Evaluation of Reestablishing Natural Production of Spring Chinook Salmon in Lookingglass Creek, Oregon, Using a Local Stock (Catherine Creek)

Confederated Tribes of the Umatilla Indian Reservation – Evaluation Studies for 1 January 2021 to 31 December 2021

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Cover Photo by Jake Kimbro

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1.1 Abstract

The objective of this study is to evaluate the reintroduction of a local, hatchery-origin spring Chinook salmon stock in Lookingglass Creek using standard sampling methods for anadromous salmonids in the Columbia River Basin. Total returns to the Lookingglass Hatchery trap in 2021 were 530, of which 81 were natural-origin. Of the 530 returns, nearly half were jacks (n=248). Adult returns released above the Lookingglass Hatchery weir totaled 171 and spawning ground surveys yielded 46 redds upstream of the hatchery trap, and 21 downstream . Brood year 2016 recruits per spawner was 0.2 for adults only (excluding jacks/jills?). We estimated 7,232 (131 outmigrants/redd) juveniles outmigrated from above Lookingglass Hatchery for brood year 2019. Survival probabilities to Lower Granite Dam ranged from 0.256-0.563 for all juveniles within PIT-tag groupings. Smolt equivalents (outmigrants surviving to Lower Granite Dam) totaled 2,794. Harmonic mean travel time to Lower Granite Dam for brood year 2019 was 267, 226, 191, and 37 days for summer, fall, winter, and spring groups, respectively. Brood year 2016 smolt-to-adult ratio was 2.5 for adults only.

1.2 Introduction

This is the latest in the series of annual progress reports documenting the reintroduction of spring Chinook salmon to Lookingglass Creek (LGC), tributary to the Upper Grande Ronde River in the Snake River Basin in northeastern Oregon (Figure 1). Many stocks of anadromous salmon in the Columbia River Basin have experienced severe declines in abundance or become extirpated over the last several decades (Nehlsen, et al., 1991). Hatcheries were built in Oregon, Washington and Idaho under the LSRCP to compensate for the loss of anadromous salmonids due to the construction and operation of the four Lower Snake River dams. The endemic Lookingglass Creek stock of spring Chinook salmon was extirpated within a few years after establishment of Lookingglass Hatchery (LH) in 1982. No fish had intentionally been released upstream of the LH weir since the construction of the hatchery, with the exception of a few fish in 1989. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR), along with co-managers Oregon Department of Fish and Wildlife (ODFW) and the Nez Perce Tribe (NPT), began work in the early 1990's to reestablish natural production of spring Chinook salmon in LGC. Lookingglass Creek was chosen as a good location to evaluate such a study due to the existence of a weir, presumed quality habitat, and an existing dataset from the endemic era population (Lofy & McLean, 1995). Several hatchery stocks, including remnants of the LGC endemic stock, Imnaha River, Carson Hatchery (Washington), and Rapid River (Idaho) were all used before co-managers settled on Rapid River stock. This study continued through the mid and late 1990's, until co-managers decided that adults should not be released upstream of the weir due to potential increases in pathogens in the water supply. This stock was phased out, and was later replaced with Catherine Creek (CC) captive broodstock (Gee, et al., 2014) progeny as the initial donor stock. This stock was chosen since CC stock are native to the Grande Ronde Subbasin and had similar habitat and attributes to LGC. The first CC juvenile hatchery-reared release occurred as pre-smolts in

September 2001, and the first adult releases upstream of the LH weir occurred in 2004. CC hatchery-origin (HOR) spring Chinook salmon have spawned successfully in nature, produced outmigrants, and these outmigrants have returned as adults to LGC. The first naturally produced returns occurred in 2007 as jacks and the first complete brood year occurred in 2009. Current management practices include the release of both HOR and natural-origin (NOR) returns to spawn in nature above the LH weir, and the use of both HOR and NOR returns in a conventional brood stock program at LH. Annual reports describing past progress in reestablishing natural production of spring Chinook salmon in LGC are listed in the Literature Cited.

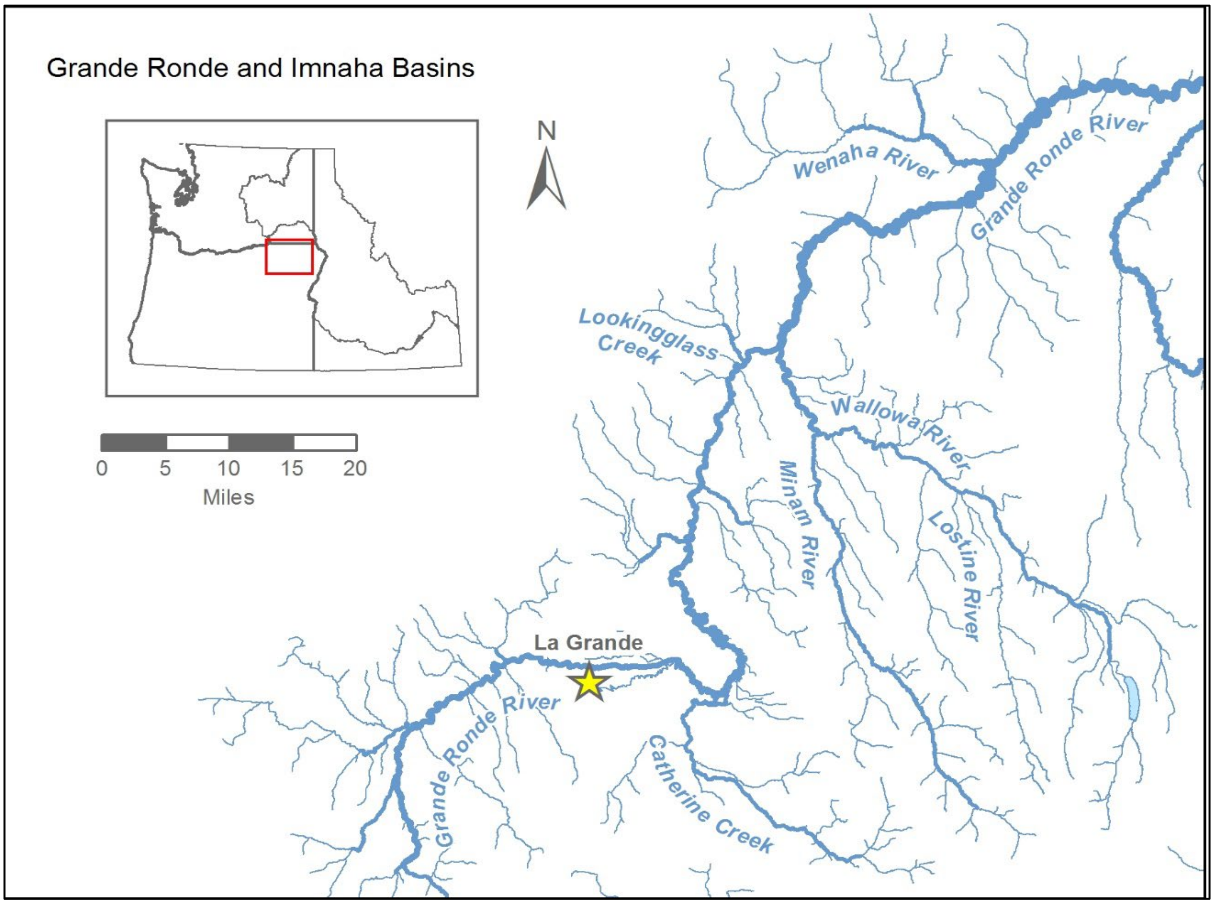

Figure 1. Location of Lookingglass Creek and the Grande Ronde Basin.

This project is guided by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) Department of Natural Resources (DNR) Mission Statement (Jones, et al., 2008)

"To protect, restore, and enhance the First Foods - water, salmon, deer, cous and huckleberry – for the perpetual cultural, economic and sovereign benefit of the CTUIR. We will accomplish this using traditional ecological and cultural knowledge and science to inform: 1) population and habitat management goals and actions; and 2) natural resource policies and regulatory mechanisms.

and the CTUIR Department of Natural Resources, Research, Monitoring and Evaluation Mission Statement:

"Generate knowledge regarding the biological performance and ecology of aquatic species of the first food order in a scientifically credible and policy relevant manner to inform management and policy decisions."

The CTUIR project goals are to evaluate the reintroduction of spring Chinook salmon into LGC using the CC stock, increase tribal harvest, and maintain a gene bank for the CC donor stock (ODFW, 2011). LGC is within the usual and accustomed areas of gathering for the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) under the Treaty of 1855 (Gildemeister, 1998). The CTUIR focuses on reestablishment of the natural population above the LH weir and ODFW on the hatchery component (Feldhaus, et al., 2011). Using the natural component of LGC fish, the CTUIR will study status and trends based on the Viable Salmonid Population metrics of abundance, population growth, spatial distribution and diversity. Metrics for abundance include total returns of adults, hatchery vs. natural proportions, sex ratios, redd counts, and juvenile outmigrant estimates. Metrics evaluated for population growth include recruits per spawner, smolt-to-adult-returns (SAR's), and juvenile survival to the dams. Spatial distribution includes redd distribution and juvenile rearing. Genetic diversity is monitored with tissue analyses, to include an ongoing relative reproductive success study (coordinated with the Columbia River Inter-Tribal Fish Commission and funded by the Bonneville Power Administration – Project # 2009-009-00), as well as looking at age structure, migration and spawn timing, and juvenile emigration. All of these metrics will be outlined and discussed in this report.

1.3 Program Objectives

Program specific objectives stated in the Hatchery and Genetic Management Plan (ODFW, 2011) for the LGC program include:

1. Restore and maintain viable naturally spawning populations of Chinook salmon in LGC.
2. Contribute to recreational, commercial and tribal fisheries in the mainstem Columbia River consistent with agreed abundance based harvest rate schedules established in the 2017-2028 *U.S. vs. Oregon* Management Agreement.
3. Establish adequate broodstock to meet annual production goals.
4. Establish a consistent total return of Chinook salmon that meets the LSRCP mitigation goal. There are no historical LSRCP or Tribal Recovery Plan (TRP) hatchery and natural adult return goals identified specifically for LGC. However, LSRCP does have a specific spring/summer Chinook goal of 58,700 hatchery adults for the Snake River and historical goal of 5,820 hatchery adults into the Grande Ronde Basin. The TRP return goal for the Grande Ronde Basin is 16,000 adults.
5. Re-establish historic tribal and recreational fisheries.
6. Minimize impacts of hatchery programs on other indigenous species.
7. Operate the hatchery program so that the genetic and life history characteristics of hatchery fish mimic those of natural fish, while achieving mitigation goals.

1.4 Study Area

Lookingglass Creek originates at Langdon Lake in the Blue Mountains of northeast Oregon at an elevation of 1,484 m above sea level. Gradient is approximately 3% and flow is to the southeast for 25 river km (rkm) through a relatively steep walled canyon within the Umatilla National Forest. The creek then flows through private land with a comparatively wider floodplain for approximately 2.7 km before entering again a narrow canyon down to the Grande Ronde River at rkm 137 (718 m above sea level). A 27-year dataset showed mean monthly flows ranging from 1.5-2.3 m^3/sec during the base flow period of July-December to 9.5-11.2 m^3/sec during spring runoff in April and May. Peak flow during this period was recorded in 1996 at 60.0 m^3/sec. LGC stream flow information was collected by electronic data recorders operated by the U. S. Geological Survey near LH from August 1982-September 2009 (http:/nwis.waterdat.usgs.gov).

One major tributary (Little Lookingglass Creek, upstream of the mouth of Lookingglass at rkm 6.4) and four smaller tributaries (Lost Creek, rkm 17.3; Summer Creek, rkm 16.5; Eagle Creek, rkm 13.3: and Jarboe Creek, rkm 3.6) contribute to LGC (Figure 2). All or nearly all spring Chinook spawning occurs in LGC and Little Lookingglass Creek (LLGC). LH is located from rkm 3.6 to 4.1 on LGC. Upstream migration of returning adult spring Chinook salmon is controlled by the LH weir and trap at rkm 4.1.

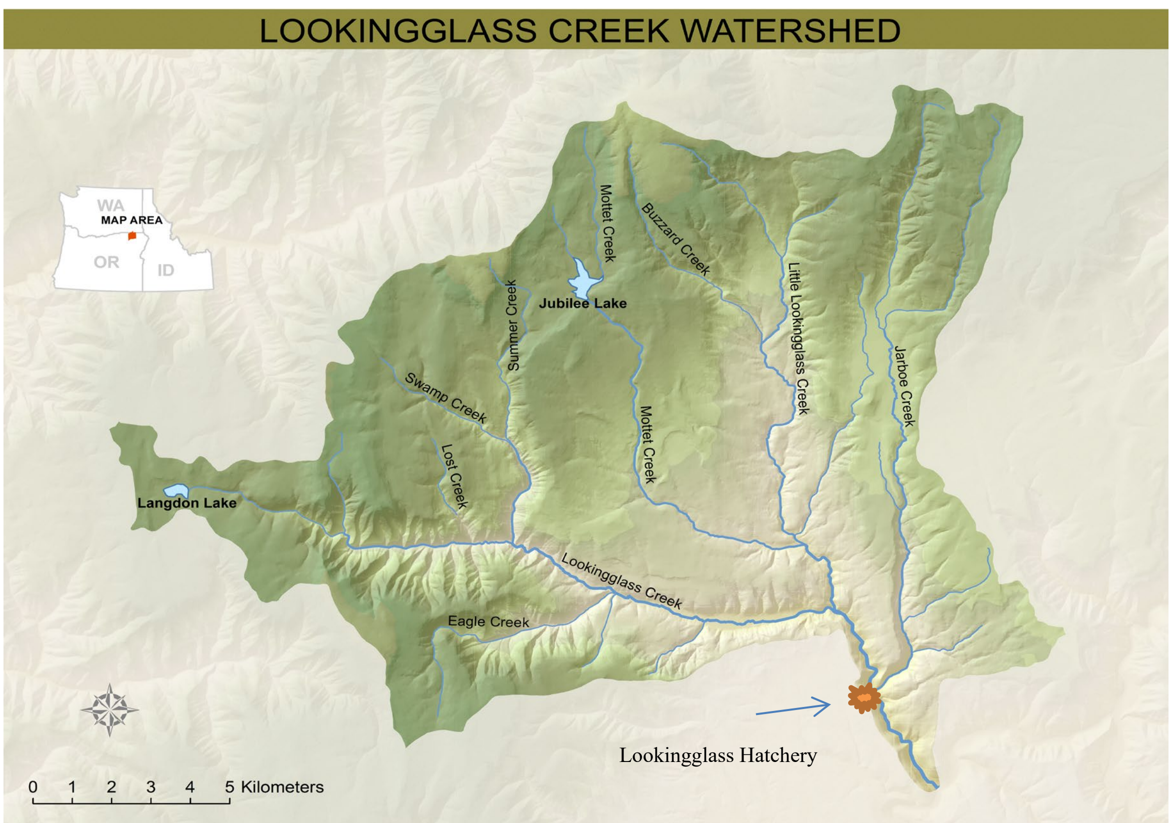

Figure 2. Lookingglass Creek watershed showing major and minor tributaries.

1.5 Methods

1.5.1 Adult Spring Chinook Salmon

Adult Returns to the LH Weir

Adult spring Chinook salmon returning to LGC are diverted by a picket weir into a trap near the LH water intake (Figure 3). The ODFW LH staff installs and operates the picket weir and trap annually from 1 March through mid-September. The trap is checked at least 3 times (Monday, Wednesday, Friday) weekly. ODFW LH staff record catch data and these are reported in detail in annual reports for the Spring Chinook Salmon Evaluation Studies, available on the LSRCP website (https://www.fws.gov/media/oregon-department-fish-and-wildlife-reports).

Figure 3. Lookingglass Hatchery adult trap located at rkm 4.1.

In 2018, the CTUIR Operations and Maintenance staff assisted ODFW with modifications to the lower adult trap on Lookingglass Creek (Figure 4 & 5), which had not been used for over ten years. Using this lower ladder in conjunction with the upper ladder was an attempt to increase broodstock collection and increase the number of fish released above the weir. CTUIR monitoring of redd spatial and temporal distributions 2004 to present showed that each year a large proportion of Chinook were not entering the upper ladder and instead were holding and spawning below the weir, many of which spawned near the LH. After presenting these data, an agreement was made by the co-managers that the lower ladder would be operated in 2018 and run in conjunction with the upper ladder. The agreement specified that the lower ladder would not be used until harvest was closed so that any available Chinook in lower LGC would have the opportunity to be harvested by tribal and/or recreational fisherman. Chinook entering the lower ladder and captured/handled would be differentially marked with 2 right opercle punches, while upper ladder collections would continue to receive 1 right opercle punch. The differential mark would allow us to identify different capture rates of HOR/NOR at the lower ladder (possibly due to an attraction to hatchery discharge). Additionally, the marking could document fallback below the picket weir (Figure 3) between HOR/NOR, and identify possible temporal or spatial spawning location differences. Operating both traps is planned to continue as a management tool and is part of the updated Lookingglass Creek Hatchery Management Plan as low adult return numbers are expected to persist (Section 1.8).

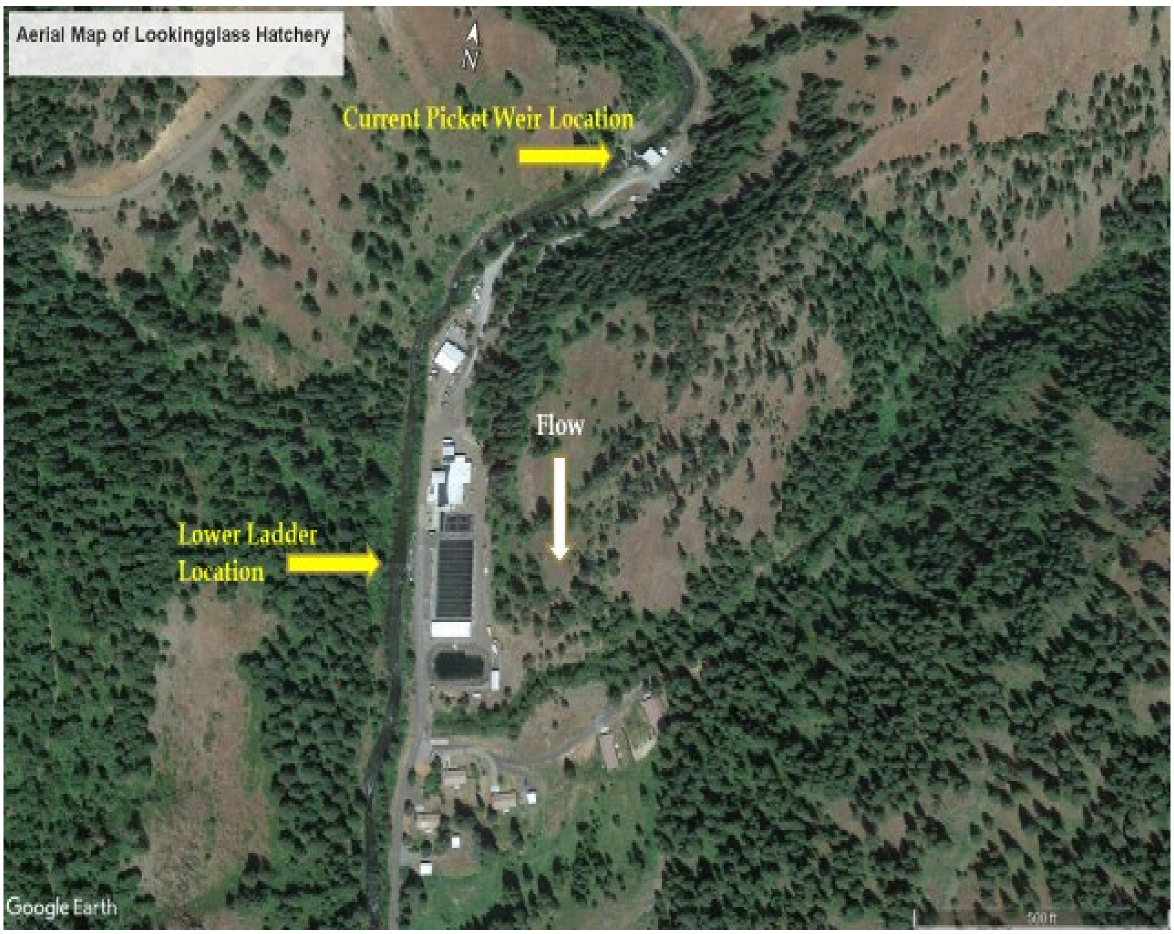

Figure 4. Aerial imagery showing the current picket weir location and the location of the lower ladder used for collections in 2021.

Figure 5. CTUIR Operations and Maintenance crews working on getting the lower Lookingglass trap working (May 2018). The first day consisted of drilling holes for the stations, boards were placed the following day.

Adult spring Chinook salmon captured in either LH trap in 2021 could have been from several sources: LGC natural or hatchery production, Grande Ronde Basin stocks (including Upper Grande Ronde River stocks) or hatchery or natural origin strays from outside the basin. Disposition of returns is determined based on a sliding scale (Section 1.7 of this report). Adult NOR and HOR returns were either passed upstream to spawn in nature or held for broodstock needs. Adults are classified as fish ages 4 and 5 (≥601mm) and jacks as age 3 (≤ 600 mm). In years where there are surplus HOR jacks, they may be sacrificed and provided to the local food bank or for ceremonial subsistence, or recycled downstream of the LH weir to supplement the fishery. No HOR jacks have been intentionally placed upstream of the weir since 2012 as per the LGC management plan.

Releases Above the LH Weir

In 2021, adults were released approximately 0.4km upstream of the adult ladder (Figure 6). All adults were measured (mm FL), sexed, scanned for PIT tag, and a small amount of tissue from the right opercle was removed with a round paper punch and placed in Rite in the Rain envelopes for later genetic analysis. The presence or absence of these opercle punches were also used to distinguish any spawners above the weir that were not handled at the trap and for estimating the spawning population and trap efficiencies. Scales were collected and aged on NOR returns passed upstream. Ages for a portion of the HOR returns were determined by Coded Wire Tag (CWT) data from the Regional Mark Information System (RMIS) database maintained by the Pacific States Marine Fisheries Commission (http://www.rmpc.org/). These CWT were collected from carcasses during spawning surveys.

Figure 6. Lookingglass Hatchery upstream adult weir and ladder. Adults are released 0.4km upriver.

Spawning Ground Surveys

Spawning ground surveys were conducted using the methods described in (Parker, et al., 1995) and (Crump & Van Sickle, 2016) [https://www.monitoringresources.org/Document/Protocol/Details/1843] during August-September 2021 to assess the temporal and spatial distribution of natural spawning. Several pre-spawn mortality surveys were also conducted in July and early August to collect carcass information and determine when the first redd was observed. Surveys were conducted in all 5 stream units each week after the first redd was observed (Figure 7). Only completed redds were counted, flagged, and a GPS point taken to eliminate double counting (Lofy & McLean, 1995; Crump & Van Sickle, 2016). Survey crews used a new app called Survey123 that was developed by CTUIR GIS staff and implemented in the field. Data collected with this app was identical to previous paper recording efforts however, the advantage with the app was the automatic upload to the CTUIR Central Database Management System (CDMS).

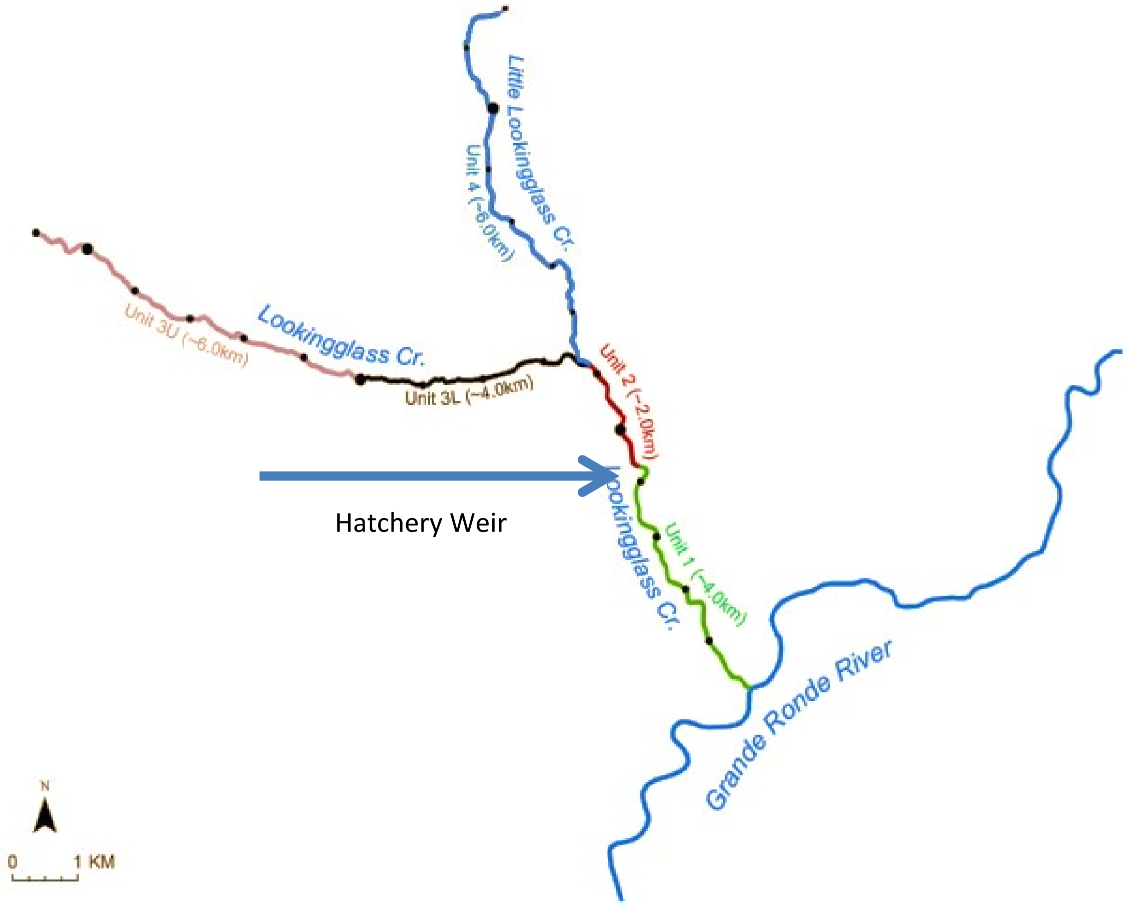

Figure 7. Lookingglass Creek section breaks for spawning surveys. Unit 1 is below the weir, while all other units are above.

Carcass Recoveries

Carcasses were enumerated and fork length (mm), sex, and external marks or fin clips were recorded for all fish, while percent spawned is recorded for females. Females that had spawned ≤ 50% were considered pre-spawn mortalities. The entire caudal fin at the caudal peduncle was cut and removed from sampled carcasses to prevent double sampling in the subsequent weeks. Snouts were taken from all carcasses with a CWT present. Above the weir this should only be on fish with an existing adipose clip, however below the weir this could also include unclipped fish that have strayed from the Upper Grande Ronde. Coded wire tag data were used for determining strays that spawned above and below the weir in addition to identifying the age of the fish. Kidney samples were taken from a portion of the carcasses to determine incidence of bacterial kidney disease for an ODFW monitoring effort (O'Connor & Hoffnagle, 2007).

Population Estimate and Spawner Estimate Above the Weir

Population estimates of fish above the LH weir were made for fish ≤ 600 mm FL (jacks) and ≥ 601mm (age 4, 5 adults) using the Chapman modification of the Petersen method (Ricker, 1975). Fish marked with an ROP recovered below the picket weir were removed from the total numbers of fish released, as these appeared to have fallen back and did not contribute to spawning in reaches upstream of the weir.

The standard error of the mean was calculated as follows:

$$SEM = \sqrt{\frac{(M)(n)(M-R)(n-R)}{R^3}}$$

where, M=number of marked fish released above the weir, n=number of carcasses recovered above the weir, R=Number of punched/marked carcasses recovered (Brower, 1977).

The spawner estimate above the weir was obtained by multiplying the percent of female pre-spawn mortality recoveries (those ≤50% spawned out) on spawning ground surveys to the population estimate above the weir. However, between 2017 and 2021, so few carcasses were recovered above the weir that assessment of pre-spawn mortality was not calculated. Thus, an average of all of the years since the reintroduction began (2004-2016) was used as the percent of pre-spawn mortality (Joseph Feldhaus-Oregon Department of Fish and Wildlife, personal communication 2017).

Recruits/Spawner
Recruits per spawner was calculated by dividing the total number of spawners (HOR and NOR) estimated to be above the weir for a given brood year (BY), by the total number of NOR offspring returning as adults to LGC weir for the completed BY. This includes offspring of both HOR and NOR that have naturally spawned and returned.

1.5.2 Juvenile Spring Chinook Salmon

Screw Trap Operations
We operated a 1.52 m diameter rotary screw trap at rkm 4.0 on LGC, which is 0.1 rkm below the LH adult trap (Crump, 2010). The rotary trap captures outmigrating naturally-produced juvenile spring Chinook salmon, as well as O. *mykiss*, dace, sculpin, and bull trout (Figure 8). Trap operation was suspended during high spring freshets, midsummer during low flows when temperatures were high and also when iced up in winter. Except for the spring freshet, these are periods when there are historically few outmigrants. We made no attempt to estimate outmigrants during these periods. The trap was checked three times per week or more frequently if catches or flows were high. All outmigrants were identified, counted, examined for external marks or injury, and scanned for PIT tags. A portion of these captures were also PIT tagged, measured (nearest mm FL), and weighed (nearest 0.1 g) each week. Only Chinook over 60mm were PIT tagged and used for trap efficiency estimates. Fish were PIT tagged using a 10 ml hand held syringe, while inserting the tag on the underside of the fish (PIT Tag Steering Committee, 1999). These PIT tagged fish were released about 100m above the trap. All other fish (counted, measured, recaptures, fry, precocials) are released below the trap (Crump, 2010). Some BY 2020 fry or small parr were caught during January-June of 2021 and were not marked or used in trap efficiency or outmigration estimates.

Figure 8. Rotary screw trap located at rkm 4.0 on Lookingglass Creek.

Outmigrant Estimate

We used DARR 3.4.4 (Bjorkstedt, 2008) to estimate the numbers of outmigrants. DARR uses stratified mark-recapture data and pools strata with similar capture probabilities. DARR calculates an estimate by using the total number of first time captures, the total number of marked individuals, and the recaptures of those marked fish over the migration period. We used the "one trap" and "no prior pooling of strata" options available in DARR. Outmigrants collected at the screw trap could be distinguished into brood years based on marks or size. The fall group of NOR BY 2019 fish was caught, PIT-tagged and released from 1 July-30 September 2020, the winter group from 1 October-31 December 2020, and the spring group from 1 January-30 June 2021. Metrics are described by Hesse et al. (2006) and correspond to the basic categories of abundance, productivity, and diversity for viable salmonid populations (McElhany, et al., 2000).

Survival Estimates and Smolt Equivalents

We estimated survival, capture probability, and travel time of PIT-tagged captures using the Pacific States Marine Fisheries Commission PIT tag database at http://www.ptagis.org/ and PitPro (Westhagen & Skalski, 2009). We used the standard configuration in PitPro, excluded the *.rcp file (recapture), and included the *.mrt file (mortality). Observation sites, in downstream order, were Lower Granite Dam, Little Goose Dam, Ice Harbor Dam, Lower Monumental Dam, McNary Dam, John Day Dam, The Dalles, and Bonneville Dam. Bonneville Dam was selected as the last recapture site. Smolt equivalents (S_{eq}) for BY 2019 natural production above the weir were calculated as the seasonal outmigrant estimate (fall, winter, spring) multiplied by each seasonal survival estimate to Lower Granite Dam.

SAR's

Smolt to Adult Returns (SARs) were calculated as the number of returning NOR adults to the weir from a given BY divided by the estimate of outmigrating NOR smolts surviving to LGD (S_{eq}) for that BY. SAR's for HOR releases into LGC are calculated and reported by ODFW under LSRCP contract number F16AC00030 (https://www.fws.gov/media/oregon-department-fish-and-wildlife-reports).

Monthly Sampling

We monitored seasonal growth of naturally-produced BY 2019 spring Chinook salmon by obtaining fork lengths (mm) and weights (+/- 0.1 g) of up to 50 fish collected by snorkel/seining at two locations above the LH adult trap (rkm 8.9, and 10.5) on the 20th (+/- 5 d) of July, August, September 2020. Burck (1993) used similar methods to describe growth of juvenile spring Chinook salmon during the endemic era (1964-1970) and also sampled juveniles at rkm 8.9, known as the standard site.

Precocials

A small amount of precocious Chinook salmon are captured in the rotary screw trap each year, usually during the August and September months when adult Chinook are spawning. There are also a small number captured during our monthly sampling and summer parr sampling efforts (described below). We take fork length and weights, as well as genetic samples from these fish, so that their contribution to the population can be identified from the relative reproductive success study that is ongoing (see BPA Project # 2009-009-00 for genetic analysis details) .

Summer Parr Sampling

We targeted approximately 1,000 BY 2019 parr using snorkel/seine methods from the primary rearing area (rkm 8.9- 12.0) above LH in early August 2020. These tagged fish are used to monitor reach specific stream survival to the screw trap while also providing a sample of fish to determine survival to Lower Granite Dam (LGD). A remote station was set up at rkm 10.0 to process these fish. These fish were PIT-tagged using standard procedures (PIT Tag Steering Committee, 1999) and released back to site of capture. Recaptures in the screw trap of these PIT-tagged parr (referred to later in document as summer group) were not reused for trap efficiency but counted as unmarked first time captures and released below the screw trap.

1.5 Results/Discussion

1.5.1 Adult Abundance

Returns to the LH weir

There were a total of 449 HOR and 81 NOR returns to the LH weir in 2021 (Figure 9). This is a combined total for both the upper ladder and the lower ladder. The lower ladder was operational on 25 June after tribal harvest was complete. The CTUIR Tribal harvest information can be found at (Contor C.R., 2020). Out of the 530 total returns, 262 of the fish were captured in the lower ladder (225 HOR and 37 NOR) between 25 June and 5 September. It is of note that nearly identical numbers of fish were caught in the upper and lower ladders (n=269 upper, n=262 lower), even though the lower ladder was operational for a much shorter time frame (n=41 upper ladder, n=31 lower ladder). Both the upper and lower ladder had nearly identical HOR to NOR return ratios at

84% and 86%, respectively. In general, there had been an upward trend in returns since reintroduction efforts began in 2004. However, run year 2017 through 2021 returns were extremely low for both HOR and NOR (Figure 9). This year was also unusual in that 47% of the total run were aged 3 jacks.

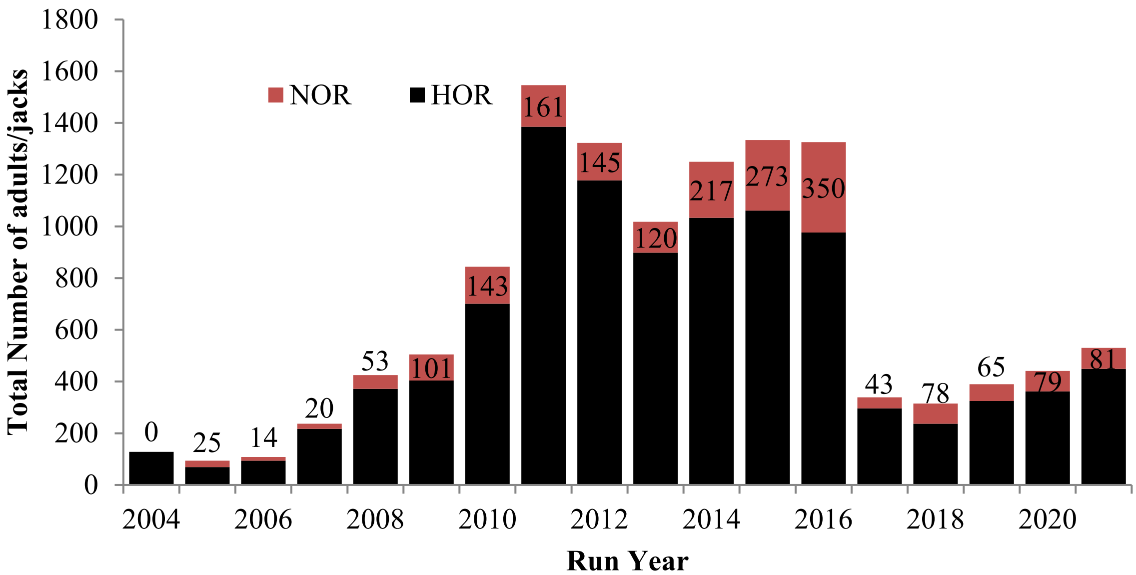

Figure 9. Lookingglass Creek spring Chinook HOR vs NOR total returns to the weir, RY 2004-2021. These data include fish taken for broodstock and those passed upstream of the weir.

When looking at completed NOR BY returns (Table 1), the estimated age composition based on fork length of NOR returns to the LH weir for completed BY 2016 were 11 (12%) age 3, 70 (79%) age 4, and 8 (9%) age 5 . There were 207 redds above the weir for BY16, which was very similar to BY14 in adult returns and redd numbers. Age composition of NOR returns in most years has been dominated by age 4, but substantial numbers of age 3 returns occurred in RY 2009-2011 and 2013-2015. In RY 2013, age 3 NOR returns surpassed both age 4 and 5 returns combined and may have contributed to the low numbers observed for the complete BY 2013 totals.

Arrival of the first NOR Chinook to the LH weir has ranged from 12 May to 15 June between RY 2007 and 2021 (Table 2). The last NOR Chinook to arrive has been between 26 August and 12 September.

Table 1. NOR returns to the LH weir for each Run Year (RY), and by completed Brood Year (BY) with age based on fork length.

Returns by RY					Returns by Completed BY				
	Age					Age			
RY	3	4	5	Totals	BY	3	4	5	Totals
2007	7			7	2004	7	46	9	62
2008	4	46		50	2005	4	69	9	82
2009	24	69	9	102	2006	24	124	14	162
2010	17	124	9	150	2007	17	120	15	152
2011	30	120	14	164	2008	30	129	12	171
2012	3	129	15	147	2009	3	47	14	64
2013	60	47	12	119	2010	60	174	11	245
2014	35	174	14	223	2011	35	228	26	289
2015	35	228	11	274	2012	35	325	10	370
2016	6	325	26	357	2013	6	18	7	31
2017	15	18	10	43	2014	15	62	12	89
2018	9	62	7	78	2015	9	42	5	56
2019	11	42	12	65	2016	11	70	8	89
2020	13	70	5	88					
2021	28	52	8	88					

**2004 were the first outplants above the weir, therefore the first NOR returns were in 2007 as jacks.*

Table 2. Dates of first, median, and last returns to the adult trap for NOR Chinook, RY 2007-2021.

RY	First	Median	Last
2007	3-June	11-June	3-Sept
2008	12-June	2-July	8-Sept
2009	5-June	18-June	26-Aug
2010	26-May	21-June	27-Aug
2011	1-June	22-June	7-Sept
2012	29-May	12-June	27-Aug
2013	12-May	12-June	6-Sept
2014	16-May	22-June	5-Sept
2015	13-May	2-June	9-Sept
2016	20-May	7-June	8-Sept
2017	15-June	3-July	12-Sept
2018	27-May	26-June	8-Sept
2019	3-June	20-June	6-sept
2020	1-June	24-June	8-Sept
2021	31-May	25-June	8-Sept

Releases above the LH weir

During the early years (2004-2006) of the current reintroduction era, small numbers were released above the LH weir (Figure 10). In 2012 and 2015, the current reintroduction era numbers released above the weir surpassed the endemic study era high of 727 (Burck, 1993) (Lofy & McLean, 1995) with 926 and 769 respectively. Prior to 2017, the population had appeared to be on an overall upward trend. Numbers since have been much lower. After the removal of fish for broodstock there were 104 HOR and 67 NOR passed above the weir in 2021, for a total of 171 (Figure 11). Of the 171 total fish passed upstream, 87 were captured at the upper trap and 84 were captured at the lower trap. Of the 104 HOR released upstream, all but one were estimated as age 4 and 5 adults. Of the 67 NOR Chinook passed upstream, 39 were estimated as age 4 and 5 adults and 28 as jacks. There were a total of 91 females released, which were 74% HOR.

HOR fish were 100% of the Chinook released above the LH weir in 2004-2006. Since then, HOR releases have ranged from 39% to 90% of the total, with an average over those 15 years of 70%. While we do release some NOR jacks upstream to spawn naturally, beginning in 2012 no HOR jacks have been intentionally released upstream of the LH weir. The sex ratio above the weir has been kept near 1:1 for most years (Figure 12).

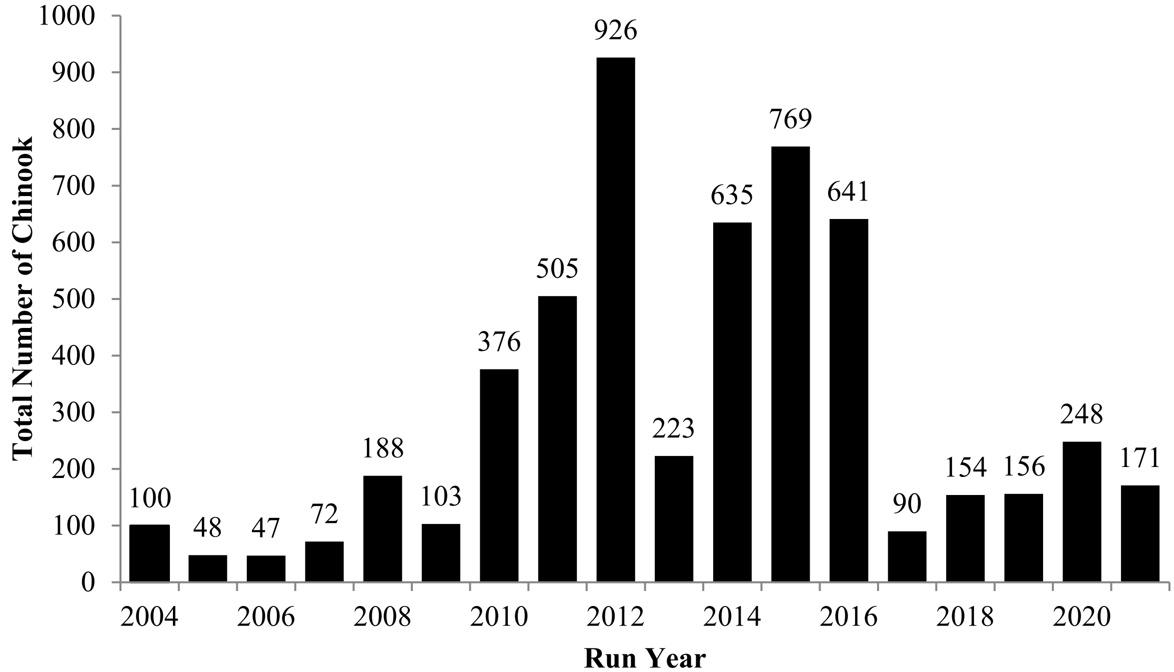

Figure 10. Lookingglass Creek spring Chinook salmon total releases above the weir, RY (Run Year) 2004-2021. Includes all ages, hatchery and natural origin.

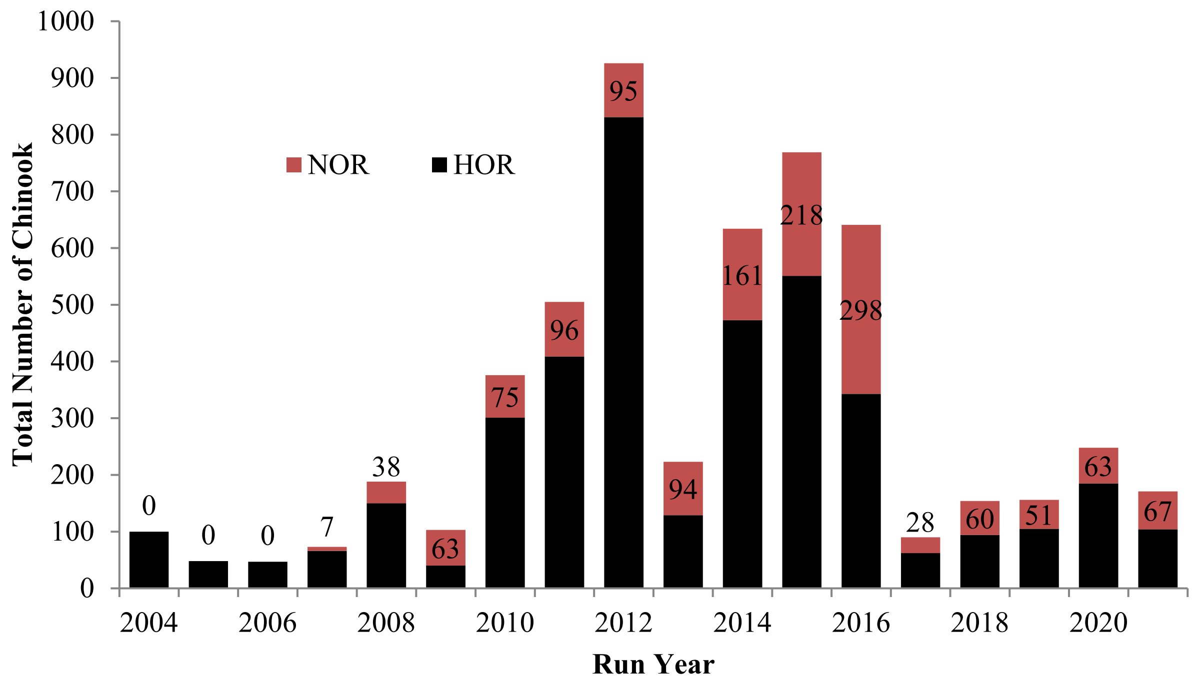

Figure 11. Lookingglass Creek spring Chinook HOR vs NOR total releases above the weir, RY 2004-2021.

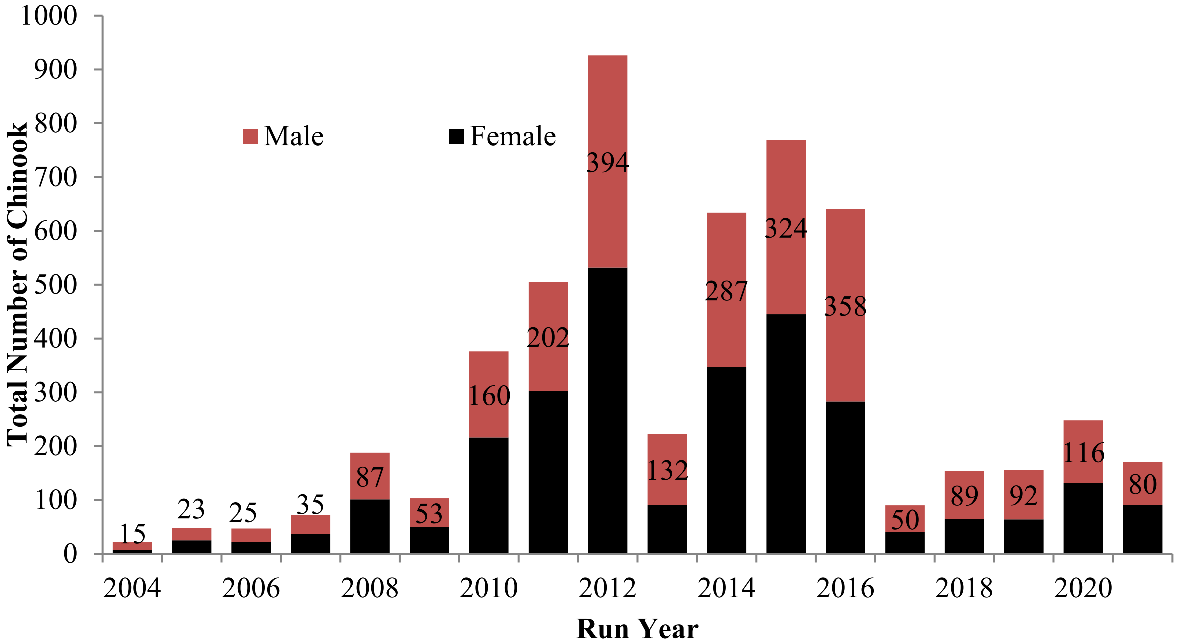

Figure 12. Lookingglass Creek spring Chinook salmon Male vs Female releases above the weir, RY 2004-2021. In 2004, 78 HOR adults were hauled from Catherine Creek and released upstream. These 78 fish were excluded due to lack of data on sex ratios.

Spawning Ground Surveys

We completed 18 spawning ground surveys on LGC during 17 August-16 September and observed, flagged, and took GPS coordinates on a total of 65 Chinook redds (Table 3). The first completed redds were observed on 17 August in units 3U and 3L. This is fairly typical, as a general pattern of redds being constructed in the upper reaches of Unit 3U and 3L occur first, and then move downstream to the lower reaches as the season progresses. There were a total of 46 Chinook redds observed in Units 2, 3L, 3U and 4 (LLGC) above the LH weir and 21 in Unit 1 below the weir. Redds in Units 3L and 3U made up 50% of all redds observed above the LH weir in 2021, however most of these occurred in 3L (n=20). The percentage of redds in these two sections has ranged from 63-94% since 2004.We have seen a shift in spatial distribution of redds in recent years, with fewer redds in section 3U and more in section 2. There were 14 total redds counted in section 2 this year. This is likely due to gravels dropping out and creating more spawning habitat in different areas with two back to back years of heavy flooding. Most redds observed above and below the LH weir were constructed between 17 August and 10 September.

Table 3. New redds observed on surveys of LGC by work week and by unit, RY 2021.

	Redds by Unit				
Period	1	2	3L	3U	4
8/16-8/20			6	2	
8/23-8/27		2	6	4	
8/30-9/3	18	12	5	1	4
9/6-9/10	3	0	3	1	0
9/13-9/17	0	0	0	0	0
Totals	21	14	20	8	4
2021 Percentage by unit (%)	31	21	30	12	6
2004-2021 Percentage by unit (%)	36	8	23	26	7

With approximately 4.0 rkm of available spawning habitat below the weir, the redds/per km is typically much higher and redds are often superimposed over one another (Figure 13). In some years (2010 and 2012), outplants from CC have been placed below the weir in LGC to supplement the fishery and these fish may also spawn in Unit 1. Since reintroduction efforts began in 2004, Unit 1 has had more redds than any other section in 11 out of 18 years, including 2021 (Table 4). The mean percentage of redds occurring below the weir between RY 2009 and 2021 was 36% (Figure 14). There were low numbers of redds observed in Unit 4 (LLGC) which may be due to higher gradients and less spawning gravel. Between 2017 and 2021, there have been so few fish upstream of the LH weir, the Chinook had the ability to be selective and the majority of redds were observed in Unit 3L. This has been interesting to examine since prior to 2017, Unit 3U typically has had more redds than any other section above LH the weir. During the endemic era, Unit 3U had substantially more redds than any other unit (Table 5).

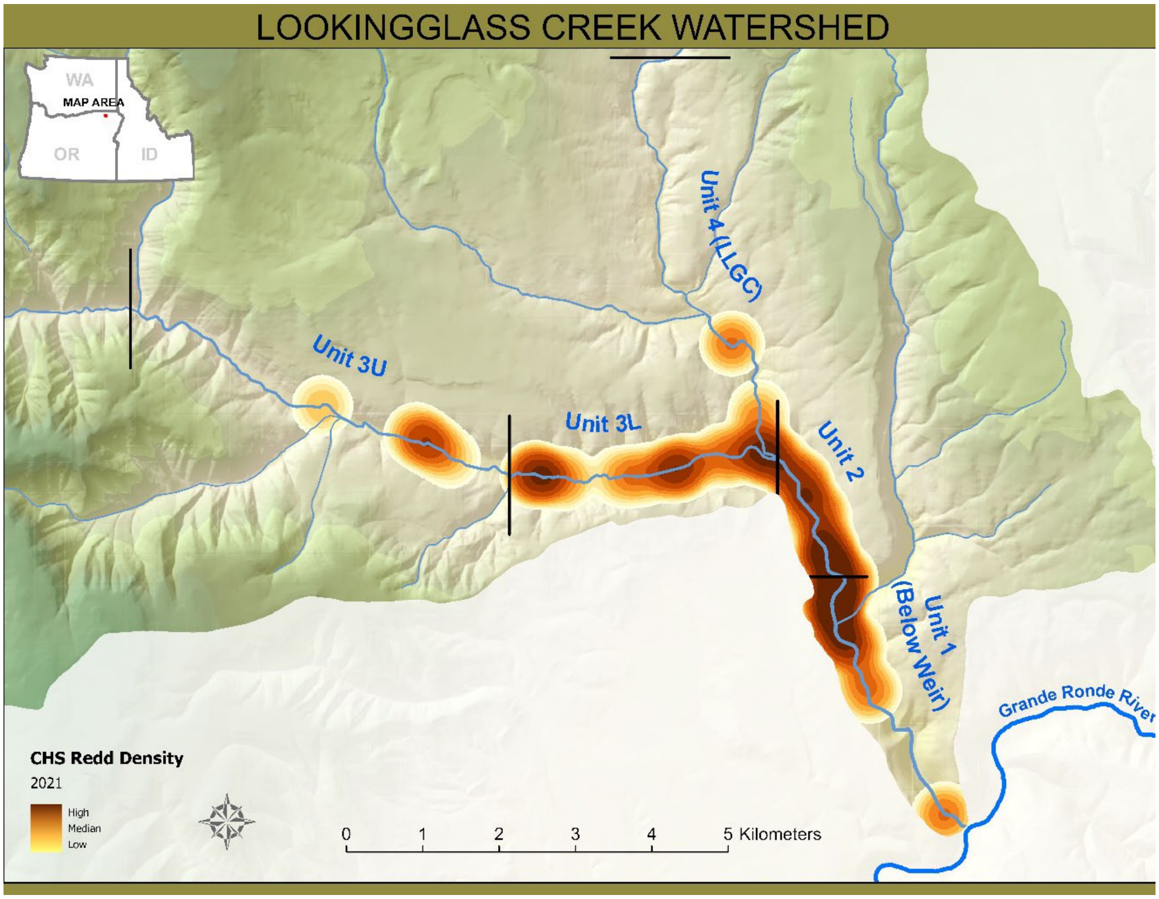

Figure 13. Density map of spring Chinook spawning distribution in Lookingglass Creek by unit, RY 2021. Map courtesy of Kaylyn Costi.

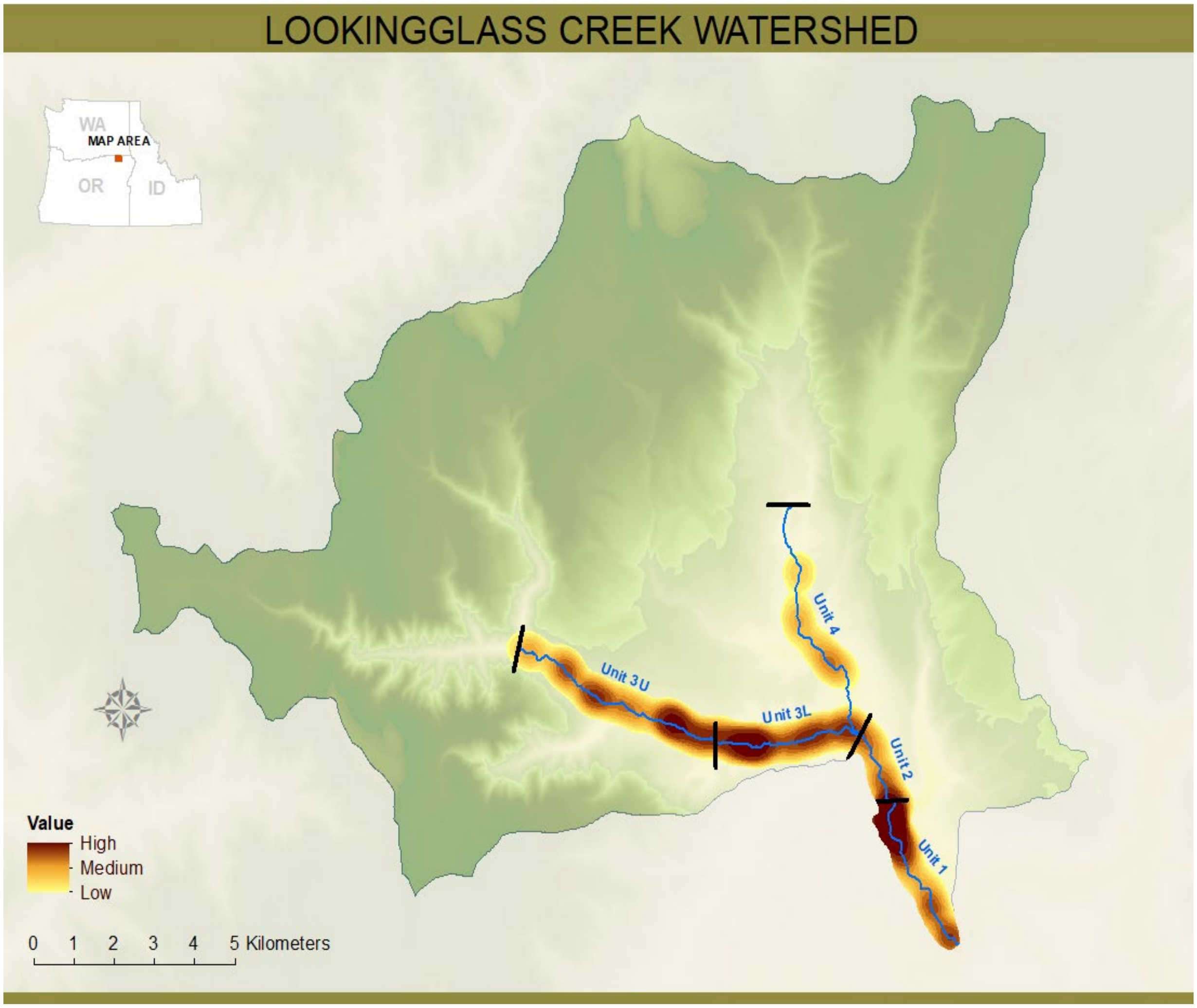

Figure 14. Density map of spring Chinook spawning distribution in Lookingglass Creek by unit, RY 2009-2020 Heat map displays large number of redds constructed near hatchery grounds prior to operating lower ladder. Map courtesy of Zoe Mathias.

Table 4. Number of spring Chinook salmon redds by unit, RY 2004-2021. Unit 1 is below the weir, all other Units are above the weir.

RY	Unit 1	Unit 2	Unit 3L	Unit 3U	Unit 4	Total
2004	49	7	11	20	11	98
2005	10	4	5	20	0	39
2006	28	5	10	12	1	56
2007	22	2	7	23	0	54
2008	39	10	19	56	19	143
2009	30	2	23	40	2	97
2010	89	24	63	62	21	259
2011	129	15	71	105	21	341
2012	133	31	100	136	47	447
2013	47	4	25	30	1	107
2014	105	24	71	82	28	310
2015	91	33	64	67	21	276
2016	144	24	81	83	19	351
2017	68	5	19	7	1	100
2018	42	9	22	8	0	81
2019	9	8	35	9	3	64
2020	32	25	51	28	3	139
2021	21	14	20	8	4	67
Mean	60	14	39	44	11	168
SE	10	2	7	9	3	30

Table 5. Number of spring Chinook salmon redds by unit during the endemic era, RY 1964-1971. Unit 1 is below the weir, all other Units are above the weir.

RY	Unit 1	Unit 2	Unit 3L	Unit 3U	Unit 4	Total
1964	24	1	83	77	21	206
1965	22	5	23	59	12	121
1966	92	7	73	154	45	371
1967	31	3	42	63	12	151
1968	12	3	28	86	16	145
1969	78	17	82	147	30	354
1970	39	7	77	156	42	321
1971	30	6	55	102	32	225
Mean	41	6	58	105	26	237
SE	10	2	9	15	5	35

We looked at redds per km by unit between 2009 to 2020 because 2009 was the first complete brood year since reintroduction efforts began (Table 6). The early years of the reintroduction would not be representative of actual redds per km since the numbers released above the weir in several years were capped at 25 or 50 pair, or fish were hauled from Catherine Creek and released upstream due to very low returns to LGC. Additionally, prior to 2009 fish were released upstream of the confluence of LLGC which could have influenced fish distribution. The percentage of redds below the weir were plotted with those observed during the endemic era study (1964 to 1971) for comparison (Figure 15). In 2019, only 14% of the total redds being constructed on LGC were below the weir, in comparison to 52% the previous year. In 2020, there was 23% of the total redds constructed below the weir, however this is still much lower than in previous years since the lower ladder has been in operation in conjunction with the upper ladder. In 2021, section 1 again had more redds below the weir than any other section, but the percentage was only 31% of the total. The mean percentage of redds below the weir for the current era are nearly twice that of the endemic era (t-ratio assuming unequal variance = -4.73048, p = <0.001).

Table 6. Number of spring Chinook salmon redds per km by unit, RY 2009-2021.

RY	Unit 1	Unit 2	Unit 3L	Unit 3U	Unit 4
2009	8	1	6	7	0
2010	22	12	16	10	4
2011	32	8	18	18	4
2012	33	16	25	23	8
2013	12	2	6	5	0
2014	26	12	18	14	5
2015	23	17	16	11	4
2016	36	12	20	14	3
2017	17	3	5	1	0
2018	11	5	6	1	0
2019	2	4	9	2	1
2020	8	6	13	7	1
2021	5	4	5	2	1
rkm	4.0	2.0	4.0	6.0	6.0

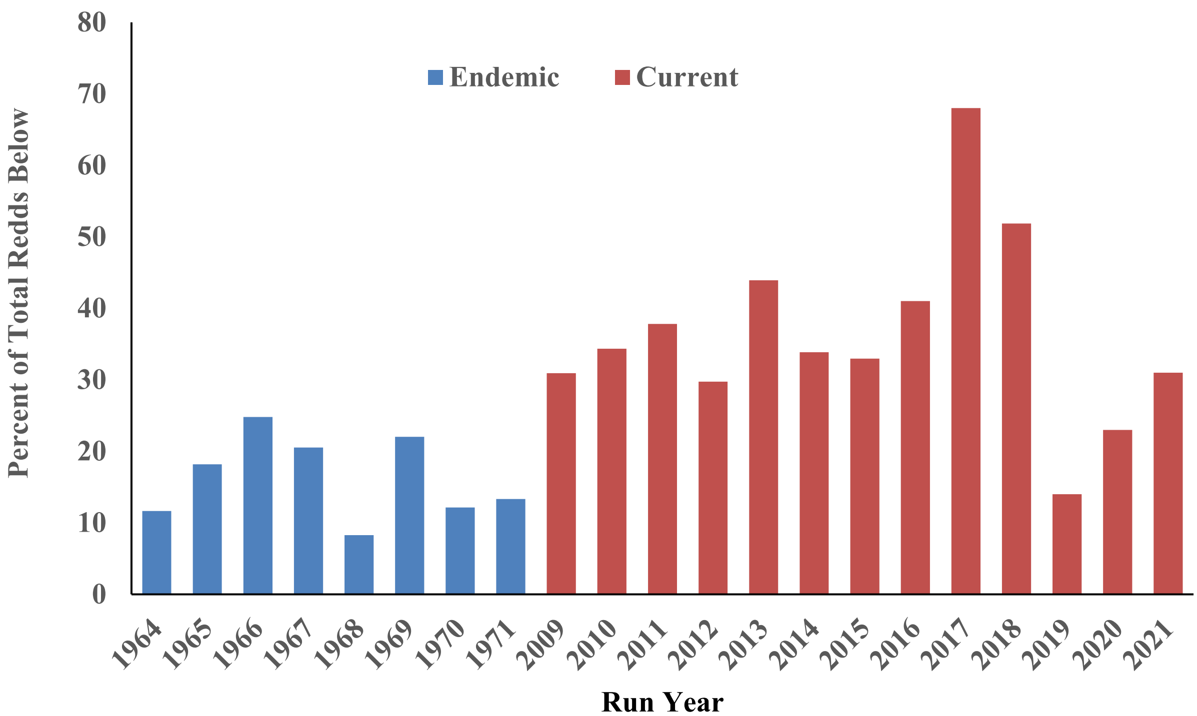

Figure 15. Percentage of total Chinook salmon redds observed below the weir during the endemic era (RY 1964-1971) and the current reintroduction era (RY 2009-2021).

A Wilcoxon Rank Sum test with all pairwise comparisons was used to test if there was a statistical difference in percentage of redds observed between each of the spawning units for pooled data RY

2009-2021 (Table 7). The pairwise comparisons that were not statistically significantly different from each other (using an a priori Alpha level of 0.05) were Unit 3U and Unit 3L (p = 0.7196), whereas all other pairwise comparisons were significantly different.(Table **7**).

Table 7. Results of Wilcoxon Rank Sum test used to test for differences in percent redds between each survey unit, pooled data for RY 2009-2021.

Unit	Unit	Z	p-Value	Lower CL	Upper CL
One	Four	4.30769	<.0001*	29.7218	24.3408
ThreeL	Four	4.30769	<.0001*	19.8211	16.4714
ThreeU	Four	4.05128	<.0001*	18.3754	9.9000
Two	Four	2.02599	0.0428*	3.4913	0.0000
ThreeU	ThreeL	-0.35897	0.7196	-2.2714	-12.3246
ThreeL	One	-2.30769	0.0210*	-9.7826	-15.4585
ThreeU	One	-2.87179	0.0041*	-11.3783	-22.7539
Two	ThreeU	-3.33333	0.0009*	-13.9516	-20.1999
Two	One	-4.20513	<.0001*	-26.0359	-32.8252
Two	ThreeL	-4.25641	<.0001*	-16.2533	-20.3095

**Indicates pairwise comparisons by unit that were statistically significantly different from each other*

Carcass Recoveries

Carcasses recovered above the LH weir from 1 September through 16 September totaled 12, with 5 identified as female and 7 as male. Eleven of these recovered carcasses were adults and 1 was a jack. Eight (8) had an opercle punch indicating they had been sampled at the LH weir and 4 were "unknown" since the operculum was missing and was unable to be determined. Based on these numbers, the weir appeared to be 100% effective at blocking upstream passage. Of note is that there were 2 carcasses recovered above the LH weir that were from the lower trap and identifiable due to the presence of a 2ROP mark, and 6 carcasses recovered that were from the upper trap and identifiable due to the presence of a 1ROP mark. This is interesting since there were similar numbers of fish from both traps released upstream to spawn naturally (n=84 lower trap, 87 upper trap). Of these 12 carcass recoveries above the weir, all were HOR and except for one of unknown origin due to decomposition. This was interesting since only 61% of the adults passed upstream to spawn were of HOR, suggesting a possible difference in recovery rates among origins. Carcass recovery efficiency for fish released above the LH weir was only 7%, much lower than in most years. With fewer fish returning in recent years, scavengers and predators are likely rapidly consuming carcasses before they can be recovered. This is most evident in Unit 3U, the most remote section of LGC. While many LGC redds are typically constructed in this section, there are frequently fewer carcasses found there than any other unit. With 2021 having so few total returns and thus fish released upstream (n=171), carcasses were likely in high demand from predators which may have resulted in the low carcass recovery this year (n=12) compared to the mean recovery rate since 2004 of 26%.

Carcasses recovered below the LH weir from 2 September through 16 September totaled 21. Of these 21 carcasses sampled, there were 19 HOR and 2 NOR. There were only 2 recoveries that had a 1ROP indicating they had been sampled at the upper weir, passed upstream, and then dropped back below the weir, both of HOR.

Hatchery-origin carcasses (with a CWT present) collected between 2004-2021 indicate that the Upper Grande Ronde River fish stray into LGC more than other local stocks (Table 8). The Upper Grande Ronde strays are identifiable by their lack of an adipose clip and presence of a CWT, and they are not passed upstream of the LGC weir. These strays are usually placed in the holding ponds with the other Grande Ronde Conventional Broodstock. Other hatchery stocks have a CWT and an adipose clip, however stock is unknown until the CWT has been recovered and read. In 2021, there were two Catherine Creek and one Lostine River origin strays collected on LGC during spawning surveys. Carcasses collected on LGC are processed by CTUIR staff and are submitted to RMIS for CWT retrieval by ODFW staff.

Table 8. Hatchery-origin carcasses with a coded-wire tag (CWT) present that were recovered on Lookingglass Creek, 2004-2021.

Year	Catherine Cr	Lookingglass	Lostine	Upper Grande Ronde
2004	39	8	1	4
2005	16	3	0	11
2006	2	13	0	2
2007	3	15	2	0
2008	2	61	4	0
2009	4	28	0	8
2010	7	104	2	6
2011	11	213	3	18
2012	8	127	0	4
2013	1	47	1	10
2014	3	83	0	6
2015	4	70	2	7
2016	2	106	0	26
2017	2	14	0	10
2018	0	20	0	5
2019	1	9	0	0
2020	1	16	0	1
2021	2	12	1	3
Total	108	948	16	121

Lookingglass Creek hatchery-origin carcasses (with a CWT present) collected between 2004-2021 in neighboring streams were greatest in the Wenaha, Minam and Lostine Rivers (Table 9). This has been a cause for concern to co-managers due to the fact that the Minam and Wenaha are natural, unsupplemented population. However, there were no Lookingglass strays collected in these streams in 2021. The snouts recovered in these neighboring streams are collected by ODFW survey staff and submitted to RMIS by ODFW.

Table 9. Lookingglass Creek stock hatchery-origin carcasses with a CWT present that have strayed to neighboring streams, 2004-2021.

Year	Bear	Catherine	Hurricane	Lostine	Minam	UGR	Wallowa	Wenaha
2004								
2005								
2006								
2007								
2008					2		2	1
2009								
2010					2			5
2011				5	4	3		15
2012								3
2013		1			1			8
2014				2	1			16
2015			1	0	2			1
2016				1				1
2017				0				1
2018	1			1				5
2019								
2020								
2021								
Total	1	1	1	9	12	3	2	56

Population Estimate Above the Weir

The total number of Chinook passed above the weir was 171 (142 adults, 29 jacks), and decreased by 2 as that number of “punched” (passed) adults were recovered below the weir. The Chapman modification of the Peterson method was then applied using marked/unmarked recoveries. The population estimate of jacks was 29, and the adult estimate was 140 (Table 10). Fish per redd estimates were 3.04 for adults, with an average of 2.36 since reintroduction began.

Table 10. Population estimates, mean, and standard error of the mean (SEM), redds, and fish/redd of naturally spawning spring Chinook salmon above the LH weir, RY 2004-2021. Data are for HOR and NOR adults.

	Population Estimate			Fish/Redd	
RY	Adults (SEM)	All Ages (SEM)	Redds	Adults/redd	All/redd
2004	99 (11.9)	99 (11.9)	49	2.02	2.02
2005	40 (4.9)	46 (5.6)	29	1.38	1.59
2006	47 (10.8)	53 (12.1)	28	1.69	1.91
2007	65 (11.9)	71 (13.2)	32	2.03	2.22
2008	179 (18.1)	188 (18.8)	104	1.72	1.81
2009	83 (19.7)	151(34.7)	67	1.24	2.26
2010	344 (20.4)	372 (21.1)	170	2.02	2.19
2011	439 (26.4)	507 (29.1)	212	2.07	2.39
2012	941 (56.2)	941 (56.0)	314	3.00	3.00
2013	160 (20.0)	228 (27.6)	60	2.67	3.83
2014	611 (44.8)	646 (46.4)	205	2.98	3.15
2015	720 (74.8)	748 (77.9)	185	3.89	4.04
2016	569 (40.6)	574 (41.0)	207	2.75	2.77
2017	69 (23.3)	84 (28.6)	32	2.16	2.63
2018	129 (35.8)	136 (37.8)	39	3.31	3.49
2019	131 (30.9)	142 (33.7)	55	2.38	2.33
2020	229 (59.6)	242 (63.0)	107	2.14	2.26
2021	141 (48.4)	169 (55.1)	46	3.04	3.67
Means	278	300	108	2.36	2.65

Spawner Estimate Above the Weir

Chinook were released approximately 0.4 km upstream of the picket weir as in years past. We observed low pre-spawn mortality, however few carcasses were observed in general due to the low numbers released above the weir (Table 11). Pre-spawning mortality has varied from zero to a high of 54.2% during the current reintroduction era. For the years 2017 through 2021, the mean percent of pre-spawn mortality between 2004-2016 was used since only a handful of female carcasses were recovered above the weir (Joseph Feldhaus ODFW, personal communication). Spawner estimates above the weir (adults only) have ranged from 37-742, with a mean of 210 over the reintroduction period.

Table 11. Population Estimates (HOR and NOR), Pre-spawn Mortality (PSM), and Spawner Estimate for spring Chinook salmon above the LH weir, RY 2004-2021.

	Population Estimate			Spawner Estimate	
RY	Adults	All Ages	PSM	Adults	All Ages
2004	99	99	0.000	99	99
2005	40	46	0.083	37	42
2006	47	53	0.000	47	53
2007	65	71	0.083	60	65
2008	179	188	0.000	179	188
2009	83	151	0.125	73	132
2010	344	372	0.085	315	340
2011	439	507	0.136	379	438
2012	941	941	0.212	742	742
2013	160	228	0.263	118	168
2014	611	646	0.299	428	453
2015	720	748	0.542	330	342
2016	569	574	0.305	395	399
2017	69	84	0.164*	58	70
2018	129	136	0.164*	108	114
2019	131	142	0.164*	110	119
2020	229	242	0.164*	191	202
2021	140	169	0.164*	117	141
Means	278	300	0.164	210	228

Spawner estimate is population estimate above the weir multiplied by pre spawn mortality of females above the weir.

**In 2017, 2018, 2019, 2020, 2021 due to only retrieving a few female carcasses above the weir, a valid PSM percent could not be determined. Therefore an average from 2004-2016 was used, (Joseph Feldhaus ODFW, personal communication)*

1.5.1.1 Life History

Length at Known Age

Scales were collected on a portion of returning NOR fish at the LH weir or on spawning surveys and were used to determine age (n=53). All carcasses were scanned for a CWT and snouts were collected when a CWT was present to determine age (n=22). Snouts were collected from only 7 carcasses above the LH weir and 15 below. All but 3 of the tags were able to be successfully read (n=19 total aged snouts).Tags can be lost, unreadable, or damaged by the knife during extraction. Since so few carcasses were recovered this year, the sample size for HOR known ages is much smaller than NOR. All snouts were scanned to verify the presence of a wire prior to submittal to the ODFW Clackamas lab. If the snout did not have a CWT, it was discarded. These snouts were submitted to the Clackamas lab for retrieval of the CWT, and data were processed and returned to CTUIR. These HOR and NOR known ages are represented in the table below (Table 12).

Of the 19 snouts successfully processed, there were 13 LGC-origin returns and 6 strays. There were one Lostine, two CC, and three UGR stray recoveries this year. The two CC strays were recovered above the weir, the UGR and Lostine strays were all recovered below the weir. There were 3 male HOR recoveries measuring between 185 and 190 mm, however only one had a CWT and was a mini-jack (age 2). This fish is not included in Table 12. This is the fifth consecutive year that we have recovered at least one HOR "mini" jack on LGC. These fish have all been recovered below the weir and likely successfully spawned. There were 11 NOR jacks that were aged and no HOR jacks. Age 3 NOR males were an average of 456 mm. There were no HOR age 5 recoveries and only 2 NOR age 5 recoveries. There are typically small sample sizes for known age 3 and age 5 fish for both NOR and HOR, with the majority of fish being age 4.

Table 12. Mean FL (mm) at known age by sex and origin of LGC spring Chinook, RY 2021.

Origin	Sex	Age	$\bar{X}$ FL	Range	SE	N
NOR	M	3	456	365-526	15	11
NOR	M	4	646	435-770	40	10
NOR	F	4	683	615-740	9	17
NOR	Combined	4	670	435-770	16	27
NOR	M	5	839	812-865	27	2
NOR	F	5				0
NOR	Combined	5	839	812-865	27	2
HOR	M	3				0
HOR	M	4	746	685-840	18	8
HOR	F	4	706	645-790	14	10
HOR	Combined	4	723	645-840	12	18
HOR	M	5				0
HOR	F	5				0
HOR	Combined	5				0

**One HOR male at 185 mm not included in this table, verified age 2*

Female Fork Lengths:

Using data from 2007 to 2021, we calculated means and 95% confidence intervals of female fork lengths of NOR and HOR returns to the adult weirs for CC and LGC stocks (Table 12). Data was removed from the analysis that pre-dated 2007, as these data could have Rapid River stock influences that could upwardly skew LGC mean fork lengths. Moreover, 2007 was the first naturally spawned returns to LGC (jacks). We also plotted frequency distributions of female fork length for both NOR and HOR LGC stock (Figure 16, Figure 17). Mean female fork length of all ages combined for the LGC 2021 return year was 683 mm for NOR, which was well below the 16-year mean of 727.5 (Table 13). For HOR, the 2021 mean was 705.7 mm compared to a 16-year mean of 723.4 (Table 13) Over the 2007 to 2021 period, fork lengths are very similar between both HOR and NOR for both stocks.

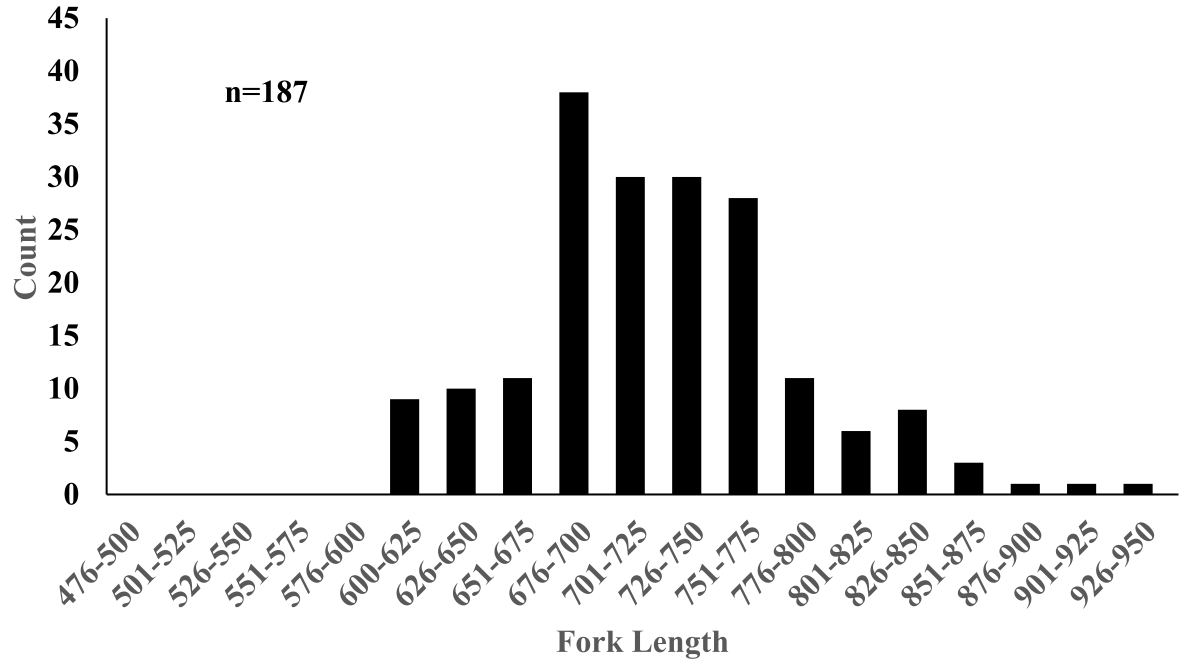

Figure 16. Frequency distribution of NOR FL (mm) of returning adult female spring Chinook salmon for Lookingglass Creek, RY 2007-2021. Data are from known age females.

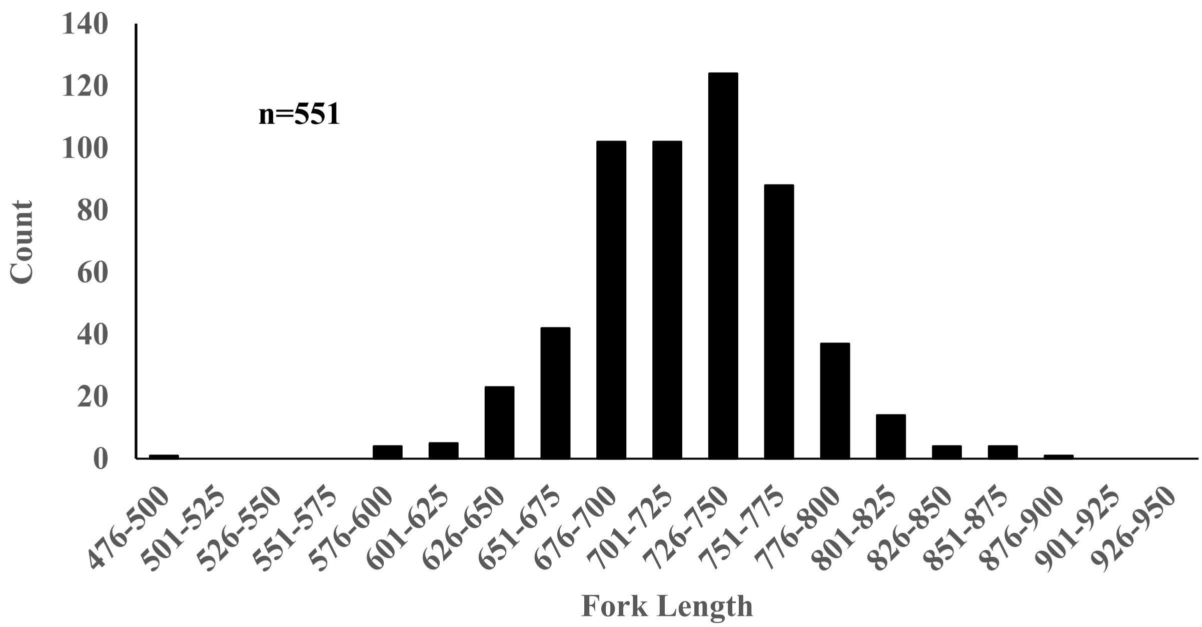

Figure 17. Frequency distribution for HOR FL (mm) for returning adult female spring Chinook salmon to Lookingglass Creek, RY 2007-2021. Data are from known age females and does not include strays.

Table 13. Mean FL (mm) and 95% confidence intervals for known age females by stock and origin, RY 2007-2021.

Stock	Origin	Mean FL(mm)	Upper 95 %	Lower 95%	N
CC	NAT	718.1 (± 4.0)	722.1	714.1	880
LGC	NAT	727.5 (± 8.9)	736.4	718.6	187
CC	HAT	719.9 (± 4.6)	724.5	715.3	386
LGC	HAT	723.4 (±4.3)	728.0	719.1	551

1.5.1.2 Productivity

Recruits per Spawner (R/S)

BY 2013 through BY 2016 Recruits per Spawner for adults (excluding jacks) was lower than any year calculated since 2004, at 0.2 (Table 14). This low Recruit per Spawner for these years was not unique to LGC, as returns in the entire basin have been low and likely due to multiple extenuating factors outside the tributaries. Recruits per Spawner for BY 2001-2005 CC NOR (adults+jacks) ranged from 0.1-0.7 (Feldhaus, et al., 2012) and increased to 2.2 in BY 2006 and 3.2 in BY 2007 (Feldhaus, et al., 2011). Recruits per Spawner (adults) were also higher for LGC NOR in 2006 and 2007 at 2.9 and 2.3, respectively. It is not clear what factor may have led to the higher Recruits per Spawner in those years in both streams, and the decreasing Recruits per Spawner in each year since. Recruits per Spawner has been below the replacement value of 1.0 for 9 out of the last 13 completed brood years. In the latest status review update, spring Chinook populations in CC and UGR remained at high risk for both abundance and productivity, even though short-term natural spawner abundance had increased in CC (NOAA, 2011; NOAA, 2019).

Table 14. Completed Brood Year (BY) NOR returns, spawners by BY, and Recruits per Spawner (R/S) for LGC NOR spring Chinook salmon, BY 2004-2016.

BY	BY NOR returns[a]		Spawners[b]		R/S	
	Adults	All	Adults	All	Adults[c]	All[d]
2004	55	62	99	99	0.6	0.6
2005	78	82	37	42	2.1	1.9
2006	138	162	47	53	2.9	3.1
2007	135	152	60	65	2.3	2.3
2008	141	171	179	188	0.8	0.9
2009	61	64	73	132	0.9	0.5
2010	185	245	315	340	0.6	0.7
2011	254	289	379	438	0.7	0.7
2012	335	370	742	742	0.5	0.5
2013	25	31	118	168	0.2	0.2
2014	74	89	428	453	0.2	0.2
2015	73	64	330	342	0.2	.02
2016	87	98	396	399	0.2	0.2
Means	126	145	246	266	0.94	.91

[a] *Complete NOR BY returns from BY X for Adults and All ages*
[b] *Total Adult and All Spawners for BY X*
[c] *(NOR BY X returns at ages 4 and 5)/BY X Adult spawners;*
[d] *(NOR BY X returns at ages 3, 4 and 5)/BY X All spawners*

1.5.2 Juvenile Spring Chinook Salmon

1.5.2.1 Abundance

Screw Trap Operations

Beginning in March of 2020, sac fry began to be captured in the screw trap from the BY 19 cohort. Obtaining an accurate estimate of (fry) outmigrants is difficult because of high flow and debris during the spring and the small size of fish which limits the marking options available. The fry captured during these times were counted and passed below the trap (n=116). These fry are not included in the outmigrant estimate as they appeared to not be emigrating, but instead are getting flushed into the trap during high flows. The majority were captured during the month of March (n=60).

Fish are PIT tagged that have a fork length over 60 mm beginning 1 July of the migration year through the following 30 June of the next year. BY 2020 total first-time captures in the screw trap from 1 July 2020-30 June 2021 was 3,204. During July-December 2020, the rotary trap was fished 74% of the time. The trap was pulled on several occasions in June during harvest to allow Tribal fisherman to access the “flume hole” that it is located in. This hole is one of the most lucrative fishing spots below the weir. Therefore, each Friday the screw trap is pulled to the side of the creek and not fished until the following Monday. and then for the pandemic shutdown which occurred in October. During January-July 2021, the rotary trap was fished 75% of the time. High spring flows occurred in May followed by a drought in June and therefore the trap was pulled on several occasions during that time frame.

Outmigrant Estimate
The BY 2019 outmigrant estimate was derived using DARR 2.9.1 and was estimated to be 7,232 for the period of July 1 2020 through 30 June 2021 (Table 15). This is the third lowest outmigrant estimate calculated since reintroduction efforts began. The number of outmigrants per redd was estimated at 131.

Table 15. LGC NOR spring Chinook salmon outmigrant summary, BY 2004-2019.

BY	MY	Outmigrants	SE	Redds AW[a]	Outmigrants/Redd
2004	2006	9,404	1,278	49	192
2005	2007	14,091	1,980	29	486
2006	2008	12,208	3,866	28	436
2007	2009	7,847	1,174	32	245
2008	2010	30,289	2,266	104	291
2009	2011	12,279	759	67	183
2010	2012	13,749	805	170	81
2011	2013	21,517	1,185	212	101
2012	2014	54,759	4,569	314	174
2013	2015	10,191	610	60	170
2014	2016	26,384	1,777	205	129
2015	2017	26,502*	1,758	185	143
2016	2018	17,784*	893	207	86
2017	2019	3,671	146	32	115
2018	2020	4,759*	481	39	122
2019	2021	7,232	178	55	131
	Means	17,042	1,483	112	193

[a]AW=above the LH weir
**MY2015 was a very low water year which did not allow for good detection rates at LGD*
**MY2016 Trap did not fish during high migration period and therefore is an underestimate*
**MY2018 Trap did not fish during most of February and April due to record flood levels and staffing due to global pandemic. High flows continued through June and allowed for poor catches all spring. Therefore this is an underestimate of outmigrants for MY 2018.*

Outmigration timing

Fish numbers leaving LGC during July and August are typically low as flows decrease and water temperatures increase. Low flows make screw trapping difficult, as the cone may turn very slowly, or become "hung up" on rocks in the shallow water. Outmigrants by season estimated from the screw trap catch were 13% for fall 2020, 61% winter 2020, and 26% spring 2021 (Table 16). In general, the majority of LGC juvenile Chinook migrate between the months of October-December. However, there have been a couple of years where larger percentages left from July-September, such as BY12 and BY15. Even with some of these shifts between fall and winter months, the majority of LGC stock leave as pre-smolts in the fall/winter. The mean from BY 2004-2019 indicates that number to be 84%, with only 16% of outmigrants leaving in the spring (Table 16). This observed pattern was similar to that reported for the previous Rapid River stock reintroduction era (McLean, et al., 2001)(Burck, 1993). However for both reintroduction eras, higher percentages left during the winter months while Burck (1993) observed more outmigrants leaving in the fall. It is not clear from our data why there is a slight shift in outmigration timing to the colder, winter months and it may be an indication of density dependence (such as lack of over winter habitat). A similar pattern of most outmigrants leaving as presmolts during fall/winter occurs for CC outmigrants, our donor stock (Anderson, et al., 2011).

Table 16. Summary of seasonal outmigration of LGC NOR spring Chinook salmon, BY 2004-2019.

BY	MY	Jul-Sept %	Oct-Dec %	Jan-Jun %
2004	2006	43	47	10
2005	2007	33	64	2
2006	2008	36	44	20
2007	2009	16	64	21
2008	2010	21	55	24
2009	2011	9	69	22
2010	2012	34	49	17
2011	2013	26	55	20
2012	2014	73	24	4
2013	2015	30	60	10
2014	2016	37	53	10
2015	2017	49	37	15*
2016	2018	41	48	11
2017	2019	39	42	19
2018	2020	27	49	23
2019	2021	13	61	26
	Means	33	51	16

MY totals may not sum to 100 due to rounding

**For Spring of 2017, the trap was not fished often enough to calculate a valid population estimate due to record high snow fall followed by rain. . The mean of 15% spring outmigrants from 2004-2016 was applied to the fall estimate (assumed to be 85%).*

Size of tagged outmigrants in the screw trap by season

Totals for PIT-tagged outmigrating juvenile Chinook were 341, 937, and 681 for fall, winter and spring respectively. Mean FL by season of these tagged fish were 87, 97, and 98 mm for fall, winter and spring groups, respectively. Mean weights increased from 7.9 to10.8g from fall 2020 to spring 2021. Mean K was 1.12, 1.08, and 1.20 for the fall, winter, and spring groups, respectively. In general, K factor is highest in the spring, when conditions are more favorable. The size of the fish in all three seasons were larger in comparison to other years. This could be due to the low number of redds above the weir affording ample rearing habitat and an increase in food availability. As expected, fish increased in size from fall to spring (Figure 18).

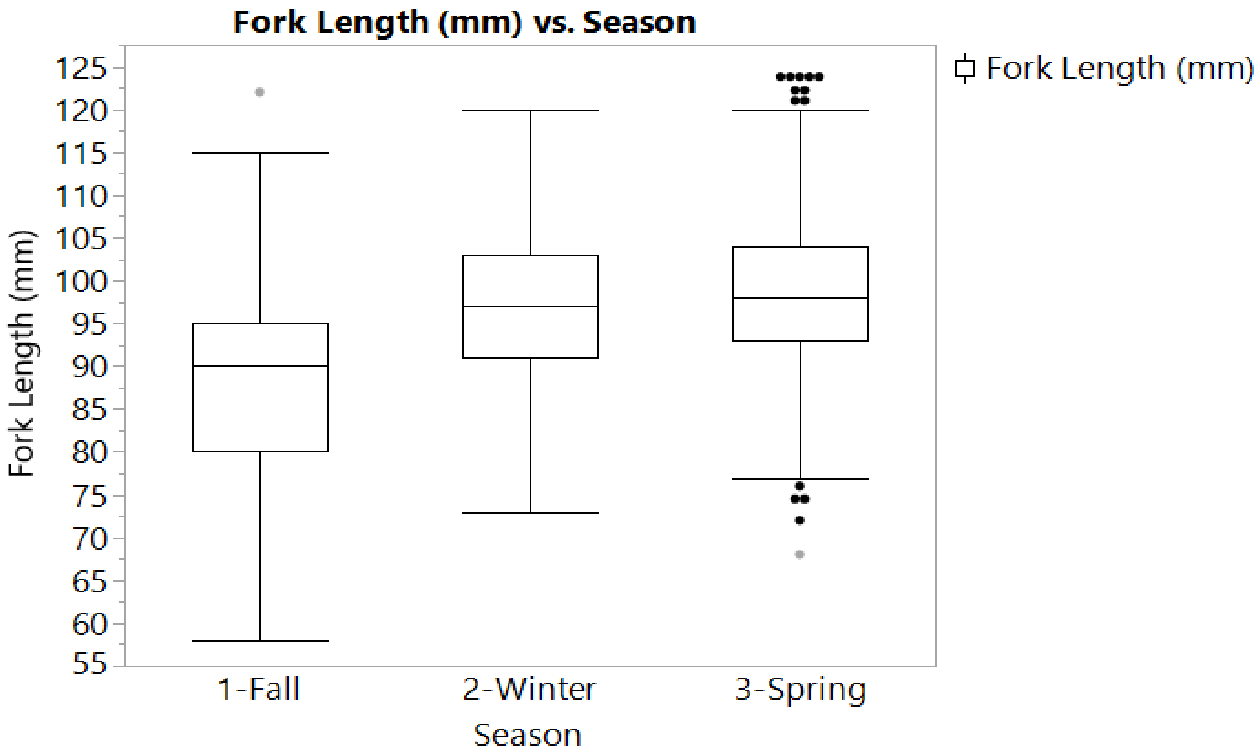

Figure 18. Box plots of fork length (mm) by seasonal group for NOR spring Chinook salmon outmigrants tagged or measured in the Lookingglass Creek screw trap, BY 2019. Error bars indicate minimum and maximum sizes observed by season and points are outliers not included in the creation of the boxplot.

The BY 2012 outmigrant total was the highest observed during the current reintroduction era, which correlated well with the largest amount of redds above the weir; however the outmigrant estimate was not as high as expected (Figure 19). This could indicate spawner saturation, though observing this pattern is not necessarily a negative pattern, (Peter Galbreath, CRITFC personal communication). This will be looked at more in depth with multiple metrics and be discussed with managers and co-managers in the future.

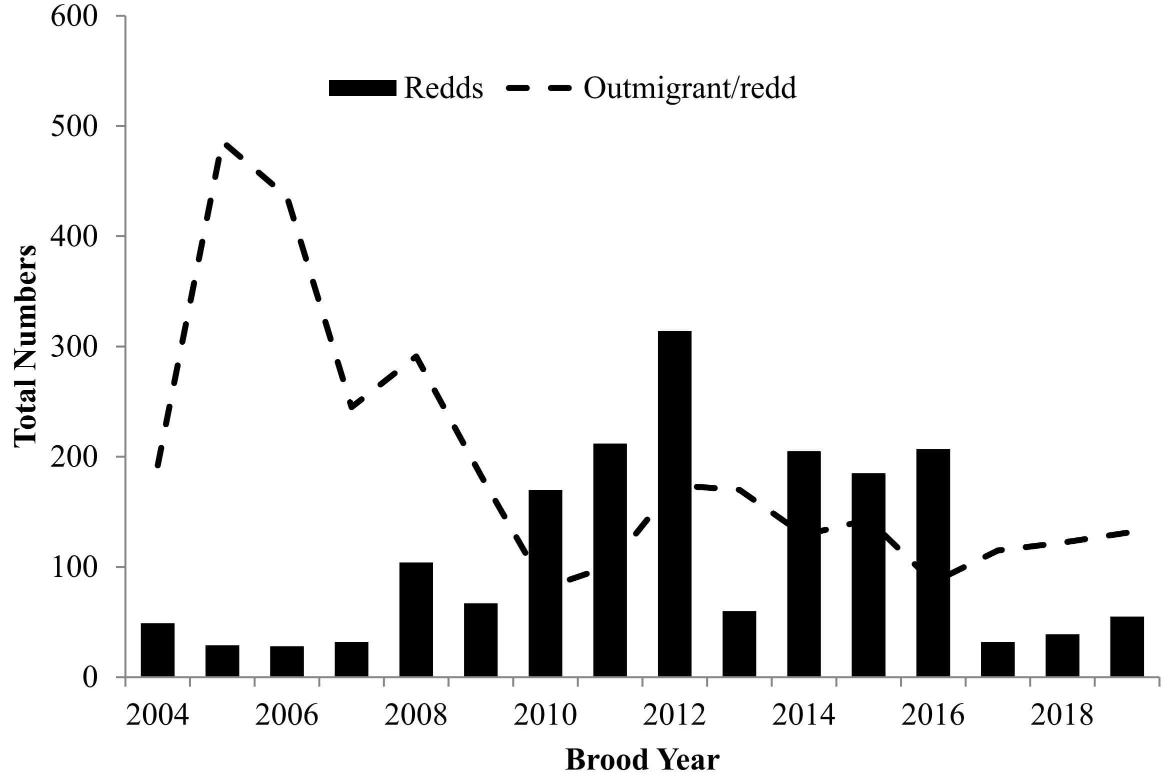

Figure 19. Outmigrants/redd and redds above the weir for BY 2004-2019.

Precocious Chinook

There was 9 BY 2018 NOR precocious juveniles caught in the screw trap during 24 August through 11 September 2020. There were also 42 adipose clipped precocious juveniles captured between 26 June and 18 September 2020 that must have moved upstream from the LH and then down again looking for potential mates (release date from the hatchery was 22 April). This time frame is when adult Chinook are spawning and the majority of precocials are captured in the rotary trap. Each year several wild and hatchery precocious Chinook are caught in the screw trap. These are scanned for PIT tags, a genetic sample taken, measured, weighed and released downstream of the trap. The numbers of precocious juveniles Burck (1993) reported in the bypass trap ranged from 158-575 annually (359 mean), much higher than the numbers seen during the current reintroduction era. The lower numbers observed are likely a function of the overall lower abundance of outmigrants, and the different type of trapping mechanisms, however this is an interesting difference in population dynamics.

1.5.2.2 Life History

Survival Estimates

Survival probabilities and standard error [SE] to Lower Granite Dam (LGD) were calculated as 0.256 [SE 0.094], 0.425 [SE 0.115], 0.302 [SE 0.035], and 0.563 [SE 0.080] respectively for the summer, fall, winter, and spring groups of BY 2019 (Figure 20). Spring survival is substantially higher than the summer, fall and winter groups on a consistent basis, however all seasons had higher than normal survival (Figure 20). The increased survival in the spring could in part be due to the much shorter travel time to LGD for the spring group, and is typically a time of year when flows are favorable (Figure 22). The juveniles that are leaving in the fall and winter are overwintering somewhere within the Grande Ronde Subbasin where water quality conditions may be a limiting factor and predation may be higher. Until recently, there had been an increase in the number of redds documented above the weir, which may have led to a slight decrease in survival for all seasonal groups as competition for resources became more likely (Figure 21). With fewer redds above the weir, the outmigrants were substantially larger, and survivals were among the highest observed in all four groups, in particular the fall and spring groups (Figure 20).

During the current reintroduction era, we have observed that a greater number of fish typically leave during the winter months (Oct-Dec) than the fall months (July-Sept). Juveniles emigrating in the winter have a higher mean survival rate to LGD compared to the fall, so this shifted migration pattern could prove complimentary (Figure 22). Mean survival for fall, winter and spring is 18%, 21%, and 45%, respectively. Conversely, the mean percent of juveniles emigrating during the fall, winter, and spring is 33%, 51%, and 16%, respectively. Therefore, while spring survival is the highest at 45%, only 16% of all LGC juveniles are emigrating during that time, (Figure 23).

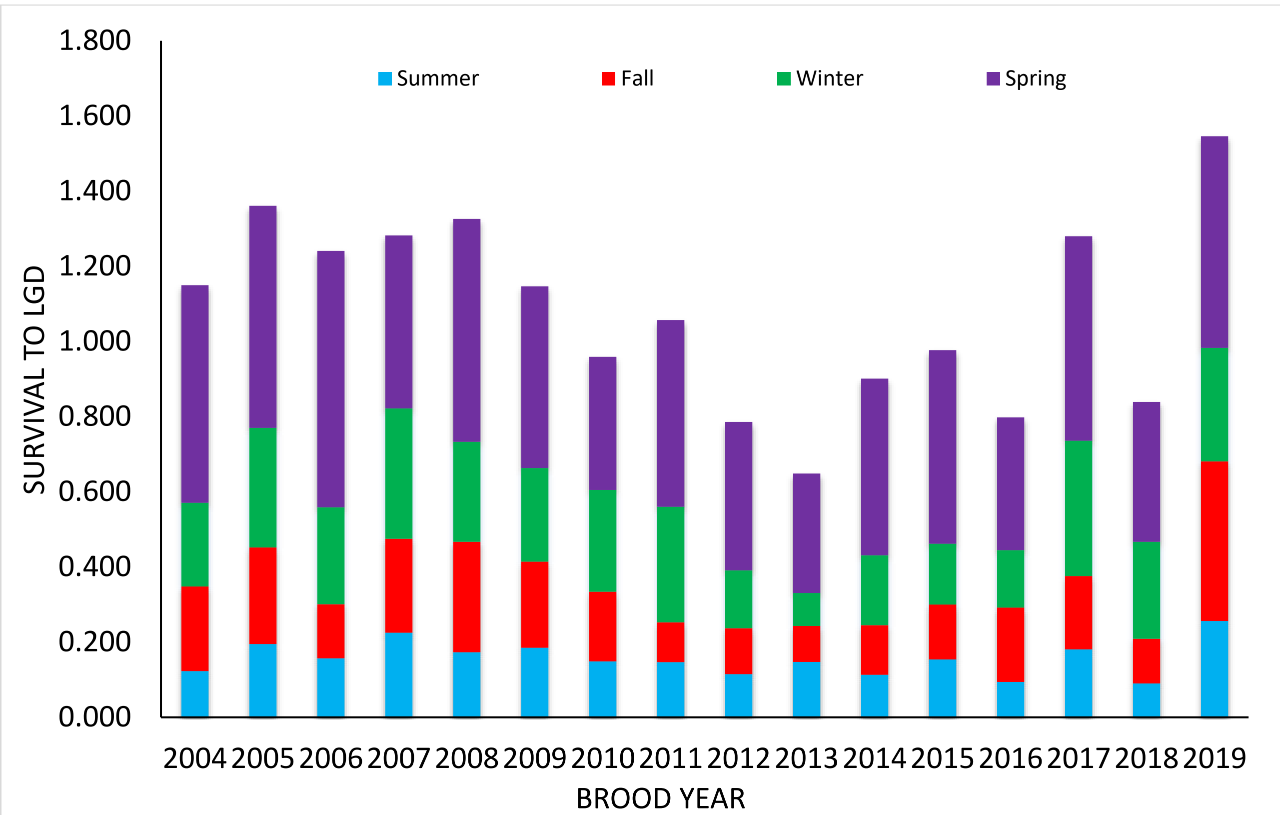

Figure 20. Survival probabilities of NOR spring Chinook salmon for summer, fall, winter, and spring groups, BY 2004-2019.

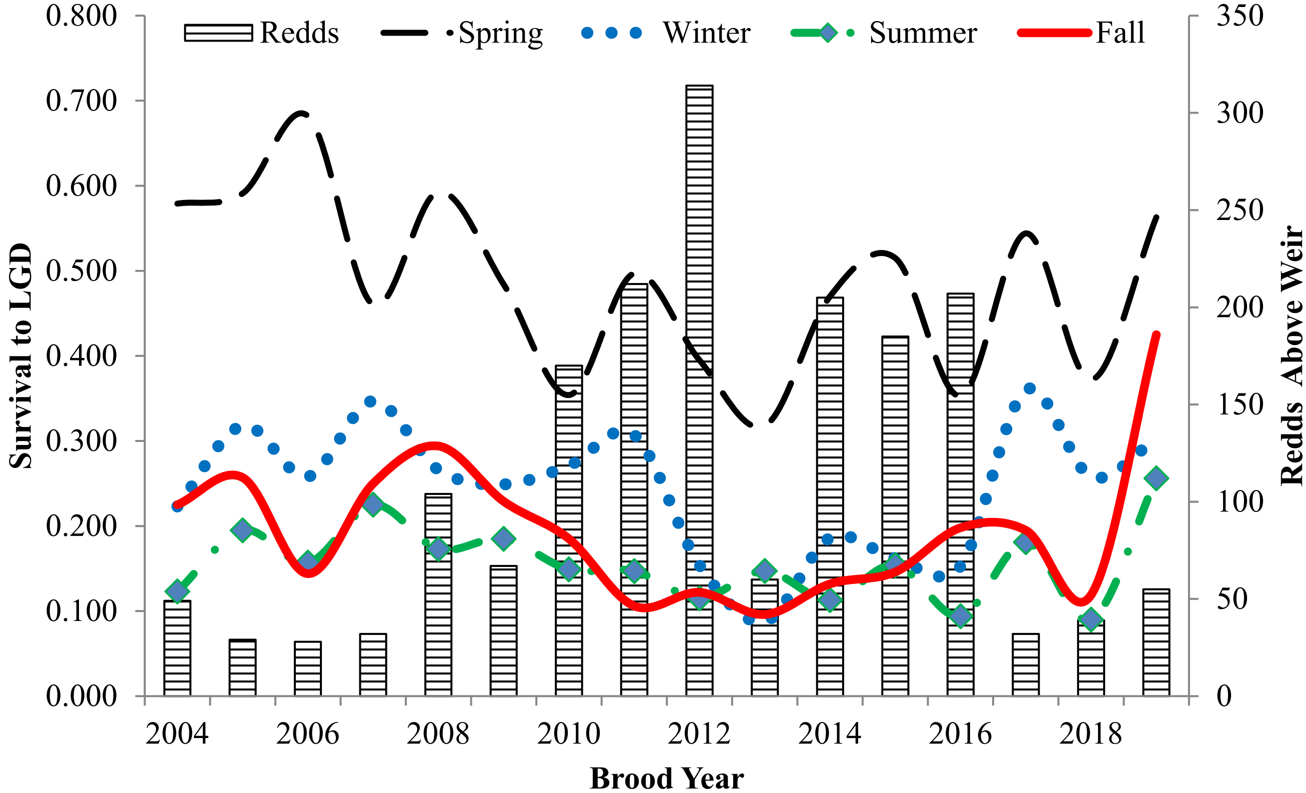

Figure 21. Survival probabilities of NOR spring Chinook salmon for summer, fall, winter, and spring groups, BY 2004-2019, with redds on the z axis.

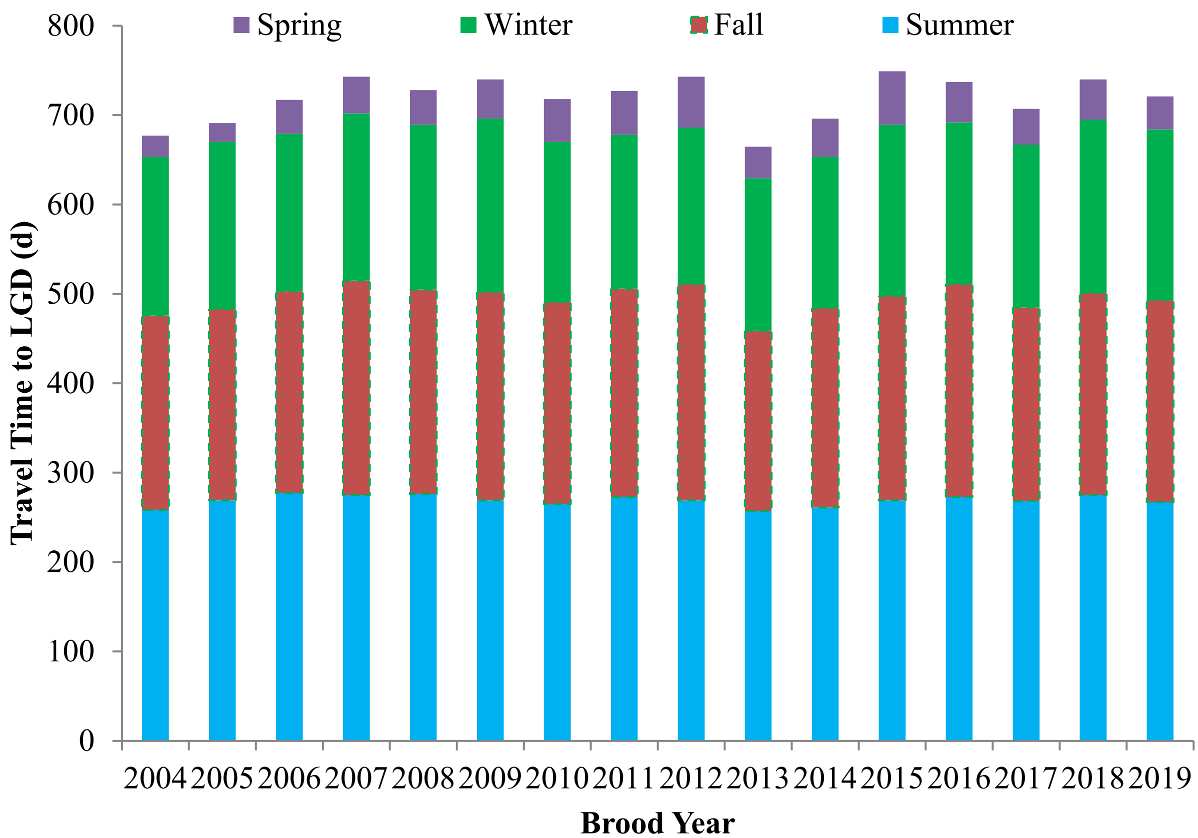

Figure 22. Harmonic mean travel time (d) to LGD for Lookingglass Creek NOR summer parr, and fall, winter, spring outmigrants, BY 2004-2019.

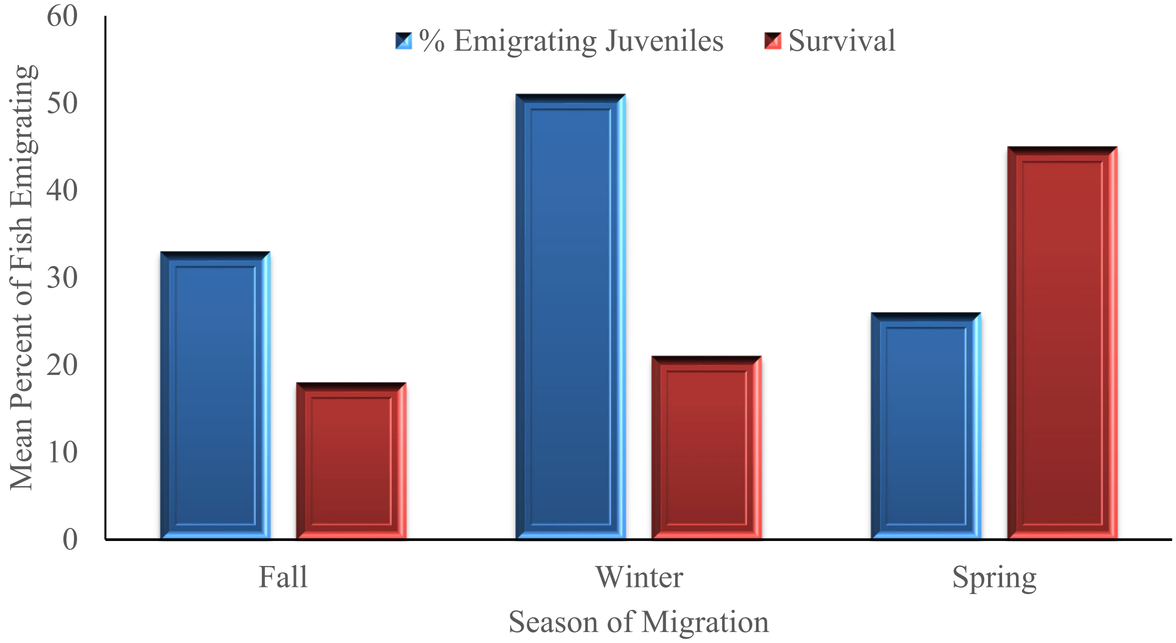

Figure 23. Plot of mean percent of fish emigrating and the corresponding survival by season, BY 2004-2019.

In the early years of the LGC reintroduction, the returns and/or outplants available were small and therefore small numbers were released above the weir to spawn. The mean number of tabulated redds for BY 2004-2009 was 52, compared to 193 between BY 2010-2016. When looking at juvenile mean size and survival variances during low redd years vs. high redd years, we observed a marked increase in the mean FL of the outmigrants and the survival to LGD for all seasonal groups when the number of redds above the weir was lower (Table 17). This observed difference could be due to less competition for habitat and nutrients in low redd years. For BY 2017, there were only 32 redds above the weir and the mean FL was substantially larger than in years where redd numbers were high (BY 2010-2016). Mean survival to LGD was also noticeably higher in BY 2017 than BY 2010-2016. Due to having low redds above the weir again in 2018 (n=39) it was expected to see the mean FL of each group being larger and similar in size to other low redd years. However the survival for all seasonal groups was quite low. It is unclear why this brood year had such poor survival to LGD. BY 2019 again had low numbers of redds (n=55), and in all seasonal groups the fork length was larger and the survival was high.

Table 17. Summary of BY 2004-2009 and BY 2010-2016 mean FL, and 2017, 2018, and 2019 total, showing survival during low redd years vs high redd years.

Brood Year	Season	Redds	Mean FL	Mean Survival
2004-2009	Summer	52 (Mean)	72	0.18
2010-2016		193 (Mean)	69	0.13
2017		32 (Total)	76	0.18
2018		39 (Total)	74	0.09
2019		55 (Total)	77	0.26
2004-2009	Fall	52 (Mean)	80	0.23
2010-2016		193 (Mean)	72	0.14
2017		32 (Total)	93	0.20
2018		39 (Total)	85	0.12
2019		55 (Total)	87	0.42
2004-2009	Winter	52 (Mean)	89	0.28
2010-2016		193 (Mean)	83	0.19
2017		32 (Total)	93	0.36
2018		39 (Total)	92	0.26
2019		55 (Total)	97	0.30
2004-2009	Spring	52 (Mean)	97	0.57
2010-2016		193 (Mean)	88	0.42
2017		32 (Total)	96	0.54
2018		39 (Total)	96	0.37
2019		55 (Total)	98	0.56

The plots below further outline the correlation between size, number of outmigrants, and survival through the hydrosystem (Figure 24, Figure 25, Figure 26). With increased fork length we have observed an increase in survival in those years (Figure 24). Therefore, in years when there are more redds above the weir and thus increased outmigrants, fish are notably smaller (Figure 25). Those years have proven to have much lower survival than in years with fewer redds and larger outmigrants. Therefore, more outmigrants tends to lead to smaller fish, which in turn leads to decreased survival (Figure 26). This trend could indicate a carrying capacity threshold or a food limiting factor when there are larger numbers of fish.

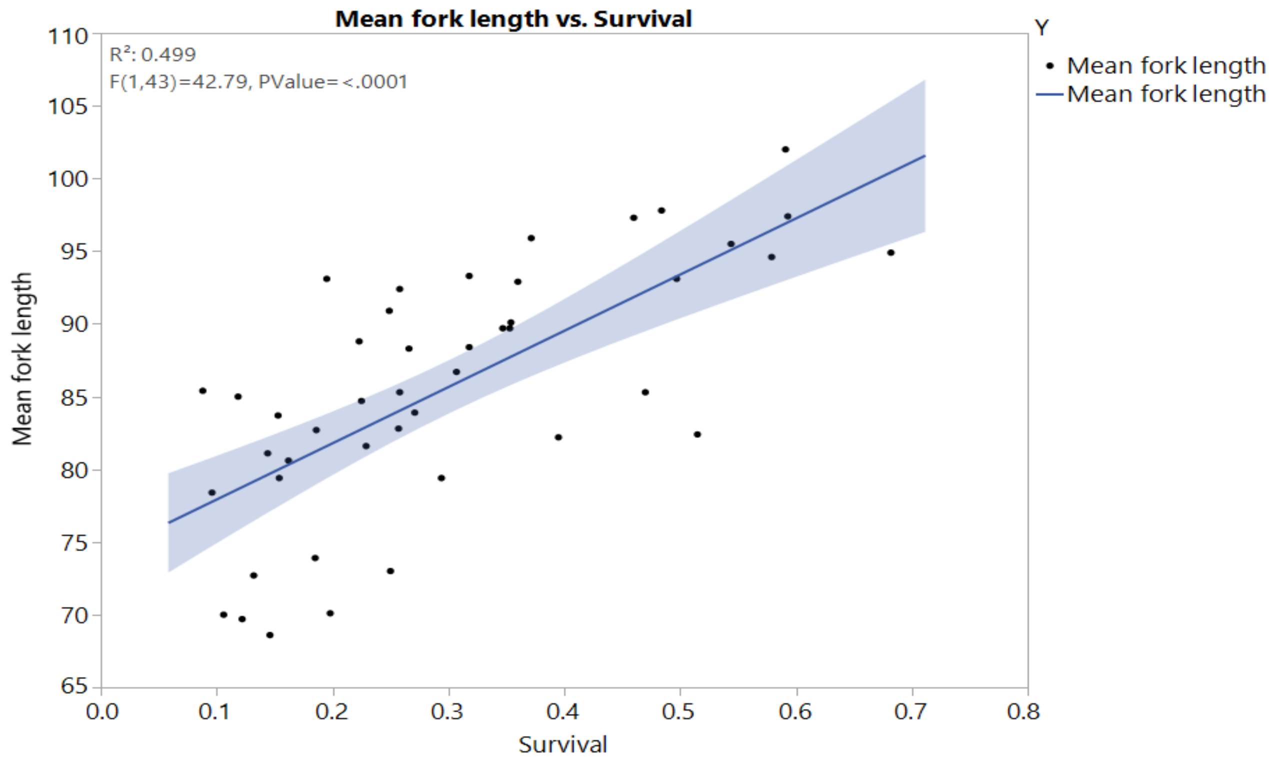

Figure 24. Plot of fork length and survival, indicating that as fork length increases, so does survival through the hydrosystem.

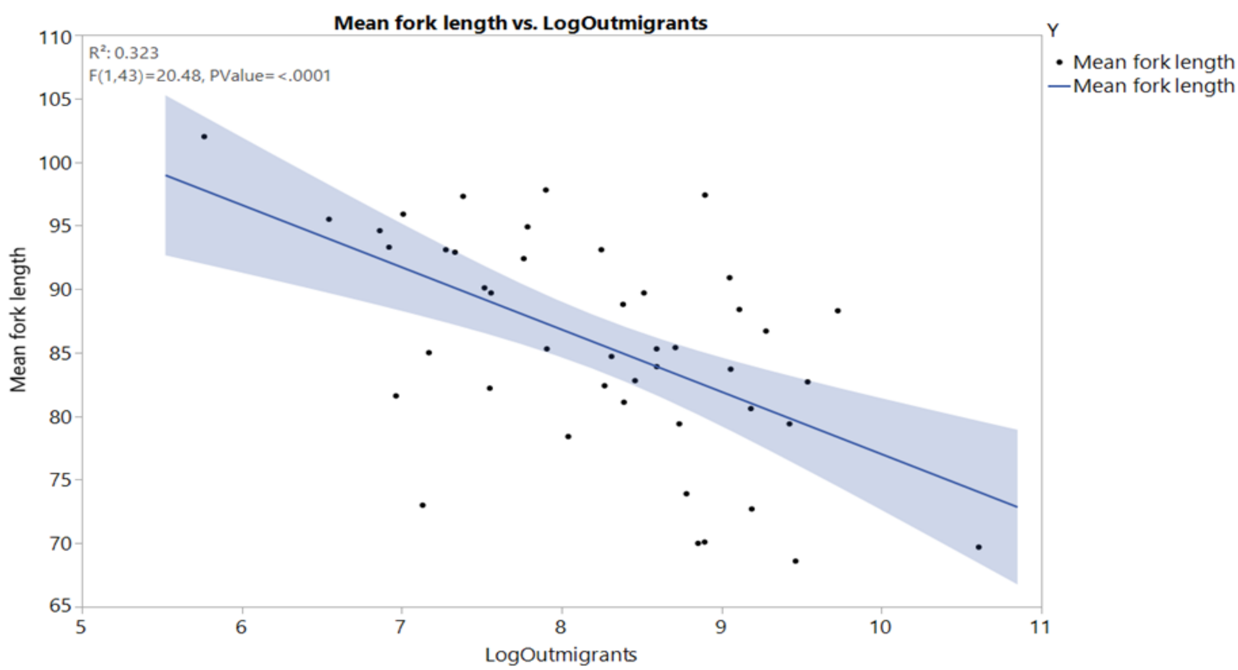

Figure 25. Plot of fork length and number of outmigrants in a given year, indicating that with increased numbers of outmigrants, the fork length decreases.

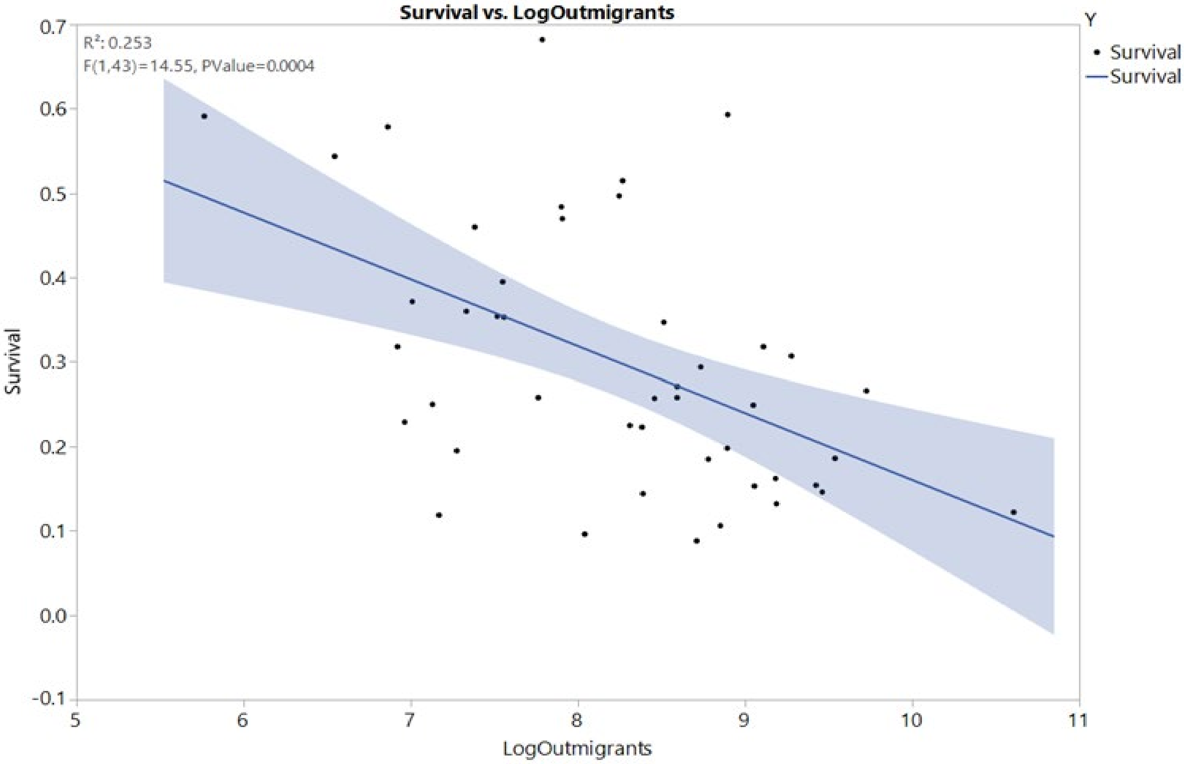

Figure 26.Plot of survival and number of outmigrants in a given year, indicating that survival decreases in years with increased outmigrants.

Smolt Equivalent Estimate

Smolt equivalent (S_{eq}) estimates (estimated outmigrants for each group surviving to LGD) for fall 2020, winter 2020, and spring 2021 were 398, 1,329, and 1,067, respectively. This equated to a BY 2019 total S_{eq} of 2,794. S_{eq}/spawner was the highest it has been since 2010, (n=25), which is not surprising given the very high survivals to LGD for BY 2019 (Table 18). S_{eq} /spawner since 2010 has ranged between 9 and 25. Why S_{eq} /spawner was consistently higher prior to 2010 is unclear.

Smolt to Adult Return

BY 2016 NOR SARs were below the BY 2004-2014 mean at 2.5 for adults only (Table 18). The BY 2004-2014 adult only mean of 2.9% is at the low end of the 2-6% range and below the 4% average recovery objectives for Snake River Chinook and steelhead (NWPCC , 2014). SAR's for BY 2016 are the highest calculated since BY 2012 whilst still being below the mean since reintroduction began.

Table 18. S_{eq} to LGD and SAR for LGC NOR spring Chinook salmon, BY 2004-2019.

	NOR BY returns				SAR (%)	
BY	All	Adult	S_{eq}	S_{eq}/spawner[a]	All[b]	Adults[c]
2004	62	55	2,446	24	2.5	2.2
2005	82	78	4,280	116	1.9	1.8
2006	162	138	3,669	78	4.4	3.8
2007	152	135	2,784	46	5.5	4.8
2008	171	141	10,620	59	1.6	1.3
2009	64	61	3,671	50	1.7	1.7
2010	245	185	3,319	11	7.4	5.6
2011	289	254	5,925	16	4.9	4.3
2012	370	335	7,596	10	4.9	4.4
2013	31	25	1,153	10	2.7	2.2
2014	89	74	5,151	12	1.7	1.4
2015	73	64	5,464	17	1.3	1.2
2016	98	87	3,432	9	2.8	2.5
2017			1.211	21		
2018			1,176	11		
2019			2,729	25		
Mean	145	126	3,964	32	3.3	2.9

[a] S_{eq} for BY*/Adult spawners from Table 7 BY*

[b] *(NOR BY X returns All ages)/S_{eq} BY X*

[c] *(NOR BY X returns at ages 4 and 5)/S_{eq} BY X*

**Caveat for 2015, Smolt equivalent low due to spill and low detects at LGD caused by uncharacteristically low flows that MY.*

Monthly sampling

The section of LGC known as 3L (formerly Nielson's property) was purchased by the CTUIR and has restoration work planned to restore the streams connection with the floodplain. This work is slated for implementation in the near future, possibly as early as 2024. This section contains the "standard site" that has been sampled consistently during the endemic era, the RR reintroduction era, and currently with the LGC stock (Boe, et al., 2014). The standard site (rkm 8.9) in the future may be used as the "treatment" location and the upstream site at the section break of 3U/ 3L at the footbridge (rkm 10.5) used as the "control" while we evaluate habitat usage before, and after in stream work is completed. Each month, around the 20th (July, August, September), we attempt to capture 50 fish using snorkel/seine methods at both of these sites. We typically are not able to snorkel for parr in June due to higher spring flows coupled with the small size of the fish and the mortality risks of handling and anesthetizing them. Beginning in 2019 and in partnership with CRITFC, the CTUIR collected stable isotopes, periphyton, gastric lavage samples, and leaf litter at both of these sites during these normal monthly sampling events in an effort to identify food web dynamics in LGC. The CRITFC received a BIA grant to enable them to collect data on salmon bearing streams and attempt to understand the climate impacts at a macroinvertebrate level, as invertebrates are important indicators of stream health (Kaylor, 2019). This also afforded an opportunity to identify population and environmental responses to restoration work and how quickly those responses might occur after restoration work has been conducted. Since restoration work has not yet occurred, this data will allow us a before and after glimpse at what nutrient base is present prior to restoration work, as well as a control and treatment group after the work is conducted. This data will help link the biological interactions and food web metrics to restorative habitat work. The analysis of this data will be published by CRITFC in the near future.

For BY 2019, there were 58 captured in July at the standard site (rkm 8.9) and the mean fork length was 69 mm. There were 60 chinook parr captured in August and the mean FL was 84 mm. There were no parr observed or captured during the sampling event in September. The K factor was 1.24 and 1.22 for July and August, respectively, indicating that these fish were healthy. Parr sampled at the upstream footbridge site are consistently smaller than at the standard site (Figure 27, Figure 28) likely due to colder water temperatures.

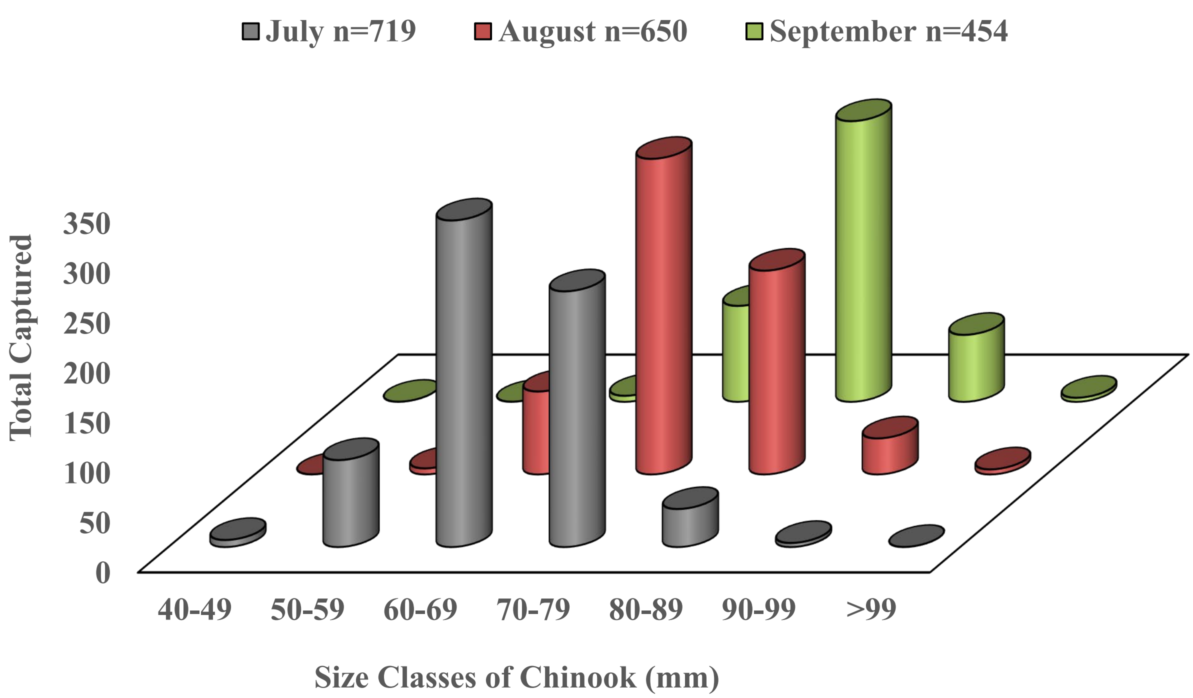

Figure 27. Seasonal growth of juvenile spring Chinook salmon captured during monthly sampling for July, August, September at the standard site (rkm 8.9), BY 2005-2019.

For BY 2019, there were 56 parr captured in July at the upstream footbridge site (rkm 10.5) and the mean fork length was 73 mm. There were 61 parr captured in August and the mean FL was 82 mm. There were only 24 parr captured during the sampling event in September and the mean FL was 79 mm. The K factor was 1.22, 1.17 and 1.14 for July, August, and September respectively, indicating that these fish were healthy. There was much more variability a few kilometers upstream at the footbridge site compared to the standard site, with much smaller fish observed in August and September and a much wider area of overlap between months (Figure 28).

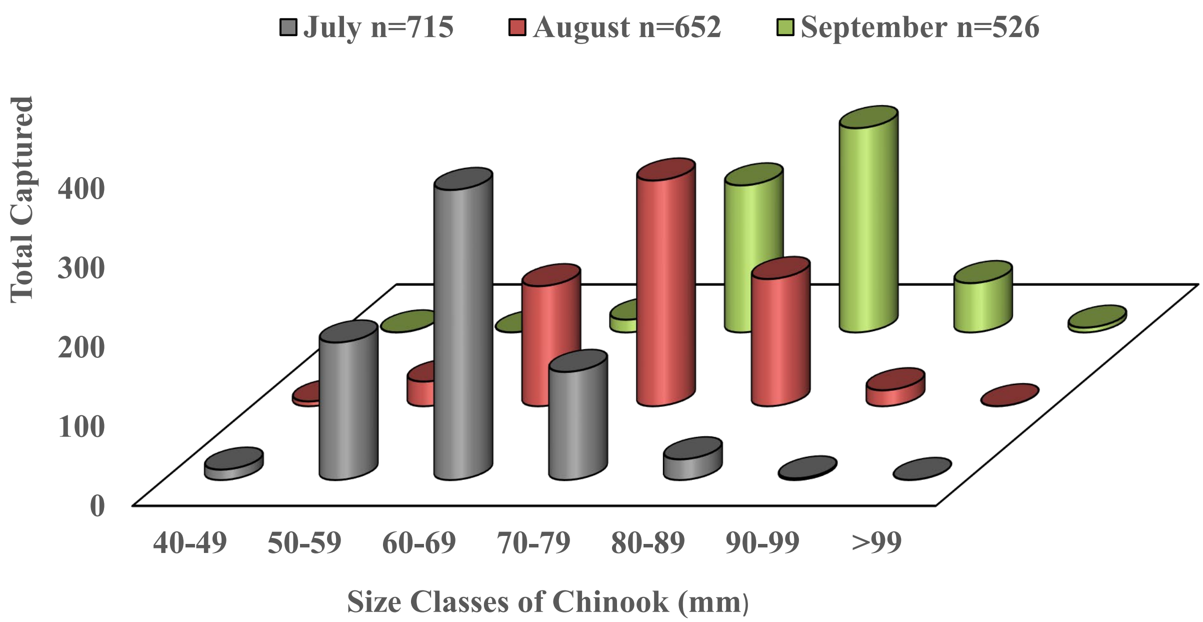

Figure 28. Seasonal growth of juvenile spring Chinook salmon captured during monthly sampling for July, August, September at the footbridge site (rkm 10.5), BY 2005-2019.

Summer Parr Sampling
A total of 647 BY 2019 parr where collected using snorkel/seine methods on 3 August 2020 (Figure 29). This was far below our collection goal of 1,000 parr, however was more successful than last year (Crump C., 2019). These fish were collected entirely from the upper rearing areas of LGC in section 3L (Figure 30) and will be used to evaluate their movement and survival to LGD. The CTUIR staff tagged these fish and returned them to the stream reach from which they were collected. Fork lengths were taken from 193 parr at the time of tagging (Figure 31). The average FL was 77 mm and the range was 60-103 mm. Of the 647 summer parr tagged, there were 169 recaptured in the screw trap during outmigration between 5 August 2020 and 19 April 2021. The majority of the summer parr group emigrated during the fall and winter months between release date of 5 August and 26 October (80%). This movement corresponded to the natural outmigration of parr captured in the screw trap.


Figure 29. Snorkel/seining of juvenile spring Chinook for the summer parr group collected in unit 3L.

Figure 30. Circled area indicated the location of fish collection during the summer parr group sampling.

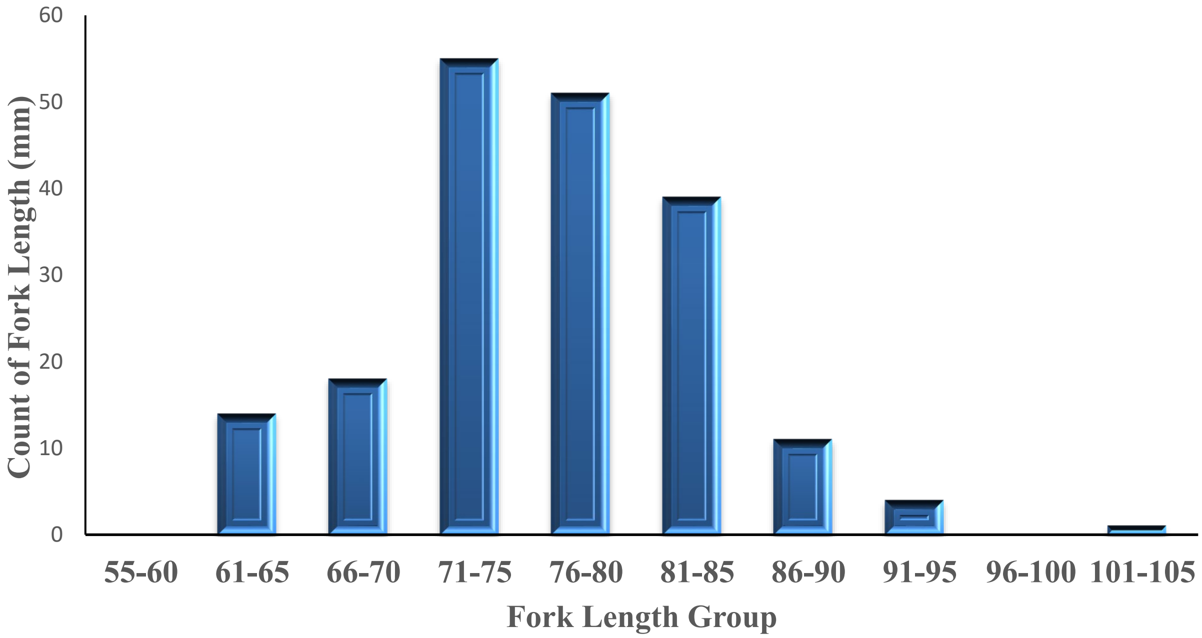

Figure 31. Size of summer parr spring Chinook salmon tagged in early August 2020, (BY 2019) during the summer parr collection effort.

1.6 Adaptive Management

Natural origin adult returns in recent years have displayed an upward trend, but are still below the 500 adults of the minimum threshold for recovery (Zimmerman & Patterson, 2002). However, since 2017 there have been low numbers of returns for both HOR and NOR returns. This was true for the entire Grande Ronde Basin and not specific to LGC. Due to the low returns, there was only a brief tribal harvest on LGC in 2021.

In years past, there have been a large percentage of redds being constructed in the 4.1 rkm below the weir. The mean percentage of redds constructed below the weir prior to using the lower ladder (between 2004-2018) was 37%. The high density of redds below the weir has likely caused a lack of viability of some redds due to superimposition. The number of redds below the weir in 2018 was an alarming 52% of the total redds observed, compared to only 14% in 2019, 23% in 2020, and 31% in 2021 with the lower ladder in operation.

CTUIR presented results from multiple years of spawning data at the LSRCP annual meeting in 2018 and following that co-managers were able to adapt the original LGC management plan to incorporate the use of an existing adult ladder trap near the hatchery outlet with the goal of reducing the number of redds below the weir while maintaining the ability to meet broodstock needs. The lower ladder was used in conjunction with the upper ladder once Tribal harvest ended on 25 June 2021. Activation of the lower ladder proved again to be very effective at capturing fish. However, nearly half of the returns to the weir were jacks and therefore broodstock needs were not met. Catherine Creek donor stock fish were incorporated into the LGC broodstock this year. This is the first year since early reintroduction efforts began that these measures were needed. The lower ladder caught nearly equal numbers of fish as the upper ladder, despite being open and fishing for a much shorter time frame. Identical numbers of HOR fish were captured in both the upper and lower ladder (n=225). The two ladder strategy will continue to be operated in ensuing years until co-managers decide broodstock collection at the upper ladder is sufficient. This may happen after the proposed modifications to the upper weir and hatchery water inlet are completed and several years of data are collected, however the timeline for this work is currently unknown.

There were 3 “mini jacks” collected below the weir on spawning surveys that ranged between 185 and 190 mm. We have not collected any mini-jacks above the weir to date. There was only 1 jack carcass recovered above the weir and 1 below in 2021. Total jack returns to the weir have been lower in 2018 and 2019 at 8% and 17%, respectively, compared to 42% of total returns in 2017. Jack returns in 2020 were only 10%, which seemed unusual due to the poor ocean conditions which might determine a higher jack return. Nearly half of the entire 2021 return to LGC were age 3 jacks (n=46%). Increases in early maturation rates could indicate poor ocean conditions as described by (Siegel, et al., 2017) (Weitkamp, 2019). The “warm blob” affecting the Pacific Ocean formed in the winter of 2013/2014 due to unusually high pressure over the Pacific, limiting vertical mixing and not allowing heat to transfer into the atmosphere (Weitkamp, 2019). There have been 6 consecutive years of warm ocean conditions due to this that are likely not proving favorable to salmonids.

Pre-spawn mortality was greatly reduced this year. Releasing adults directly upstream near the water intake building into a deep pool likely played a factor in reducing handling related stress and mortality. In years where adults were hauled several miles to their release location, we observed much greater loss (Table 10). There were no female carcasses collected this year that were not fully spawned out, however recovery rates have been lower due to small fish returns leading to fewer releases upstream after broodstock collection.

We have observed a shift in juvenile outmigration from fall months (August and September) to winter months (October and November) and observed smaller parr leaving in years where there are many redds above the weir (Crump C., 2019) (Crump & Van Sickle, 2016). We have also observed lower survival in these same years. This may be an indication of over winter carrying capacity limitations or other density dependent factors such as food limitations (Crozier, et al., 2010), (Independent Scientific Advisory Board, 2015). Burck (1993) suggested density dependent seasonal movement of outmigrants, with more leaving early as fry or small parr in brood years when there were more redds. The author also suggested that this movement was habitat-related and a tradeoff of higher growth for the risk of higher mortality, since outmigrants moving into the Grande Ronde River encountered higher water temperatures and more predators and competitors. The BY 2019 parr and smolts captured in the screw trap and field group were noticeably larger. This larger size correlates with having only 46 redds above the weir and likely having less competition for rearing habitat and food resources. However, there was a lower outmigrant per redd estimate indicating in stream survival was not as successful as expected (n=131 outmigrants/redd). Moving forward with the habitat improvement on section 3L could improve in stream survival for LGC salmonids. Interestingly, survival to LGD for summer, fall, winter and spring were some of the highest calculated, indicating that after leaving LGC, conditions through the hydrosystem were much more favorable this year.

The purchasing of the (formerly) Nielson property (Figure 32, Figure 33) will provide the CTUIR the opportunity to reconnect the stream with its floodplain, increase sinuosity by removing the stream from its simplified alignment, and increase habitat capacity within this 2-mile section. The current reintroduction evaluation provides data that can be used to investigate the biological response of this restoration. Metrics observed will include redd distribution/timing, outmigration timing/quantity, differences in size and condition factor of outmigrating fish, and survival of outmigrants compared to pre-restoration levels. Our belief is that restoring the river's natural floodplain and meanders will increase the available habitat for juveniles to rear, as well as increase the area available for adult holding and spawning and thusly increase natural production. Having several years of pre-restoration data readily available enables us to observe and quantify fish use and response to the habitat restoration in a BACI design method. Restoration efforts may address the smaller mean size and survival estimates currently observed in outmigrating spring Chinook in higher redd years. It could also increase the amount juveniles overwintering in the headwaters, allowing those fish to emigrate during spring freshets when survivals are the highest.

To be adaptive in our approach to evaluating the reintroduction of Chinook to LGC we needed to include the effects of restoration work not only on salmonids but also on their habitat and as such we embarked on a partnership with CRITFC to understand the stable isotopes of juvenile Chinook salmon, benthic macroinvertebrates, leaf litter, and periphtyon present during our monthly sampling efforts (July-September). The lower sampling site (standard) is within the CTUIR property where we plan to do the habitat reconstruction and will be the "treatment" site, while the upper sampling site (footbridge) will remain untouched and be used as our "control".

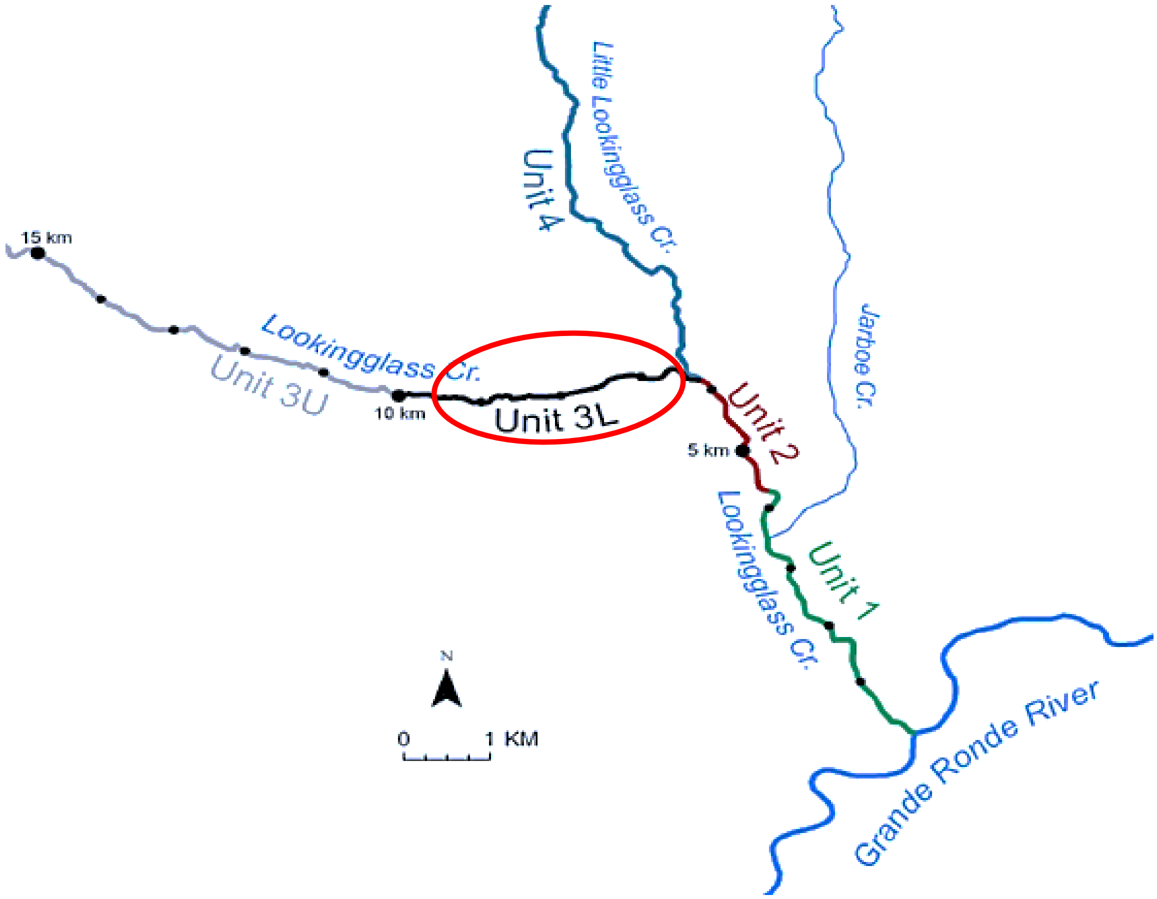

Figure 32. Lookingglass Creek section breaks for spawning surveys. The red circled area indicates the acquired conservation property slated for restoration work in the future.

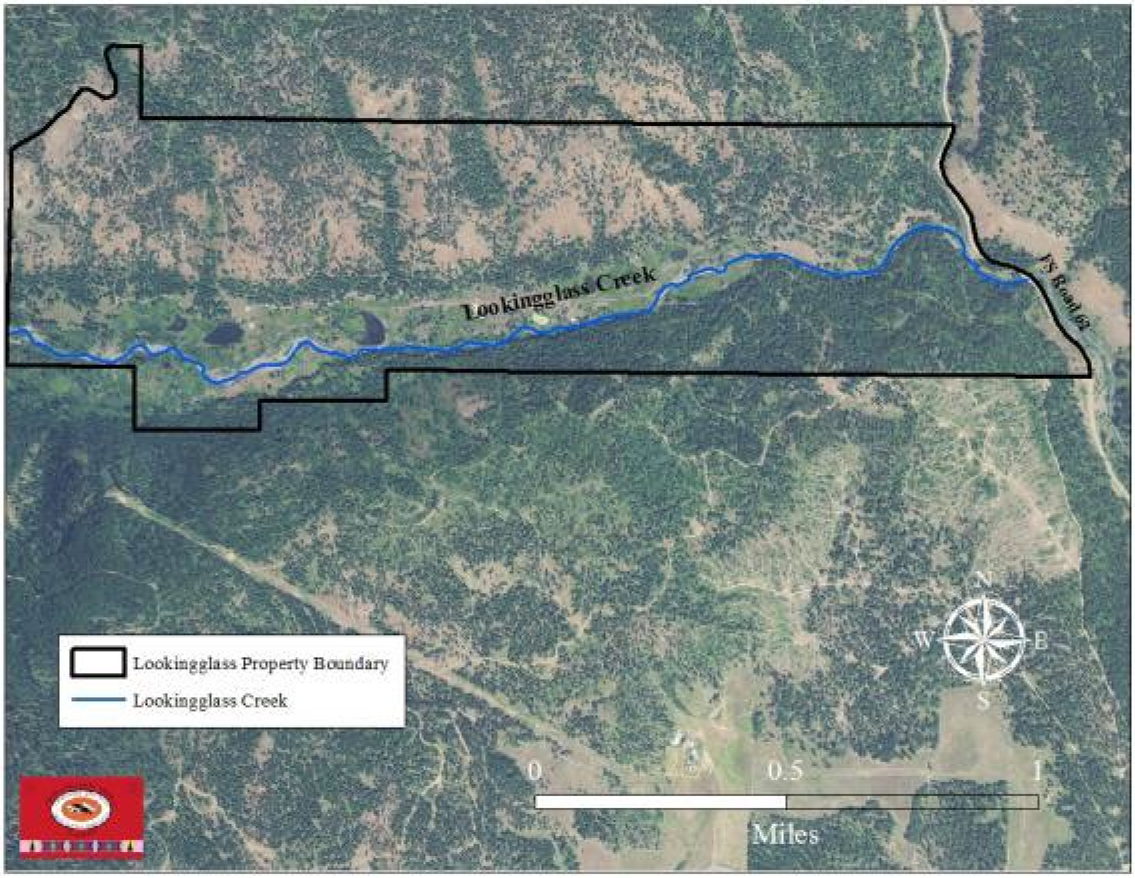

Figure 33. The conservation property purchased by CTUIR in 2015.

1.7 Summary

The CTUIR has studied the NOR "fish in and fish out" metrics on LGC to obtain stock-specific life history strategies which help guide our management practices. We have observed status and trends for the reintroduced CC hatchery donor stock since 2004 and have observed life stage specific metrics to identify VSP criteria and help assess the effectiveness of our program in increasing natural production of reintroduced spring Chinook salmon. In 2009, the first complete naturally spawning BY returned to LH. While some of our methods have varied slightly over the years, the overall experimental design has remained the same and will continue to be replicated to observe across year variation as well as achieve stronger statistical power.

A sustained improvement in productivity will be needed to rebuild and maintain a naturally reproducing population above the LH weir as we still observe low SAR's. It is unlikely that without the continued HOR component to this program the NOR would be able to self-propagate and increase each year, as well as provide tribal harvest.

1.8 Management Plan

Lookingglass Creek is co-managed by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Nez Perce Tribe (NPT), and Oregon Department of Fish and Wildlife (ODFW). The primary objective of this plan is to coordinate restoration of spring Chinook into Lookingglass Creek.

Program Goal

The goal of the Lookingglass Creek Spring Chinook Hatchery Program is to reintroduce spring Chinook into Lookingglass Creek to support tributary harvest, natural population restoration, and maintenance of a gene bank for the Catherine Creek stock.

Adult Return Goals

There are no LSRCP or Tribal Recovery Plan (TRP) hatchery and natural adult return goals specifically identified for Lookingglass Creek. However, LSRCP does have a specific spring/summer Chinook goal of 58,700 hatchery adults for the Snake River and 5,820 hatchery adults into the Grande Ronde Basin. The TRP return goal for the Grande Ronde Basin is 16,000 adults. Restoration of a genetically independent Lookingglass spring Chinook population to a “viable status” is not necessary to achieve viable status of the Grande Ronde Major Population Group (MPG).

Historically, Lookingglass Creek abundance exceeded 1,000 adults based on redd count data from 1950s-1970s. The Interior Columbia Technical Recovery Team (ICTRT) has designated Lookingglass Creek as a “Basic Population” with a Minimum Abundance Threshold (MAT) of 500 natural adults.

Juvenile Production and Releases

To meet the LSRCP Grande Ronde Basin adult mitigation goal, a juvenile production target of 900,000 fish at 20 fish per pound with an estimated return rate of 0.87% was originally identified with all the production coming from Lookingglass Hatchery (LGH). The production goals for LGH as listed in Table B1 of the 2018-2027 *United States v. Oregon* Management Agreement are outlined in Table 1.

Table 1. Lookingglass Hatchery production outlined in US v OR Table B1.

Release Site	Rearing Facility	Stock	Life stage	Target Release Number	Primary Program Purpose	Funding
Lookingglass Creek	Looking glass	Lookinggl ass/ Catherine Creek	Smolts	250,000	Fishery/ Reintroduction	LSRCP/ BPA
Catherine Creek	Looking glass	Catherine Creek	Smolts	150,000	Supplementation / Fishery	LSRCP/ BPA
Upper Grande Ronde River	Looking glass	Upper Grande Ronde	Smolts	250,000	Supplementation / Fishery	LSRCP/ BPA
Lostine River	Looking glass	Lostine	Smolts	250,000	Supplementation / Fishery	LSRCP/ BPA
Imnaha River subbasin	Looking glass	Imnaha	Smolts	490,000	Supplementation / Fishery	LSRCP

Releases for the Lookingglass Creek component occur on-station from LGH. The release goal is 250,000 at 20 fish/lb. in mid-April. Fish will be volitionally released for at least one week prior to force out in mid-April. Changes in size or release strategies will be coordinated through the LGH Annual Operating Plan (AOP).

Marking

Marking for the Lookingglass Creek program is outlined in Attachment C of the 2018-2027 *United States v. Oregon* Management Agreement. Releases will be 100% Ad clipped with a 62.5K representative coded-wire-tag (CWT) group.

Weir Management
Disposition of Lookingglass Creek adults trapped at either the LGH intake weir or lower ladder will occur at a 50:50 escapement to brood pass:keep ratio. The 50:50 ratio is expected to be met on a weekly basis. Scale and genetic samples will be collected from all adults passed upstream. Adults arriving at the weir that are identifiable as Upper Grande Ronde stock (Ad clip + wire) will be kept for broodstock.

Broodstock Management
The goal for the Lookingglass Creek broodstock composition will be to incorporate 30% natural origin adults to maintain genetic diversity and counteract any potential for domestication selection in the program. However, no more than 25% of the returning natural origin adults shall be retained for brood. The broodstock collection goal will not be constrained by the 25% cap on natural adult collection. If a shortage of natural adults occurs, then additional hatchery adults will be collected in order to meet the brood target.

The target is to collect 86 females (76 spawned), 78 males, and eight jacks for brood in order to meet the 250,000 smolt production level. The goal is to use large or 5-year old males in at least 30% of the matings. In order to help meet this target, large males may be used up to three times. Jacks will not be used in more than 10% of the matings. Adjustments to the brood collection and spawning numbers are made as needed annually through the AOP process.

Escapement
The ICTRT has established a MAT of 500 adults for the Lookingglass Creek population in order to reach viable status with an estimated 90% of the historical habitat located upstream of the hatchery. Other documents have suggested that historically the full seeding level is much higher than this figure. Lookingglass Creek in the reach above the facility will be managed for an escapement of up to 1,000 adults.

Jack Management
All natural jacks will be released upriver. No hatchery jacks will be released upriver. Hatchery jacks will be incorporated into the brood at a target rate of one for every 10 adult males collected (8 fish). All CWT hatchery jacks not taken for broodstock will be sacrificed for tag recovery. Other hatchery jacks will either be sacrificed with carcasses provided to the Tribes and food banks or recycled into lower Lookingglass Creek for harvest benefits.

Surplus Production
Every attempt will be made to adhere to the production goals. However, surplus production may occur due to higher than anticipated fecundities or survival rates. Any production above the identified goals will be reared to full term yearling smolts if hatchery space is available. If space is not available, surplus production will be outplanted in the fall as fingerlings into lower Lookingglass Creek. These fish would be 100% Ad clipped to indicate hatchery origin.

Fish Health

Bacterial Kidney Disease (BKD) is of special management concern with the Lookingglass Creek spring Chinook program. Adults from this program released above the hatchery can release pathogens that enter the facility water supply, potentially jeopardizing production for multiple programs. Due to this disease concern, eggs for the Lookingglass Creek program will be culled at a more restrictive level than that agreed upon in the Grande Ronde Spring Chinook Hatchery Management Plan. Eggs from individual females will be incubated separately and those with an ELISA value of 0.20 or higher will be culled from the program. In addition, adult broodstock will receive erythromycin (or Draxxin) and oxytetracycline injections and juveniles will receive a prophylactic erythromycin feeding.

Individual spawned females will also be tested for culturable viruses. Broodstock mortality will be tested for systemic bacteria and BKD by ELISA. A minimum sub-sample of 30 kidney samples from adult Chinook carcasses above the weir (hatchery intake) will be collected during spawning ground surveys for BKD ELISA and culturable viruses and bacteria.

Harvest

It is anticipated that returns back to Lookingglass Creek will continue to be heavily skewed toward hatchery origin adults which provide opportunities for harvest. Management details for harvest of spring Chinook in Lookingglass Creek are outlined in the respective Tribal Resource Management Plans (TRMP) and Fishery Management and Evaluation Plan (FMEP).

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2.1 Appendices of Water Temperatures and Diurnal Fluctuations

The LGC screw trap logger was lost during the season. Therefore there is no comparisons to be made to the LLGC culvert site. A new Hobo Tidbit logger will be placed in the same flume hole, but will be affixed to the large rock wall on the opposite bank and secured with adhesive. LLGC is typically on average a couple of degrees cooler than the mainstem at the screw trap site, however it still reached nearly 18° C in early July (Figure 34). The LLGC probe site is roughly 5.5 km upstream from the screw trap site which likely explains the cooler temperatures frequently observed. Since 2013, zero contiguous hours were logged on the LLGC culvert probe that were ≥20ºC, and only 3 hours were logged ≥ 20°C for the LGC Screw Trap probe (minus 2016 and 2021 data for lost probe). Diurnal fluctuations at the LLGC site are shown in Figure 34 and average daily temperature in Figure 35.

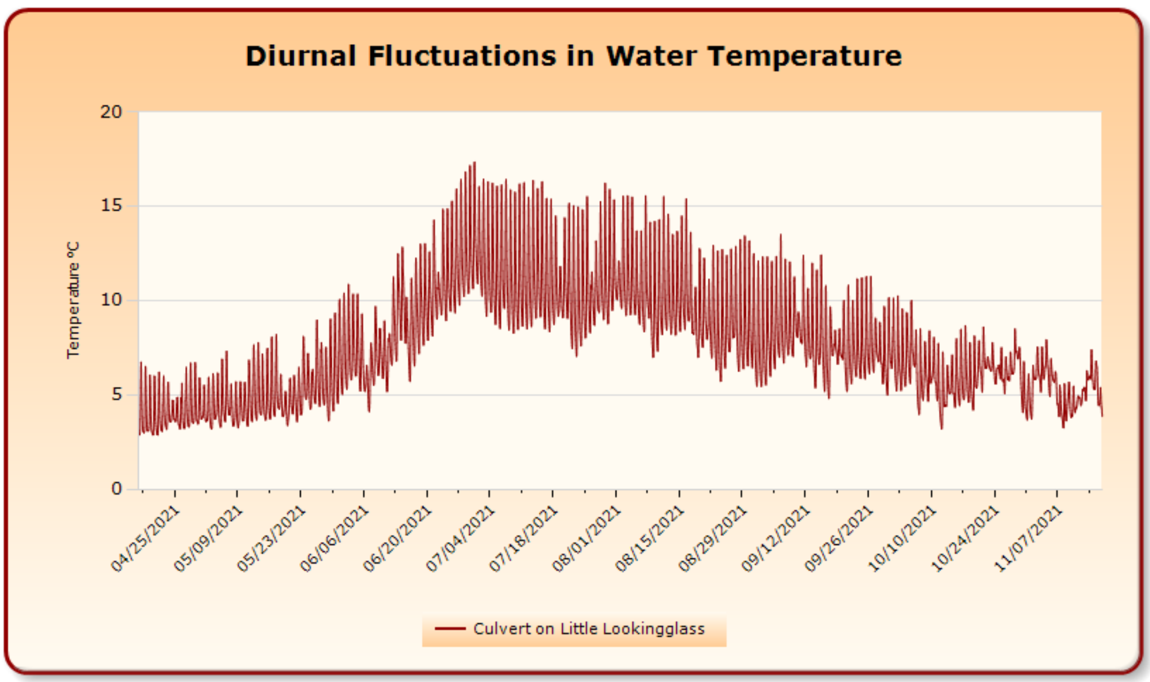

Figure 34. Diurnal fluctuations at the Little Lookingglass Creek culvert site, 2021.

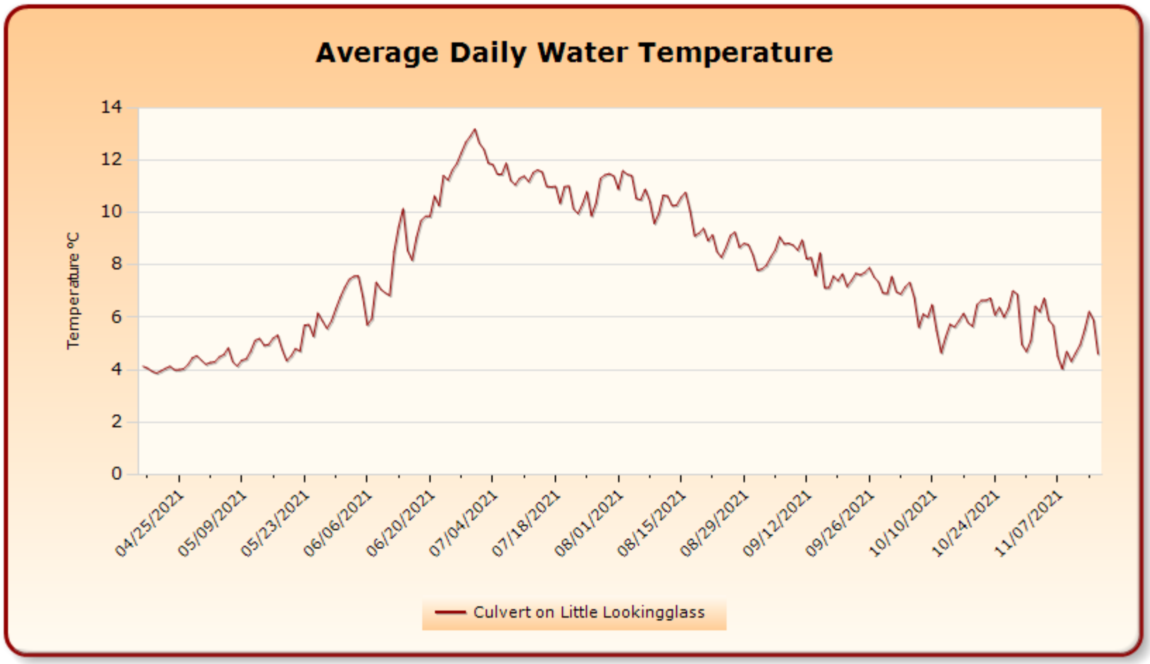

Figure 35. Average daily water temperature at the Little Lookingglass Creek culvert site, 2021.

2.2 Appendices of Data Used for Wilcoxon Statistical Analysis

Table 19. Number of redds by unit for RY 2009-2021. Data in table are used in Wilcoxon Rank Sum analysis on page 28 of report.

Year	Unit 1	Unit 2	Unit 3L	Unit 3U	Unit 4	Total
2009	30	2	23	40	2	97
2010	89	24	63	62	21	259
2011	129	15	71	105	21	341
2012	133	31	100	136	47	447
2013	47	4	25	30	1	107
2014	105	24	71	82	28	310
2015	91	33	64	67	21	276
2016	144	24	81	83	19	351
2017	68	5	19	7	1	100
2018	42	9	22	8	0	81
2019	9	8	35	9	3	64
2020	32	25	51	28	3	139
2021	21	14	20	8	4	67
Mean	72	17	50	51	13	203

2.3 Appendices of Methods Previously Used

Methods described below for determining "population estimates above the weir" were used from 2004-2014. While these methods were not <u>incorrect</u>, they were not consistent with how our other co-managers and cohorts calculate population estimates. In an effort to maintain comparability and consistency basin wide, these methods were abandoned and recalculations of these numbers are in the body of this report and in tables and figures. Since some of these data may have been used by others, we will continue to list them in our appendices, as well as methods used to calculate them. The former method is stated below. Data was calculated both ways for 2015 so that you may observe the difference in outcome from each method.

2004-2014 Previous Method of Calculating Population Estimate Above the Weir
Actual "population estimate" above the weir were obtained by subtracting any mortalities (male or female) observed prior to the flagging of the first redd on spawning ground surveys from the total numbers released above the weir and then applying the Chapman modification of the Peterson method using marked/unmarked recoveries. After determining this estimated population above the weir, the percent of female pre-spawn mortalities ONLY recovered during the regular spawning season is applied to calculate the "spawner estimate".

The three tables below have the data that was calculated in this manner. Since past population estimates were calculated by removing all mortalities recovered prior to the flagging of the first redd from the "population" these population estimates differ from the 2015 calculations. We currently remove any 1ROP fish recovered below the weir on surveys from the total number passed upstream of the weir, and then use the Chapman modification to the Peterson method using marked/unmarked recoveries. The pre-spawn mortality was also calculated differently since we currently do not "remove" any females that died prior to the first redd being flagged from the calculation of pre-spawn mortality. Therefore, the pre-spawn mortality is simply calculated as the total number of females recovered on spawning surveys that are, $\leq$50% spawned out, with no reference to when the first redd was observed. This in turn, effects the "spawners above the weir" and thus R/S, Seq/spawner, and fish/redd (Table 21, Table 22, Table 23). The corresponding tables in the body of this report will have updated data using methods described here and in the methods section.

Table 20. Previous method of calculating population estimates, spawners, and R/S for LGC NOR spring Chinook salmon, 2004-2015.

	Population[a]		Spawners[b]		R/S	
Year	All	Adults	All	Adults	All[c]	Adults[d]
2004	100	100	100	100	0.6	0.6
2005	50	42	46	39	1.8	2.0
2006	60	55	60	55	2.7	2.5
2007	72	66	66	61	2.3	2.2
2008	190	180	190	180	0.9	0.8
2009	109	84	95	74	0.7	0.9
2010	371	342	363	334	0.7	0.6
2011	500	431	470	405		
2012	937	937	772	772		
2013	210	154	210	154		
2014	620	583	564	531		
2015	711	676	678	644		

[a] *Fish present above LH weir prior to start of regular spawning ground surveys*
[b] *Adjusted for prespawning mortality*
[c] *(Sum of BY X returns at ages 3, 4, and 5)/BY X All spawners;* [d] *(Sum of BY X returns at ages 4 and 5)/BY X Adult spawners*

Table 21. Previous method of calculating Fish/redd and prespawn mortality for naturally spawning spring Chinook salmon above the LH weir, 2004-2015.

	Fish/redd		
Year	Adults only	Jacks and Adults	Prespawning mortality
2004	2.04	2.04	0.00
2005	1.45	1.72	8.33
2006	1.95	2.13	0.00
2007	2.06	2.25	8.33
2008	1.73	1.83	0.00
2009	1.25	1.63	12.50
2010	2.01	2.18	2.27
2011	2.03	2.36	6.00
2012	2.98	2.98	17.56
2013	2.56	3.50	0.00
2014	2.84	3.02	8.96
2015	3.65	3.84	4.70
Means	2.21	2.46	5.72

Table 22. Previous method for calculating S_{eq} to LGD and SAR for LGC NOR spring Chinook salmon, BY 2004-2013.

			SAR (%)	
BY	S_{eq}	S_{eq}/spawner[a]	All[b]	Adults[c]
2004	2,446	24	2.5	2.2
2005	4,280	110	1.9	1.8
2006	3,669	67	4.4	3.8
2007	2,784	46	5.5	4.8
2008	10,620	59	1.6	1.3
2009	3,671	50	1.8	1.7
2010	3,319	10	7.4	5.6
2011	5,925	15		
2012	7,596	10		
2013	*1,152	*8		
Mean	4,546	40	3.6	3.0

[a] *Adult spawners from Table 16 (Old Method)*

[b] *(Sum of NOR BY X returns at ages 3, 4, and 5)/S_{eq} BY X*

[c] *(Sum of NOR BY X returns at ages 4 and 5)/S_{eq} BY X*

**Caveat for 2015, Smolt equivalent low due to spill and low detects at LGD caused by uncharacteristically low flows that BY.*

2.4 Assistance Provided to LSRCP Cooperators and Other Projects

We provided assistance to Lower Snake River Compensation Plan (LSRCP) cooperator Oregon Department of Fish and Wildlife (ODFW) in 2021 for ongoing hatchery evaluation research. Project personnel assisted with spawning ground surveys for spring Chinook salmon in the Grande Ronde basin. CTUIR provided assistance in pre-release sampling of spring Chinook salmon at Lookingglass Hatchery and conventional spawning of adult spring Chinook salmon at Oregon LSRCP facilities. CTUIR also assisted with production tagging of hatchery origin fish in November 2021.

We assisted Bonneville Power Administration (BPA) funded projects with data collection in 2021. Tissues taken with the opercle punch on adult returns to LGC weir were placed in dry rite in the rain envelopes for a study of relative reproductive success (Galbreath, et al., 2008). We assisted ODFW personnel who have been collecting data on bull trout (*Salvelinus confluentus*) in the Grande Ronde River basin by providing estimated fork length data from bull trout captured in the LGC screw trap and during monthly sampling of juveniles.

Lamprey Releases

In May 2016, approximately 150 adult lamprey were transplanted into LGC at the bridge on Unit 3L (Figure 36). In 2017, there were 100 placed at the same location on Unit 3L, and another 50 placed at the culvert on LLGC (rkm 2.0). In 2018, there were 151 lamprey released at the same two sites. In 2019, there were 300 adult lamprey released into LGC at the bridge on section 3L. In 2020, there was a 100 year flood event which destroyed the holding facility for this year's releases and killed most of the lamprey bound for translocation. Therefore, any lamprey being held for spring release in 2021 were released in the fall of 2020. There were 250 adults translocated to LGC in September 2020. There was another fall release in 2021 of 400 adult lamprey. Lamprey tend to spawn in the summer months of June and July, so several surveys were completed to observe them. These surveys occurred in conjunction with annual pre-spawn mortality surveys for spring Chinook salmon. However, flows remained high late into the summer and therefore many redds were likely missed. We counted 2 completed lamprey redds during these surveys (Figure 37). The observed lamprey redds were counted in areas where we currently see large numbers of Chinook redds also. The two redds were in section 3L. There will typically be annual releases of lamprey each year as long as supply is available. This is of great historical and cultural significance to the CTUIR. Lamprey had not been released into LGC prior to 2016, however there is documentation that they were present here over 50 years ago (Burck, 1993).

Figure 36. Approximately 250 adult lamprey were released into Lookingglass and Little Lookingglass Creek in 2020. There were fall releases in 2021 totaling 400.

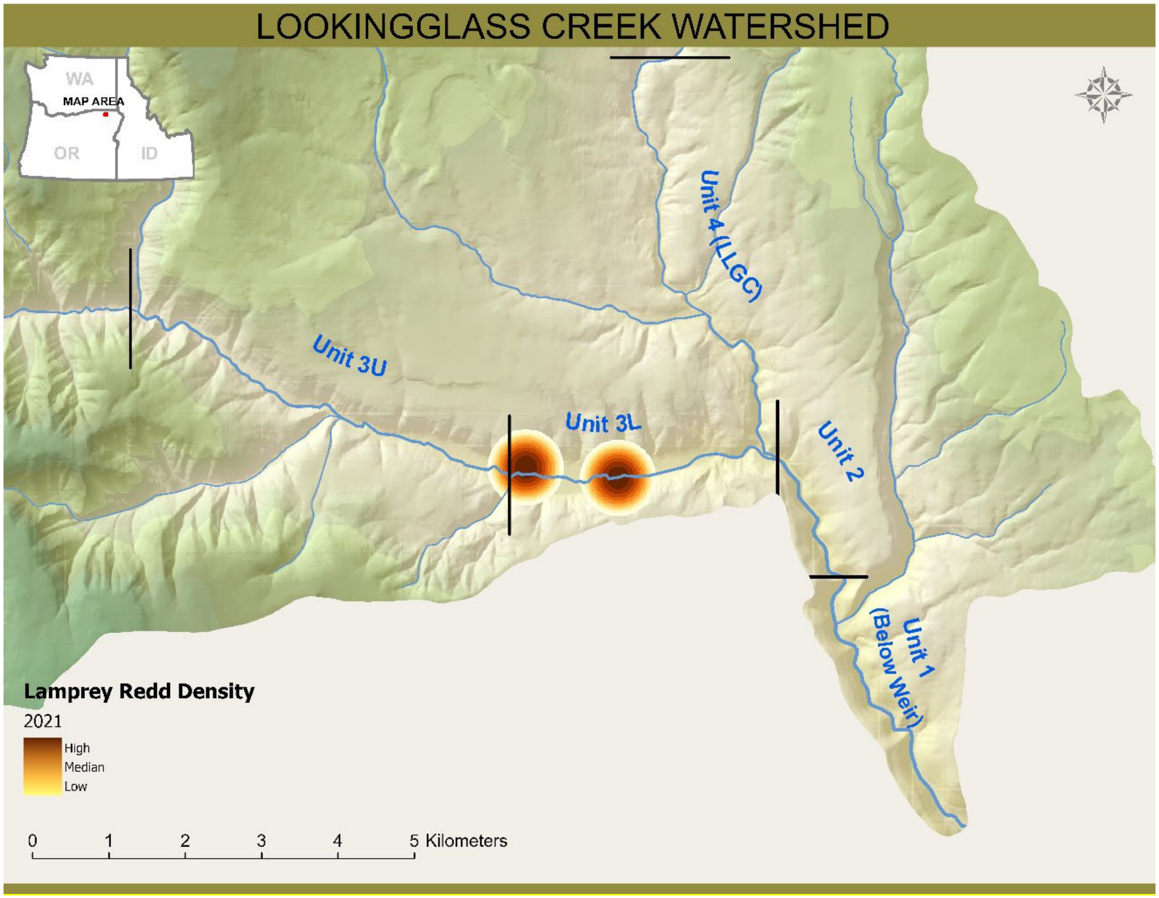

Figure 37. Location of the observed lamprey redds, 2021. Map courtesy of Kaylyn Costi.

Coho Observation and Spawning Ground Surveys

On 16 November 2021, several Coho salmon were seen constructing redds near the LH. These Coho are likely strays from the Lostine River releases that began several years ago. The return this year was large and some of the returns were observed moving into streams such as the Minam, Sheep and Bear Creeks. CTUIR staff conducted several spawning ground surveys to confirm whether any of these Coho had escaped past the weir and spawned upstream, or had remained below the weir due to passage difficulties. There were no redds or fish counted or observed above the weir. There were six adults and 3 redds counted below the weir, all in the upper section of Unit 1 nearest the LH. Co-managers are discussing the potential of CTUIR staff operating the LH trap until 30 November in the future to allow Coho passage upstream.

2.5 Acknowledgments

We thank the private landowners along LGC, including Hancock Properties, and Vern and Linda Jennings for allowing us to access and work on their property. Thanks to Rod Engle, Chris Starr, Brian Devlin, and Anna Copeland (LSRCP, United States Fish and Wildlife Service) for administering this contract and coordinating project activities between the CTUIR and other agencies. Gary James, Michelle Thompson, Julie Burke, Celeste Reves, Chelsey Dick

(CTUIR), provided technical and administrative support. Thanks go to members of the ODFW NE Oregon Fish Research Section for field and office assistance. CTUIR O&M staff and CTUIR staff from other projects assisted in various field activities. ODFW LH staff tended the adult trap, collected tissues and trap data, provided the use of hatchery facilities and equipment, and kept an eye on the screw trap for us. Bethy Rogers-Pachico (CTUIR) provided the original redd density maps, and Kaylyn Costi updated them with current data. Gene Shippentower (CTUIR) reviewed previous drafts of this report. The Bureau of Reclamation provided support for this project and our BPA related tasks in the amount of approx. $50,000 for seasonal help to complete field work, and equipment purchases. Joseph Feldhaus (ODFW) provided methodology for calculating population estimates detailed in Appendices 2.2 that enabled us to be consistent with our partner agencies.