2	112
4/12/2020		24.00		2	2	112
4/13/2020		24.00		2	2	112
4/14/2020		24.00		2	2	112
4/15/2020		19.25		2	2	112
4/16/2020	29.25		2		2	112
4/17/2020	23.50		1		1	56
4/18/2020	24.00		2		2	112
4/19/2020	24.00		2		2	112
4/20/2020	24.50		6		6	335
4/21/2020	23.75		1		1	56
4/22/2020	24.25		0		0	0
4/23/2020	23.50		1		1	56
4/24/2020	23.75		6		6	335
4/25/2020	24.75		2		2	112
4/26/2020	24.00		4		4	224
4/27/2020	24.00		1		1	56
4/28/2020	23.00		2		2	112

Table continued next page

APPENDIX B.─ continued.

Date	Time Fished Hours In	Time Fished Hours Out	Unmarked Sub-yearling Chinook Catch Actual	Unmarked Sub-yearling Chinook Catch Est	Total	Migration
4/29/2020	24.00		0		0	0
4/30/2020	24.00		0		0	0
5/1/2020	24.75		1		1	56
5/2/2020	24.25		0		0	0
5/3/2020	24.17		0		0	0
5/4/2020	23.83		0		0	0
5/5/2020	23.00		2		2	112
5/6/2020	24.00		1		1	56
5/7/2020	24.00		2		2	112
5/8/2020	14.25	10.75	0	0	0	0
5/9/2020	13.33	10.67	0	0	0	0
5/10/2020	13.00	11.00	0	1	1	56
5/11/2020	24.00		2		2	112
5/12/2020	23.00		1		1	56
5/13/2020	24.25		0		0	0
5/14/2020	24.25		0		0	0
5/15/2020	22.50		4		4	224
5/16/2020	23.75		0		0	0
5/17/2020	24.00		1		1	56
5/18/2020	24.25		0		0	0
5/19/2020	24.00		2		2	112
5/20/2020	24.50		1		1	56
5/21/2020	24.25		2		2	112
5/22/2020	23.25		4		4	224
5/23/2020	23.00		8		8	447
5/24/2020	25.00		5		5	280
5/25/2020	24.00		0		0	0
5/26/2020	24.50		2		2	112
5/27/2020	24.00		6		6	335
5/28/2020	24.00		3		3	168
5/29/2020	24.25		0		0	0
5/30/2020	23.00		3		3	168
5/31/2020	19.50	4.50	27	0	27	1,510
6/1/2020	24.25		4		4	224
6/2/2020	24.50		8		8	447

Table continued next page

APPENDIX B.— continued.

Date	Time Fished Hours In	Time Fished Hours Out	Unmarked Sub-yearling Chinook Catch Actual	Unmarked Sub-yearling Chinook Catch Est	Total	Migration
6/3/2020	23.50		3		3	168
6/4/2020	23.75		1		1	56
6/5/2020	12.75	11.50	1	0	1	56
6/6/2020		24.00		2	2	112
6/7/2020	24.50		0		0	0
6/8/2020	23.33		3		3	168
6/9/2020	23.92		1		1	56
6/10/2020	24.00		13		13	727
6/11/2020	24.25		4		4	224
6/12/2020	24.00		3		3	168
6/13/2020	23.75		1		1	56
6/14/2020	24.25		1		1	56
6/15/2020	24.00		0		0	0
6/16/2020	23.75		5		5	280
6/17/2020	12.75		1		1	56
6/18/2020	24.00		1		1	56
6/19/2020	24.50		0		0	0
6/20/2020	23.50		0		0	0
6/21/2020	23.50		1		1	56
6/22/2020	24.50		0		0	0
6/23-7/31	Post-trapping					425
Total	**2,693.58**	**1089.42**	**582**	**902**	**1484**	**85,277**

Appendix C

Fork length of natural origin subyearling Chinook in the Green River, 2020

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 2020.

Week				Range		Number		Percent
Begin	End	Average	St.Dev.	Min	Max	Sampled	Caught	Sampled
1/12/2020	1/18/2020	41.67	1.21	40	43	6	6	100.00%
1/19/2020	1/25/2020	42.14	1.23	39	43	14	19	73.68%
1/26/2020	2/1/2020	39.51	1.92	36	44	49	74	66.22%
2/2/2020	2/8/2020	Trap Outage						
2/9/2020	2/15/2020							
2/16/2020	2/22/2020	41.97	3.03	36	52	63	130	48.46%
2/23/2020	2/29/2020	43.67	3.41	38	51	33	49	67.35%
3/1/2020	3/7/2020	43.02	3.34	37	50	41	75	54.67%
3/8/2020	3/14/2020	42.54	4.11	37	55	39	41	95.12%
3/15/2020	3/21/2020	46.55	4.51	39	54	20	25	80.00%
3/22/2020	3/28/2020	45.60	6.35	40	53	5	5	100.00%
3/29/2020	4/4/2020	Trap Outage						
4/5/2020	4/11/2020							
4/12/2020	4/18/2020	48.40	7.44	38	54	5	5	100.00%
4/19/2020	4/25/2020	56.50	13.83	38	75	18	18	100.00%
4/26/2020	5/2/2020	54.25	16.64	39	78	8	8	100.00%
5/3/2020	5/9/2020	66.50	13.18	49	80	4	5	80.00%
5/10/2020	5/16/2020	60.71	12.16	39	78	7	7	100.00%
5/17/2020	5/23/2020	73.00	12.51	52	94	18	18	100.00%
5/24/2020	5/30/2020	72.68	7.42	60	88	19	19	100.00%
5/31/2020	6/6/2020	75.57	11.48	55	92	30	44	68.18%
6/7/2020	6/13/2020	80.72	11.41	56	100	25	25	100.00%
6/14/2020	6/20/2020	88.38	7.39	76	101	8	8	100.00%
6/21/2020	6/27/2020	83.00	na	83	83	1	1	100.00%
Season Total		52.29	16.57	36	101	413	582	70.96%

Appendix D

Daily estimated catch of coho, chum, pink and sockeye salmon, steelhead and cutthroat trout in the Green River, 2020

APPENDIX D.— Daily estimated catches of coho, chum and pink salmon and steelhead and cutthroat trout caught in the Green River screw trap in 2020. 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	Times		Coho Smolts Mixed	Coho Fry Nat	Chum Fry Mixed	Pink Fry Nat	Steelhead Smolts Nat	Cutt Smolt Nat	Trout Parr Nat
	In	Out							
1/17	26.50	0.00	7	0	0	1	0	0	0
1/18	24.25	0.00	5	0	0	2	0	0	0
1/19	23.75	0.00	3	0	0	0	0	0	0
1/20	24.17	0.00	2	0	0	2	0	0	0
1/21	25.83	0.00	4	0	0	3	0	0	0
1/22	20.00	0.00	3	0	0	7	0	0	0
1/23	0.00	28.00	3	0	0	9	0	0	0
1/24	0.00	24.00	2	0	0	7	0	0	0
1/25	0.00	24.00	2	0	0	7	0	0	0
1/26	0.00	17.00	3	0	0	8	0	0	0
1/27	29.00	0.00	3	0	0	10	1	0	0
1/28	24.00	0.00	0	0	0	16	0	0	0
1/29	23.50	0.00	0	0	0	31	0	0	0
1/30	24.50	0.00	0	0	0	33	0	0	0
1/31	14.50	11.00	0	0	0	62	0	0	0
2/1	0.00	24.00	4	2	2	364	0	0	0
2/2	0.00	24.00	4	2	2	364	0	0	0
2/3	0.00	24.00	4	2	2	364	0	0	0
2/4	0.00	24.00	4	2	2	364	0	0	0
2/5	0.00	24.00	4	2	2	364	0	0	0
2/6	0.00	24.00	4	2	2	364	0	0	0
2/7	0.00	24.00	4	2	2	364	0	0	0
2/8	0.00	24.00	4	2	2	364	0	0	0
2/9	0.00	24.00	4	2	2	364	0	0	0
2/10	0.00	24.00	4	2	2	364	0	0	0
2/11	0.00	24.00	4	2	2	364	0	0	0
2/12	0.00	24.00	4	2	2	364	0	0	0
2/13	0.00	24.00	4	2	2	364	0	0	0
2/14	0.00	24.00	4	2	2	364	0	0	0
2/15	0.00	24.00	4	2	2	364	0	0	0
2/16	0.00	24.00	4	2	2	364	0	0	0
2/17	8.00	15.00	5	2	3	402	0	0	0

Table continued next page

APPENDIX D.─ continued.

Date	Times		Coho Smolts	Coho Fry	Chum Fry	Pink Fry	Steelhead Smolts	Cutt Smolt	Trout Parr
	In	Out	Mixed	Nat	Mixed	Nat	Nat	Nat	Nat
2/18	23.50	0.00	8	5	4	751	0	0	0
2/19	24.17	0.00	6	1	2	48	3	0	0
2/20	24.33	0.00	6	0	2	28	0	0	0
2/21	24.00	0.00	3	10	3	45	0	0	0
2/22	24.00	0.00	6	4	2	43	0	0	0
2/23	24.00	0.00	1	1	1	104	0	1	1
2/24	24.25	0.00	2	4	2	178	0	0	0
2/25	23.75	0.00	0	2	4	203	0	0	0
2/26	24.00	0.00	6	4	1	195	0	0	0
2/27	19.75	4.75	10	1	2	160	0	0	0
2/28	23.00	0.00	7	4	7	229	0	0	0
2/29	25.00	0.00	14	0	25	447	0	0	0
3/1	24.00	0.00	15	2	211	680	0	0	0
3/2	24.00	0.00	5	0	54	871	0	0	0
3/3	23.50	0.00	7	1	60	753	0	0	0
3/4	24.00	0.00	8	0	27	645	0	0	0
3/5	24.00	0.00	4	5	14	430	0	0	0
3/6	24.00	0.00	1	2	33	430	0	0	0
3/7	24.50	0.00	1	1	24	591	0	0	0
3/8	24.50	0.00	7	0	30	555	0	0	0
3/9	24.50	0.00	7	0	267	1,971	0	0	0
3/10	23.25	0.00	6	4	237	1,883	0	0	0
3/11	23.75	0.00	7	0	38	1,304	0	0	0
3/12	24.25	0.00	5	4	218	2,709	0	0	0
3/13	24.00	0.00	1	2	95	2,002	0	0	0
3/14	24.75	0.00	2	2	122	1,652	0	0	0
3/15	24.00	0.00	1	1	110	1,689	0	0	0
3/16	24.00	0.00	1	1	92	1,334	0	0	0
3/17	23.50	0.00	0	1	114	1,695	0	0	0
3/18	24.25	0.00	1	4	137	1,737	0	0	0
3/19	24.00	0.00	3	0	63	703	0	0	0
3/20	23.75	0.00	1	2	94	841	0	0	0

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APPENDIX D.─ continued.

	Times		Coho		Chum	Pink	Steelhead	Cutt	Trout
			Smolts	Fry	Fry	Fry	Smolts	Smolt	Parr
	In	Out	Mixed	Nat	Mixed	Nat	Nat	Nat	Nat
3/21	24.75	0.00	0	0	86	1,231	0	0	0
3/22	23.75	0.00	0	1	179	1,478	0	0	0
3/23	24.00	0.00	0	1	31	3,000	0	0	0
3/24	24.25	0.00	0	1	447	3,391	0	0	0
3/25	13.25	10.50	0	0	492	2,794	0	0	0
3/26	0.00	24.00	2	1	326	2,411	0	0	0
3/27	0.00	24.00	2	1	326	2,411	0	0	0
3/28	0.00	24.00	2	1	326	2,411	0	0	0
3/29	0.00	24.00	2	1	326	2,411	0	0	0
3/30	0.00	24.00	2	1	326	2,411	0	0	0
3/31	0.00	24.00	2	1	326	2,411	0	0	0
4/1	0.00	24.00	2	1	326	2,411	0	0	0
4/2	0.00	24.00	2	1	326	2,411	0	0	0
4/3	0.00	24.00	2	1	326	2,411	0	0	0
4/4	0.00	24.00	2	1	326	2,411	0	0	0
4/5	0.00	24.00	2	1	326	2,411	0	0	0
4/6	0.00	24.00	2	1	326	2,411	0	0	0
4/7	0.00	24.00	2	1	326	2,411	0	0	0
4/8	0.00	24.00	2	1	326	2,411	0	0	0
4/9	0.00	24.00	2	1	326	2,411	0	0	0
4/10	0.00	24.00	2	1	326	2,411	0	0	0
4/11	0.00	24.00	2	1	326	2,411	0	0	0
4/12	0.00	24.00	2	1	326	2,411	0	0	0
4/13	0.00	24.00	2	1	326	2,411	0	0	0
4/14	0.00	24.00	2	1	326	2,411	0	0	0
4/15	0.00	19.25	2	1	314	2,357	0	0	0
4/16	29.25	0.00	6	0	286	2,041	0	0	0
4/17	23.50	0.00	6	0	349	2,353	0	0	0
4/18	24.00	0.00	5	0	1,038	2,206	0	0	0
4/19	24.00	0.00	3	0	655	5,359	0	0	0
4/20	24.50	0.00	2	0	416	2,920	0	0	0
4/21	23.75	0.00	3	0	164	2,357	0	0	0

Table continued next page

APPENDIX D.─ continued.

Date	Times		Coho		Chum	Pink	Steelhead	Cutt	Trout
			Smolts	Fry	Fry	Fry	Smolts	Smolt	Parr
	In	Out	Mixed	Nat	Mixed	Nat	Nat	Nat	Nat
4/22	24.25	0.00	3	0	104	2,735	0	0	0
4/23	23.50	0.00	5	0	1,937	2,007	0	0	0
4/24	23.75	0.00	4	0	101	277	0	0	0
4/25	24.75	0.00	5	12	24	289	0	0	0
4/26	24.00	0.00	9	14	648	149	0	0	0
4/27	24.00	0.00	7	4	142	207	0	0	0
4/28	23.00	0.00	38	0	18	55	0	0	0
4/29	24.00	0.00	85	0	14	61	0	0	0
4/30	24.00	0.00	17	0	20	34	0	0	0
5/1	24.75	0.00	47	0	4	9	0	0	0
5/2	24.25	0.00	13	0	3	17	1	0	0
5/3	24.17	0.00	24	0	11	11	1	0	0
5/4	23.83	0.00	31	0	6	4	0	0	0
5/5	23.00	0.00	10	0	6	15	0	0	0
5/6	24.00	0.00	3	0	3	8	0	0	0
5/7	24.00	0.00	14	0	2,949	14	0	0	0
5/8	14.25	10.75	13	0	162	5	0	0	0
5/9	13.33	10.67	7	0	101	7	0	0	0
5/10	13.00	11.00	3	0	101	4	0	0	0
5/11	24.00	0.00	5	0	96	3	0	0	0
5/12	23.00	0.00	8	0	101	5	0	0	0
5/13	24.25	0.00	0	0	175	0	0	0	0
5/14	24.25	0.00	7	0	196	1	0	0	0
5/15	22.50	0.00	8	0	185	0	0	0	0
5/16	23.75	0.00	3	0	33	1	0	0	0
5/17	24.00	0.00	3	0	24	1	0	0	0
5/18	24.25	0.00	4	0	19	1	0	0	0
5/19	24.00	0.00	1	0	9	0	0	0	0
5/20	24.50	0.00	1	0	1	0	0	0	0
5/21	24.25	0.00	3	0	5	1	0	0	0
5/22	23.25	0.00	3	0	5	0	0	0	0
5/23	23.00	0.00	7	0	36	0	0	0	0
5/24	25.00	0.00	4		2				

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APPENDIX D.─ continued.

Date	Times		Coho		Chum	Pink	Steelhead	Cutt	Trout
			Smolts	Fry	Fry	Fry	Smolts	Smolt	Parr
	In	Out	Mixed	Nat	Mixed	Nat	Nat	Nat	Nat
5/25	24.00	0.00	5	0	0	0	1	0	0
5/26	24.50	0.00	3	0	6	0	0	0	0
5/27	24.00	0.00	5	0	5	0	0	0	0
5/28	24.00	0.00	3	0	1	0	0	0	0
5/29	24.25	0.00	1	0	3	0	0	0	0
5/30	23.00	0.00	5	0	0	0	0	0	0
5/31	19.50	4.50	4	1	2	0	2	0	0
6/1	24.25	0.00	4	1	2	0	0	0	0
6/2	24.50	0.00	3	0	1	0	0	0	0
6/3	23.50	0.00	0	0	1	0	1	0	0
6/4	23.75	0.00	0	0	0	0	0	0	0
6/5	12.75	11.50	0	0	0	0	0	0	0
6/6	0.00	24.00	0	0	0	0	0	0	0
6/7	24.50	0.00	0	0	0	0	0	0	0
6/8	23.33	0.00	0	0	1	0	0	0	0
6/9	23.92	0.00	0	0	0	0	0	0	0
6/10	24.00	0.00	1	0	4	0	0	0	0
6/11	24.25	0.00	3	0	0	0	0	0	0
6/12	24.00	0.00	2	0	0	0	0	0	0
6/13	23.75	0.00	1	0	0	0	0	0	0
6/14	24.25	0.00	1	0	0	0	0	0	0
6/15	24.00	0.00	0	0	0	0	0	0	0
6/16	23.75	0.00	0	1	0	0	0	0	0
6/17	12.75	0.00	1	1	0	0	0	0	0
6/18	24.00	0.00	0	0	0	0	0	0	0
6/19	24.50	0.00	0	0	0	0	0	0	0
6/20	23.50	0.00	0	0	0	0	0	0	0
6/21	23.50	0.00	0	1	0	0	0	0	0
6/22	24.50	0.00	0	0	0	0	0	0	0
Grand Total	2693.5	1089.9	762	161	20,374	118,958	10	1	1

Appendix E

Fork lengths of mixed-origin coho smolts in the Green River, 2020

APPENDIX E.─Mean fork length (mm), standard deviation (St.Dev.), range, and sample size of mixed-origin coho smolts in the Green River in 2020.

Dates		Sample results				
Start	**End**	**Average**	**Std Dev**	**Min**	**Max**	**Count**
1/12/20	1/18/20	94.50	11.52	71	107	12
1/19/20	1/25/20	97.00	11.53	65	110	12
1/26/20	2/1/20	96.67	7.02	90	104	3
2/2/20	2/8/20		Trap outage			
2/9/20	2/15/20					
2/16/20	2/22/20	106.00	11.61	69	124	29
2/23/20	2/29/20	99.81	11.62	66	115	31
3/1/20	3/7/20	104.97	13.08	75	125	31
3/8/20	3/14/20	105.96	11.95	76	120	27
3/15/20	3/21/20	104.43	9.27	91	115	7
3/22/20	3/28/20					
3/29/20	4/4/20		Trap outage			
4/5/20	4/11/20					
4/12/20	4/18/20	116.33	24.01	90	137	3
4/19/20	4/25/20	117.95	16.09	95	152	22
4/26/20	5/2/20	123.88	18.17	89	146	24
5/3/20	5/9/20	118.76	15.09	96	150	33
5/10/20	5/16/20	110.47	10.78	92	138	30
5/17/20	5/23/20	111.37	12.20	92	140	19
5/24/20	5/30/20	109.38	11.11	95	137	24
5/31/20	6/6/20	121.91	13.69	102	140	11
6/7/20	6/13/20	99.43	8.85	87	110	7
6/14/20	6/20/20	94.00	19.80	80	108	2
Season Total		**109.23**	**15.19**	**65**	**152**	**327**

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