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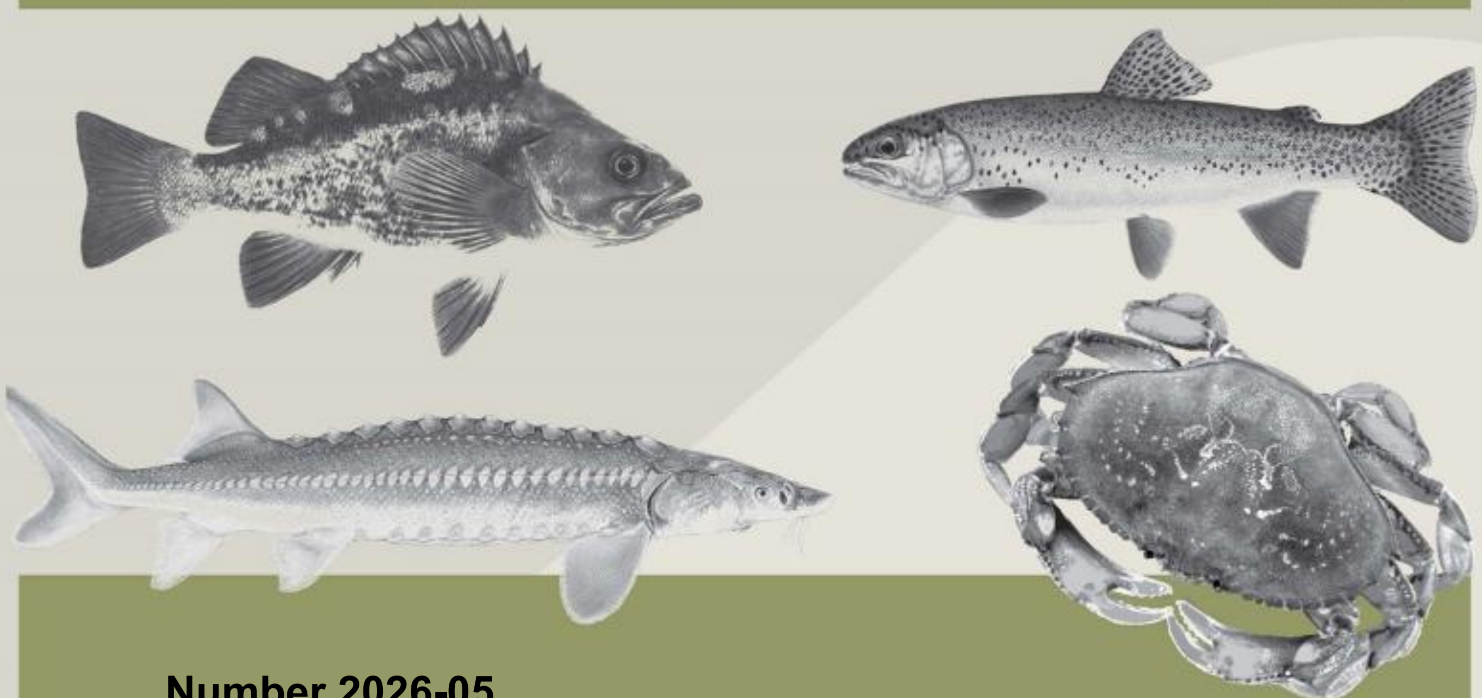

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Program to Restore Oregon’s Chum Salmon

Chum Salmon (*Oncorhynchus keta*) in the Oregon Portion of the Lower Columbia River: Report for 2023 & 2024 Brood Years

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Chum Salmon (*Oncorhynchus keta*) reintroduction in the Oregon portion of the Lower Columbia River: Report for 2023 & 2024 Brood Years

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PROJECT OVERVIEW

Historically, over a million adult Chum Salmon (*Oncorhynchus keta*) returned to the Lower Columbia River (LCR) and its tributaries to spawn each fall (McElhany et al. 2004). However, beginning in the 1940s and extending into the 1950s, Chum Salmon experienced precipitous declines in abundance and distribution in the LCR (Johnson et al., 1997). Cascading effects from river modifications, including diking, channelization, and construction and operation of large dams, led to altered hydrology in tributaries which reduced spawning habitat and access to it. These habitat modifications coupled with changes to estuarine ecology, predation, and over-harvest, means that only hundreds to thousands of Chum Salmon return to the LCR today, representing a loss of 90% of historical populations (Myers et al. 2006). Remaining populations primarily return to Washington tributaries of the LCR, while returns to Oregon tributaries are so low that they are considered functionally extirpated (ODFW 2006; McElhany et al. 2007). Historical distribution has also been reduced, especially above the Bonneville Dam to Celilo Falls, where only isolated populations remain. In response to these declines, Chum Salmon were listed as Threatened under the Endangered Species Act in 1999 (NOAA-NMFS 1999; 64 FR 14508).

The loss of Chum Salmon has had important ecological consequences in the LCR. Chum Salmon typically spawn in the lowest reaches of tributaries or in the mainstem LCR in shallow water, and their spawning activity can result in fine sediment transport and gravel cleaning. Carcasses may provide a substantial nutrient addition in the stream and riparian area. Chum Salmon fry outmigrate rapidly from their natal stream, such that the nutrient deposits provided by adults are not taken up by fry. Consequently, streams with Chum Salmon in them may be more suitable for all species of salmon (Bilby et al., 1996; Minakawa and Gara 2011).

Given the importance of Chum Salmon, it is a major priority of Oregon Department of Fish and Wildlife (ODFW) to rebuild historical populations in Oregon tributaries of the LCR. To this end, ODFW developed a Chum Salmon recovery strategy (ODFW 2010) and initiated a conservation broodstock at Big Creek Hatchery (BCH). In 2010, the Chum Reintroduction project was formed (now called PROCS: Program to Restore Oregon's Chum Salmon) to implement recovery efforts. PROCS operates under five organizing principles, to: (1) collaborate on habitat restoration in areas within the historical Chum Salmon spawning distribution, (2) maintain a conservation broodstock, (3) reintroduce Chum Salmon into areas they are currently absent, supplement populations at a low abundance, or promote recolonization through habitat restoration, (4) collect monitoring data on juveniles and adults to determine if reintroduction efforts are increasing population abundance, distribution, productivity, and diversity, and (5) identify and address limiting factors inhibiting recovery of Chum Salmon in Oregon. These efforts are currently focused within the coastal geographic stratum, encompassing four recovery populations: Youngs Bay, Big Creek, Clatskanie River, and Scappoose Creek (Figure 1).

In this report, we describe the performance of the conservation broodstock, reintroduction and monitoring efforts, and progress towards recovery. This evaluation includes Chum Salmon data collected from brood years 2023–2024, including hatchery metrics, spawning ground survey data, juvenile estimates of Chum Salmon, and all biological data (e.g., fecundity, age structure, origin) from the Coastal Stratum.

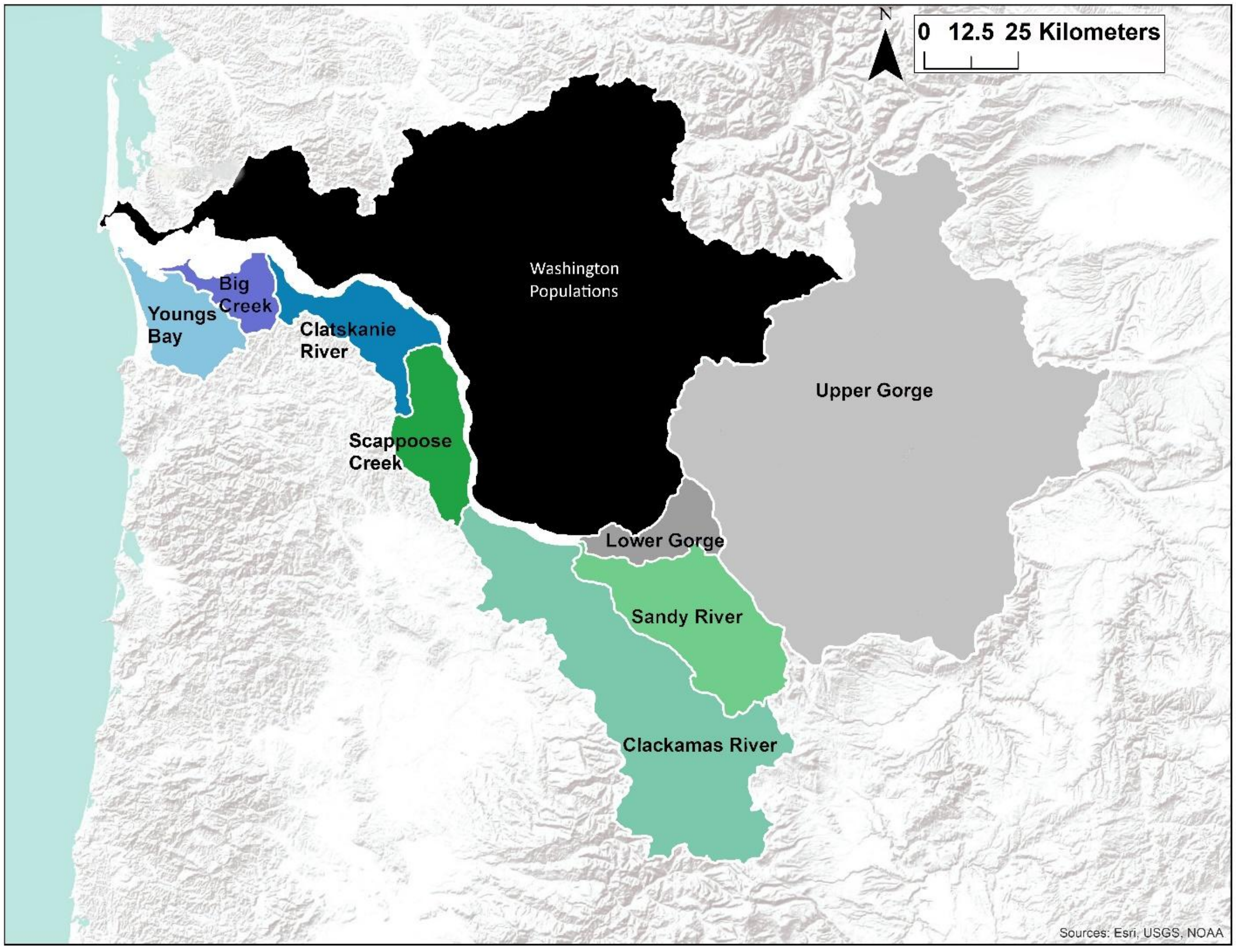

Figure 1. Map of the Columbia River Chum Salmon (*Oncorhynchus keta*) Evolutionary Significant Unit (ESU) Recovery Populations in Oregon. The ESU is divided into three geographic strata: coastal (Youngs Bay, Big Creek, Clatskanie River, and Scappoose Recovery Populations), cascade (Clackamas River and Sandy River Recovery Populations), and gorge (Lower and Upper Gorge Recovery Populations). There are eight additional Recovery Populations in Washington.

CONSERVATION BROODSTOCK

Background & Establishment

The BCH Chum Salmon broodstock was derived from hatchery and wild Chum Salmon collected from the population in Grays River, Washington. The BCH broodstock was created over five years (2010–2014) by releasing >100,000 fed-fry of Grays River origin from Big Creek. There was a transition year in 2014 when the fry released from Big Creek were of mixed origin (i.e., Grays River and Big Creek fish). Beginning in 2015, marked and unmarked adults returning to BCH were used exclusively for spawning. However, adult returns were unexpectedly low in 2016 and 2017 and <100,000 fry were released in those years. To avoid a third year of low releases, adult Chum Salmon from both Big Creek and Grays River were spawned in 2018 and 2019 to ensure a minimum release of 100,000 fry from Big Creek. Since 2020, adult returns to the Columbia River (and BCH) have been above average, rendering egg transfers from Grays River unnecessary, resulting in releases of around 300,000 fry (Table 1).

Currently, BCH operates an integrated Chum Salmon broodstock, incorporating wild fish with BCH fish (ODFW 2016). A program is considered integrated if "the principal goal is to manage the broodstock as an artificially propagated component of a naturally spawning population or gene pool" (HSRG 2004). The minimum egg collection goal to maintain the Big Creek broodstock is 110,000 eggs, but the minimum collection goal to have excess returns for reintroduction work is 220,000 eggs. Additional eggs may be collected in accordance with the HGMP report (ODFW 2016) and the specific goals for broodstock collection are generated each fall by PROCS and BCH staff. Recent, large returns have allowed for egg collection and fry release goals to be exceeded and for the opportunity to experimentally reintroduce Chum Salmon at different life stages in sequential years.

Table 1. Fry releases and adult source of Chum Salmon (*Oncorhynchus keta*) from the Big Creek Hatchery broodstock from 2010–2024.

Brood Year	Fry Released	Broodstock Source	Brood Year	Fry Released	Broodstock Source
2010	107,000	Grays River	2018	171,649	Grays R. & Big Cr.
2011	110,000	Grays River	2019	120,189	Grays R. & Big Cr.
2012	108,500	Grays River	2020	351,358	Big Creek
2013	101,000	Grays River	2021	403,152	Big Creek
2014	190,188	Grays R. & Big Cr.	2022	422,955	Big Creek
2015	192,147	Big Creek	2023	357,041	Big Creek
2016	32,725	Big Creek	2024	299,879	Big Creek
2017	84,958	Big Creek			

Methods

Broodstock Collection and Spawning

A full description of the collection, spawning, and biological sampling methods can be found in Homel et al. (2021) and in previous reports (Smith et al., 2025a). In brief, adult Chum Salmon (both hatchery- and wild-origin) volitionally return to BCH each fall. Spawning typically occurs once a week to preserve natural run timing. Typically, fish are spawned in groups of 10 pair and a 2x2 factorial cross is generated for each group to maximize genetic diversity.

During spawning, female fecundity is estimated from a selection of females across a range of body sizes. The total number of eggs per female is estimated by multiplying the total egg weight by the number of eggs per ounce measured in a Von Bayer trough. Measuring fecundity during spawning serves two purposes: to determine if in-season broodstock collection goals are being met and to act as a guide for estimating egg deposition of wild fish on spawning grounds.

After spawning, biological data are collected from individuals contributing to the broodstock, including sex, length, otoliths for determining origin, scales for determining age-structure, and DNA for genetic analysis. Fish origin is determined by the presence/absence of adipose fins, otolith thermal marks, and/or genetic relationships, and subsequently used to calculate the proportion of hatchery origin spawners (pHOS). Age structure is determined by identifying growth bands on scales and validated with thermal marks on otoliths, and fork length (FL; mm) is measured on all spawned Chum Salmon. Length and age data are combined to calculate length at age, annually. A small fin clip is taken from each spawned Chum Salmon to determine previous and future genetic relationships via Parentage-Based Tagging (PBT). PBT has been used to assign returning adults to a population or stream of origin based on prior analysis of the parent generation (Jones and Ardren 2003), thus verifying origin, identifying individuals that stray, and monitoring genetic diversity over time.

Marking & Fry Releases

All Chum Salmon produced at BCH are marked thermally on the otolith and by PBT since parental genotypes are collected and analyzed annually. Thermal marks on the otolith can be applied pre-hatch or post-hatch by varying water temperature in the rearing tanks (Volk et al. 1994; Schroder et al. 1996; Volk et al. 1999). Water chillers are used to pump colder water (typically 10° C colder than ambient water temperatures) into the rearing tanks on a prescribed schedule to produce a unique banding pattern on the otolith. The annual and program-specific thermal banding pattern and subsequent temperature schedule is created by the Washington Department of Fish and Wildlife (WDFW) otolith lab in Olympia, WA. After hatchery fry are marked and hatch, they are reared either outside in a single raceway or inside in circular tanks with spring water and given feed. Finally, fed-fry are released under specific circumstances to maximize survival. Chum Salmon fry should be released when they reach 1-1.5g in size, at dusk on an outgoing tide, in large groups avoiding other hatchery smolt releases, and before the Columbia River reaches 10° C. Since 2020, fry have been transported to Big Creek just above its confluence with the Columbia River for release under these conditions, typically in late March or early April.

Marine Survival

Marine survival is calculated for each brood year and denotes the percentage of hatchery released fry that would be expected to return to the hatchery as adults. It is calculated by dividing the number of hatchery-origin returning adults by the number of outmigrating fry for that brood year. This estimate includes juvenile mortality in the estuary, harvest in the ocean, harvest of returning adults in the estuary, natural causes of mortality, and straying. Because adult Chum Salmon returning to BCH display no external mark, otoliths or fin clips must be collected to determine the origin of each fish. Similarly, otoliths and/or fin clips must be collected from carcasses on spawning ground surveys to determine whether a hatchery-origin Chum Salmon has strayed or not (see Adult Monitoring section).

Results

Broodstock Collection & Spawning (2023–2024)

Since 2020, high adult returns to BCH have allowed for large egg takes, genetic diversity maintenance, and independence from Washington hatcheries. From 2020–2022, more wild-origin Chum Salmon were incorporated into the broodstock than hatchery-origin individuals, but in the most recent years, this trend has reversed (Figure 2). Wild-origin fish represented 23.1% (2023) to 12.2% (2024) of the broodstock collection (Table 2), which is sufficient for maintaining genetic diversity (HSRG 2004). Finally, due to sufficient adult returns to BCH during the study period (n = 784 in 2023 and n = 949 in 2024), no additional eggs were collected from Grays River, WA broodstock.

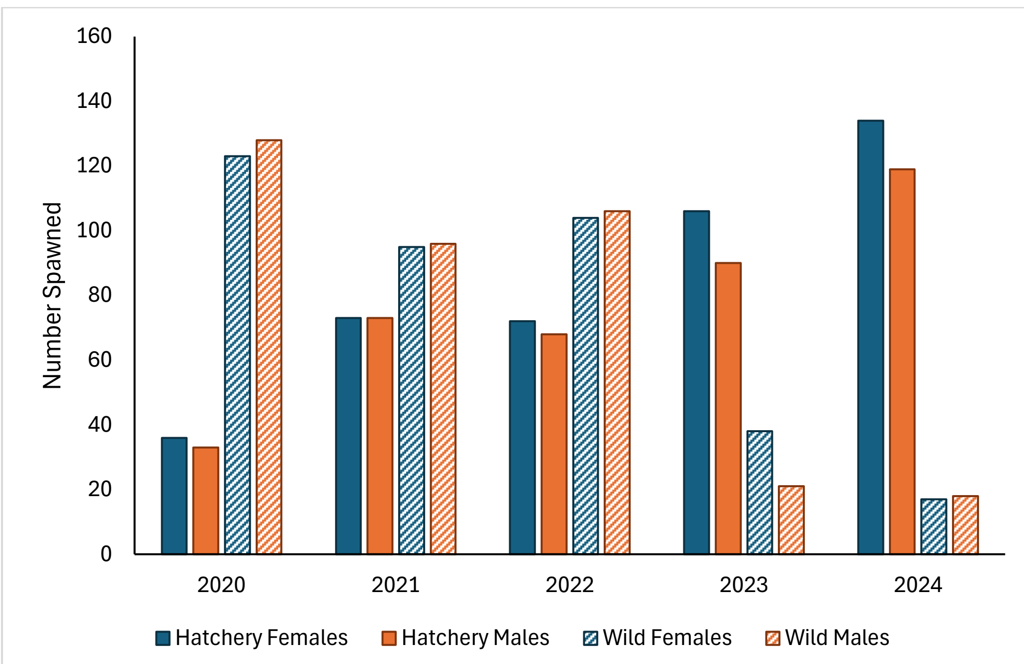

Figure 2. Hatchery and wild female (navy) and male (orange) adult Chum Salmon (*Oncorhynchus keta*) collected for the conservation broodstock at Big Creek Hatchery, Oregon, 2020–2024.

Table 2. Number and origin of adult Chum Salmon (*Oncorhynchus keta*) collected at Big Creek Hatchery (2020–2024) for the conservation broodstock. Totals do not include mortalities or fish collected for outplanting activities (adults, eyed-eggs, or unfed fry).

Brood Year	Females	Males	Total	% Wild	% Hatchery
2020	159	161	320	78.4	21.6
2021	168	169	337	56.7	43.3
2022	176	174	350	60.0	40.0
2023	144	111	255	23.1	76.9
2024	151	137	288	12.2	87.8

From 2020–2024, age structure of both hatchery and wild returns to BCH has largely been comprised of age-3 and age-4 fish, while age-5 fish have been seen sporadically. Age structure shifts from mostly age-3 individuals (e.g., 2020 and 2021) to mostly age-4 individuals (e.g., 2022 and 2023), every two years. Individuals spawned in 2024 were mostly age-3. No age-2 fish were observed during this time, but only one age-2 male has been encountered in the program's history (2019). For returning hatchery fish, age structure was similar between females and males across years. For wild-origin Chum Salmon, there have been almost equal numbers of age-3 and age-4 females returning in 2021 and 2023 and almost equal numbers of age-3 and age-4 males in 2023 and 2024. It is more common for wild fish to return as age-5, but in general more females than males return at age-5. For the 2023 and 2024 brood years, fewer wild-origin fish have been incorporated into the broodstock. (Table 3).

Table 3. Age composition (percent) of hatchery and wild origin female and male Chum Salmon (*Oncorhynchus keta*) returning to Big Creek Hatchery, Oregon from 2020–2024. Totals include fish spawned for the conservation broodstock, as well as mortalities. Individuals spawned for reintroduction activities or recovered on spawning ground surveys are not included.

		Hatchery				Wild			
	Age	**3**	**4**	**5**	**Total**	**3**	**4**	**5**	**Total**
Females	2020	76.2	23.8	0.00	42	72.0	27.2	0.80	125
	2021	74.7	25.3	0.00	87	55.6	43.5	0.81	124
	2022	21.3	73.3	5.40	75	8.50	85.8	5.70	106
	2023	30.8	67.3	1.90	107	47.4	52.6	0.00	38
	2024	71.4	28.6	0.00	140	31.6	57.9	10.5	19
Males	2020	78.4	21.6	0.00	37	81.7	18.3	0.00	131
	2021	84.9	15.1	0.00	93	73.3	25.0	1.70	120
	2022	8.60	90.0	1.40	70	15.9	81.3	2.80	107
	2023	37.4	61.5	1.10	91	57.1	42.9	0.00	21
	2024	71.1	27.3	1.60	128	50.0	44.4	5.60	18

For both wild and hatchery fish combined, the smallest individuals tended to be the youngest, but lengths varied annually and there was considerable overlap in length-at-age (Figure 3 a-b). From 2020–2024, females ranged from 560 to 788 mm fork length (FL) and males ranged from

571 to 880 mm FL. Females that returned in 2022 were significantly larger on average (703 mm FL; p = <0.00) than females returning in any other year, but 2022 females were also older (Figure 3a). In contrast, females that returned in 2024 were significantly smaller on average (664 mm FL; p = <0.00) than females returning in every year except 2021 (669 mm FL; p = 0.09). A similar trend was observed for males returning in 2022 and 2024: males were significantly larger in 2022 (754 mm FL; p = <0.00) compared to average lengths in all other years, but smaller on average in 2024 (719 mm FL; p = <0.00) than other years, except 2021 (712 mm FL; p = 0.09; Figure 3b). Both females and males returning in 2023 were average in length, 681 and 737mm FL, respectively.

a)

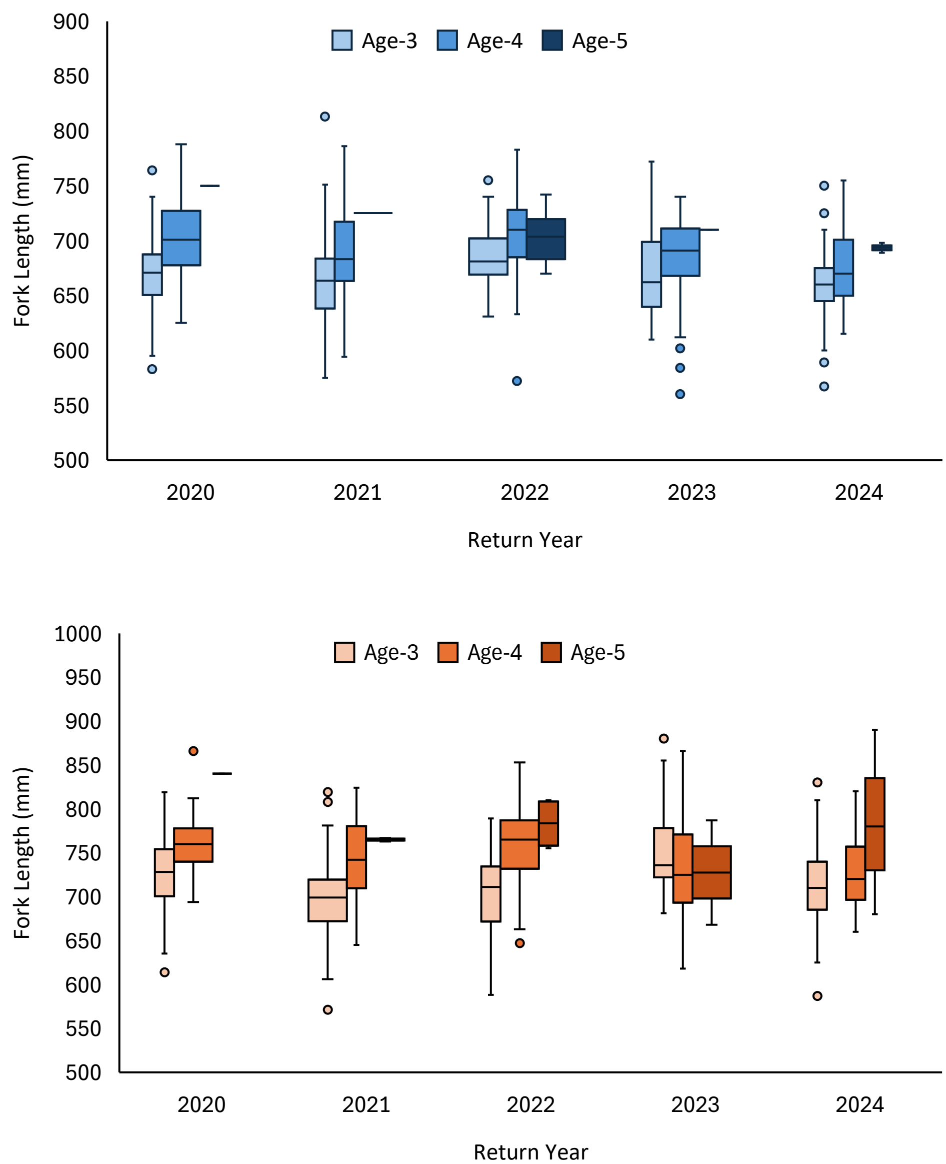

Figure 3a-b. Length-at-age of marked and unmarked female (3a) and male (3b) Chum Salmon (*Oncorhynchus keta*) captured at Big Creek Hatchery, OR from 2020–2024. Only one Age-5 female returned in 2020, 2021, and 2023. Only one Age-5 male returned in 2020 and two in 2021.

There were no significant differences in average fecundity between spawned hatchery and wild fish annually. However, there were significant differences among spawned hatchery fish between years 2020–2024 (one-way ANOVA, df = 4, F = 40.65, p = <0.00; Figure 4). For instance, average fecundity for spawned hatchery females was significantly higher in 2023 (mean = 2,906 eggs/female) than in any other year, except in 2022 (mean = 2,868, df = 157, p = 0.290; Table 4a). However, in 2024, average fecundity for hatchery females was significantly lower (mean = 2,331 eggs/female) than in any other year. Spawned wild fish had more variation in average fecundity between years (one-way ANOVA, df = 4, F = 23.19, p = <0.00; Figure 4), but patterns mimicked hatchery fish. Wild fish spawned in 2023 also had significantly higher fecundity (mean = 2,804 eggs/female) than in any other year, except in 2022 (mean = 2,906, df = 64, p = 0.160) and 2020 (mean = 2,600, df = 42, p = 0.016; Table 4b). Wild fish spawned in 2024 also had significantly lower fecundity (mean = 2,279 eggs/female) than any other year, similar to their hatchery counterparts. In summary, females spawned in 2023 had significantly higher average fecundity than other years, but was comparable to 2022 females, while females spawned in 2024 had significantly lower average fecundity than any other year.

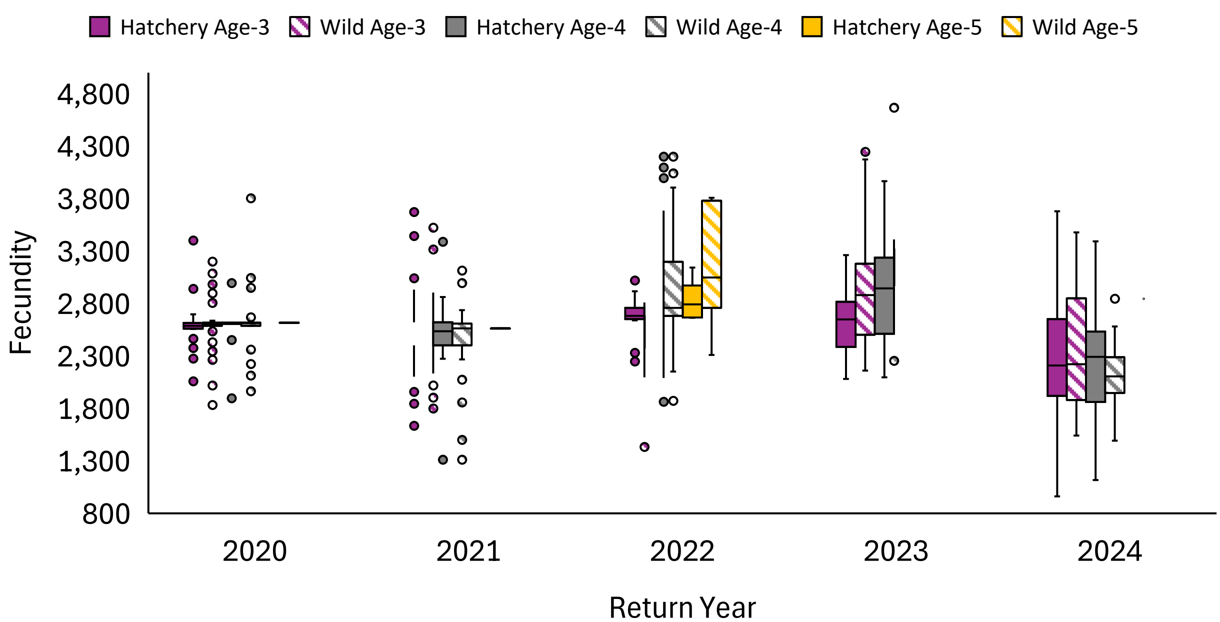

Figure 4. Fecundity-at-age of spawned hatchery- and wild-origin Chum Salmon (*Oncorhynchus keta*) for the conservation broodstock at Big Creek Hatchery, Oregon from 2020–2024. Three age-5, wild-origin females were spawned in 2020, 2021, and 2024, and one age-5 hatchery-origin female in 2023.

Table 4. Pairwise comparisons of fecundity between years for hatchery (a) and wild (b) females spawned at Big Creek Hatchery from 2020-2024. Diagonal values are mean ± standard deviation of fecundity each year. P-values were adjusted using Bonferroni correction (α = 0.005).

(a)

Hatchery	2020	2021	2022	2023	2024	n
2020	2,586±256					39
2021	0.136	2,520±370				73
2022	0.000	0.000	2,869±455			72
2023	0.000	0.000	0.290	2,906±547		177
2024	0.000	0.000	0.000	0.000	2,331±438	180

(b)

Wild	2020	2021	2022	2023	2024	n
2020	2,600±223					118
2021	0.000	2,476±301				95
2022	0.000	0.000	2,906±516			104
2023	0.016	0.000	0.160	2,804±560		39
2024	0.000	0.005	0.000	0.000	2,279±299	21

Marking & Fry Releases

Since 2020, all Chum Salmon fry produced by BCH have received an otolith thermal mark post-hatch due to the logistical requirements of thermally marking a large volume of eggs pre-hatch (Table 5). These logistics have been especially complicated since the 2022 brood year, when reintroduction expanded, and identification of different groups or methods was necessary (see Reintroduction and Supplementation Section).

Since inception, BCH has been permitted to collect up to 600,000 eggs for production needs through the approved HGMP, though PROCS has set a broodstock collection goal of at least 220,000 eggs before conducting reintroduction activities. For the 2023 and 2024 brood years, egg collection goals were met and the total number of fed fry released was 357,041 and 299,879, respectively (Table 6). Fry from the 2023 brood year were reared in three separate groups: ponded early, ponded late, and indoor circular tank. Fry from the 2024 brood year were separated into six groups: one in the outdoor pond and five groups in the indoor circular tanks. In all years, fry were released from late March to mid-April at a site located in a tidal area of Big Creek under previously described conditions.

Table 5. Marks applied to the Big Creek Hatchery Chum Salmon (*Oncorhynchus keta*) conservation broodstock 2015–2024, and years when marks are expected to be present in age 3–5 adult returns to the hatchery or spawning grounds.

Brood Year	Marks	Expected Return Years
2015	Pre and post-hatch thermal mark, Ad-Clip	2018–2020
2016	Pre and post-hatch thermal mark, Ad-Clip	2019–2021
2017	Pre and post-hatch thermal mark, PBT	2020–2022
2018	Pre and post-hatch thermal mark, PBT	2021–2023
2019	Pre and post-hatch thermal mark, PBT	2022–2024
2020	Post-hatch thermal mark, PBT	2023–2025
2021	Post-hatch thermal mark, PBT	2024–2026
2022	Post-hatch thermal mark, PBT	2025–2027
2023	Post-hatch thermal mark, PBT	2026–2028
2024	Post-hatch thermal mark, PBT	2027–2029

Table 6. Number, date, location, and size of Chum Salmon (*Oncorhynchus keta*) fry released from Big Creek Hatchery for the last five brood years (2020–2024).

Brood Year	Method	Location	Release Number	Release Year	Date(s)	Size (fish/pound)
2020	Liberation truck	Big Cr tidewater	351,358	2021	3/31	454
2021	Liberation truck	Big Cr tidewater	403,152	2022	3/22; 4/18	494; 428
2022	Liberation truck	Big Cr tidewater	422,955	2023	3/29; 4/10	482; 467
2023[a]	Liberation truck	Big Cr tidewater	357,041	2024	3/26	282; 374; 216
2024[b]	Liberation truck	Big Cr tidewater	299,879	2025	4/2; 4/3	357; 332; 311; 315; 518; 527

[a] Fry from were reared in three separate groups (ponded early, ponded late, and indoor circular tank), but all were released on 3/26.
[b] Fry from Big Creek were reared outside in a pond (357 fish/pound, released 4/2) and inside in five separate circular tanks (332; 311; 315; 518; 527 fish/pound, released 4/3).

Broodstock Returns & Marine Survival

The BCH Chum Salmon broodstock has produced a variable number of adult returns, but marine survival has been low overall, especially in the early years of the program. During broodstock establishment (2010–2014) and one year after (2015), marine survival was particularly low (>0.05%; Table 7). Marine survival was moderate for the 2016 brood year (0.13%) but has steadily increased in subsequent years (2017–2019). To date, brood year 2018 has had the highest marine survival (0.45%) of the years for which there are complete returns of all age classes (Table 7).

The variation in marine survival over the program's history is likely due to variation in ocean conditions and hatchery release practices, which both affect early survival in Chum Salmon. In the ocean, a suite of climactic, physical, and biological factors can influence the growth and survival of juvenile salmon. These factors are measured and ranked by National Oceanic and Atmospheric Administration Northwest Fisheries Science Center (NOAA-NFSC) every year and summarized in the Ocean Conditions Indicators Trend Stoplight Chart (i.e., Stoplight Chart; Figure 5). According to the Stoplight Chart, ocean conditions were favorable for juvenile salmon growth and survival for several years during the establishment of the BCH broodstock (e.g., 2011–2013). However, fry released during this time likely didn't benefit from good ocean conditions because BCH release practices didn't mimic natural Chum Salmon fry outmigration. Prior to 2016, Chum Salmon fry were released at a larger size, in a single group, and later in the spring to facilitate physical marking experiments (e.g., coded-wire tag application). For example, the 2014 brood year fry were released in one group during mid-April at 4 grams in size. These fry would've had to navigate a warm Columbia River, survive a predator-packed estuary, only to enter an ocean with poor physical and biological conditions – 2015 was ranked the second worst ocean year for juvenile salmon since 1998. Ultimately, poor ocean conditions and uninformed release practices resulted in a marine survival rate of 0.00% for brood year 2014.

To combat the poor marine survival trend (and because physical marking experiments were unsuccessful; Homel et al., 2021), PROCS began releasing Chum Salmon fry under conditions similar to natural outmigration. Since 2017, Chum Salmon fry have been released when they reach 1-1.5 grams in size, at dusk on an outgoing tide, in multiple, large groups avoiding other hatchery smolt releases, and before the Columbia River reaches 10° C to avoid interacting with *Ceratonova shasta* (Homel and Alexander 2022). These release practices have resulted in above average marine survival rates (0.21-0.45%), despite fair or poor ocean conditions from 2017–2019.

Table 7. Summary of hatchery Chum Salmon (*Oncorhynchus keta*) returns to Big Creek Hatchery by age (rows), brood year (columns), and return year (diagonals). The number of fry released (* consisted of both Big Creek Hatchery and Grays River Hatchery broodstock) and subsequent calculation of marine survival are listed by brood year.

	Brood Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Age-2	*Return Year*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
	Adult Returns	0	0	0	0	0	0	0	1	0	0	0
Age-3	*Return Year*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
	Adult Returns	8	109	6	6	0	51	5	142	165	31	115
Age-4	*Return Year*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*
	Adult Returns	32	195	49	8	8	15	37	41	151	219	110
Age-5	*Return Year*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*
	Adult Returns	4	1	1	0	1	0	0	5	6	2	N/A
Total		44	315	56	14	9	66	42	189	322	252	N/A
Fry Released		107,162	110,029	108,728	101,038	190,188*	192,147	32,725	84,958	71,649*	120,189*	351,358
% Marine Survival		0.04	0.29	0.05	0.01	0.00	0.03	0.13	0.22	0.45	0.21	N/A

2024 OCEAN CONDITIONS INDICATORS TREND

good fair poor

	ECOSYSTEM INDICATORS	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
CLIMATE & ATMOSPHERIC	PDO (Sum Dec-March)	24	10	5	18	11	26	17	22	19	14	8	2	21	6	4	12	15	27	25	23	16	20	13	9	3	1	7
	PDO (Sum May-Sept)	15	6	12	9	14	24	19	22	18	20	8	17	10	5	4	11	25	27	26	21	16	23	13	7	3	2	1
	ONI (Average Jan-June)	26	1	1	9	17	19	18	21	10	15	3	13	22	6	8	10	12	23	27	16	7	24	20	5	4	14	25
LOCAL PHYSICAL	SST NDBC buoys (°C; May-Sept)	22	7	9	5	6	14	27	15	2	18	1	13	3	8	10	20	25	24	23	16	19	26	11	4	21	17	12
	Upper 20 m T (°C; Nov-Mar)	26	14	11	13	8	19	20	16	17	7	1	12	22	6	4	9	3	27	25	23	18	21	2	10	15	5	24
	Upper 20 m T (°C; May-Sept)	19	12	15	5	1	3	27	22	10	11	2	7	20	9	8	21	25	16	17	14	18	26	24	4	23	6	13
	Deep Temp (°C; May-Sept)	26	7	10	5	1	13	16	18	14	6	2	9	8	12	4	17	25	22	15	20	21	19	27	3	24	23	11
	Deep Salinity (May-Sept)	26	4	12	5	7	21	22	13	8	2	3	18	17	15	16	14	27	20	10	9	6	11	25	1	24	19	23
LOCAL BIOLOGICAL	Copepod richness (May-Sept anom)	25	3	1	11	10	20	19	24	21	14	12	13	23	6	8	4	15	26	27	22	18	17	7	5	2	9	16
	N copepod biomass (May-Sept anom)	25	19	11	15	9	22	20	26	21	17	10	13	16	3	4	7	8	23	27	24	12	5	2	1	18	14	6
	S copepod biomass (May-Sept anom)	27	2	7	4	3	19	21	26	18	14	1	9	22	13	10	8	16	24	25	23	17	20	12	5	6	11	15
	Biological transition	25	14	10	9	12	19	15	24	18	5	1	2	22	3	13	6	6	25	25	23	17	19	8	11	4	16	21
	Coastal Ichthyoplankton Prey Biomass (Jan-Mar)	22	4	13	14	1	25	26	19	10	21	3	17	2	9	5	12	24	18	20	16	11	23	8	6	15	7	27
	Ichthyoplankton Community Composition (community index Jan-Mar)	11	6	4	7	10	12	20	24	1	16	3	13	18	5	2	8	9	22	25	26	21	23	19	15	14	17	27
	Chinook salmon juvenile catch	24	2	7	21	6	10	19	26	15	12	1	8	5	17	3	4	9	18	23	27	22	16	25	13	11	20	14
	Coho salmon juvenile catch	25	14	22	7	9	8	24	26	20	2	4	11	12	21	16	1	13	19	18	27	3	17	23	15	10	6	5
MEANS & RANKS	Mean of ranks	23.0	7.8	9.4	9.8	7.8	17.1	20.6	21.5	13.9	12.1	3.9	11.1	15.2	9.0	7.4	10.3	16.1	22.6	22.4	20.6	15.1	19.4	14.9	7.1	12.3	11.7	15.4
	Rank of the mean rank	27	4	7	8	4	20	22	24	14	12	1	10	17	6	3	9	19	26	25	22	16	21	15	2	13	11	18
NOT INCLUDED IN THE MEAN OF RANKS OR STATISTICAL ANALYSES	Physical Spring Trans (UI based)	4	8	25	22	5	16	19	26	16	1	7	3	11	14	23	12	24	13	6	21	14	16	10	2	27	20	8
	Physical Spring Trans. Hydrographic	26	4	14	9	6	13	18	27	7	10	1	10	22	4	12	2	20	8	21	25	18	17	23	2	23	16	14
	Upwelling Anomaly (sum April-May)	13	4	22	9	12	19	17	26	13	7	10	11	20	22	20	15	24	1	3	25	8	6	17	2	27	16	4
	Length of Upwelling Season (UI based)	6	2	22	14	1	16	12	26	5	3	9	3	18	21	18	17	24	13	8	15	7	10	20	10	24	23	5
	Copepod Community Index (May-Sept)	26	4	7	10	3	21	19	25	22	13	1	8	18	12	9	6	16	24	27	23	17	20	14	2	5	11	15

Figure 5. The Ocean Conditions Indicators Trend Stoplight Chart created by National Oceanic and Atmospheric Administration Northwest Fisheries Science Center summarizing and ranking climactic, physical, and biological factors affecting juvenile salmon growth and survival, which can be accessed here.

Summary of Broodstock Performance (2023–2024)

From 2023–2024, there have been large adult returns of Chum Salmon to BCH, allowing for the collection of a robust conservation broodstock, in-depth analysis of biological metrics, and substantial fed fry releases to ensure the continuation of the program. During the study period we found that wild-origin fish have been less represented in broodstock collection overall. Age structure has shifted from mostly age-4 fish in 2023 to mostly age-3 fish in 2024. We found that females (both hatchery and wild) returning in 2023 were average in length, but more fecund on average than females in any other year (except 2022). In contrast, females (both hatchery and wild) returning in 2024 were significantly smaller in size compared to other years (except 2021), and as a result had significantly lower fecundity. Despite this, egg collection goals were met in both years, and subsequent fry have been reared in a combination of outdoor raceways and indoor circular tanks. Lastly, we have found that marine survival has been increasing since 2016, suggesting the importance of releasing broodstock fry under ideal conditions to ensure long-term survival. Although more data is needed, it might be possible to counteract the deleterious effects of poor ocean conditions on survival with large, well-timed releases of Chum Salmon broodstock fry.

REINTRODUCTION AND SUPPLEMENTATION

Background & Strategies

From 2020–2024, Chum Salmon returns to BCH were sufficient to meet both broodstock collection goals and to conduct reintroduction efforts. Previous reintroductions and population supplementation efforts were designed to test specific techniques with relatively small numbers of released adults or eggs over short periods. For example, in the Clatskanie River Recovery Population, adults were transported to Stewart Creek in 2013 (n = 21) and in 2014 (n = 31) to spawn volitionally and eyed-eggs were transferred to a remote site incubator and reared on Perkins Creek in both 2014 and 2015, but all reintroduction operations ceased in low return years (see Homel et al., 2021 for full details). These reintroduction efforts likely produced too few returning adults to make a substantial impact because the density of outplanted individuals was too low, freshwater survival rates were too low, and ocean conditions were too poor. Over time, if reintroduction events are too small, Chum Salmon returns will be consistently low and the population will be perpetually at risk of extirpation from small population dynamics. However, the large return of adults since 2020 has allowed for reintroduction efforts to be more robust and expansive. Large reintroduction events in these systems are important for determining whether repeated efforts will establish a self-sustaining population. From a biological perspective, larger releases are required for reintroduced populations to meet a critical density threshold (Courchamp et al., 1999; Deredec and Courchamp 2007) and to avoid demographic stochasticity and inbreeding (Armstrong and Wittmer 2011).

Guidance on reintroduction strategies has been outlined in the Chum Recovery Strategy section of the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010). Initially, the Scappoose Creek and Clatskanie River Recovery Populations were selected as primary reintroduction areas. However, after habitat surveys revealed poor conditions (Alfonse et al., 2017b), multiple years of monitoring effort yielded no documentation of Chum (juveniles or adults; Homel et al., 2021), and consultation with the Chum Salmon Working Group, the Scappoose Creek Recovery Population was eliminated as a potential reintroduction area. Today, reintroduction activities take place primarily in the Clatskanie River Recovery Population, with some activity in the Big Creek Recovery Population, when necessary.

The Chum Recovery Strategy also suggests testing multiple methods of reintroduction, including outplanting adults to spawn volitionally, rearing eyed-eggs in a remote site incubator (RSI), and releasing unfed fry at select sites, among other methods. Outplanting adults to suitable habitat to spawn allows for natural mate selection, redd construction, and juvenile imprinting on the reintroduction site, which is important for reproductive success (Geist et al., 2002; Ueda et al., 2016; Auld et al., 2021). While this method prevents any potential deleterious effects of hatchery rearing, egg-to-fry survival rates in the wild are much lower (7–22.2%; Lister et al., 1980; Scrivener and Brownlee 1989; Bonnell 1991; Bradford 1995) than they are in a hatchery setting (>90%; Wampler and Manuel 1992; Schroder 2000). Spawning individuals at the hatchery but transferring the eggs to an RSI increases early survival and can be another viable reintroduction method. Besides high survival, the benefit of rearing eyed-eggs in an RSI is that fish have a higher probability of imprinting on the stream, increasing the likelihood that they return to the reintroduction site instead of the hatchery (Ueda et al., 2016). Similarly, spawning individuals at the hatchery and raising them to the unfed fry stage increases early survival rates. Although unfed fry enter reintroduction sites at a smaller size, it is still possible for them to imprint on and return to the reintroduction site instead of the hatchery where they would have received feed (Ueda et al., 2016). Because these reintroduction strategies have different ecological advantages and disadvantages and require various levels of effort, expertise, and time, it is important to test multiple methods to determine the strategy that is most effective for a particular reintroduction site.

From 2020–2024, PROCS has tested three reintroduction methods in the two recommended recovery populations with excess fish (i.e., those not needed to maintain the conservation broodstock) returning to BCH: 1) releasing excess adults in pre-selected reintroduction sites to spawn volitionally, 2) spawning excess adults to collect eggs for rearing in a RSI, and 3) spawning excess adults to collect eggs that are reared at BCH to the unfed fry stage before release into pre-selected reintroduction sites. The efficacy of these reintroduction techniques can only start to be evaluated when multiple generations have returned (2023–2029), but this section outlines the methods and reasoning behind specific decisions and provides preliminary results for the early stages of evaluation. These initial results, combined with extensive monitoring, will allow PROCS to adaptively manage the recovery of Chum Salmon populations in Oregon tributaries of the Lower Columbia River.

Methods

Reintroduction Site Selection

Reintroduction sites were chosen based on a variety of factors that would facilitate successful reintroduction. The following four factors were considered in site selection:

Historical and/or current wild presence. Historical data was evaluated from ODFW monitoring surveys, published scientific papers or reports, and newspaper articles, fishing encounters, or other records of Chum Salmon presence and used to identify specific reintroduction sites. ODFW monitoring surveys were also used to identify sites where Chum Salmon were still present in low numbers where supplementation could help restore the population (ODFW 2010).

Physical characteristics suitable for Chum Salmon spawning and rearing. Spawning ground characteristics identified as essential for Chum Salmon are low gradient (<5%), presence of cold-water seeps or springs, low levels of fine sediment (<20%), and low or no access barriers (<1 m; Alfonse et al., 2017a, Alfonse et a., 2017b). The length of suitable habitat is also considered as well as any potential limiting factors (e.g., land use practices, competing hatchery releases).

Ability to monitor production. Monitoring includes rotary screw traps, spawning ground surveys, and environmental DNA sampling. Monitoring may be limited by landowner cooperation, available personnel, weather, or stream morphology (e.g., feasibility of operating certain equipment).

Logistics that would facilitate safe and successful reintroduction. This includes the distance from BCH to the potential reintroduction site (i.e., time fish would be in the liberation truck, distance to travel for RSI checks), feasibility of off-loading fish from a liberation truck (e.g., adequate substrate and space for truck maneuvering, water depth, personnel safety), location in the watershed (i.e., minimize adult fallbacks, increase chances of egg/fry imprinting), number of individuals needed for the site (i.e., number of liberation truck loads needed), and other considerations.

Adult Releases

Excess adult Chum Salmon returning to BCH were outplanted throughout the run to reintroduction sites based on the above criteria and logistics. Individuals were measured (fork length; FL), given a body condition, uniquely tagged with an external T-bar Floy Tag (Floy Tag, Seattle, WA), sexed, and fin clipped for genetic analysis before being loaded into a liberation truck. The tank on the truck was 350 gallons, equipped with aerators to deliver oxygen, and could hold approximately 60 adult Chum Salmon. The number of trips per site per day were dependent on the size and habitat availability of the site, the number of fish previously outplanted to that site, and the number of excess fish still available for outplanting. Once at the site, individuals were hand-released two at a time to spawn volitionally. Excess water in the liberation truck was released at the site and refilled at the hatchery upon return for the next load. Any outplanted individuals returning to BCH (i.e., fallbacks) were identified by tag number/color and sex and re-outplanted to the appropriate reintroduction site. Any outplanted individuals that moved to another site on their own volition (i.e., strays) were documented via spawning ground surveys. Fin clips collected from outplanted individuals were analyzed by reintroduction site, depending on prioritized research questions and available funds. Finally, the expected number of fry produced from adult releases was estimated for each reintroduction site based on the number of females released, average annual fecundity measured from conservation broodstock females, and various freshwater survival (survival from the egg to fry stage) scenarios found in the literature (5%, 10%, 15%, 20%). These fry estimates were used as comparisons to in-season rotary screw trap catches and long-term monitoring effort.

Eyed-Egg Rearing in Remote Site Incubator (RSI)

Excess adult Chum Salmon returning to BCH were spawned so that the collected eggs (up to 50,000) could be reared in an RSI located in Page Creek in the Clatskanie River Recovery Population. Spawning protocols followed those used for conservation broodstock egg collection. This group was raised to the eyed-egg stage at the hatchery and given a unique otolith thermal mark to distinguish it from other reintroduction groups. In addition, all adults spawned for the RSI egg take were genotyped, so that resulting offspring could later be identified via PBT. Eyed-eggs were shocked at 600 thermal units (TUs) and were transferred to the RSI at around 800 TUs. Eyed-eggs were transported in mesh bags (~5,000 per bag) and covered with damp burlap in a large cooler. At the site, eyed-eggs were distributed among three 208L drums, each containing five egg trays. Water flows from two intake pipes into three

208L drums lined with water filtration material before going into the egg barrels. An outflow pipe from each egg barrel allows the developed fry to leave the RSI volitionally (Figure 6). Water quality, flow, and developing fry were monitored daily throughout spring (January-April) and any dead eggs, alevins, or fry were enumerated. After all fry outmigrated, actual freshwater survival (survival from the egg to fry stage) was calculated with the following equation:

$$Freshwater\ Survival = \frac{Total\ Eggs - (DE + DA + DF)}{Total\ Eggs}$$

Where Total Eggs = the total number of eyed-eggs placed in an RSI at a site, DE = dead eggs in the RSI, DA = dead or dying alevins in the RSI, and DF = dead or dying fry in the RSI.

Figure 6. The remote site incubator (RSI) constructed alongside Page Creek in the Clatskanie River Recovery Population used to house Chum Salmon (*Oncorhynchus keta*) eyed-eggs in 2022–2024. Water flows into the blue filtration barrels from two intake pipes secured in Page Creek. From there, water flows into the black barrels holding the eyed-eggs, each of which has an outflow pipe to allow fry to leave volitionally.

Unfed Fry Releases

Lastly, PROCS experimented with releasing groups of unfed fry to select reintroduction sites. To accomplish this, excess adults were spawned following conservation broodstock protocols and eggs were reared to the fry stage at BCH. The fry were never ponded and received no feed from hatchery staff during development. Unfed fry groups were also given a unique otolith thermal mark to distinguish individuals from other reintroduction groups. In addition, all adults spawned for the unfed fry egg take were genotyped, so that resulting offspring could later be identified via PBT. In the spring, the unfed fry were released under similar conditions as the fed, broodstock fry (e.g., large groups, late in the day, outgoing tide, avoiding other hatchery releases, before Columbia River reaches 10° C) into select reintroduction sites. Freshwater survival for unfed fry groups was calculated at the hatchery (unfed fry released/ number of eggs collected) and used to inform in-season rotary screw trap catches and long-term monitoring effort.

Results

Big Creek Recovery Population

In the Big Creek Recovery Population, ideal locations for reintroduction were the Bear Creek watershed and Gnat Creek (Figure 7). The Bear Creek watershed was chosen because of its proximity to Big Creek Hatchery which made outplanting large numbers of fish feasible (~12 min travel time, one-way), historical occupation of Chum Salmon (200 pairs; Parkhurst et al., 1950; Fulton 1970), current occupation of small numbers of natural Chum Salmon (Alex Neerman, ODFW, pers. comm.), ability to monitor adult spawning by PROCS and OASIS crews, and feasibility for operating a rotary screw trap to monitor juvenile production (in operation since 2017). Gnat Creek was chosen for many of the same reasons as the Bear Creek watershed: proximity to Big Creek Hatchery allowing for safe transport of fish (~10 min travel time, one-way), it is a tributary historically occupied by Chum Salmon with suitable spawning habitat (Parkhurst et al., 1950; Fulton 1970), and spawning ground surveys occur regularly as part of larger salmonid monitoring efforts in the region.

Bear Creek Watershed Reintroduction (2020–2024)

From 2020–2024, excess adult Chum Salmon were outplanted into the Bear Creek watershed to spawn volitionally. No other reintroduction method was tested in this watershed during this time. A similar number of adults were outplanted in 2020 and 2021, but fewer have been outplanted in recent years (Table 8). However, all the excess adults returning to BCH in 2020 were outplanted to the Bear Creek watershed, whereas excess returns in the following years were used for a wider variety of reintroduction methods. Because of the large return to BCH in 2021, adults were outplanted to the Bear Creek watershed over a shorter period, while in other years adults were well-distributed temporally. In all three years, outplanting generally peaked in early to mid-November (Julian week 45-46; Figure 8).

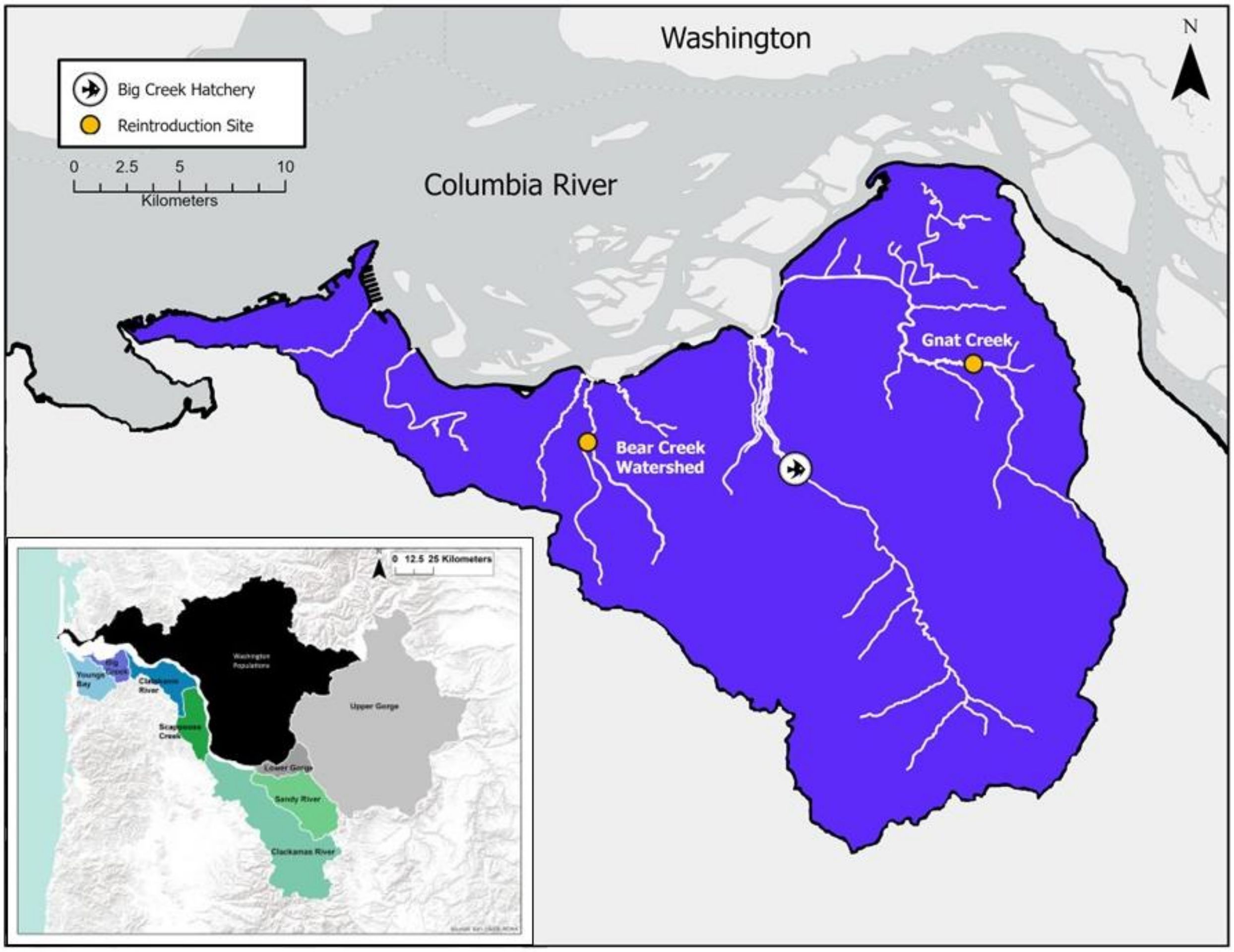

Figure 7. Chum Salmon (*Oncorhynchus keta*) reintroduction sites within the Big Creek Recovery Population that were used from 2020–2024. Inset shows the Big Creek Recovery Population in relation to the other seven Chum Salmon recovery populations in Oregon.

Table 8. Summary of the Chum Salmon (*Oncorhynchus keta*) reintroduction effort in the Big Creek Recovery Population from 2020–2024.

			Number			
Release Location	**Brood Year**	**Stage**	**Females**	**Males**	**Eggs**	**Fry**
Bear Cr Watershed	2020	Adults	400	241		
	2021	Adults	353	283		
	2022	Adults	307	172		
	2023	Adults	127	80		
	2024	Adults	158	146		
Gnat Cr	2021	Adults	49	54		
	2022	Adults/Fry	28	17		24,882
	2023	Adults/Fry	25	13		26,800
	2024	Adults/Fry	29	16		24,000

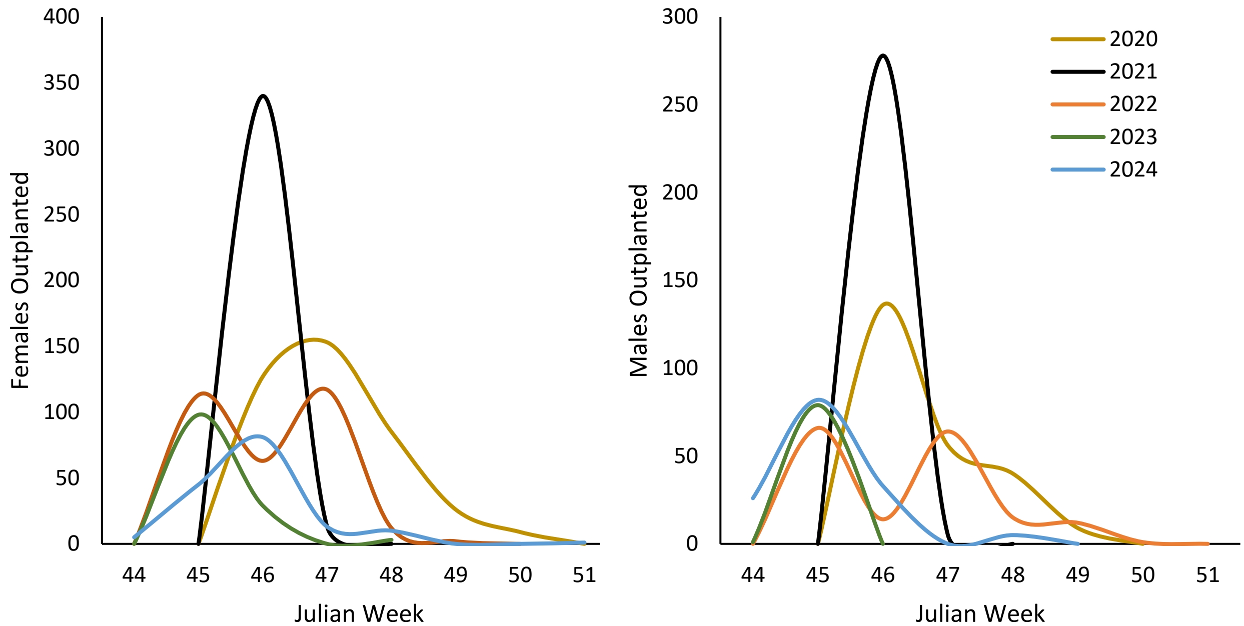

Figure 8. The number of excess adult Chum Salmon (*Oncorhynchus keta*) outplanted into the Bear Creek watershed from 2020–2024. Females are in the left panel and males are in the right panel; note difference in scale.

Gnat Creek Reintroduction (2021–2024)

Two reintroduction methods were tested in Gnat Creek during the study period: adult releases (2021–2024) and unfed fry releases (2022–2024). Excess adult Chum Salmon returning to BCH were transferred to Gnat Creek typically in a single day in mid-November, except in 2022 when individuals were moved in late November. More individuals were released in 2021 (n = 103) because of the large return to BCH, but since then, an average of 27 females and 15 males have been released into Gnat Creek to spawn volitionally (Figure 9).

From 2022–2024, PROCS has also experimented with releasing unfed fry into Gnat Creek to supplement adult outplanting. To do this, ~10 pairs of excess adults were spawned each year and the ~25,000 collected eggs were reared to the unfed fry stage at BCH. Each year, the unfed fry group was released into Gnat Creek under similar conditions as the fed broodstock fry (Figure 9). Raising half the annual production in a hatchery setting increases egg to fry survival, but mate selection in the wild may also be important for early survival, so multiple generations of consistent reintroduction methods will be needed to determine which reintroduction method is most successful. Returning adults to Gnat Creek (2025-2027) will be identifiable by reintroduction method since unfed fry received an otolith thermal mark.

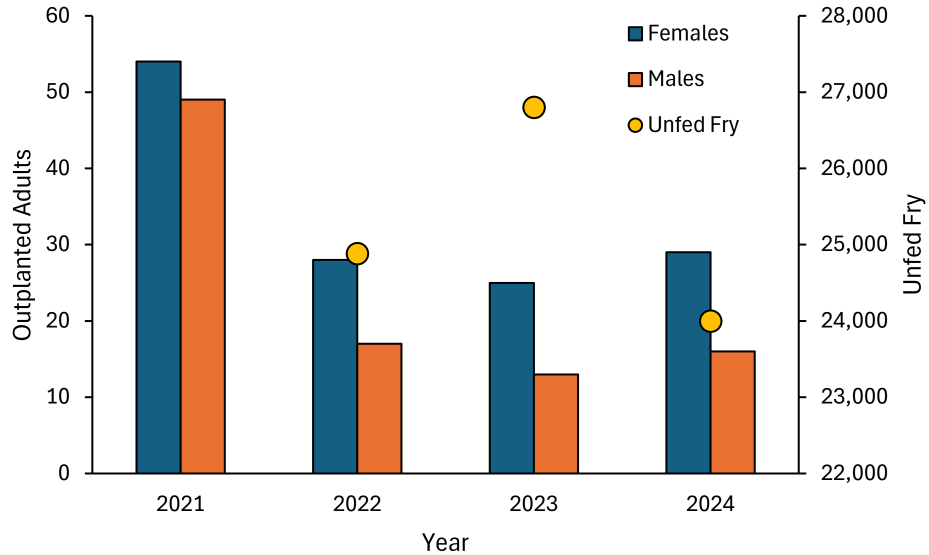

Figure 9. The number of excess Chum Salmon (*Oncorhynchus keta*) adults (left axis) and unfed fry (right axis) released into Gnat Creek from 2021–2024. Adult fallbacks to BCH are not included.

Fallbacks, Strays, & Freshwater Survival in the Big Creek Recovery Population (2020–2024)
Each year, outplanted Chum Salmon were uniquely tagged to monitor movement, including any fallbacks to BCH and strays in/out of the reintroduction site. Most of the fallbacks observed throughout the study period were from the Bear Creek Watershed (Table 9) and on average, 9.86% of adults outplanted to the Bear Creek watershed returned to BCH each year. In all years, more females (54.7–76.9%) tended to return to the hatchery than males (28.2–53.8%). In 2023, of the individuals that came back to the hatchery (n = 17), about half were re-outplanted to Bear Creek Watershed, while most of the others were taken to Conyers Creek. In 2024, 17 of the 18 fallbacks were returned to the Bear Creek Watershed (one male was transferred to Gnat Creek). However, several fallbacks from other reintroduction sites were secondarily taken to Bear Creek Watershed (seven females and 2 males; Table 9). Outplanted individuals have also strayed to other parts of the Big Creek Recovery Population, but there have been few. Over the last five years of outplanting, only 12 outplanted individuals have moved into or out of the Bear Creek Watershed and been recovered on spawning ground surveys (0.53%; Table 10).

Fallbacks originating from Gnat Creek were all re-outplanted to other locations in 2023 (Conyers Creek) and 2024 (Bear Creek Watershed; Table 9). There were more female fallbacks than males in both years (>60%). Two males strayed out of Gnat Creek in 2023 and were recovered in Big and Little Creeks, presumably on their way back to the hatchery. Overall, only three individuals have strayed out of Gnat Creek after four years of outplanting (1.30%; Table 10).

Table 9. The number of adult Chum Salmon (*Oncorhynchus keta)* that returned to Big Creek Hatchery (i.e., fallbacks) after being outplanted to reintroduction sites in the Big Creek Recovery Population from 2020–2024. Upon return to the hatchery, adults were either re-outplanted to the same site (neutral) or re-outplanted to (-) or from (+) a different site. Individuals that returned to the hatchery, but died before being re-outplanted are indicated with (*).

			Females			Males			
Site	**Year**	**Total Fallbacks**	**Re-outplanted to same site (neutral)**	**Re-outplanted to different site (-)**	**Re-outplanted from different site (+)**	**Re-outplanted to same site (neutral)**	**Re-outplanted to different site (-)**	**Re-outplanted from different site (+)**	**Net**
Bear Creek Watershed	2020	86	45	2*	0	32	7*	0	-9
	2021	39	0	28	0	0	11	0	-39
	2022	26	8	8	4	7	3**	4	-2
	2023	17	5	6	0	3	3	0	+2
	2024	18	11	0	7	6	1	2	+26
	Average	37	14	8	2	10	3	1	
Gnat Creek	2021	7	0	6	0	0	1	0	-7
	2022	8	0	4	2	0	4	1	+3
	2023	5	0	3	0	0	2	0	-5
	2024	6	0	5	0	0	1	1	+1
	Average	7	0	5	1	0	2	1	

**One of the three was a mortality, the other two were re-outplanted to a different site.

Table 10. The number of adult outplanted Chum Salmon (*Oncorhynchus keta*) that strayed into or out of Big Creek Recovery Population reintroduction sites from 2020–2024. All strays were recovered on spawning ground surveys in a location other than where they were originally outplanted based on tag number/color.

Site	Year	Total Outplanted	Females		Males		%
			Strays In	Strays Out	Strays In	Strays Out	
Bear Creek Watershed	2020	641	0	1	0	1	0.31
	2021	636	2	7	0	1	1.57
	2022	479	0	0	0	0	0.00
	2023	207	0	0	0	0	0.00
	2024	304	0	0	0	0	0.00
	Total	2,267	2	8	0	2	0.53
Gnat Creek	2021	103	0	1	0	0	0.97
	2022	45	0	0	0	0	0.00
	2023	38	0	0	0	2	5.26
	2024	45	0	0	0	0	0.00
	Total	231	0	1	0	2	1.30

Changes in the total number of outplanted females in the Big Creek Recovery Population due to straying or falling back to BCH were accounted for in fry production estimates for each year (Table 11). In the Bear Creek Watershed, the expected number of fry produced was similar in 2023 and 2024, despite differing average fecundities. However, both years had lower estimates than the 2020–2022 period because more females were outplanted in those years. Similar trends occurred in Gnat Creek: 2023 and 2024 expected fry production was lower than previous years. However, the number of outplanted females from 2022–2024 was comparable: 26, 22, and 24, respectively (Figure 9), meaning that fry estimates were largely driven by variation in fecundity each year. Although unfed fry releases are not included in these estimates, consistent additions of unfed fry to Gnat Creek could be an important supplement to overall production, especially when freshwater survival is low for progeny of outplanted adults. In the Bear Creek Watershed, expected fry production were compared to fry outmigration estimates produced from rotary screw trap monitoring each year and used to estimate the number of adult returns under constant marine survival (0.2%; see Monitoring Section).

Table 11. The expected number of fry produced from outplanted adult female Chum Salmon (*Oncorhynchus keta*) in the Big Creek Recovery Population adjusted for fallbacks to Big Creek Hatchery, individuals re-outplanted, and strays from 2020–2024. The average annual fecundity was used to estimate egg deposition, which were then used to estimate fry production under four freshwater survival scenarios (5%, 10%, 15%, and 20%).

Site	Year	Outplanted Females	Adjusted	Actual Females	Avg. Fecundity	Est. Egg Dep.	Freshwater Survival Scenarios			
							5%	10%	15%	20%
Bear Creek Watershed	2020	400	-3	397	2,605	1,034,185	51,709	103,419	155,128	206,837
	2021	353	-33	320	2,528	808,960	40,448	80,869	121,344	161,792
	2022	307	+4	311	2,955	919,005	45,950	91,901	137,851	183,801
	2023	127	-6	121	2,932	354,772	17,739	35,477	53,216	70,954
	2024	158	+7	165	2,330	384,450	19,223	38,445	57,668	76,890
Gnat Creek	2021	54	-7	47	2,528	118,816	5,941	11,882	17,822	23,763
	2022	28	-2	26	2,955	76,830	3,842	7,683	11,525	15,366
	2023	25	-3	22	2,932	64,504	3,225	6,450	9,676	12,901
	2024	29	-5	24	2,330	55,920	2,796	5,592	8,388	11,184

Clatskanie River Recovery Population

In the Clatskanie River Recovery Population, ideal reintroduction sites were Conyers Creek, Stewart Creek, Carcus Creek, and Page Creek in 2023 and 2024 (Figure 10). The Clatskanie River mainstem was used for reintroduction activities in 2021–2022, but not in 2023–2024 because excess adults were used for other reintroduction activities in other locations. The main reintroduction site was Conyers Creek, which is a large tributary of the Clatskanie River that has suitable spawning habitat (~815m^2 of low gradient habitat) that would support upwards of 900 individuals and is large enough to operate a rotary screw trap to monitor fry production. Stewart Creek was chosen as a reintroduction site because of the available spawning habitat (~250m^2 of low gradient habitat) that would support up to 230 spawners. Stewart Creek was also a site where previous outplanting efforts and success were likely limited by the number of fish transferred (see Homel et al., 2021). Carcus Creek was chosen because of its low gradient, logistical advantages, and location in the watershed. Lastly, Page Creek was chosen because it is a small tributary of the Clatskanie River with suitable spawning habitat that is an ideal location for an RSI. Page and Carcus Creeks are also frequently monitored via spawning ground surveys and a rotary screw trap at the head of tide in the Clatskanie River.

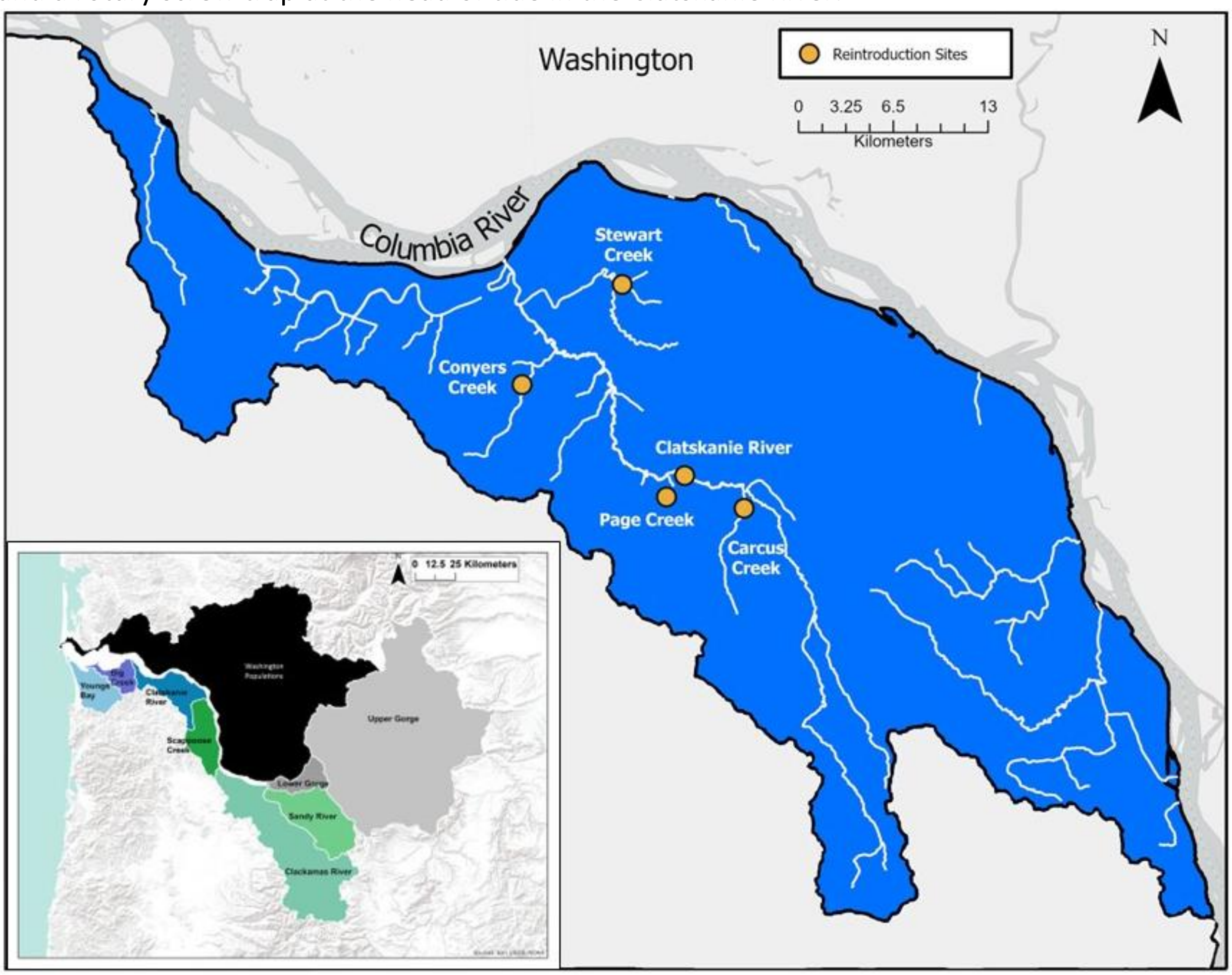

Figure 10. Chum Salmon (*Oncorhynchus keta*) reintroduction sites within the Clatskanie River Recovery Population that were used from 2020–2024. Inset shows the recovery population in relation to the other seven Chum Salmon recovery populations in Oregon.

Clatskanie River Reintroduction (2021–2024)

Over two years (2021–2022), excess adult Chum Salmon were outplanted into the mainstem of the Clatskanie River to spawn volitionally (see Smith et al. 2025a). In 2023 and 2024, outplanting did not continue in the Clatskanie River mainstem due to other priorities taking precedence and limited returning adults to BCH (Table 12). In the future, it is possible that adults will be outplanted into the Clatskanie River mainstem again.

Table 12. Summary of the Chum Salmon (*Oncorhynchus keta*) reintroduction effort in the Clatskanie River Recovery Population from 2021–2024.

			Number			
Release Location	**Brood Year**	**Stage**	**Females**	**Males**	**Eggs**	**Fry**
Clatskanie River	2021	Adults	706	299		
	2022	Adults	217	186		
	2023	None				
	2024	None				
Conyers Creek	2021	Adults	120	48		
	2022	Adults	79	67		
	2023	Adults	90	39		
	2024	Adults	71	85		
Stewart Creek	2021	Adults	28	22		
	2022	Adults	26	34		
	2023	Adults	13	1		
	2024	Adults	31	8		
Page Creek	2021	None				
	2022	Eggs/Fry			46,093	50,623
	2023	Eggs/Fry			49,225	55,600
	2024	Eggs/Fry			46,748	48,000
Carcus Creek	2021	None				
	2022	None				
	2023	Fry				49,900
	2024	None				

Conyers Creek Reintroduction (2021–2024)

To further support recovery in the Clatskanie River, excess adults were outplanted to Conyers Creek, a major tributary, again in 2023 and 2024 (Table 12). No other reintroduction method was tested at this reintroduction site during this time. Comparable numbers of females were outplanted in 2023 and 2024, but 2024 is the only year when more males than females were outplanted into the system. Individuals have been distributed differently throughout the month of November over the years (Figure 11). In 2021, outplanting to Conyers Creek occurred on one day during the peak return, but since 2022, smaller groups have been outplanted over several different days. The earliest outplanting in November occurred in 2024.

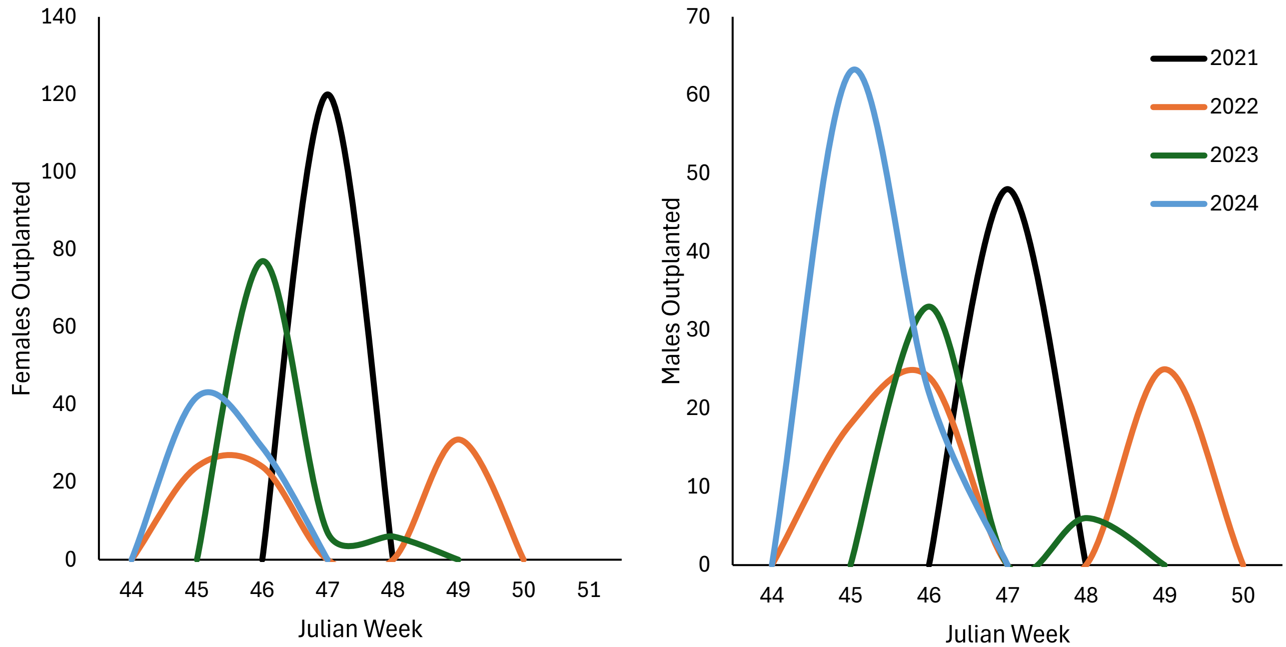

Figure 11. The number of excess adult Chum Salmon (*Oncorhynchus keta*) outplanted into Conyers Creek from 2021–2024. Females are in the left panel and males are in the right panel; note difference in scale.

Stewart Creek Reintroduction (2021–2024)

To determine if previous reintroduction efforts in Stewart Creek were limited by duration and quantity, excess adults were outplanted to Stewart Creek from 2021–2024. No other reintroduction method was tested at this reintroduction site during this time. Excess adults were transferred to Stewart Creek on a single day each year at various times throughout the return to spawn volitionally (Figure 12). In 2023-2024, more females were outplanted than males, and only one male was outplanted to Stwart Creek in 2023.

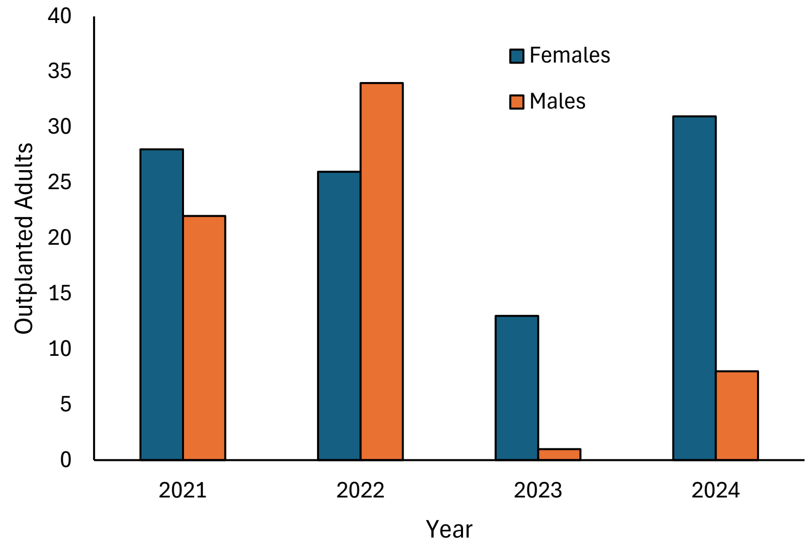

Figure 12. The number of excess adult Chum Salmon (*Oncorhynchus keta*) outplanted into Stewart Creek from 2021–2024.

Page Creek Reintroduction (2022–2024)
Since 2022, two reintroduction methods have been tested in Page Creek: incubating eggs in an RSI and releasing unfed fry (Table 12). Each year, ~50,000 eggs have been reared in an RSI and ~50,000 unfed fry have been released into Page Creek. Over these three seasons, PROCS estimates that 46,093–49,225 fry left the RSI volitionally, an egg-to-fry survival rate of 92.2–98.5%, which is comparable to hatchery-rearing survival at this stage. To compliment this, anywhere from 48,000–55,600 unfed fry have been released in the spring. All groups have been given a unique otolith thermal mark to distinguish individuals from each other, making any returning adults to Page Creek (2025-2028) identifiable by reintroduction method. Results from these reintroduction methods were used to estimate the number of adult returns under constant marine survival (0.2%; see Monitoring Section).

Carcus Creek Reintroduction (2023)
In 2023, a group of uniquely marked unfed fry were released into Carcus Creek and served as a control for other reintroduction methods in the recovery population (Table 12). These fish are expected to return 2026–2028. PROCS intended to operate a complimentary RSI in Carcus Creek, but limited flows prevented its operation in 2023 and 2024. No unfed fry were released in 2024 due to a limited number of returns to BCH and commitment to other reintroduction priorities. In the future, it is possible that unfed fry will be released (and an RSI will be operated) in Carcus Creek.

Fallbacks, Strays, & Freshwater Survival in Clatskanie River Recovery Population (2021–2024)
Each year, individuals were uniquely tagged to monitor movement, including fallbacks to BCH and strays into and out of the reintroduction site to ultimately evaluate freshwater survival. Details for these metrics in the Clatskanie River for 2021–2022 can be found in Smith et al., (2025a). In Conyers Creek, there were four fallbacks to BCH in 2023 (all females) and all were

re-outplanted to Conyers Creek, but an additional nine females and five males were also outplanted form other reintroduction sites (Table 13). In 2024, there were also four fallbacks from Conyers, but all were re-outplanted to different sites. Only 2.56% and 3.10% of fish outplanted to Conyers Creek came back to BCH in 2023 and 2024, respectively. There were no documented strays into or out of Conyers Creek in 2023, and only one female strayed out in 2024 (carcass recovered in West Creek; Table 14). From 2021–2024, PROCS has outplanted almost 600 adults into Conyers Creek and only six individuals have been recovered in other locations, suggesting a very low stray rate (1.00%; Table 14).

There were no fallbacks to BCH from Stewart Creek in 2023 or 2024. However, in 2024, one fallback from Conyers Creek was re-outplanted to Stewart Creek (Table 13). There were also no strays into or out of Stewart Creek in 2023 or 2024 (Table 14). Since 2021, only three individuals of the 163 total outplanted fish to Stewart Creek have strayed out of the system (1.84%; Table 14).

Changes in the total number of outplanted females each year, including fallbacks, re-outplants from other reintroduction sites, and strays, were accounted for in fry production estimates (Table 15). In Conyers Creek, the estimated number of fry produced was comparable between 2021–2023, when a large number of females were outplanted (e.g., 2021) or when average fecundity was high (e.g., 2022–2023). In 2024, the actual number of females spawning in Conyers Creek was the lowest, and coupled with a low average fecundity, means that fry production estimates were also the lowest. In Stewart Creek, the actual number of spawning females ranged from 25-31 in most years, resulting in consistent estimates of freshwater survival. However, only 13 females were outplanted in Stewart Creek in 2023, and even though average fecundity was high, fry production was likely low even under the highest freshwater survival scenario. In the future, it is possible that PROCS would experiment with releasing unfed fry in Stewart Creek, so that it can be compared to reintroduction efforts in Gnat Creek. In Conyers Creek, the estimated number of fry produced from outplanted females were compared to fry outmigration estimates produced from rotary screw trap monitoring each year and used to estimate the number of adult returns under constant marine survival (0.2%; see Monitoring Section).

Table 13. The number of adult Chum Salmon (*Oncorhynchus keta)* that returned to Big Creek Hatchery (i.e., fallbacks) after being outplanted to reintroduction sites in the Clatskanie River Recovery Population from 2021–2024. Upon return to the hatchery, adults were either re-outplanted to the same site (neutral) or re-outplanted to (-) or from (+) a different site.

			Females			Males			
Site	**Year**	**Total Fallbacks**	**Re-outplanted to same site (neutral)**	**Re-outplanted to different site (-)**	**Re-outplanted from different site (+)**	**Re-outplanted to same site (neutral)**	**Re-outplanted to different site (-)**	**Re-outplanted from different site (+)**	**Net**
Conyers Creek	2021	1	0	1	7	0	0	2	+9
	2022	0	0	0	3	0	0	0	+3
	2023	4	4	0	9	0	0	5	+14
	2024	4	0	2	0	0	2	0	-4
	Average	2	1	1	5	0	1	2	
Stewart Creek	2021	1	0	1	0	0	0	0	-1
	2022	0	0	0	0	0	0	0	0
	2023	0	0	0	0	0	0	0	0
	2024	0	0	0	0	0	0	1	+1
	Average	0	0	0	0	0	0	0	

Table 14. The number of adult outplanted Chum Salmon (*Oncorhynchus keta*) that strayed into or out of Clatskanie River Recovery Population reintroduction sites from 2021–2024. All strays were recovered on spawning ground surveys in a location other than where they were originally outplanted based on tag number/color.

			Females		Males		
Site	**Year**	**Total Outplanted**	**Strays In**	**Strays Out**	**Strays In**	**Strays Out**	**%**
Conyers Creek	2021	168	0	2	0	0	1.19
	2022	146	0	1	0	2	2.05
	2023	129	0	0	0	0	0.00
	2024	156	0	1	0	0	0.64
	Total	599	0	4	0	2	1.00
Stewart Creek	2021	50	0	0	0	0	0.00
	2022	60	0	1	0	2	5.00
	2023	14	0	0	0	0	0.00
	2024	39	0	0	0	0	0.00
	Total	163	0	1	0	2	1.84

Table 15. The estimated number of fry produced from outplanted adult female Chum Salmon (*Oncorhynchus keta*) in the Clatskanie River Recovery Population adjusted for fallbacks to Big Creek Hatchery, individuals re-outplanted, and strays from 2021–2024. The average annual fecundity was used to estimate egg deposition, which were then used to estimate fry production under four freshwater survival scenarios (5%, 10%, 15%, and 20%).

Site	Year	Outplanted Females	Adjusted	Actual Females	Avg. Fecundity	Est. Egg Dep.	Freshwater Survival Scenarios			
							5%	10%	15%	20%
Clatskanie River	2021	706	+36	742	2,528	1,875,776	93,789	187,578	281,366	375,155
	2022	217	+3	220	2,955	746,816[a]	37,341	74,682	112,022	149,363
	2023	0	0	0	2,932	154,725[b]	7,736	15,473	23,209	30,945
	2024	0	0	0	2,330	94,748[b]	4,737	9,475	14,212	18,950
Conyers Creek	2021	120	+5	125	2,528	316,000	15,800	31,600	47,400	63,200
	2022	79	+2	81	2,955	239,355	11,968	23,936	35,903	47,871
	2023	90	+9	99	2,932	290,268	14,513	29,027	43,540	58,054
	2024	71	-3	68	2,330	158,440	7,922	15,844	23,766	31,688
Stewart Creek	2021	28	-1	27	2,528	68,256	3,413	6,826	10,238	13,651
	2022	26	-1	25	2,955	73,875	3,694	7,388	11,081	14,775
	2023	13	0	13	2,932	38,116	1,906	3,812	5,717	7,623
	2024	31	0	31	2,330	72,230	3,612	7,223	10,835	14,446

[a] Calculated based on the estimated eggs deposited from 220 females outplanted, plus the estimated fry emerging from the RSI and the number of unfed fry released.

[b] Based on estimated fry emerging from the RSI and the number of unfed fry released.

Summary of Reintroduction & Supplementation Efforts

In 2023 and 2024, fewer adults were outplanted across the selected reintroduction sites as PROCS focused on RSI operations and releasing unfed fry. Adult outplanting continued in the Bear Creek watershed, Gnat Creek, Conyers Creek, and Stewart Creek so that individuals could spawn volitionally. The Bear Creek watershed remains the most consistent and largest adult outplanting effort, which is a good test for determining whether or not large releases can overcome the negative effects of stochastic events (e.g., inbreeding, not finding mates, incomplete spawning, weather events). However, if freshwater survival remains low (<20%), adult outplanting may not increase abundance as expected, which is why other reintroduction methods should continue to be tested.

Reintroduction methods that support high freshwater survival, like unfed fry releases and RSI operation, may be more effective than adult outplanting in some situations or systems. For example, no adults were outplanted in the Clatskanie River mainstem in 2023 or 2024, but freshwater survival was very high because of unfed fry releases in Page and Carcus Creeks and from fry outmigrating from the RSI in Page Creek (see Juvenile Monitoring Section). In general, we have found that many more adult females need to be outplanted to yield comparable production to RSI and unfed fry releases (e.g., 48 outplanted females vs. 10 spawned females for unfed fry in Gnat Creek). Much of the literature suggests that selected reintroduction sites historically supported many more Chum Salmon than PROCS was able to outplant, even in high return years (e.g., up to 3,000 individuals in the Clatskanie River; Parkhurst et al., 1950; Fulton 1970; Meyers et al. 2003). If PROCS is unable to outplant significant numbers of adults to a reintroduction site due to low returns to BCH, operating RSIs and releasing unfed fry may be the best reintroduction methods for quickly increasing abundance to overcome stochastic events at reintroduction sites, although results can only be confirmed when all adults have returned (2024–2029). Despite their utility, the RSI and unfed fry reintroduction methods are limited by hatchery space, the thermal marking schedule required for marking multiple reintroduction groups, staff and resources, and the requirement for more long-term planning and biological sample analysis than outplanting adults. Thus, each reintroduction site will need to be evaluated separately over several years and PROCS will need to coordinate with BCH staff to determine the best approach for each situation.

MONITORING ADULT CHUM SALMON

Background

ODFW conducts spawning ground surveys (SGS) to monitor trends in abundance and distribution of multiple salmonid species. Spawning ground surveys are primarily carried out by ODFW's Oregon Adult Salmonid Inventory and Sampling (OASIS) project, which has been conducting salmon spawning ground surveys for over 20 years. OASIS surveys are selected using a spatially balanced random selection from a defined sampling frame that are surveyed opportunistically (hereafter: random sites), as well some long-term index sites that are sampled regularly (hereafter: standard sites) for a variety of salmonids, including Chum Salmon (Jacobs et al. 2002). Surveys are conducted in the fall when adult salmon are returning to freshwater habitat to spawn. Live fish can be observed and enumerated on the spawning grounds, redds can be counted, and carcasses can be recovered to collect biological samples. This information is used to create annual estimates of salmon populations returning to specific watersheds, which is important for long-term monitoring of wild and hatchery populations, and in terms of Chum Salmon, evaluation of recovery efforts as well as any natural recolonization in the LCR.

Over the years, PROCS has worked closely with OASIS staff in most aspects of adult Chum Salmon monitoring, including Chum Salmon-specific site selection, biological sample collection, and the development of a Chum Salmon spawning frame. Initially, from 2012-2016, PROCS conducted surveys that were exploratory in nature, filled in gaps around OASIS surveys, and meant to expand the limited knowledge of Chum Salmon spawning distribution in the LCR Basin (e.g., are Chum Salmon present in the Scappoose Creek Recovery Population?). PROCS also selected additional sites to monitor high priority streams such as reintroduction sites (e.g., Stewart and Graham Creeks). In 2016, the largest adult Chum Salmon return to the LCR in over 50 years occurred (41,620 adults, estimate from Todd Hillson, WDFW; accessed on cax.streamnet.org on 7 July 2024). To capitalize on the data gained from this return, PROCS and OASIS created a Chum Salmon sampling frame for the Youngs Bay, Big Creek, and Clatskanie River Recovery Populations with a primary goal of producing population estimates for these areas. The sampling frame included sites accessible to Chum Salmon with desirable spawning habitat features (i.e., < 1% gradient, small gravel, cold water upwelling). With baseline data collected and a sampling frame created, PROCS and OASIS began surveying Chum Salmon-specific sites in 2017. Since then, three types of sites are surveyed for Chum Salmon each fall: standard sites (i.e., known spawning areas with a high likelihood of encountering carcasses), random sites (i.e., potential spawning areas where carcasses may or may not be encountered depending on the year), and high priority streams (i.e., reintroduction sites). The data is important to track the progress of recovery efforts for Chum Salmon across all Recovery Populations, as well as in specific locations where reintroductions have occurred.

Finally, PROCS expanded monitoring efforts to include areas in the Scappoose Creek, Clackamas River, and Sandy River Recovery Populations from 2022–2024. Environmental DNA (eDNA) is an effective way to determine the presence or absence of rare species, like Chum Salmon, in a system without the laborious efforts of spawning ground surveys. Previous research by Homel et al. (2020) demonstrates that eDNA monitoring techniques are effective at detecting Chum

Salmon presence/absence over a wide distribution (i.e., Upper Gorge Recovery Population). With the recent large returns of Chum Salmon to the LCR (2020–2024), establishing a consistent eDNA monitoring program will be important for determining run timing and size, directing habitat restoration projects or spawning channel construction, estimating density, and monitoring recovery progress in populations where limited resources are available.

Methods

Spawning Ground Surveys

Chum Salmon SGS sites were randomly selected from the Chum sampling frame, landowners were contacted, and any new SGS sites were assessed. Landowner permission was obtained through phone calls, mail/email correspondence, or an in-person visit to the residence. Once landowner permission to conduct the survey was secured, a surveyor visited the site (February to September) to verify that it contained Chum Salmon spawning habitat and to determine if there were any barriers to adult Chum Salmon migration. If the site had suitable habitat and was accessible for Chum Salmon, a new SGS site was established. Surveys were generally 1.6km (i.e., 1 mile) in length, but actual boundaries were determined by the site's physical characteristics. Surveys were bound by significant landscape features including beginning or ending of Chum Salmon spawning habitat, confluence with other streams containing Chum Salmon spawning habitat, and other established features such as bridges or roads. Specific methods used in SGS setups can be found in the annual site verification procedure manual (ODFW 2023).

Both OASIS and PROCS spawning ground surveys follow the same sampling protocol (ODFW 2024). In brief, surveys were conducted weekly or at most on a 10-day rotation starting in early October and continuing through mid-December. Surveyors walked upstream and recorded conditions (i.e., weather, visibility, coordinates) and the number of live and dead Chum Salmon, along with other salmon and steelhead, in each survey reach. Redds were tallied and biological samples were collected from carcasses, including scales to age fish, otoliths to determine fish origin (i.e., wild or hatchery), presence of any other marks or tags, a tissue sample for genetics, lengths, and percent spawned for females. Because of the degraded nature of Chum Salmon carcasses, not all biological samples could be collected for every individual recovered (e.g., scales absorbed, no tissue left on fin rays). Biological samples were processed and analyzed following methods described in the Conservation Broodstock section.

Population Estimates

During the study period, PROCS and OASIS used a unified data collection method so that Chum Salmon population estimates could be generated for each Recovery Population and three Core Areas: Lewis and Clark River, Big Creek Watershed, and Bear Creek Watershed. These three Core Areas were chosen because they represent a wild population, a hatchery influenced population, and a population influence by reintroduction activities. As reintroduction activities continue in the Clatskanie River Recovery Population, a fourth Core Area will be added.

The trapezoidal Area-Under-the-Curve (AUC) technique is used to estimate the number of Chum Salmon adults spawning in a given stream segment throughout the spawning season

(Jacobs et al. 2002). Spawning Coho Salmon (*O. kisutch*) and Chum Salmon are assumed to have an average spawning life of 11.3 days across the region and season (Beidler and Nickelson 1980; Perrin and Irvine 1990). Live Chum Salmon observations are adjusted for the estimated bias associated with visual counts by surveyors (Solazzi 1984). Spawner density is calculated for each population, as the total adult Chum Salmon AUC / total survey length (miles) for all surveys. Abundance and timing calculations are only done with random sites, as they are evaluated to determine if they meet the criteria to qualify for inclusion in population estimates. The criteria to determine if a site is a qualified survey are based on minimizing the possibility for an inaccurate AUC calculation. This could occur if the chance of a Chum Salmon migrating to the site, spawning, and dying in the period between survey visits is considered too high. The standard method for determining whether a site was successfully surveyed for the year involves three steps. First, the critical period is determined for each stratum. Critical period is defined as the time interval in which 90% of the live Chum Salmon were seen in a stratum for the year. Second, the number of days between valid surveys is calculated for each site for the year. Finally, the "gaps" between survey dates are evaluated to determine if they meet the criteria for minimizing the chance of missing Chum Salmon in the live counts. The standard criteria used are no gap of 16 or more days, and no more than one gap between 12 and 15 days during the critical period. Thus, maintaining a 10-day survey rotation is critical for creating population estimates, making Chum Salmon spawning surveys a high priority for PROCS crews during the fall season.

Environmental DNA

Water samples were collected to detect adult Chum Salmon presence during and after spawning in historically occupied streams in three recovery populations (Scappoose Creek, Clackamas River, and Sandy River). Sites in the three recovery populations were chosen based on historical distribution of adult Chum Salmon and were intended to maximize detection in the watershed. In general, sampling occurred at sites high enough in the river or creek to avoid influence from the Columbia River (i.e., above head of tide), but still within a lower gradient and below any potential barriers (i.e., within Chum Salmon spawning habitat). Sites were sampled at the peak of the return (mid–November) and at the end of the return (early December) each year. Select sites were also sampled again in the spring (once in mid-April and again in early May) to detect any Chum Salmon fry that may be outmigrating from the system. If presence was detected in the spring, but not the fall at a site, then we would be able to verify that spawning occurred in the fall, but a detection was missed (i.e., false negative). Water was collected following the methods outlined in Carim et al. (2016). After collection, filters were shipped to the National Genomics Center for Wildlife and Fish Conservation (Missoula, MT) for analysis.

Results

Age, Origin, & Sex Distribution of Recovered Carcasses

Youngs Bay Recovery Population

There have been no reintroduction activities in the Youngs Bay Recovery Population from 2020–2024, so any hatchery-origin individuals recovered are expected to be strays. There has only been one hatchery-origin carcass recovered: Age-3 female in 2020; all other individuals that were recovered were wild-origin. In 2023, the number of recovered carcasses was relatively low, but one was an Age-5, wild-origin female from the South Fork of the Klaskanine River (Table 16). However, in 2024, there were no Chum Salmon carcasses recovered in the Youngs Bay Recovery Population.

Big Creek Recovery Population

Most Chum Salmon observations on spawning ground surveys over the study period took place in the Big Creek Recovery Population because it supports both hatchery- and wild-origin Chum Salmon across several sites (Table 16). Monitoring effort has stayed the same over the last five years in this recovery population: ~12–14km over 8–10 reaches. Hundreds of carcasses were recovered in 2020, the most in any year, due to the large return and the proximity of the only reintroduction site to BCH. As reintroduction efforts have focused on the Clatskanie River Recovery Population, there have been fewer recovered carcasses in Big Creek relative to 2020. In 2023 and 2024, most carcasses were recovered in the Bear Creek watershed, Big Creek, or Little Creek (a tributary to Big Creek). Although individuals were recovered in Gnat Creek in 2021 and 2022, none were found there in 2023 or 2024 despite continued reintroduction efforts.

Of the 207 adults outplanted into the Bear Creek Watershed in 2023, 14 tagged individuals were recovered on SGS (6.89%; 10 females and 4 males). Most of these fish were hatchery-origin (n = 8; 57.1%) and Age-4 (n = 12; 85.7%). Of the 304 adults outplanted into the Bear Creek Watershed in 2024, 12 tagged individuals were recovered on SGS (3.95%; 8 females and 4 males), and like 2023, most hatchery-origin fish (n = 8; 66.7%), but they are mostly Age-3 (n = 10; 83.3%). There were other carcasses recovered in the Bear Creek Watershed in 2023 and 2024 (Table 16), but because they were untagged (or lost their tags), it's difficult to know if those fish were outplanted or strayed.

In 2023 and 2024, the number of carcasses recovered in Big Creek was generally low, but consistent and revealed the movements of both hatchery- and wild-origin Chum Salmon. In 2023, only four carcasses were recovered (three untagged females and one tagged male) and in 2024, seven, untagged females and one, untagged male were found. Of these 12 fish, most were hatchery-origin (n = 7; 58.3%), demonstrating that some hatchery fish actually spawn in Big Creek and never make it back to the hatchery. There is also evidence that tagged, outplanted fish sometimes return to Big Creek to spawn intentionally. The one, tagged male recovered in 2023 was hatchery-origin and originally outplanted in Gnat Creek. Continued monitoring of Big Creek will further reveal these patterns of habitat use among tagged/untagged and hatchery-/wild-origin individuals (Table 16).

Finally, it is of note that Chum Salmon carcasses were recovered on Little Creek (n = 25 in 2023 and n= 6 in 2024). In 2023, two recovered fish were tagged, one female that was originally outplanted in Bear Creek and one male that was originally outplanted in Gnat Creek. In 2024, none of the recovered fish were tagged and most were wild-origin and Age-3 (n = 4; 66.7%), suggesting that they strayed from Big Creek.

Clatskanie River Recovery Population

The number of Chum Salmon recovered on SGS in the Clatskanie River Recovery Population has increased over the study period due to initiating outplanting and monitoring effort in the watershed (Table 16). No Chum Salmon were recovered on SGS in the area in 2020, and all the individuals recovered from 2021–2024 were fish that had been outplanted. In 2023, there was only one carcass recovered in this recovery population: hatchery-origin, Age-4 male from Plympton Creek. In contrast, a total of 18 carcasses were recovered in 2024, the most during the study period. These carcasses were also collected from a wider distribution than previous years: Plympton Creek (n = 9), North Fork Stewart Creek (n = 6), Conyers Creek (n = 2), and West Creek (n = 1). Although the number of outplanted individuals was similar between years (Table 14), the survey effort doubled from 2023 to 2024, 10.65 km to 19.70 km, respectively. Monitoring effort expanded in 2024 to account for any returning progeny from outplanted adults in 2021. Unfortunately, the three wild-origin, Age-3 females recovered in 2024 were untagged, meaning that they either lost their tags after being outplanted, or that they're related to fish outplanted in 2021; further genetic analysis may be able to identify these individuals.

Table 16. The age, origin, and sex distribution of Chum Salmon (*Oncorhynchus keta*) carcasses recovered on spawning ground surveys in the Youngs Bay, Big Creek, and Clatskanie River Recovery Populations by PROCS and OASIS staff from 2020–2024.

			Youngs Bay			Big Creek			Clatskanie River		
Sex	**Origin**	**Year**	**Age-3**	**Age-4**	**Total**	**Age-3**	**Age-4**	**Total**	**Age-3**	**Age-4**	**Total**
Females	Hatchery	2020	1	0	1	34	2	36	0	0	0
		2021	0	0	0	18	3	21	1	0	1
		2022	0	0	0	1	2	3	2	0	2
		2023	0	0	0	3	17	20	0	0	0
		2024	0	0	0	8	4	12	1	5	6
	Wild	2020	0	2	2	101	22	123	0	0	0
		2021	8	3	11	61	20	81	3	0	3
		2022	3	6	9	2	18	20	1	5	6
		2023	1	1	3[a]	2	12	15[a]	0	0	0
		2024	0	0	0	4	2	6	3	3	7[a]
Males	Hatchery	2020	0	0	0	7	3	10	0	0	0
		2021	0	0	0	8	3	11	0	0	0
		2022	0	0	0	0	0	0	0	0	0
		2023	0	0	0	4	6	10	0	1	1
		2024	0	0	0	5	0	5	2	2	4
	Wild	2020	3	1	4	52	8	60	0	0	0
		2021	6	3	9	38	10	50[b]	0	0	0
		2022	0	0	0	0	13	13	1	4	5
		2023	1	1	2	4	4	8	0	0	0
		2024	0	0	0	2	2	4	0	0	0

[a] Includes one Age-5 individual; [b] Includes one Age-2 and one Age-5 individual.

Population Estimates
Spawning ground survey data was used to estimate Chum Salmon population size in each recovery population from 2020–2024, and, beginning in 2023, these data were also used to estimate population size in three Core Areas. An average of 17.18 km, 8.17 km, and 9.51 km of spawning habitat in Youngs Bay, Big Creek, and Clatskanie River Recovery Populations, respectively, was randomly selected and surveyed each season by PROCS and OASIS crews. Survey effort was highest in the Youngs Bay Recovery Population, but despite the high effort, the population estimates were moderate and decreasing in recent years compared to other recovery populations (n = 3–139; Table 17; Figure 13). Population estimates in the Lewis and Clark River Core Area have also been declining over the last three years (Table 18). This is probably because no reintroduction activities occurred in Youngs Bay, so any population estimate represents naturally returning adult Chum Salmon. The majority of Chum Salmon spawning activity in the Youngs Bay Recovery Population was observed in the mainstem Lewis and Clark River (Core Area), as well as the South Fork Klaskanine River.

The population estimates produced for the Big Creek Recovery Population are influenced by wild-origin Chum Salmon spawning in Big Creek, hatchery-origin Chum Salmon moving through Big Creek on their way to the hatchery, Chum Salmon returning to Big Creek from other reintroduction sites (i.e., fallbacks), as well as adult Chum Salmon naturally occurring or reintroduced at other sites (e.g., Bear Creek watershed). As a result, Chum Salmon population estimates were highest in the Big Creek Recovery Population in almost every year (n = 128–641; Table 17; Figure 13).

In the Clatskanie River Recovery Population, all Chum Salmon recorded on SGSs were adults outplanted by PROCS, meaning that the population estimates represent a proportion of outplanted individuals. In 2020, no Chum Salmon were outplanted in the Clatskanie River Recovery Population and no Chum Salmon carcasses were recovered, so the population estimate is zero (Figure 13). However, with consistent reintroduction over the years population estimates are increasing (with the exception of 2023). The population estimates generated from the random sites represent natural Chum Salmon recolonization (i.e., Youngs Bay Recovery Population), effects of natural and reintroduced Chum Salmon (i.e., Big Creek Recovery Population), and effects of reintroduction actions in an area where Chum Salmon were previously extirpated (i.e., Clatskanie River Recovery Population).

Table 17. Population estimates of the number of Chum Salmon (*Oncorhynchus keta*) returning to spawn based on randomly selected spawning ground survey data collected by PROCS and OASIS in three recovery populations from 2020–2024.

Recovery Population	Year	Reaches Surveyed	Total Km Surveyed	Total Observed Chum Salmon	Population Estimate
Youngs Bay	2020	9	14.42	22	75
	2021	9	18.12	176	139
	2022	12	20.32	100	106
	2023	12	21.15	10	21
	2024	6	11.60	1	3
Big Creek	2020	9	10.62	106	229
	2021	4	4.65	18	128
	2022	6	8.29	270	641
	2023	5	8.43	124	511
	2024	6	8.87	80	297
Clatskanie River	2020	3	6.26	0	0
	2021	8	12.80	46	50
	2022	8	9.99	80	113
	2023	7	10.73	13	17
	2024	5	7.76	185	244

Table 18. Population estimates of the number of Chum Salmon (*Oncorhynchus keta*) returning to spawn based on spawning ground survey data collected by PROCS and OASIS in three Core Areas from 2022–2024.

Core Area	Year	Reaches Surveyed	Total Km Surveyed	Total Observed Chum Salmon	Population Estimate
Lewis & Clark River	2022	3	5.18	50	36
	2023	3	4.20	11	8
	2024	2	2.37	0	0
Big Cr Watershed	2022	--	--	--	--
	2023	3	3.72	53	53
	2024	3	3.73	121	147
Bear Cr Watershed	2022	1	1.64	42	34
	2023	4	5.31	113	108
	2024	4	5.31	60	72

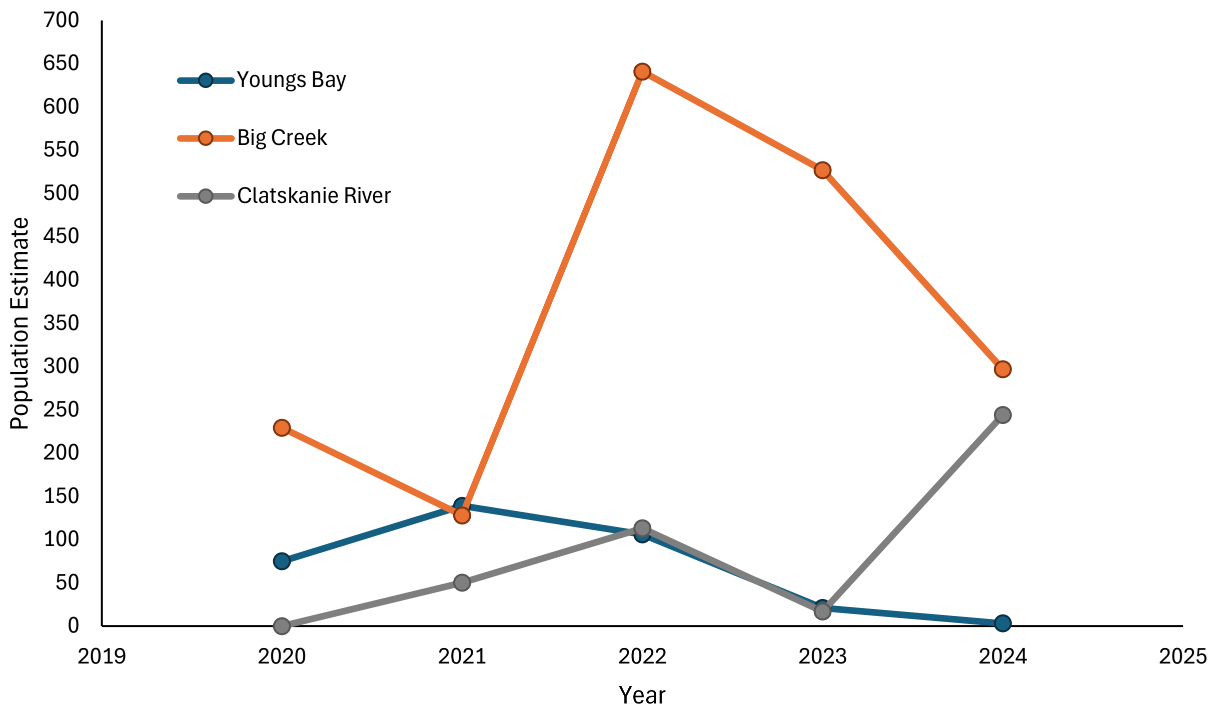

Figure 13. Population estimates for Chum Salmon (*Oncorhynchus keta*) returning to spawn in the Youngs Bay (blue), Big Creek (orange), and Clatskanie River (grey) Recovery Populations from 2020-2024.

Environmental DNA

From 2022–2024, 26 sites were sampled for Chum Salmon eDNA across three recovery populations in both fall and spring, and there were four positive detections. Three of these detections occurred in the Clackamas River Recovery Population: November 2023 (Clackamas River mainstem, just upstream of Eagle Creek), November 2024 (Clackamas River mainstem, just upstream of Eagle Creek), and November 2024 (Clackamas River mainstem at Cross Park). The fourth positive detection was collected at Dabney State Recreation Area in the Sandy River Recover Population in November 2024. Despite the sampling effort, there were no positive detections of Chum Salmon eDNA in the Scappoose Creek Recovery Population and no spring detections of fry at any location during the study period (see Smith et al., 2025b for full details). It is most likely that the positive eDNA detections of Chum Salmon in these recovery populations is the result of individuals straying from adjacent populations in Washington. Although Chum Salmon have not yet reoccupied the sampled sites, continued eDNA monitoring in these recovery populations will be important for evaluating natural reoccupation, planning future reintroduction activities, and restoring spawning habitat.

Summary of Adult Monitoring Efforts

The number of Chum Salmon returning to the LCR to spawn is a fraction of the known historical population (McElhany et al., 2004). However, the number of spawners observed on SGS over the last five years represents a good start for Chum Salmon recovery in the Youngs Bay, Big Creek, and Clatskanie River Recovery Populations, especially compared to the previous decade. While Chum Salmon are still present in the Coastal Stratum, population estimates indicate that these populations are not yet recovered (NOAA-NMFS 2022). In the Youngs Bay Recovery Population, where no reintroduction activities occur, the number of recovered carcasses and population size decreased in 2023 and 2024. Because this population is composed of wild individuals, it may experience “boom and bust” cycles that fluctuate with large Chum Salmon returns to LCR (e.g., 2016 and 2021). Conversely, the Clatskanie River Recovery Population has seen a steady increase in carcass recoveries and population size since reintroduction began in 2021, except for 2023 when very few adults were outplanted and no progeny from previous outplantings were expected to return. The increase in carcasses recovered or population size could be the result of increased effort, especially in 2024 when monitoring efforts doubled. Despite this effort, no progeny from the 2021 outplanting were recovered. Vigilant monitoring will be increasingly important in the Clatskanie River Recovery Population to properly evaluate reintroduction efforts. Finally, the Big Creek Recovery Population has seen large fluctuations in carcass recovery and population size estimates over the last five years. This area is largely influenced by BCH and the Bear Creek Watershed, which supports wild Chum Salmon and is a reintroduction site, making it difficult to deduce what influences population trends. However, population estimates in Core Areas, two of which are in the Big Creek Recovery Population, may be able to illuminate what drives population growth overall. Continued adult monitoring and refinement of population estimates will be essential for evaluating these recovery populations.

Monitoring should also continue in the Cascade Stratum where there were four positive eDNA detections of Chum Salmon adults during the study period. Although no carcasses were recovered, it is most likely that these individuals strayed from more robust Washington populations. It is possible that some Chum Salmon are attracted to recent improvements in spawning habitat conditions in the Clackamas and Sandy Rivers. However, there were no positive detections in the spring, suggesting that adults present in these areas in the fall did not spawn successfully, meaning that Chum Salmon may not be able to successfully reoccupy historically occupied areas on their own, even if overall abundance is high. Therefore, reintroduction activities may be essential for restoring Chum Salmon to many of the recovery populations in the LCR.

MONITORING JUVENILE CHUM SALMON

Background

One objective of the Chum Salmon recovery strategy (ODFW 2010) has been to collect baseline data on natural juvenile Chum Salmon production in Oregon tributaries to the LCR. This monitoring was initiated in 2012 with the installation of rotary screw or fence panel traps in tributary streams to the LCR in the Youngs Bay, Big Creek, Clatskanie River, and Scappoose Creek Recovery Populations. As baseline information was gathered, data collection needs and trapping strategy has shifted (reviewed in Homel et al., 2021). Most recently, PROCS has focused on monitoring juveniles during the spring outmigration (2021–2025) with rotary screw traps in two recovery populations. Specific monitoring sites (from west to east) were: Bear Creek in the Big Creek Recovery Population, and Conyers Creek and Clatskanie River, both in the Clatskanie River Recovery Population. These sites were monitored to quantify the current extent of natural Chum Salmon fry production in each system and measure the success of reintroduction efforts.

Bear Creek Watershed Site

Bear Creek is located 0.4 km west of the town of Svensen, OR and flows north into Svensen Slough and the Columbia River (Figure 14). The lower portion of Bear Creek is primarily rural residential and there is a water storage facility in the watershed that provides water for the town of Astoria, OR. Water withdrawals during summer can result in significant temperature and dewatering issues (Bischoff et al., 2000). Land use in the upper Bear Creek watershed is a mixture of industrial and non-industrial forest land. No hatchery releases occur in Bear Creek but spawning of wild and hatchery Coho Salmon (*O. kisutch)*, Steelhead (*O. mykiss*), and to a lesser extent Chinook Salmon (*O. tshawytscha*) are known to occur in the basin. Bear Creek has approximately 3.2 km of low gradient habitat suitable for Chum Salmon (Bischoff et al., 2000; Alfonse et al., 2017a). Historically, Bear Creek may have supported up to 200 adult Chum Salmon spawners (based on habitat area-spawner density expansions from data in Parkhurst et al., 1950 and Fulton 1970). The Bear Creek system plays a vital role in Chum Salmon recovery efforts in the Big Creek Recovery Population, with natural recolonization and spawning occurring simultaneously with adult outplanting. It is essential to continue monitoring fry production here to track the progress of Chum Salmon presence in the watershed.

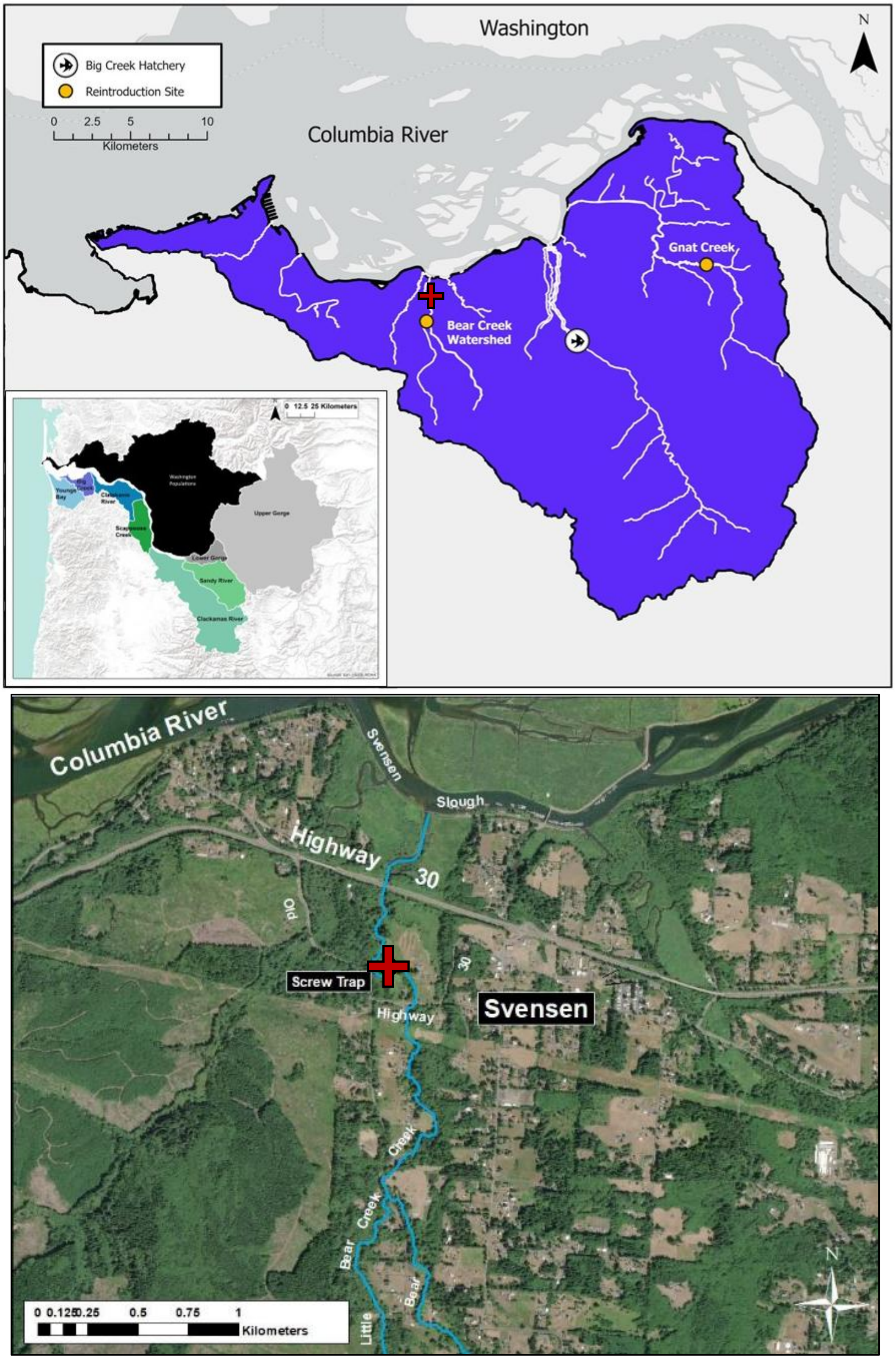

Figure 14. Location of the Bear Creek rotary screw trap from 2021–2023 (red cross) within the Big Creek Recovery Population (top), and the screw trap location in relation to the town of Svensen, Oregon downstream of Old Highway 30 (bottom).

Clatskanie River Site

The Clatskanie River flows through the town of Clatskanie, OR, before entering Beaver Slough and Westport Slough and then the Columbia River (Figure 15). Land use in the Clatskanie River is urban (in Clatskanie), rural residential, agricultural, and industrial timber. High quality spawning habitat currently exists in some areas of the watershed, and numerous additional restoration opportunities to improve lower quality spawning habitat throughout the Clatskanie River system are also possible (Alfonse et al., 2017b). Specific restoration needs include adding large woody debris to the system, bank stabilization, restoration and reconnection of side channel complexes, and reducing excess fine sediment. Despite the imperfect spawning habitat in this system, Coho Salmon, Steelhead, Coastal Cutthroat Trout (*O. clarkii clarkii*), and to a lesser extent Chinook Salmon are now observed with no hatchery releases occurring in the basin. Historically, the Clatskanie River may have supported up to 3,000 Chum Salmon based on expanded estimates of abundance (Parkhurst et al., 1950, Fulton 1970) and potential habitat availability. However, no Chum Salmon adults have been observed in this system for nearly 30 years, until outplanting began in 2021. The Clatskanie River has been continuously monitored by PROCS for juvenile outmigration since 2012, and it is important to continue monitoring to track the progress of the various Chum Salmon reintroduction efforts occurring in the Clatskanie River Recovery Population.

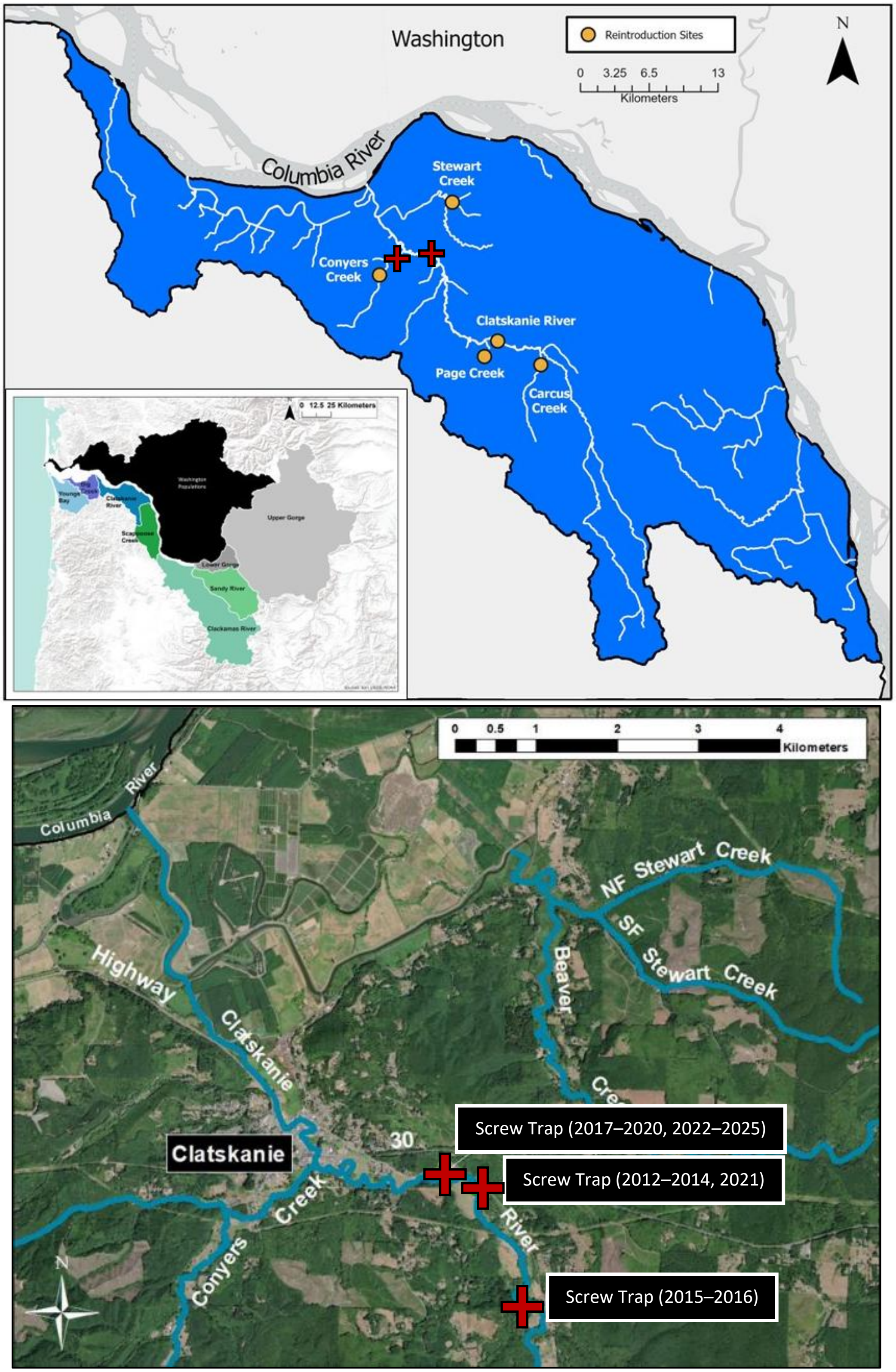

Figure 15. Locations of the Clatskanie River rotary screw trap (red cross) over the years within the Clatskanie River Recovery Population (top), and the trap locations in relation to the town of Clatskanie, Oregon (bottom).

Conyers Creek Site

Conyers Creek is a small tributary stream that flows into the Clatskanie River within the town of Clatskanie, OR (Figure 16). Conyers Creek has a low gradient (<1%) with no barriers present in the lower 3 km near the confluence with Clatskanie River. Within this section, land use is a mix of rural residential, residential, and commercial properties. This lower section of Conyers Creek has substrate dominated by sand, silt, and small gravel and the stream channel is entrenched and disconnected from the floodplain (Alfonse et al., 2017b). Upstream of this section, the gradient increases as the stream runs through agriculture, rural residential, and timber property. Presumably, Chum Salmon spawned in this creek historically (estimated number unknown), but currently only Coho Salmon, Steelhead, Coastal Cutthroat Trout and some Chinook Salmon are observed. PROCS monitored Conyers Creek for any naturally produced juvenile outmigrants in 2012, 2013, and 2016 as an exploratory effort, but discontinued because no Chum Salmon presence was detected. Since 2021, adults have been outplanted in Conyers Creek and juvenile monitoring resumed in spring 2022 and has continued to determine the effectiveness of reintroducing adults to the system.

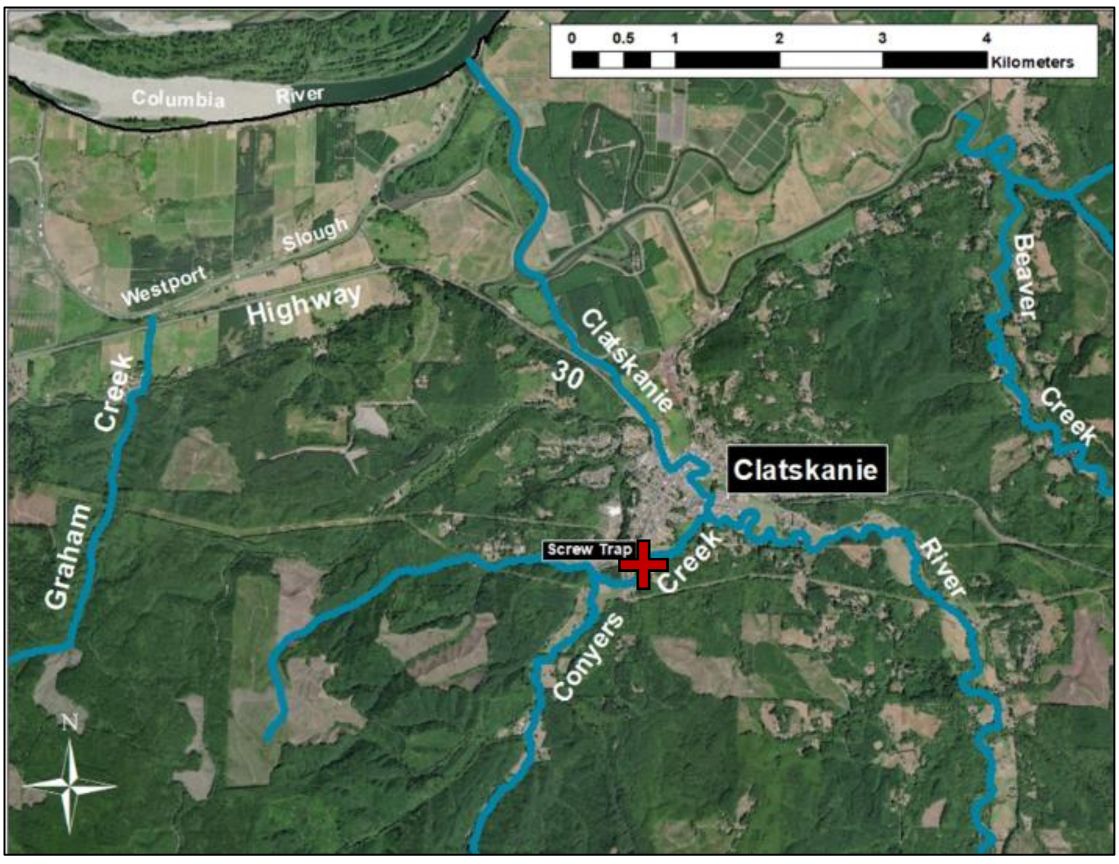

Figure 16. Location of the Conyers Creek rotary screw trap (red cross) from 2021–2025 in relation to the Clatskanie River and the town of Clatskanie, OR.

Methods

Traps generally began fishing in mid to late February and fished continuously (24 hours/day and 7 days/week) through mid-May to early June except during conditions associated with heavy rain, rising water levels, and high debris loads where operation of the trap could endanger personnel or result in fish mortality. Odometers were installed on each trap so that the actual amount of sampling in a 24-hour period could be measured. Rain gauges, temperature loggers, and staff gauges were installed at each trap site so that environmental conditions could be correlated to daily abundance in future analyses.

Fish processing methods follow Wiley and Homel (2021) but are briefly described here for Chum Salmon specifically. During each trap check, Chum Salmon fry were transferred to 5–gallon holding buckets with stream water until they were anesthetized with MS-222 (tricaine methanesulfonate, concentration = 60 mg/L) buffered with baking soda (sodium bicarbonate, concentration = 125 mg/L). Once anesthetized, Chum Salmon fry were enumerated, and fork length (FL) and weight (g) were recorded for up to 50 individuals per day. Genetic samples were also collected from a subset of Chum Salmon fry, depending on the trap location and year. Initially, genetic samples were collected for a subsample of Chum Salmon fry to determine relatedness to adults reintroduced the previous year: Bear Creek (2021 and 2022), Clatskanie River (2022), and Conyers Creek (2022). However, Chum Salmon fry genetic sampling was later minimized because genetic analysis can be cost prohibitive or inconclusive for so many tiny fry tissue samples. From 2023–2025, genetic samples from a subset of Chum Salmon fry were collected from the Clatskanie River site only to determine the production of the previous year's reintroduction activities (i.e., Chum Salmon fry produced from outplanted adults vs. RSI in Page Creek vs. unfed fry released in Page Creek).

Finally, trap efficiency was evaluated for each species and size class by marking up to 100 individuals of each species and size class per day, depending on the characteristics of the trap site and vulnerability of a species size class to recapture. Marks were produced using a razor blade by removing a diagonal slice of the upper caudal fin. Marked fish were then released in a location at least 100 m upstream from the trap site where fish could acclimate sufficiently before migrating downstream in a natural manner. Fish were manually released within 2 hours of marking to minimize overcrowding stress that sometimes occurred in the release buckets. All other fish not needed to evaluate trap efficiency were released safely downstream. Marking and recapture methods were adjusted iteratively throughout the year to maximize recapture rates without exceeding numbers allowed in sampling take permit. Weekly stratified population estimates were made when at least 5 recaptures were obtained for the trapping season, otherwise population estimates were pooled (Package BTSPAS version 2012.0219 in program R; Bonner and Schwarz 2012). Further information on juvenile monitoring methodologies and population estimate selection criteria can be found in Wiley and Homel (2021).

Results

Bear Creek Watershed

In 2023, an estimated 151,402 (93,607–209,197 95% CI) Chum Salmon fry out-migrated from the Bear Creek watershed, the most since monitoring began in 2017 (Table 19). We selected the Stratified Peterson Estimator over BTSPAS based on criteria outlined in Wiley and Homel (2021). However, more moderate estimates of Chum Salmon fry out-migrated in 2024 and 2025 (37,234 and 24,611, respectively), which is comparable to 2021 and 2022 estimates. Consistent reintroduction effort occurred in the Bear Creek Watershed from 2020–2022 (~300 to 400 outplanted females), so we suspect that the 2023 fry outmigration estimate is high because of favorable environmental conditions from November through April. Slightly above average rainfall during the majority of the spawning season (31.47 cm of rainfall in November 2022), only one minor snow event in February 2023 (3.81 cm at sea level), and cooler and wetter spring months (March 2023 was cooler than normal [avg = 6°C] and April 2023 was wetter than normal [21.39 cm of rainfall]; National Weather Service Annual Climatological Report) were probably relatively good conditions for developing eggs and emerging fry. Though not reported here, outmigration estimates for other species in the Bear Creek Watershed were also high in 2023 (e.g., Coho fry, Steelhead smolts), suggesting that conditions were favorable throughout the Bear Creek Watershed.

Based on the number of outplanted females, expected egg deposition, and estimated number of outmigrating fry, expected freshwater survival could be calculated for each year (Table 19). For the 2021 and 2022 trapping seasons, Chum Salmon freshwater survival was less than 4.0%, which is outside the range expected based on the number of outplanted females and is too low to sustain the population (Figure 22; Homel et al., 2021). However, Chum Salmon freshwater survival was 16.5% in 2023, which almost meets the threshold to maintain the population in the Bear Creek watershed. These freshwater survival estimates are likely under estimations since they assume that all outplanted females spawned successfully with 100% egg deposition; however, the contribution of any wild spawners in the watershed is ultimately unknown. From 2020–2022, PROCS outplanted between 300 and 400 females in the Bear Creek Watershed, but with the exception of 2023, expected freshwater survival estimates were very low (<4%). However, when PROCS reduced the number of outplanted females by half in 2023 and 2024, expected freshwater survival estimates more than doubled the following spring. This suggests that environmental conditions must be exceptional to support large numbers of spawning females in the Bear Creek Watershed (e.g., 2023). In years when winter forecasts are expected to be drier or warmer than normal, it might be best to outplant fewer females to maintain fry production in the system. Continued monitoring in the Bear Creek watershed will be needed to determine the effectiveness of reintroduction strategies and to evaluate the recovery status within the Big Creek Recovery Population.

Table 19. Expected freshwater survival estimates of Chum Salmon (*Oncorhynchus keta*) fry out-migrating from the Bear Creek watershed from 2021–2025. Freshwater survival is calculated based on the number of females outplanted the previous fall, average annual fecundity, estimated egg deposition, and the calculated fry estimate from a rotary screw trap.

Trap Year	Outplanted Females	Avg. Fecundity	Est. Egg Dep.	Fry Estimate	Lower 95% CI	Upper 95% CI	Expected Freshwater Survival (Range)
2021	397	2,605	1,034,185	40,249	35,276	45,222	3.89 (3.41–4.37)
2022	320	2,528	808,960	31,568	23,272	44,673	3.90 (2.88–5.52)
2023	311	2,955	919,005	151,402	93,607	209,197	16.5 (10.2–22.8)
2024	121	2,932	354,772	37,234	33,656	43,834	10.5 (9.49–12.4)
2025	165	2,330	384,450	24,611	8,792	84,147	6.40 (2.29–21.9)

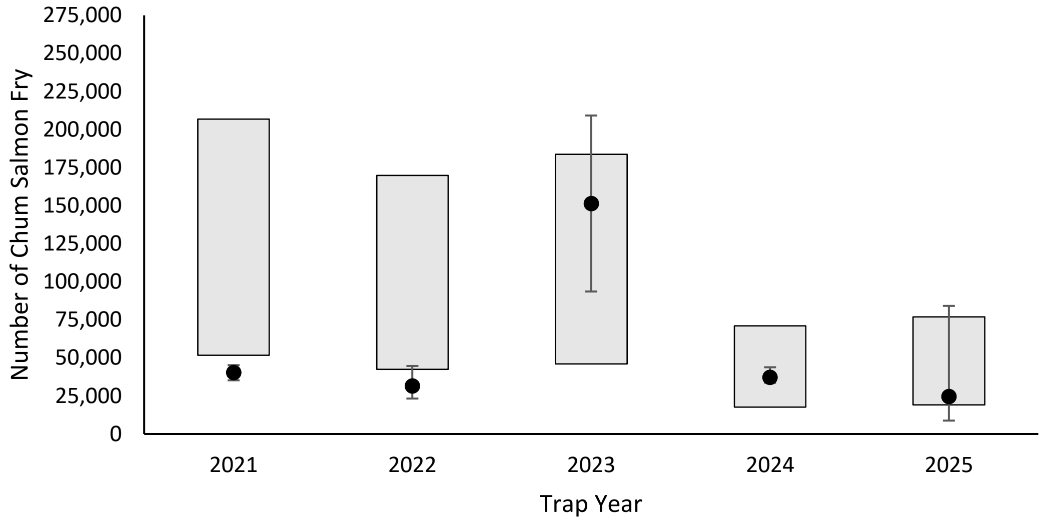

Figure 17. The estimated (black dots; 95% CI bars) and expected (grey boxes) number of Chum Salmon (*Oncorhynchus keta*) fry outmigrating from the Bear Creek watershed from 2021–2025. Estimated fry outmigration is based on recapture rates of individuals captured in a rotary screw trap each year, while expected fry outmigration is based on the freshwater survival scenarios calculated in Table 11.

Clatskanie River

The Clatskanie River has been monitored for juvenile salmonid outmigrants continuously since 2012, but the first estimate of outmigrating Chum Salmon fry was produced in 2022 (48,416; 40,630–59,998 95% CI). There were no Chum Salmon caught in the Clatskanie River trap during the 2012–2016 seasons. In 2017–2018 seasons, the total catch of Chum fry was less than 50, which were individuals found to be related to fish used in an RSI in Perkins Creek (see Homel et al., 2021). However, because reintroduction activities ceased shortly thereafter, no Chum Salmon fry were caught in the Clatskanie River trap from 2019–2021. PROCS was able to resume reintroduction efforts in the Clatskanie River in the fall of 2021 and 2022, resulting in consecutive years of outmigrating Chum Salmon fry estimates. Although fewer adults were outplanted in the fall of 2022, other reintroduction methods (RSI and unfed fry) were used, and fry estimates were similar between years. Based on the number of outplanted females, expected egg deposition, and estimated number of outmigrating fry, expected freshwater survival could be calculated for each year (Table 21). For the 2022 trapping season, Chum Salmon freshwater survival was exceedingly low (<2.60%) despite the large number of females outplanted the previous fall and the expected number of fry (Figure 23). The next year (2022–2023), both the number of outplanted females and the outmigrating fry estimate were lower, but freshwater survival was double (4.68%). This could be because in fall 2022 the sex ratio of outplanted adults was more equal (F:M = 54:46) allowing for more successful spawning or because environmental factors were more favorable. Expected freshwater survival estimates jumped in 2024 and 2025 (33–43%) because of the known numbers of unfed fry released and emerging fry from the Page Creek RSI, practically eliminating any egg to fry mortality. No females were outplanted in the Clatskanie River during these years. These results suggest that variation in environmental conditions and/or the spawning habitat quality in the Clatskanie River may prevent outplanted adults from successfully spawning and ultimately reduce egg to fry survival. Until habitat restoration projects are completed, it might be best to focus on increasing the number of operational RSIs and/or unfed fry releases to support higher freshwater survival. Continued monitoring in the Clatskanie River will be needed to determine the effectiveness of reintroduction strategies and to evaluate the recovery status within the Clatskanie River Recovery Population.

Table 20. Estimated freshwater survival estimates of Chum Salmon (*Oncorhynchus keta*) fry out-migrating from the Clatskanie River from 2022–2025. Freshwater survival is calculated based on the number of females outplanted the previous fall, average annual fecundity, estimated egg deposition, and the calculated fry estimate from a rotary screw trap. No estimate could be generated for the 2021 trap year.

Trap Year	Outplanted Females	Avg. Fecundity	Est. Egg Dep.	Fry Estimate	Lower 95% CI	Upper 95% CI	Estimated Freshwater Survival (Range)
2022	742	2,528	1,875,776	48,416	40,630	59,998	2.58 (2.17–3.20)
2023	220	2,955	746,816[a]	34,951	22,280	66,292	4.68 (2.98–8.88)
2024	0	2,932	154,725[b]	66,658	44,000	159,175	43.1 (28.4–100)
2025	0	2,330	94,748[b]	31,653	4,957	118,975	33.4 (5.23–100)

[a] Calculated based on the estimated eggs deposited from 220 females outplanted, plus the estimated fry emerging from the RSI and the number of unfed fry released.
[b] Based on estimated fry emerging from the RSI and the number of unfed fry released.

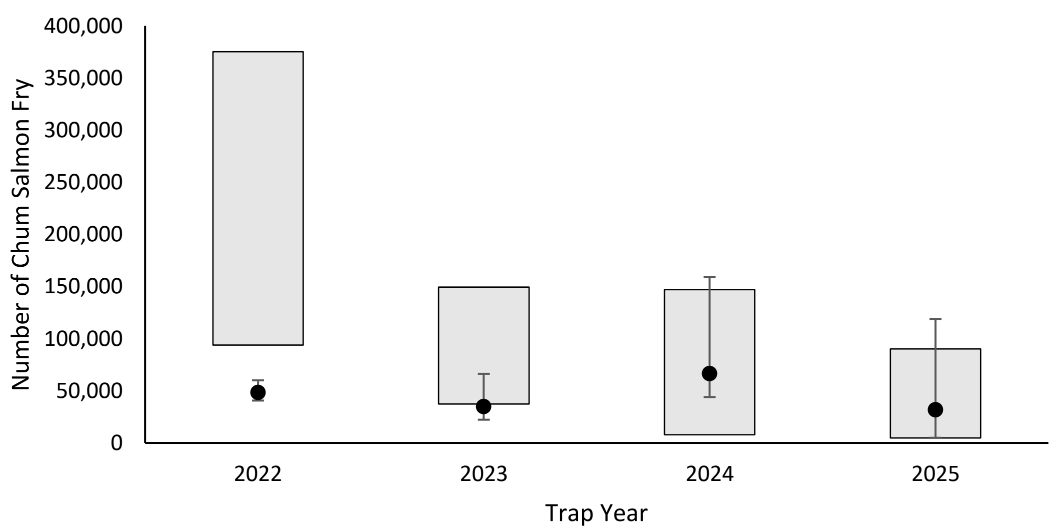

Figure 18. The estimated (black dots; 95% CI bars) and expected (grey boxes) number of Chum Salmon (*Oncorhynchus keta*) fry outmigrating from the Clatskanie River from 2022–2025. Estimated fry outmigration is based on recapture rates of individuals captured in a rotary screw trap each year, while expected fry outmigration is based on the freshwater survival scenarios calculated in Table 15.

Conyers Creek

In 2025, an estimated 11,364 (9,844–13,390 95% CIs) Chum Salmon fry outmigrated from Conyers Creek, the highest since PROCS has been monitoring. Juvenile traps were operated in Conyers Creek in 2012, 2013 and 2016, but no juvenile Chum Salmon were observed. The first

Chum Salmon fry were caught in the 2022 season after the first adult outplanting the previous fall (Table 21). However, in 2023, no direct estimate of Chum Salmon fry outmigration could be made due to low recapture rates. Instead, Coho Salmon fry recapture rates were chosen as a proxy because they have the most comparable trapping efficiency rates of all species encountered in Conyers Creek due to their similarities in size and number. It is possible that either environmental conditions or the number of outplanted females affected the overall Chum Salmon production that year (Smith et al., 2025a). Conditions improved in 2024 and PROCS estimated that 5,197 (2,615–10,568 95% CIs) Chum fry outmigrated from Conyers Creek.

Despite the large number of outplanted females, Chum fry estimates from 2022–2024 were much lower than expected (Figure 19) and had a similar freshwater survival rate (~1%). Chum Salmon recovery in Conyers Creek is not possible with such a low freshwater survival rate. Interestingly, fewer females were outplanted in the fall of 2024 but expected freshwater survival and the estimated number of outmigrating fry increased (Table 21). This suggests that females may not be finding suitable spawning habitat and/or the quality of spawning habitat is too poor to sustain developing eggs. Thus, Conyers Creek may be an ideal place for habitat improvement projects and would probably benefit from large wood structures which create stream complexity and increase the potential for gravel recruitment. Prior to implementing habitat projects, a stream basin habitat survey would help to identify sites for potential restoration. These actions would prove useful in aiding the recovery of Chum Salmon in Conyers Creek moving forward.

Table 21. Estimated freshwater survival estimates of Chum Salmon (*Oncorhynchus keta*) fry out-migrating from Conyers Creek from 2022–2025. Freshwater survival is calculated based on the number of females outplanted the previous fall, average annual fecundity, estimated egg deposition, and the calculated fry estimate from a rotary screw trap. Chum Salmon recapture rates were too low in 2023 to produce an estimate, so Coho Salmon recapture rate was used as a proxy (*).

Trap Year	Outplanted Females	Avg. Fecundity	Est. Egg Dep.	Fry Estimate	Lower 95% CI	Upper 95% CI	Estimated Freshwater Survival (Range)
2022	125	2,528	316,000	3,839	3,299	4,483	1.21 (1.04–1.42)
2023*	81	2,955	239,355	2,420	N/A	N/A	1.01 (N/A)
2024	99	2,932	290,268	5,197	2,615	10,568	1.79 (0.90–3.64)
2025	68	2,330	158,440	11,364	9,844	13,390	7.17 (6.21–8.45)

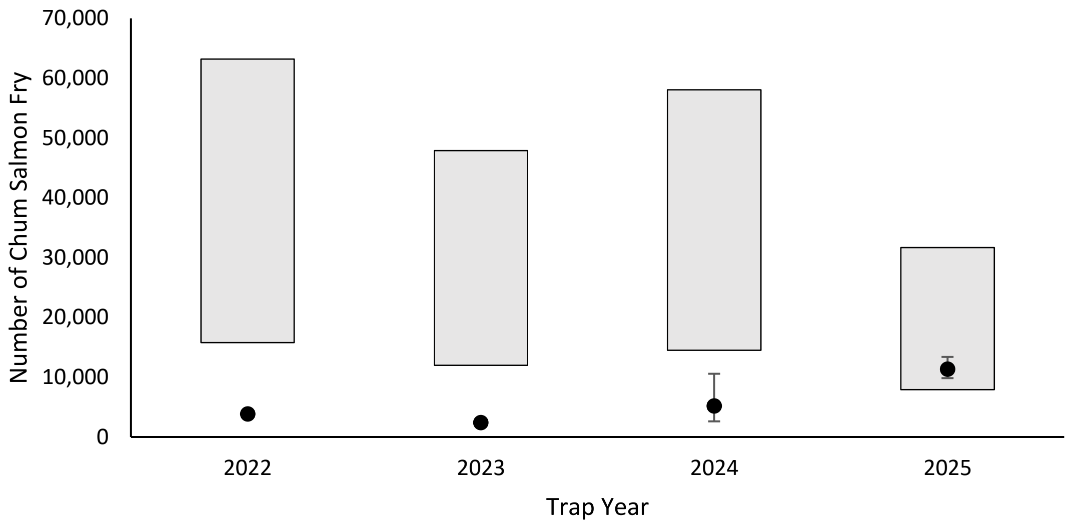

Figure 19. The estimated (black dots) and expected (grey boxes) number of Chum Salmon (*Oncorhynchus keta*) fry outmigrating from Conyers Creek from 2022–2025. Estimated fry outmigration is based on recapture rates of individuals captured in a rotary screw trap each year, while expected fry outmigration is based on the freshwater survival scenarios calculated in Table 15.

Summary of Juvenile Monitoring Efforts

Monitoring juvenile Chum Salmon production is an essential tool to help evaluate the recovery efforts of Chum Salmon in areas where reintroduction is occurring. It is also useful to monitor juvenile production in streams before reintroduction occurs to provide baseline information on the presence or absence of Chum Salmon and other salmonid production in a system. Bear Creek, where reintroductions began in 2020, has had five consecutive years of significant juvenile production, with the highest estimate and freshwater survival being in 2023. Because the effect of wild spawners is unknown, the success of outplanted adults in the Bear Creek Watershed is highly dependent on carrying capacity and annual environmental conditions. Consistent reintroductions did not occur in the Clatskanie River until the fall 2021, and it is notable that before spring of 2022 only a handful of individuals were caught during 10 years of trapping. However, outplanted adults may not successfully spawn or produce viable fry if habitat quality is poor or annual environmental conditions are unfavorable. Although fry production stayed within the average, expected freshwater survival increased in 2024 and 2025 when reintroduction methods focused on operation of an RSI and unfed fry releases in the system. Similar interactions may be occurring in Conyers Creek, where production and freshwater survival are low, but slowly increasing. It’s likely that habitat restoration will drastically improve reintroduction efforts, especially in the Clatskanie River Recovery Population.

PROGRESS TOWARDS CHUM SALMON RECOVERY

The loss of Chum Salmon has had important ecological, economic, and cultural consequences in the LCR and PROCS has made significant progress towards Chum Salmon recovery in Oregon over the last five years. Under the five organizing principles, PROCS has maintained the conservation broodstock at Big Creek Hatchery, continued experiments with several reintroduction methods across two recovery populations, continued to monitor adult spawning and subsequent juvenile production, and collaborated with partners on both habitat restoration projects and other research that would address any limiting factors. Although the latter is ongoing and not reported here, these projects will support reintroduction and monitoring activities already implemented by PROCS.

Progress toward recovering Chum Salmon in Oregon has accelerated in recent years, driven by strong broodstock returns, expanded reintroduction work, and increasingly robust monitoring. Adult returns to Big Creek Hatchery in 2023–2024 were high enough to support a full conservation broodstock, enabling detailed biological assessments and substantial fry production. Although wild-origin fish remained underrepresented and age structure shifted between years, egg-take goals were consistently met. Marine survival has been increasing since 2016, suggesting that well-timed fry releases may help buffer against poor ocean conditions. These gains in broodstock performance form the foundation for long-term recovery in the Coastal Stratum.

Reintroduction efforts have also advanced, with PROCS refining strategies to maximize freshwater survival and overall production. While adult outplanting continued in several watersheds, PROCS prioritized unfed fry releases and operation of one RSI, and both methods have shown high freshwater survival in a variety of systems. Estimates of freshwater survival increased 10-fold in the Clatskanie River in 2023–2024 broodyears despite no adult outplants, due to fry released in Page and Carcus Creeks and fry emerging from the Page Creek RSI. These results highlight the potential for fry-based methods to rapidly increase early survival, which may improve adult returns in subsequent years. Fry-based reintroduction methods may also take priority, especially in years when adult returns to the hatchery limit outplanting capacity.

Adult monitoring data indicates encouraging but uneven progress across recovery populations. In the Youngs Bay Recovery Population, where no reintroduction occurs, carcass recoveries and population size declined in 2023–2024, reflecting natural fluctuations in wild stocks. In contrast, the Clatskanie River Recovery Population has shown a steady increase in carcass recoveries and population size since reintroduction began in 2021, aside from the expected dip in 2023 when few adults were outplanted. The Big Creek Recovery Population continues to show large year-to-year variation, influenced by both hatchery and wild returns and the Bear Creek watershed, but more detailed monitoring in Core Areas may help clarify the drivers of population change. Across all sites, continued adult monitoring will be essential for evaluating recovery progress.

Juvenile monitoring further demonstrates meaningful gains in some systems while identifying challenges in others. The Bear Creek Watershed, where reintroductions began in 2020, has now produced five consecutive years of strong juvenile output. The estimated freshwater survival in the Bear Creek Watershed is comparable to other systems with naturally spawning adults (4-20% freshwater survival), which serves as an important comparison for other systems where limited volitional spawning occurs. Continued monitoring of juvenile production will be important in the Bear Creek Watershed as adult outplanting ceases. Juvenile production in the Clatskanie River has varied over the last four years and success is largely dependent on trapping conditions in such a large system; however, freshwater survival has increased by 10-fold for the 2023-2024 brood years, suggesting that fry-based reintroduction methods may work better in this watershed. In contrast, only adult outplanting has occurred in Conyers Creek and fry production as well as freshwater survival has increased since reintroduction efforts began in 2021. These results further suggest that there may be an ideal reintroduction method or strategy that needs to be implemented for each watershed. Overall, juvenile production is still dependent on habitat conditions, spawning success, or other factors affecting freshwater survival, which are likely limiting recovery and underscores the value of sustained reintroduction.

Taken together, these results show that Oregon's Chum Salmon recovery efforts are gaining traction, supported by strong broodstock performance, promising reintroduction outcomes, and increasingly detailed monitoring. While populations remain far below historical levels and recovery is not yet assured, the program has established a solid foundation for rebuilding abundance, expanding distribution, and improving long-term resilience. Continued refinement of reintroduction strategies, close coordination with hatchery operations, and vigilant monitoring across recovery populations will be critical as PROCS works toward restoring Chum Salmon throughout the Lower Columbia River.

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