Annual Progress Report
Lower Snake River Compensation Plan
Confederated Tribes of the Umatilla Indian Reservation
Evaluation Studies for 1 January 2018 to 31 December 2018

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

Photo by Les Naylor

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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 2018 were 315, of which 78 were natural-origin. Releases above the Lookingglass Hatchery weir totaled 154 and spawning ground surveys yielded 39 redds above the weir, and 42 below. Brood year 2013 recruits per spawner was 0.2 for adults only. We estimated 17,784 (86 outmigrants/redd) juveniles outmigrated from above Lookingglass Hatchery for brood year 2016. Survival probabilities to Lower Granite Dam ranged from 0.153-0.353 for summer, fall, winter, and spring PIT-tagged groups. Smolt equivalents (outmigrants surviving to Lower Granite Dam) totaled 3,432. Harmonic mean travel time (in days) to Lower Granite Dam for brood year 2016 was 273, 238, 181, and 45 for summer, fall, winter, and spring groups, respectively. Brood year 2013 smolt-to-adult ratio was 2.2 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, 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 (LGC) 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, 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.

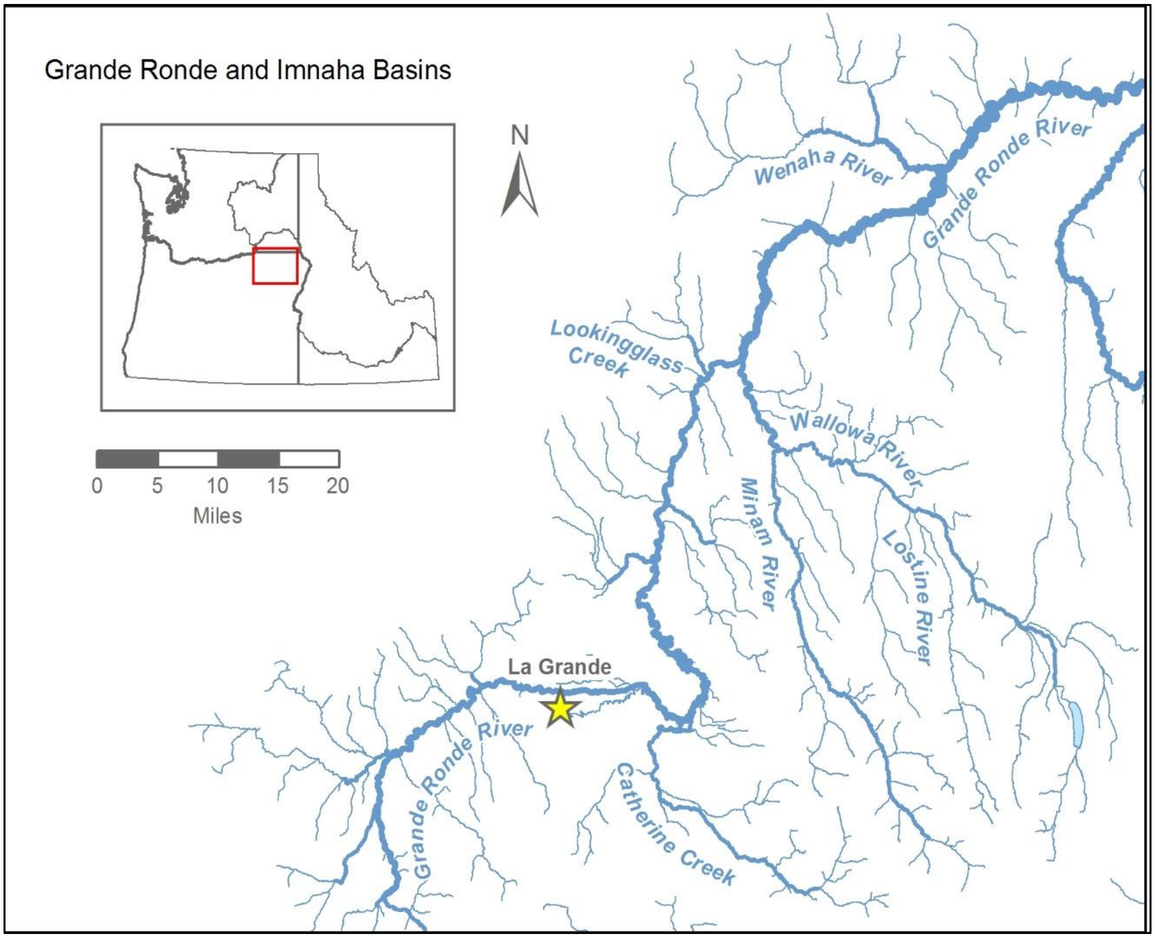


Figure 1. Location of Lookingglass Creek and the Grande Ronde Basin.

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. 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 (CRITFC), 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

The goal of the LGC Spring Chinook Hatchery Program is to reintroduce spring Chinook into LGC using the CC stock to support tributary harvest, natural population restoration, and maintenance of a gene bank for the CC stock (ODFW, 2011).

Program specific objectives stated in the Hatchery and Genetic Management Plan (HGMP) 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.

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."***

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 (http://www.fws.gov/lsnakecomplan/Reports/ODFWreports.html).

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 2016 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 decided upon by all co-managers that the lower ladder would be operated in 2018 in conjunction with the upper ladder. The agreement also stated that the lower ladder would not be used until tribal harvest was closed so that any available Chinook in lower LGC would have the opportunity to be harvested by tribal members. Chinook entering the lower ladder would be differentially marked with 2 right opercle punches, while the upper ladder would continue to receive 1 right opercle punch. The differential mark would allow us to identify if HOR Chinook were captured at a higher percentage than NOR at the lower ladder (possibly due to an attraction to hatchery discharge), as well as whether the HOR fish tended to drop back below the picket weir (Figure 3) at a higher percentage than NOR, and identify possible temporal or spatial spawning location differences. Operating both traps is planned to continue in perpetuity as low numbers are expected to persist.

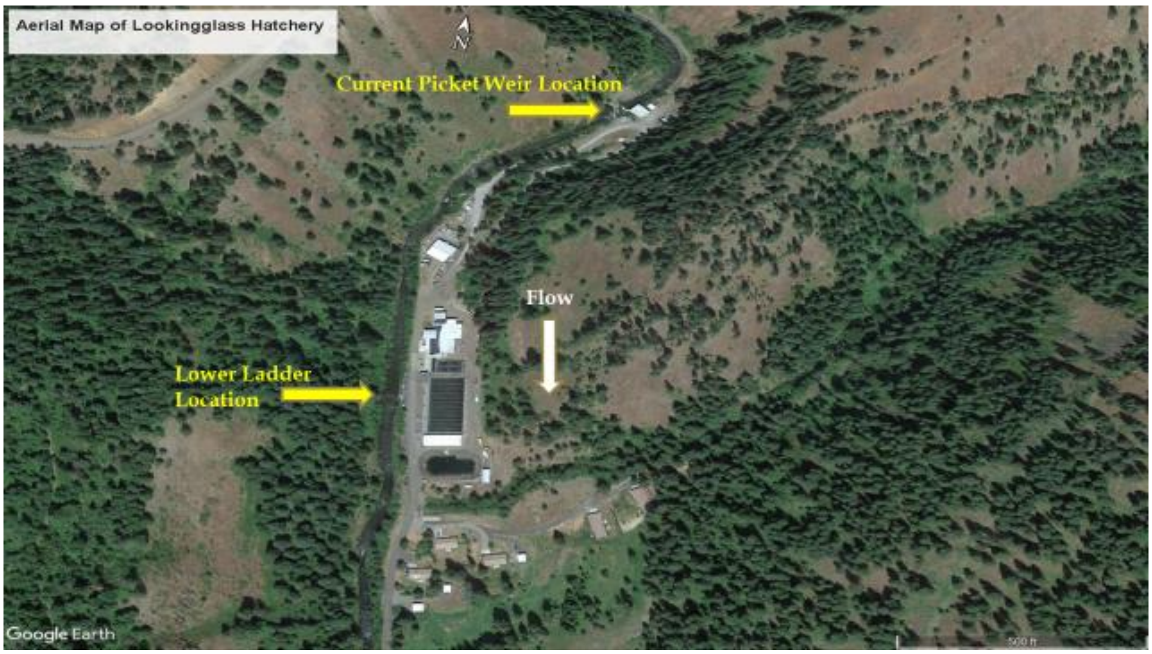


Figure 4. Aerial imagery showing the current picket weir location and the location of the lower ladder used for collections in 2018.

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 2018 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.

Releases Above the LH Weir

In 2018, passed adults were released in two locations: just upstream of the LH weir in the deep pool near the water intake building (Figure 6) and released approximately 0.4km upstream. All passed 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 return tube constructed by ODFW and CTUIR which will allow fish to be released directly into the stream after handling. The tube is still in need of a water pump to be fully functional. The arrow indicates the deep pool where passed adults were released.

Spawning Ground Surveys

Spawning ground surveys were conducted using similar methods as (Parker, et al., 1995) and (Crump & Van Sickle, 2016) during August-September 2018 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).

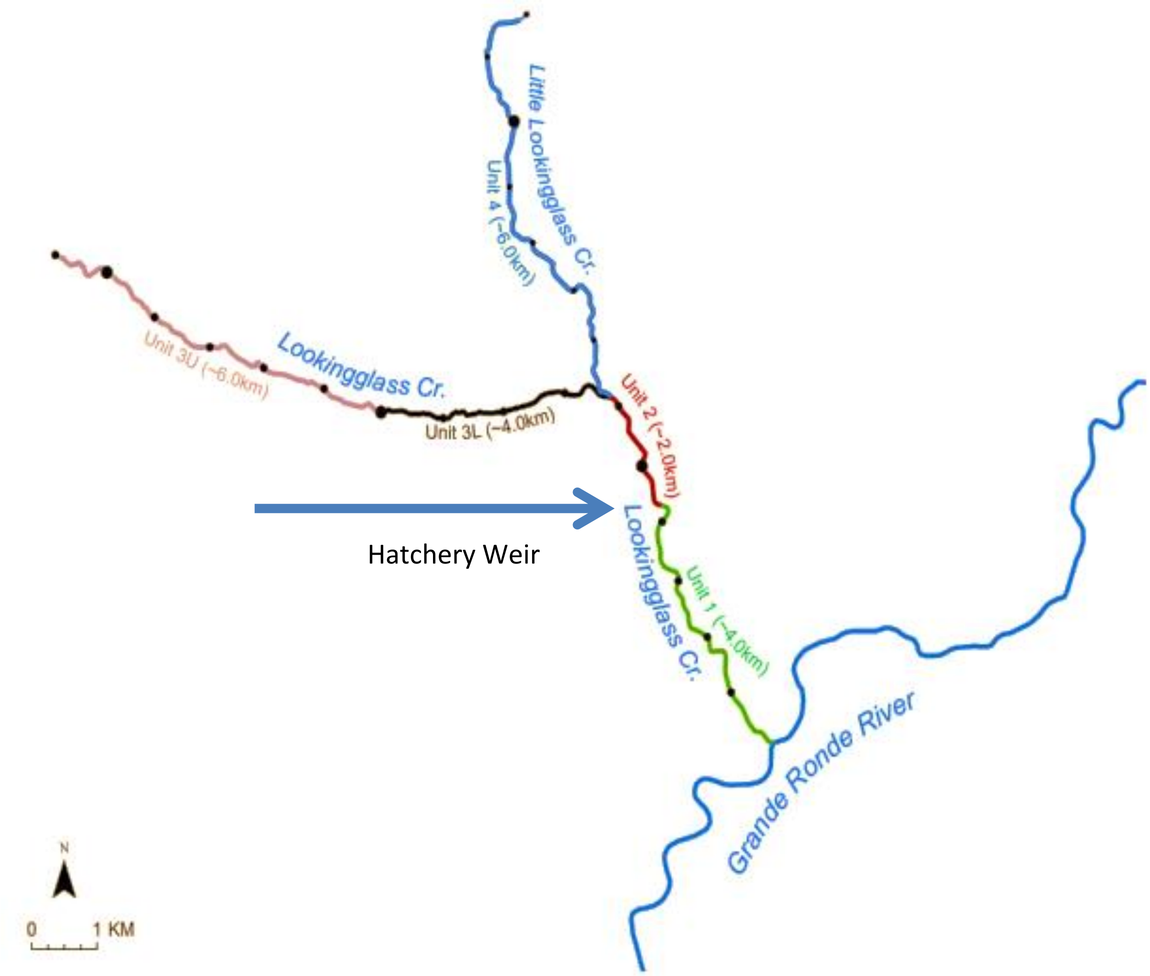


Figure 7. Lookingglass Creek section breaks for spawning surveys. Unit 1 is below the weir, while all other units are above.

Carcass Recoveries

Carcasses were enumerated and FL (mm), sex, and marks were recorded for all fish, while percent spawned is recorded for females. Females that had spawned ≤ 50% were considered pre-spawn mortalities. Tails were cut 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:

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

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 $\leq$50% spawned out) on spawning ground surveys to the population estimate above the weir. However, in 2017 and 2018, 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 birth year (BY), by the total number of NOR offspring returning as adults to LGC weir for the completed BY.

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 2017 fry or small parr were caught during January-June of 2018 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 2.9.1 (Bjorkstedt, 2008) to estimate the numbers of outmigrants. DARR 2.9.1 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 2016 fish was caught, PIT-tagged and released from 1 July-30 September 2017, the winter group from 1 October-31 December 2017, and the spring group from 1 January-30 June 2018. 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 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 2016 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 smolts surviving to LGD (S_{eq}) for that BY.

Monthly Sampling

We monitored seasonal growth of naturally-produced BY 2016 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 and October 2017. 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.

Summer Parr Sampling

We targeted approximately 1,000 BY 2016 parr using snorkel/seine methods from the primary rearing area (rkm 8.9- 12.0) above LH in early August 2017. 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 237 HOR and 78 NOR returns to the LH weir in 2018 (Figure 9). This is a combined total for both the upper ladder and the lower ladder which was put in place on 9 July after recreational and tribal harvest was complete. The CTUIR Tribal harvest information can be found at (Contor C.R., 2018 Annual Progress Report). There were a total of 86 fish captured in the lower ladder (64 HOR and 22 NOR) between 9 July and 8 September. There were nearly identical ratios of HOR and NOR returns to both the upper and lower ladders (25% and 26%). In general, we have seen an upward trend in returns. However, run year 2017 and 2018 returns were extremely low for both HOR and NOR since reintroduction efforts began (Figure **9**).

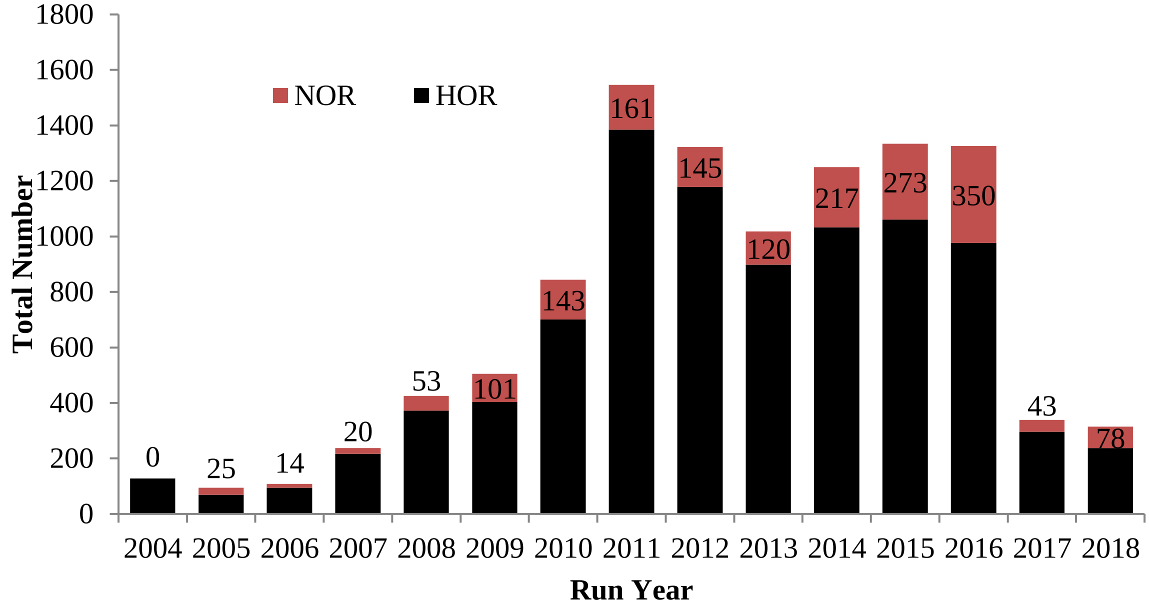


Figure 9. Lookingglass Creek spring Chinook HOR vs NOR total returns, RY 2004-2018.

When looking at completed NOR BY returns (Table 1), total returns for BY 2012 were 370, the highest since the beginning of the current reintroduction era. In direct correlation, redd numbers above the weir for BY 2012 were also the highest since reintroduction efforts began (n=314). For the completed NOR BY 2013 returns, the total returns were 31, the lowest since reintroduction efforts began. However, this also directly correlates with only 60 redds tabulated above the weir for BY 2013. The estimated age composition based on fork length of NOR returns to the LH weir for completed BY 2013 were 6 (20%) age 3, 18 (58%) age 4, and 7 (22%) age 5 (Table 1). Age composition of NOR returns in most years has been dominated by age 4, but substantial numbers of age 3 returns occurred in 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 2018 (Table 2. Dates of first, median, and last returns to the adult trap for NOR Chinook, RY 2007-2018.). 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					
2018	9	62	7	78					

**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 2007-2018.

RY	1st	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

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, with 926 and 769 respectively. Prior to 2017, the population had appeared to be on an overall upward trend. There were 94 HOR and 60 NOR passed above the weir in 2018, for a total of 154 (Figure 11). The majority of the remaining returns were taken in an attempt to meet broodstock goals. Of the 94 HOR released upstream, all but one were estimated as age 4 and 5 adults. Of the 60 NOR Chinook passed upstream, 51 were estimated as adults and 9 as jacks. There were a total of 65 females released, which were 62% 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%, with an average over those 12 years of 71%. 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).

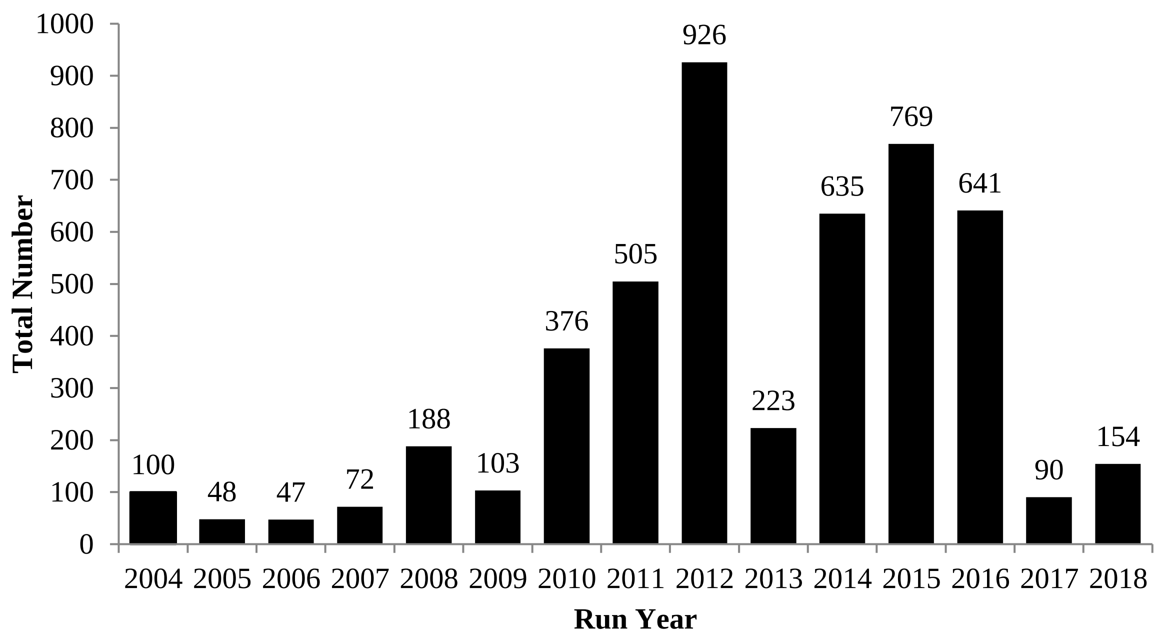


Figure 10. Lookingglass Creek spring Chinook salmon total releases above the weir, RY (Run Year) 2004-2018. Includes all ages, hatchery and natural origin.

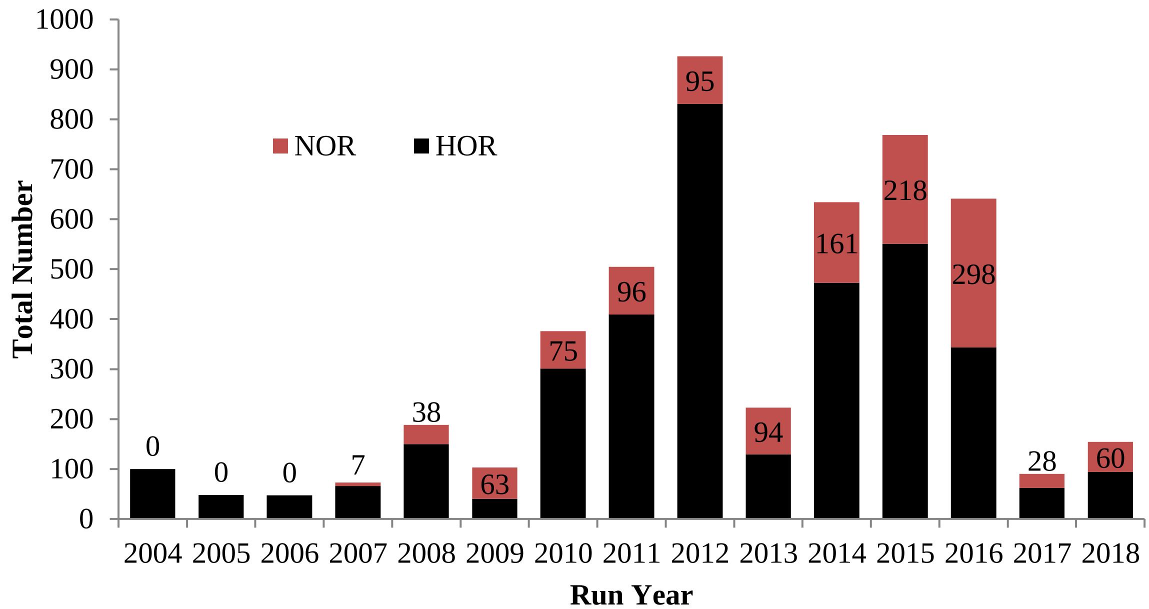


Figure 11. Lookingglass Creek spring Chinook HOR vs NOR total releases above the weir, RY 2004-2018.

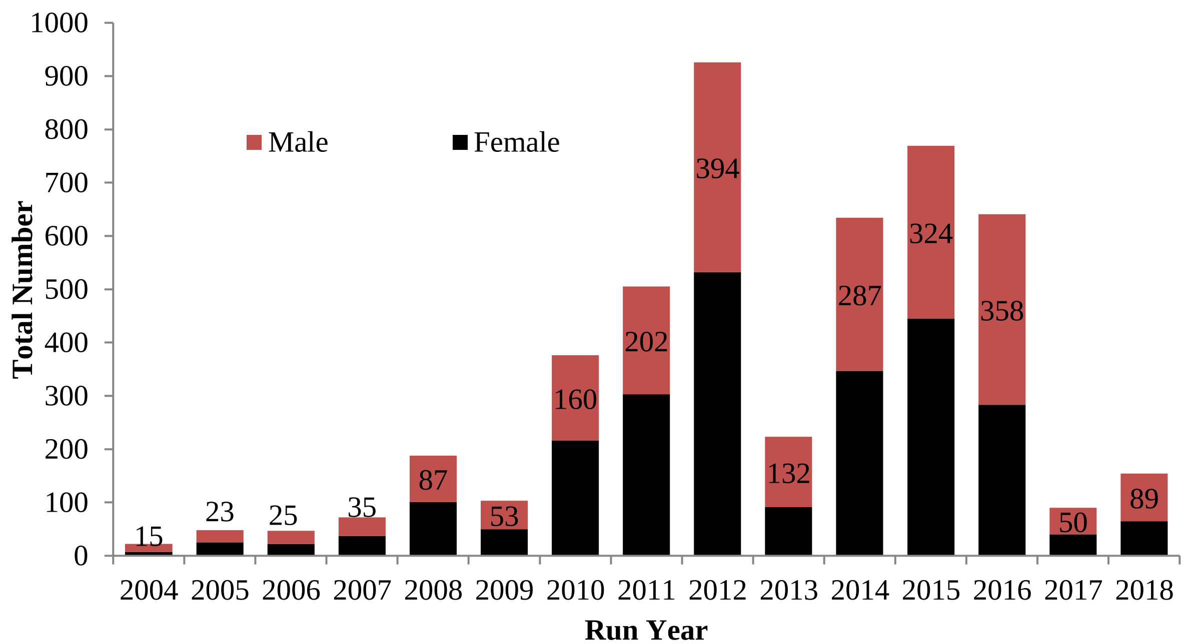


Figure 12. Lookingglass Creek spring Chinook salmon Male vs Female releases above the weir, RY 2004-2018. In 2004, 78 HOR adults were hauled from Catherine Creek and released upstream. These 78 fish were excluded due to lack of data on sex ratios.

Spawning Ground Surveys

We completed 22 spawning ground surveys on LGC during 22 August-21 September and observed, flagged, and took GPS coordinates on a total of 81 Chinook redds (Table 3). The first completed redds were observed on 22 August on Unit 1 below the LH weir. This was unusual to observe the first redd so low in the system. Typically, 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 39 Chinook redds observed in Units 2, 3L, and 3U above the LH weir and 42 in Unit 1 below the weir. There were no redds observed in Unit 4 (LLGC) this year. Redds in Units 3L and 3U made up 71% of all redds observed above the LH weir in 2018, however most of these occurred in 3L (n=22). The percentage of redds in these two sections has ranged from 63-94% since 2004. However, it is of note that only 48% of the total redds occurred above the weir this year (18km of spawning habitat), while 52% occurred below (4km of spawning habitat). In recent years, this pattern of spatial distribution has become more evident. Peak numbers of new redds observed above and below the LH weir occurred between 3 September and 7 September.

Table 3. New redds observed on surveys of LGC by work week and by unit, RY 2018.

	Unit				
Period	1	2	3L	3U	4
8/20-8/24	8	0	4	4	0
8/27-8/31	12	2	5	2	0
9/3-9/7	20	7	6	1	0
9/10-9/14	2	0	7	1	0
9/17-9/20	0	0			
Totals	42	9	22	8	0
2018 Percentage by unit (%)	52	11	27	10	0
2004-2018 Percentage by unit (%)	37	7	21	27	7

With approximately 4.0 rkm of available spawning habitat below the weir, the redds/per km is 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. There were several areas upstream of the weir with medium densities of redds in Units 3L and 3U. The smaller numbers of redds observed in Unit 2 may be due to less spawning gravel and higher gradients.

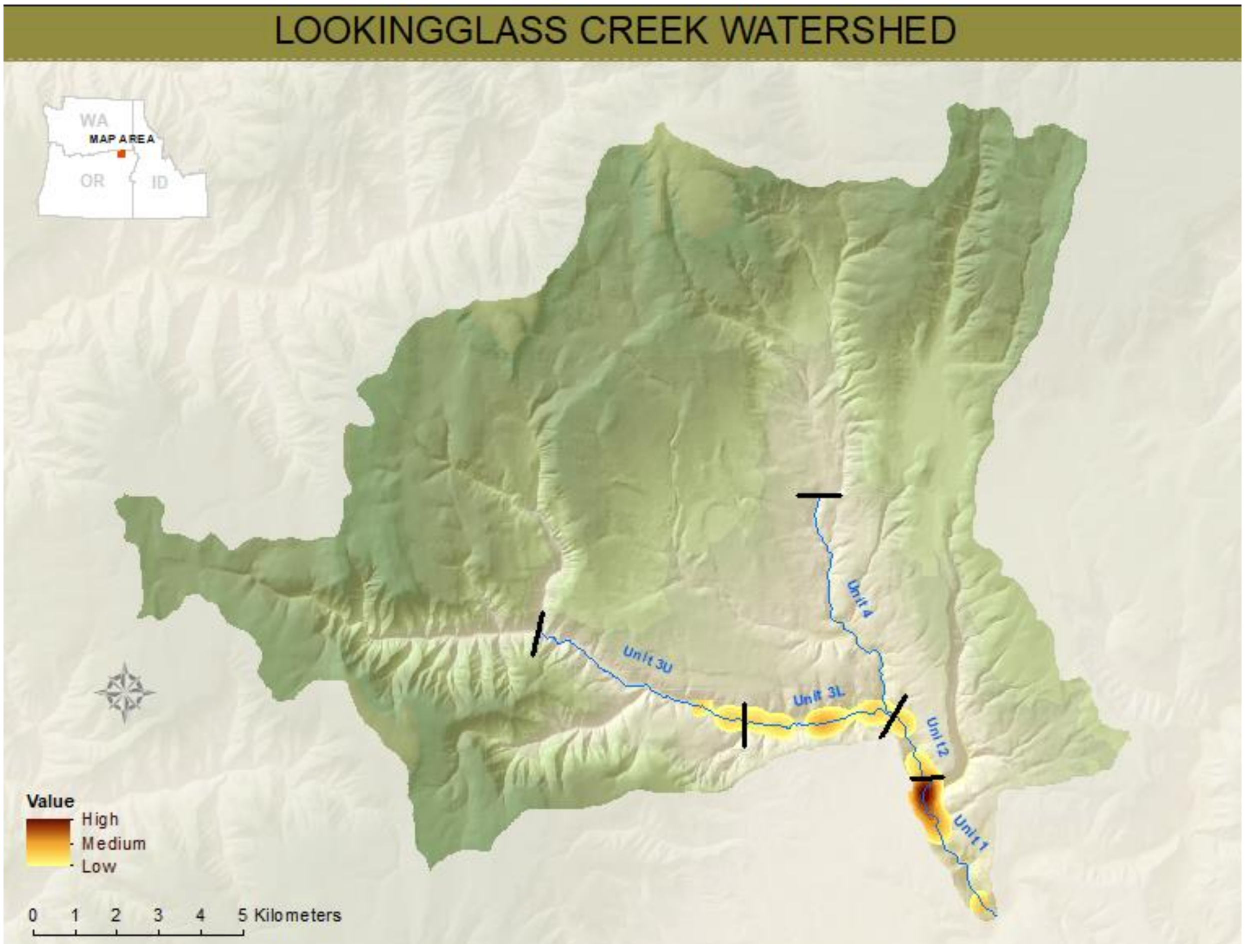


Figure 13. Density map of spring Chinook spawning distribution in Lookingglass Creek by unit, RY 2018.

Since reintroduction efforts began in 2004, Unit 1 has had more redds than any other section in 10 out of 15 years (Table 4). Of note is that 9 of these 10 years have been consecutive, beginning in 2010. Since 2010, as numbers above the weir have increased, we have observed increased numbers of redds located in Unit 2 and 4, however this year there were no redds observed in Unit 4. Presumably fish are moving into these underutilized areas as suitable spawning habitat becomes more limited. In 2018, there were 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 3U typically has had more redds than any other section above LH the weir until recently.

Table 4. Number of spring Chinook salmon redds by unit, RY 2004-2018. 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
Mean	68	13	39	50	13	184
SE	11	3	8	10	4	34

We looked at redds per km by unit between 2009 to 2018 since 2009 was the first complete brood year since reintroduction efforts began (Table 5). 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 and use for that section (Unit 4). As previously identified, a large percentage of redds were constructed in the 4 km unit below the weir during the current re-introduction era (52% of all redds were below the weir in 2018). These redds were plotted with those observed during the endemic era study (1964 to 1971) for comparison (Figure 14). The mean percentage of redds below the weir for the current era are more than twice that of the endemic era (t-ratio assuming unequal variance = -5.6530, $p = <0.001$).

Table 5. Number of spring Chinook salmon redds per km by unit, RY 2009-2018.

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

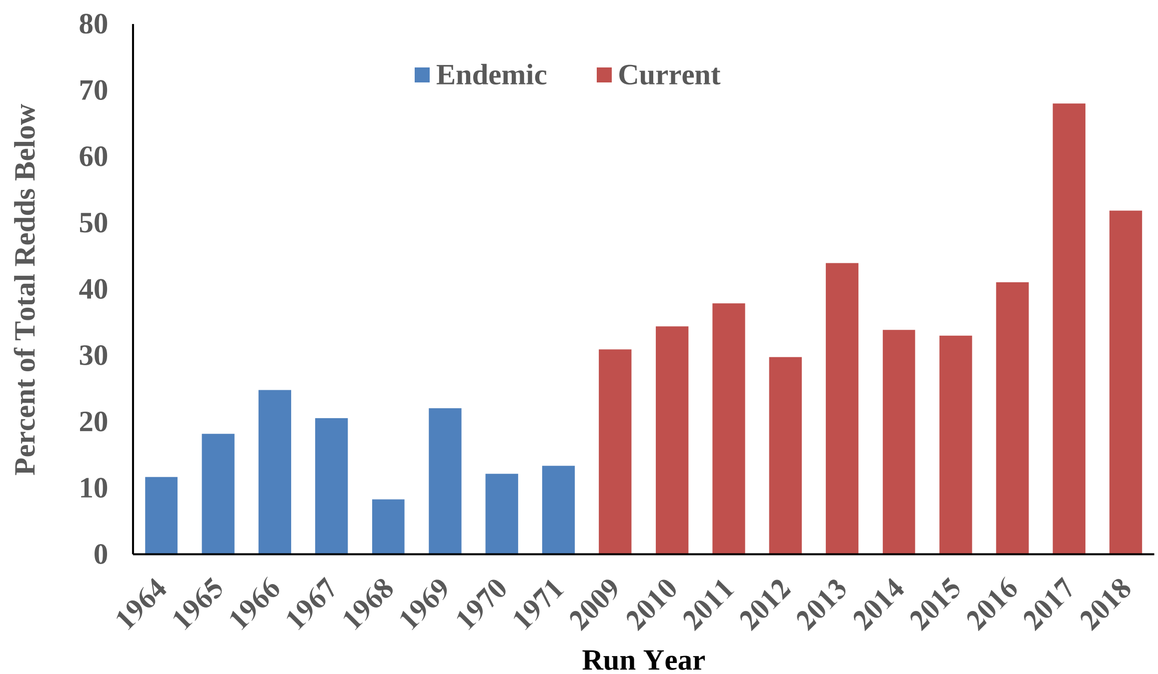


Figure 14. Percentage of total Chinook salmon redds observed below the weir during the endemic era (RY 1964-1971) and the current reintroduction era (RY 2009-2018).

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 2009-2018 (Table 6). The pairwise comparisons that were not statistically significantly different from each other (using an a priori Alpha level of 0.05) were Unit 2 and Unit 4 ($p = 0.4039$), Unit 3U and Unit 3L ($p = 0.6775$), and Unit 3U and

Unit 1 (p = 0.1617), whereas all other pairwise comparisons were significantly different (Table 6).

Table 6. Results of Wilcoxon Rank Sum test used to test for differences in spawning between each survey unit, RY 2009-2018.

Unit	Unit	Z score	p-value
One	Four	3.56091	0.0004*
ThreeL	Four	2.88012	0.0040*
ThreeU	Four	2.68861	0.0072*
Two	Four	0.83467	0.4039
ThreeU	ThreeL	0.41592	0.6775
ThreeU	One	-1.39952	0.1617
ThreeL	One	-1.92834	0.0538
Two	ThreeL	-2.46140	0.0138*
Two	ThreeU	-2.53618	0.0112*
Two	One	-3.59607	0.0003*

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

Carcass Recoveries

Carcasses recovered above the LH weir from 22 August through 12 September totaled 14, with 6 identified as female and 8 as male. All of these recovered carcasses were adults and 12 had an opercle punch indicating they had been sampled at the LH weir and two 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 these 14 carcass recoveries above the weir, all but one were HOR. Carcass recovery efficiency for fish released above the LH weir was 8%, much lower than in most years. As increased amounts of Chinook have been released above the LH weir, there has also been a marked increase in scavengers and predators. Carcasses are rapidly consumed before they can be recovered. This is evident in Unit 3U, the most remote section of LGC. While most of LGC redds are typically constructed in this section, there are frequently fewer carcasses found here than any other unit. With 2018 having so few total returns and thus fish released upstream, carcasses were likely in high demand from predators which may have resulted in the low carcass recovery this year compared to the mean recovery rate since 2004 of 28%.

Carcasses recovered below the LH weir from 27 June through 13 September totaled 52. Of these 52 carcasses sampled, there were 37 HOR, as well as 12 NOR, and 3 of unknown origin due to being too decomposed to identify. There were 18 recoveries that had a 1ROP or 2ROP indicating they had been sampled at the weir, passed upstream, and then dropped back below the weir or that dropped back and had become trapped between the pickets and the concrete wall. These trapped fish are intentionally “flushed” below the weir by hatchery personnel removing the pickets and allowing them to pass back downstream (n=14 1ROP, n=4 2ROP). The decision to flush these fish downstream knowingly makes population estimates and spawner estimates harder to calculate, however the preference is to allow them to spawn below rather than perish in this small area. Of these 18 punched carcasses, 11 were of HOR and 7 were of NOR indicating that the fish “fell back” at the same rate as one another with no respect to origin (n=61% HOR released above the weir, n=61% HOR punched carcasses recovered below the weir).

Hatchery-origin carcasses (with a CWT present) collected between 2004-2018 indicate that the Upper Grande Ronde River fish stray into LGC more than other local stocks (Table 7). 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 weir. The other hatchery stocks have a CWT and an adipose clip and the stock is unknown until the CWT has been recovered and read. Carcasses collected on LGC are processed by CTUIR staff and are submitted to RMIS for CWT retrieval.

Table 7. Hatchery-origin carcasses with a CWT present that were recovered on Lookingglass Creek, 2004-2018.

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
Total	104	912	15	117

Lookingglass Creek hatchery-origin carcasses (with a CWT present) collected between 2004-2018 in neighboring streams were greatest in the Wenaha, Minam and Lostine Rivers (Table 8). This has been a cause for concern to co-managers due to the fact that the Minam and Wenaha are natural unsupplemented populations. The snouts recovered in these streams are collected by survey staff and submitted to RMIS by ODFW.

Table 8. Lookingglass Creek stock hatchery-origin carcasses with a CWT present that have strayed to neighboring streams, 2004-2018.

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
Total	1	1	1	9	12	3	2	56

Population Estimate Above the Weir

The total number of Chinook passed above the weir was 154 (144 adults, 10 jacks), then that number was decreased by the 18 aforementioned “punched” adults that were recovered below the weir that either dropped back or where intentionally flushed downstream. The Chapman modification of the Peterson method was then applied using marked/unmarked recoveries. The population estimate of jacks was 7, and the adult estimate was 129 (Table 9). Fish per redd estimates were 3.31 for adults, with an average of 2.33 since reintroduction began.

Table 9. 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 2004-2018.

	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
Means	300	323	116	2.33	2.62

Spawner Estimate Above the Weir

Some Chinook were released right near the hatchery intake in the deep pool just upstream of the pickets and some were released approximately 0.4 km upstream 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 10). Pre-spawning mortality has varied from zero to a high of 54.2% during the current reintroduction era. In 2017 and again in 2018, the mean percent of pre-spawn mortality for 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 224 over the reintroduction period.

Table 10. Population Estimates, Pre-spawn Mortality (PSM), and Spawner Estimate for spring Chinook salmon above the LH weir, RY 2004-2018.

	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
Means	300	323	0.164	224	243

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

**In 2017 and 2018, 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 which were used to determine age (n=37). Snouts were collected on spawning surveys from HOR carcasses with a CWT present and this tag was used for determining age (n=29). Snouts were collected from only 8 carcasses above the LH weir and 21 below. 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 wire, it was discarded. A total of 25 snouts with a wire were ultimately submitted to the Clackamas lab for retrieval of the CWT, and data for all 25 snouts were processed and returned to CTUIR. These known ages are represented in the table below (Table 11). Of the 25 snouts processed, 20 were LGC releases, and 5 were strays from the UGR. There were no CC stray recoveries this year. For 2018, there were only 20% of known age recoveries that were strays, in comparison to 48% in 2017. It is of note that there were only age 4 recoveries for HOR fish in 2018, with a very wide FL range between 250 mm and 825 mm (Table 11). Included in these HOR known age recoveries are three anomalies at 250 mm, 285 mm, and 310 mm. Each of these "mini' jacks came back as verified 4 year old spring Chinook which was unexpected due to their exceedingly small size. An age of 2 or even 3 would have been expected, however after double checking with the Clackamas lab, these fish were verified to be 4 years of age. This anomaly occurred in 2017 as well with a 220 mm (3 year old) and a 290 mm (4 year old) recovery. In 2017, these data were initially "tossed out" as likely human error. However after observing this pattern again in 2018, the data seems to suggest a life history pattern developing of "mini" jacks spending time lower in the system for several years and then returning as mature fish to spawn. All of these fish were recovered below the weir and likely successfully spawned.

There were more NOR jacks that were aged when compared to HOR jacks, however with all of the HOR fish being age 4 and having such a large FL range (250 mm-825 mm), a meaningful comparison to NOR fish was problematic. These small FL sizes of HOR fish brought the mean sizes down considerably. Age 3 NOR males were an average of 480 mm. There were small sample sizes for age 5 NOR fish, with a combined mean of 825 mm. 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 11. Mean FL (mm) at known age by sex and origin of LGC spring Chinook, RY 2018.

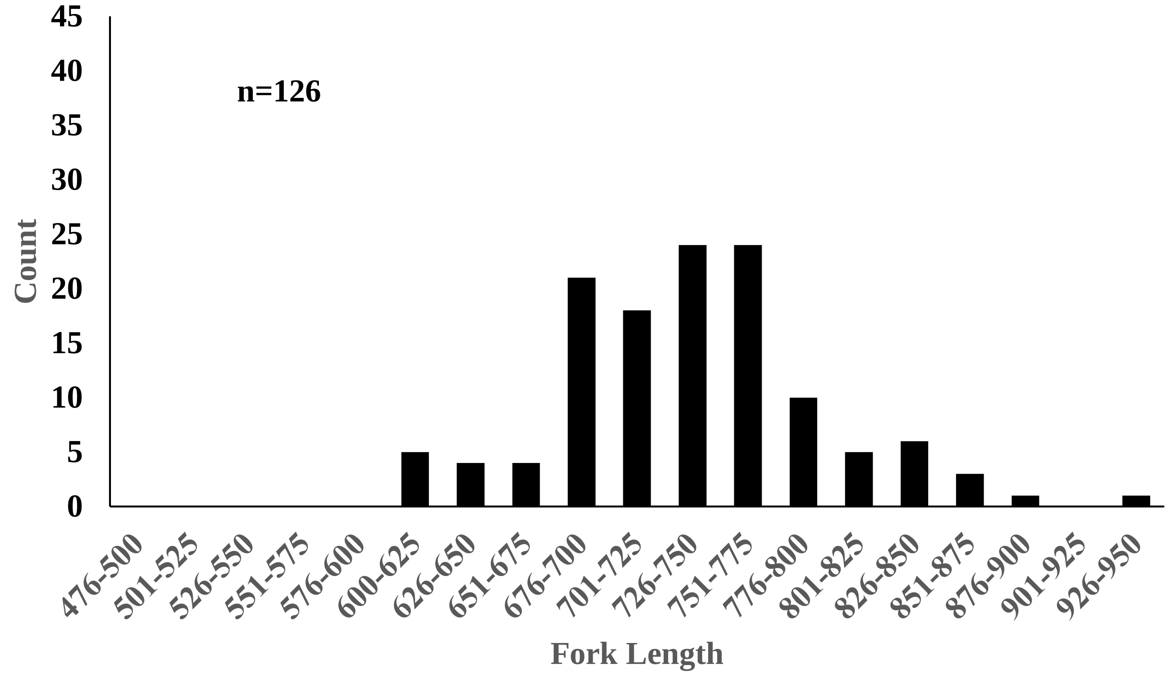
Origin	Sex	Age	$\bar{X}$ FL	Range	SE	N
NOR	M	3	480	370-590	40	5
NOR	M	4	718	598-805	18	12
NOR	F	4	701	620-753	8	16
NOR	Combined	4	709	598-805	9	28
NOR	M	5	853	840-865	13	2
NOR	F	5	797	774-820	23	2
NOR	Combined	5	825	774-865	19	4
HOR	M	4	709	310-825	37	13
HOR	F	4	622	250-755	55	11
HOR	Combined	4	669	250-825	33	24

**1 HOR fish no fork length recorded*

Female Fork Lengths:

Using data from 2007 to 2018, 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 15 and Figure 16). Mean fork length of all ages combined for the LGC 2018 return year was 690.1 mm for NOR, which was well below the 12-year mean of 738.8 (Table 12).

This is likely due to several small jacks (n=5) that captured this year between 370 mm and 590 mm. For HOR, the 2018 mean was 669.0 mm compared to a 12-year mean of 724.8.Similar to NOR, the HOR had several small returns between 250 mm and 590 mm. In general, the NOR female returns have been larger than HOR female returns for both CC and LGC (Table 12).



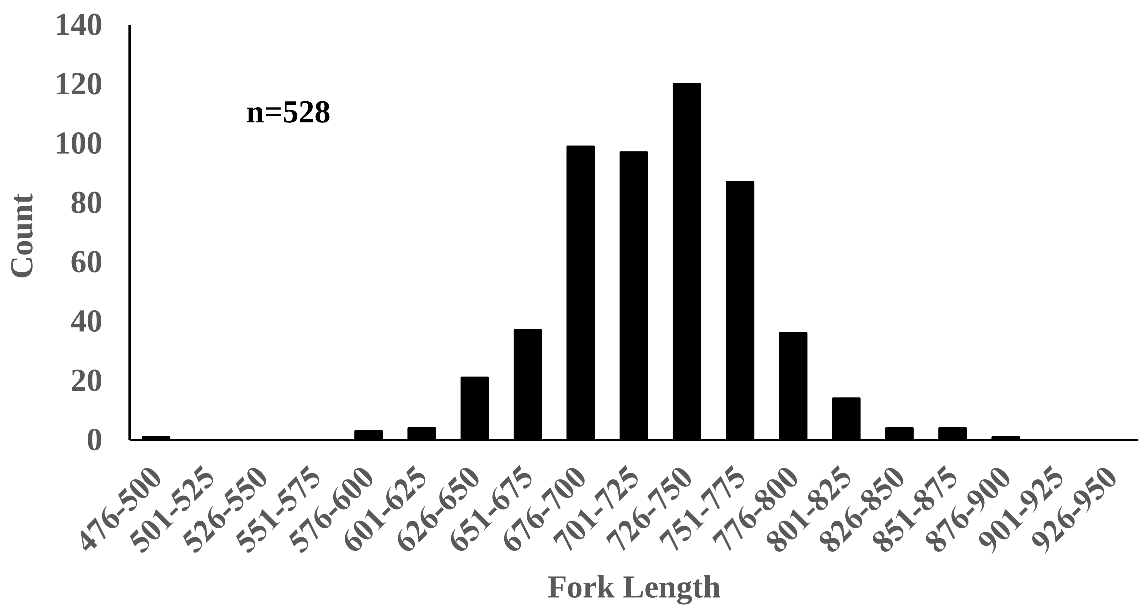


Table 12. Mean FL (mm) and 95% confidence intervals for known age females by stock and origin, RY 2007-2018.

Stock	Origin	Mean FL(mm)	SE	Upper 95 %	Lower 95%	N
CC	NAT	726.5(± 4.5)	2	731.0	722.0	714
LGC	NAT	738.8(± 11)	5	749.8	727.8	126
CC	HAT	725.9 (± 5)	3	730.9	720.9	325
LGC	HAT	724.8(±4.3)	2	729.1	720.5	529

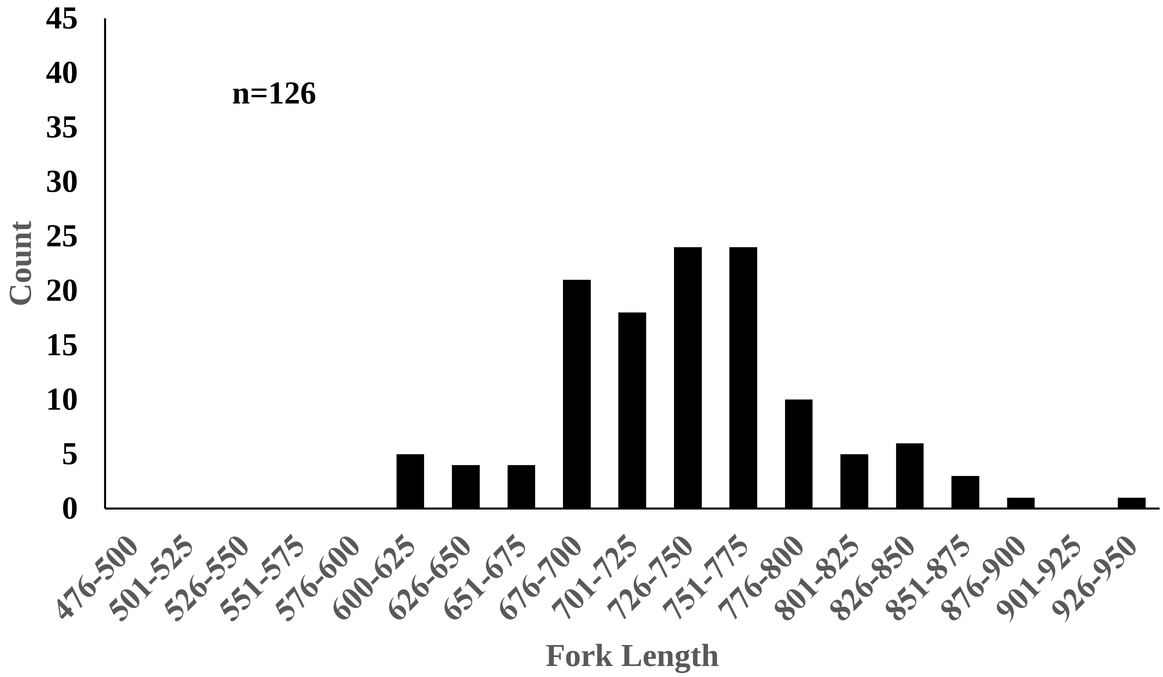


Figure 15. Frequency distribution of NOR FL (mm) of returning adult female spring Chinook salmon for Lookingglass Creek, RY 2007-2018. Data are from known age females.

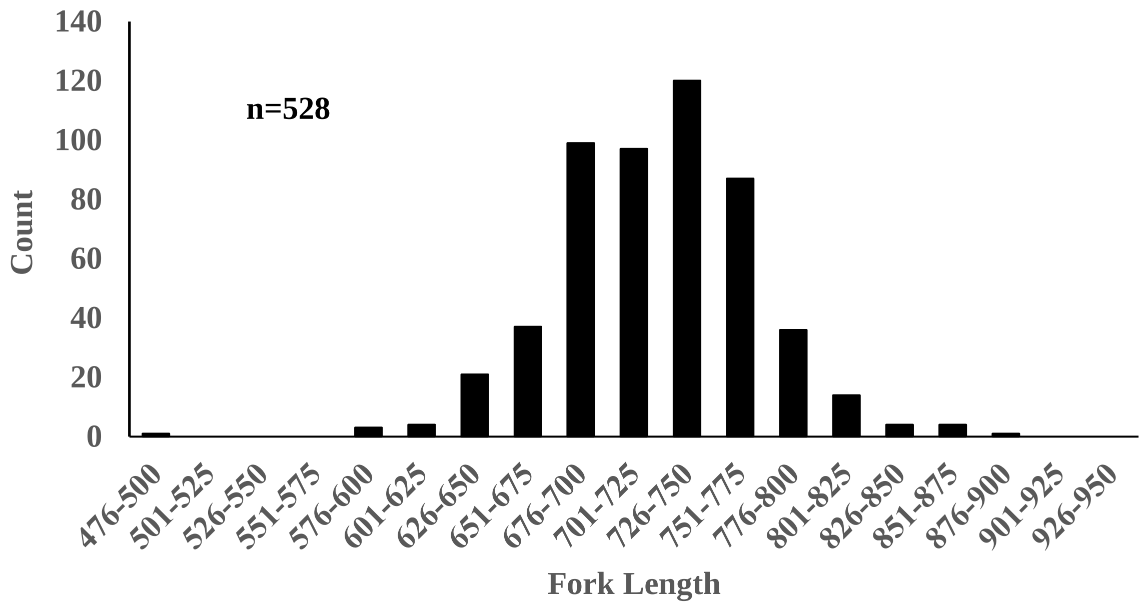


Figure 16. Frequency distribution for HOR FL (mm) for returning adult female spring Chinook salmon to Lookingglass Creek, RY 2007-2018. Data are from known age females and does not include strays. There was also one 250 mm HOR fish that was excluded from this figure.

1.5.1.2 Productivity

Recruits per Spawner (R/S)

BY 2013 Recruits per Spawner for adults (excluding jacks) was lower than any year calculated since 2004, at 0.2 (Table 13). This low Recruit per Spawner for BY 13 was not unique to LGC, as returns in the entire basin were dismal likely due to multiple extenuating factors. 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. Recruits per spawner has been below the replacement value of 1.0 for 7 out of the last 10 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).

Table 13. Completed BY NOR returns, spawners by BY, and Recruits per Spawner for LGC NOR spring Chinook salmon, BY 2004-2013.

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
Means	141	163	204	221	1.2	1.1

[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 January of 2017, sac fry began to be captured in the screw trap from the BY16 cohort. Obtaining an accurate estimate of January-June (fry) outmigrants was 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=616). These fry were not included in the outmigrant estimate as they appeared to not be emigrating, but instead were getting flushed into the trap during high flows.

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 2016 total first-time captures in the screw trap from 1 July 2017-30 June 2018 was 5,973. During July-December 2017, the rotary trap was fished 72% of the time. During January-July 2018, the rotary trap was fished 81% of the time.

Outmigrant Estimate

The BY 2016 outmigrant estimate was derived using Darr 2.9.1 and was estimated for the period of July 1 2017 through 30 June 2018 (Table 14). There was a mortality event on 18 August 2017 which killed 241 NOR BY16 Chinook. This event required us to pull the trap immediately and notify NMFS. We were unable to fish during the review of this event, between 21 August and 6 September 2017. The trap was pulled again between 10 September and 16 September 2017, due to LH road construction and an inability to access the screw trap. These are both typically periods of increased juvenile emigration. Therefore, the Fall MY 2018 outmigration estimate is an underestimate of what was likely moving past the trap. This is the fifth largest outmigrant estimate since reintroduction efforts began. This correlates well with also having the third largest number of observed redds above the weir for BY 2016. The mean outmigrants per redd for the current reintroduction era is 209.

Table 14. LGC NOR spring Chinook salmon outmigrant summary, BY 2004-2016.

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
	Means	19,770	1,763	128	209

[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*

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 41% for fall 2017, 48% winter 2017, and 15% spring 2018 (Table 15). 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 vast majority of LGC stock leave as pre-smolts in the fall/winter. The mean from BY 2004-2014 indicates that number to be 85%, with only 15% of outmigrants leaving in the spring (Table 15). This observed pattern was similar to that reported for the previous Rapid River reintroduction era (McLean, et al., 2001) and (Burck, 1993). However for both reintroduction eras, higher percentages left during the winter months while Burck observed more outmigrants leaving in the fall. We are not clear why there is a slight shift in outmigration timing. A similar pattern of most outmigrants leaving as presmolts during fall/winter occurs for CC outmigrants, our donor stock (Anderson, et al., 2011).

Table 15. Summary of seasonal outmigration of LGC NOR spring Chinook salmon, BY 2004-2016.

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
	Means	34	51	15

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

Sample sizes by season for PIT-tagged outmigrating juvenile Chinook were 288, 710, and 346 for fall, winter and spring respectively. Mean FL by season of these tagged fish were 70, 84, and 90 mm for fall, winter and spring groups. Mean weights increased from 5.9-8.3g from fall 2017 to spring 2018. Mean K was 1.17, 1.09, and 1.13 for the fall, winter, and spring groups, respectively. As expected, fish increased in size from fall to spring (Figure 17), however, fish had a slightly lower K factor in the spring. In general, K factor is highest in the spring, when conditions are more favorable. This deviation from the norm could be due to the low sample size collected in the spring.

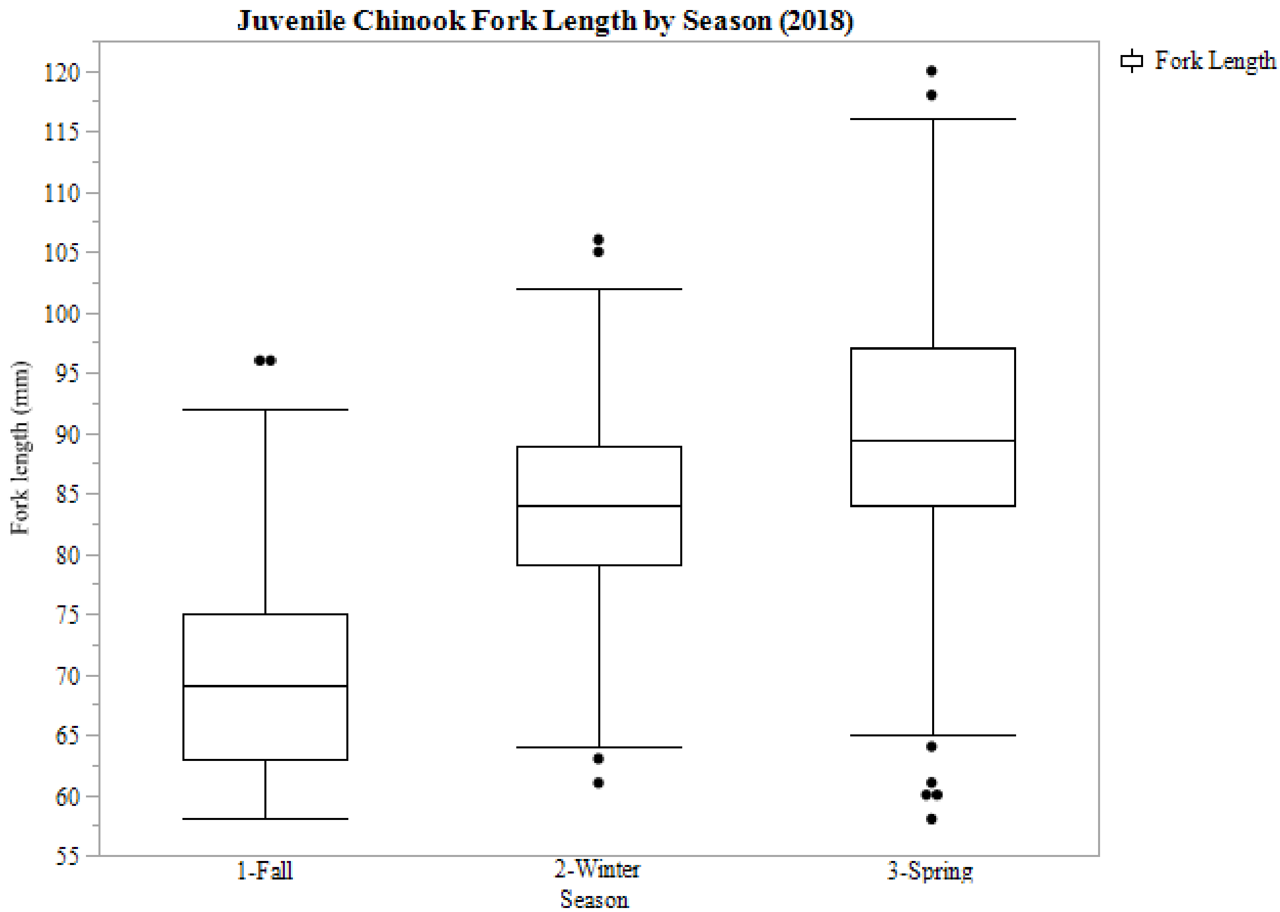


Figure 17. Box plots of FL (mm) by seasonal group for NOR spring Chinook salmon outmigrants tagged or measured in the Lookingglass Creek screw trap, BY 2016. Error bars indicate minimum and maximum sizes observed by season.

Outmigrants/redd plotted against redds above the LH weir seem to indicate that there is potentially a carrying capacity level that has been reached. Based on the figure below (Figure 18), there are generally higher outmigrants per redd when there are fewer redds above the weir. 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. 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.

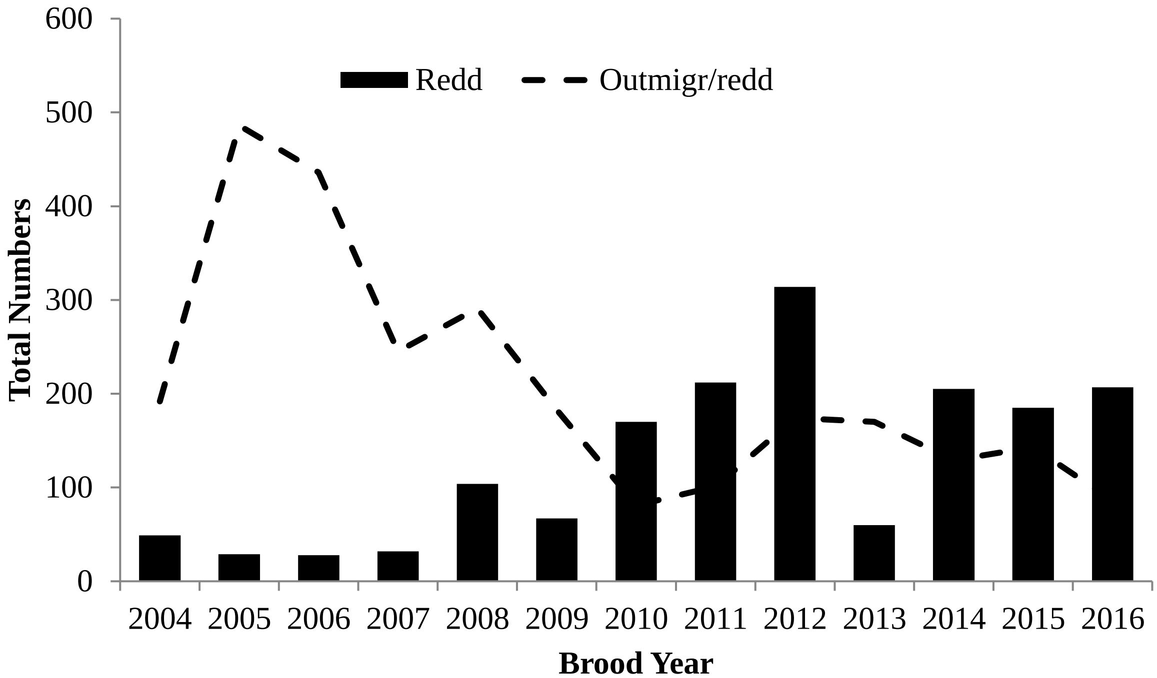


Figure 18. Outmigrants/redd and redds above the weir for BY 2004-2016.

1.5.2.2 Life History

Survival Estimates

Survival probabilities (SE) to Lower Granite Dam (LGD) were 0.198 (0.038), 0.153 (0.016), 0.162 (0.032), and 0.353 (0.043) respectively for the summer, fall, winter, and spring groups of BY 2016. Spring survival is substantially higher than the summer, fall and winter groups on a consistent basis (Figure 19). This could be in part 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 21). The juveniles that are leaving in the fall and winter are overwintering somewhere within the Grande Ronde Subbasin where conditions may be much less complimentary. Until recently, there had been an increase in the number of redds tabulated 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 20).

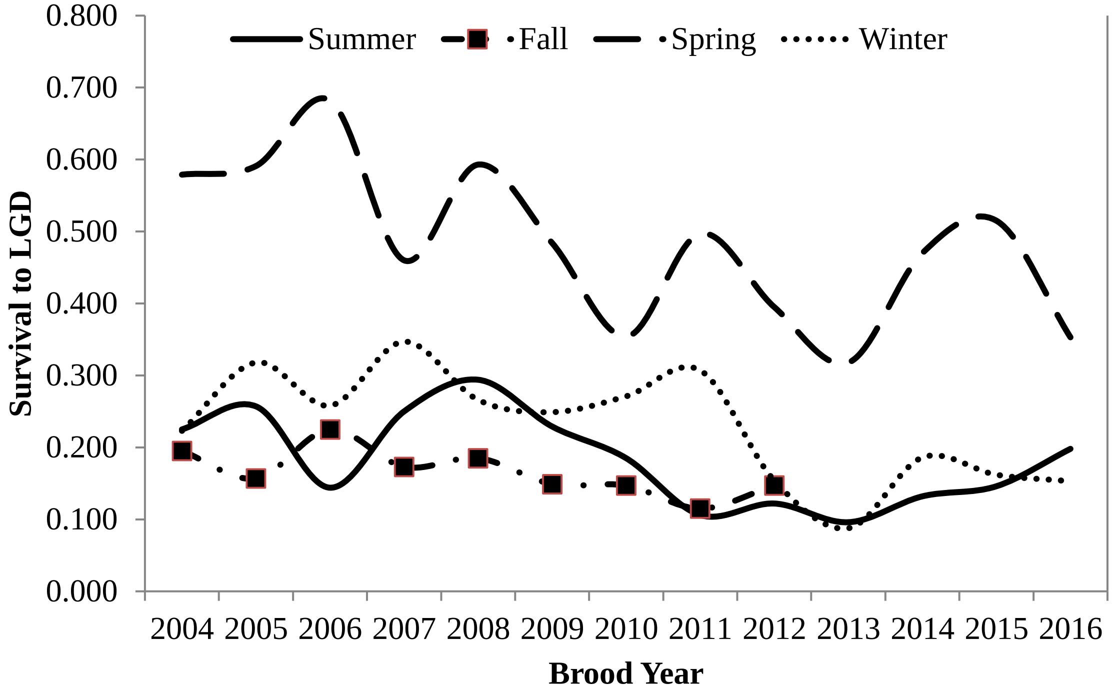


Figure 19. Survival probabilities of NOR spring Chinook salmon for summer, fall, winter, and spring groups, BY 2004-2016.

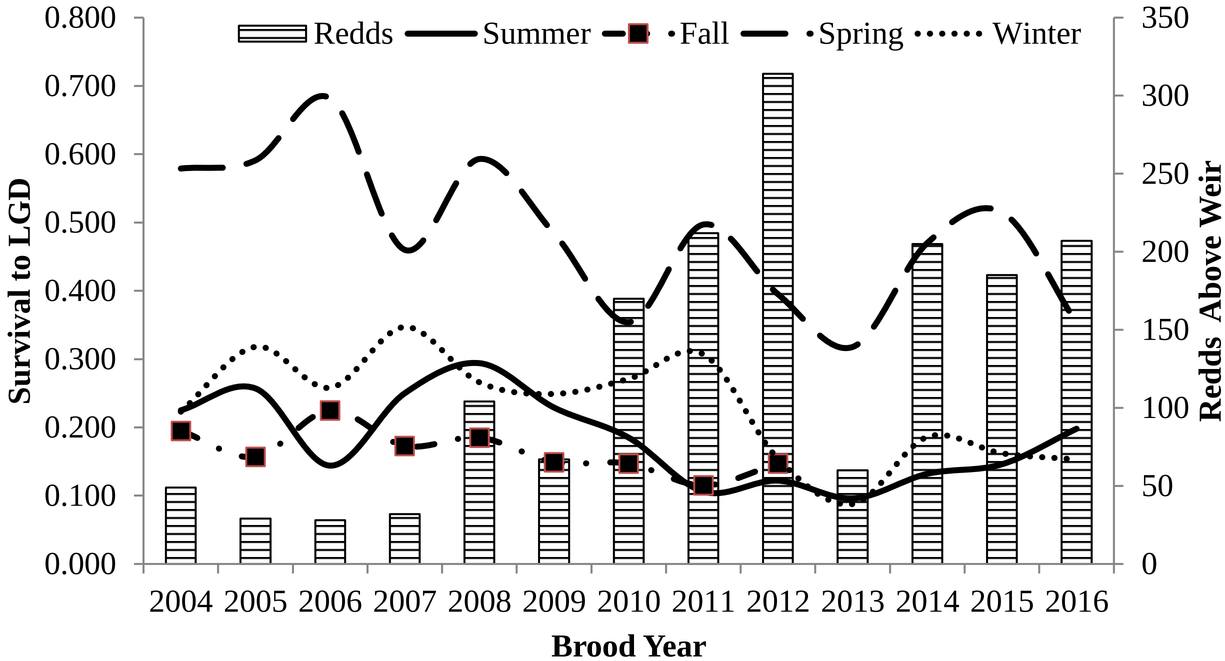


Figure 20. Survival probabilities of NOR spring Chinook salmon for summer, fall, winter, and spring groups, BY 2004-2016, with redds on the z axis.

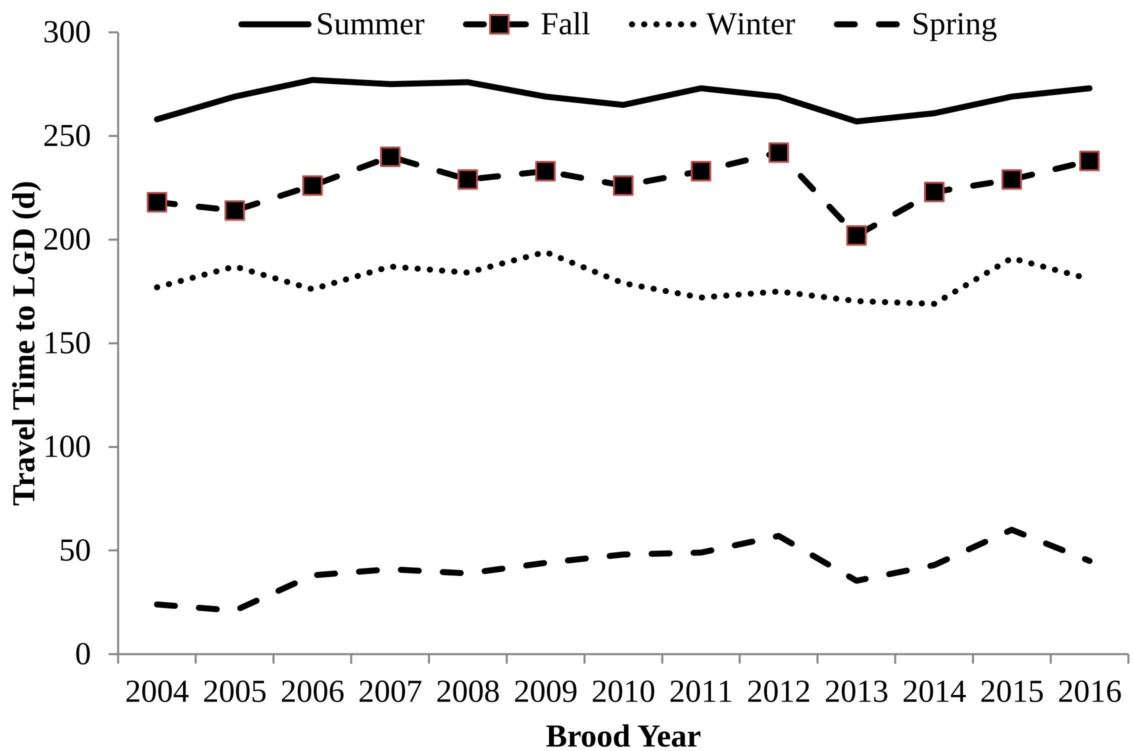


Figure 21. Harmonic mean travel time (d) to LGD for Lookingglass Creek NOR summer parr, and fall, winter, spring outmigrants, BY 2004-2016.

During the current reintroduction era, we have observed more 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%, 23%, and 48%, respectively. Conversely, the mean percent of juveniles emigrating during the fall, winter, and spring is 34%, 51%, and 15%, respectively. Therefore, while spring survival is the highest at 48%, only 15% of all LGC juveniles are emigrating during that time, (Figure 22).

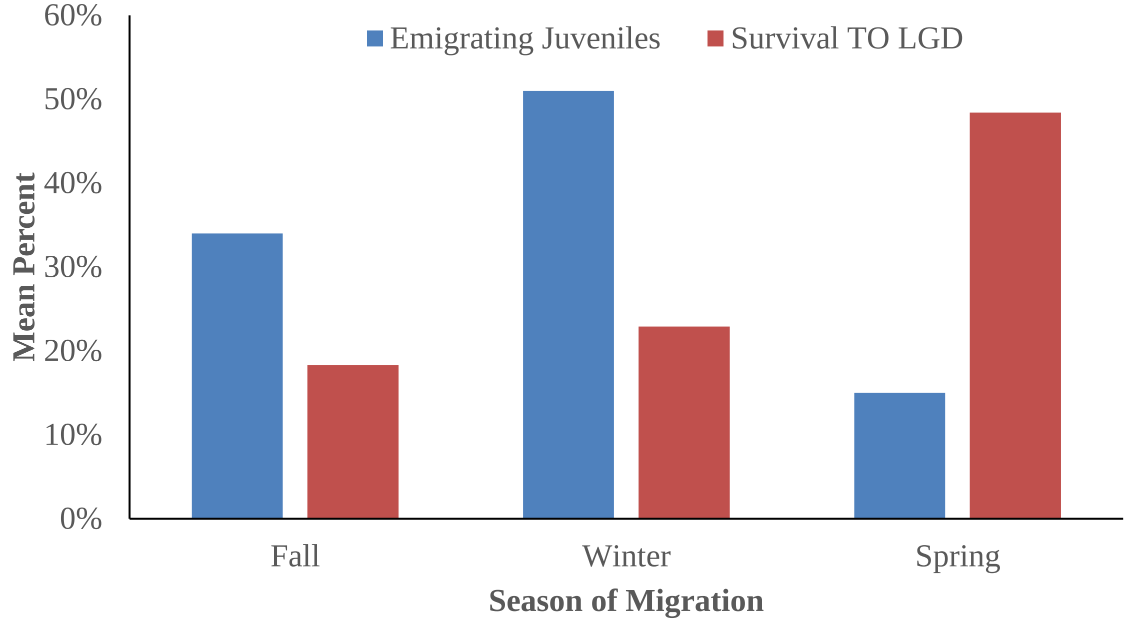


Figure 22. Plot of mean percent of fish emigrating and the corresponding survival by season, BY 2004-2016.

In the earlier 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 16). This observed difference could be due to less competition for habitat and nutrients in low redd years.

Table 16. Summary of BY 2004-2009 and BY 2010-2016 mean FL and survival during low redd years vs high redd years.

Brood Year	Season	Mean Redds	Mean FL	Mean Survival
2004-2009	Summer	52	72	0.18
2010-2016		193	69	0.13
2004-2009	Fall	52	80	0.23
2010-2016		193	72	0.14
2004-2009	Winter	52	89	0.28
2010-2016		193	83	0.19
2004-2009	Spring	52	97	0.56
2010-2016		193	88	0.41

Smolt Equivalent Estimate

Smolt equivalent (S_{eq}) estimates (estimated outmigrants for each group surviving to LGD) for fall 2017, winter 2017, and spring 2018 were 1,443, 1,313, and 1,917, respectively. This equated to a BY 2016 total of 3,432. BY 2016 S_{eq} was below the mean for the current era, with S_{eq}/spawner well below the mean (Table 17). S_{eq}/spawner since 2010 has ranged between 9 and 17. Why S_{eq}/spawner was consistently higher prior to 2010 is unclear.

Smolt to Adult Return

BY 2013 NOR SARs were below the BY 2004-2013 mean at 2.2 for Adults only (Table 17). The BY 2004-2013 adult only mean of 3.2% 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).

Table 17. S_{eq} to LGD and SAR for LGC NOR spring Chinook salmon, BY 2004-2016.

	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			5,151	12		
2015			5,464	17		
2016			3,432	9		
Mean	162	141	4,863	35	3.8	3.2

[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 2019. 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, during, 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 risks of handling and anesthetizing them. BY 2016 parr sampled totaled 79 in July, 100 in August and 113 in September 2017. Mean FL increased in a generally linear pattern from July-September at both sites, as expected. For BY 2016 parr at the standard site, mean fork length for July, August, and September was 64.5 mm, 71.4 mm, and 78.9 mm, respectively. For BY 2016 parr at the footbridge site (rkm 10.5), mean fork length for July, August, and September was 67.8 mm, 70.9 mm, 78.2 mm, and respectively. Parr sampled at the upstream footbridge site are consistently smaller than at the standard site, likely due to colder water temperatures, however this year they were very similar. At the standard site (rkm 8.9), the average FL for BY 2005-2016 in July, August, September was 68 mm, 76 mm, and 84 mm, respectively (Figure 23). During the month of September, fish have begun to move lower in the system and we often do not meet our goal of 50 fish at either site.

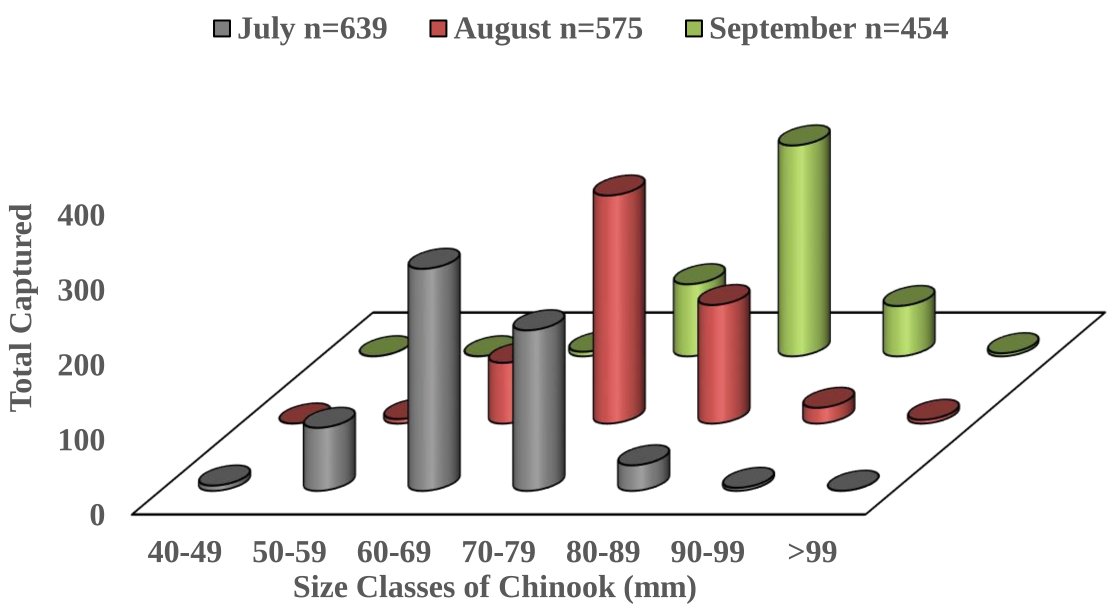


Figure 23. Seasonal growth of juvenile spring Chinook salmon captured during monthly sampling for July, August, September at the standard site (rkm 8.9), BY 2005-2016.

At the footbridge site (rkm 10.5) the average FL for BY 2005-2016 in July, August, September was 63 mm, 73 mm, and 81 mm, respectively. There was much more variability a few kilometers upstream at the footbridge site, with much smaller fish observed in August and September and a much wider area of overlap between months (Figure 24).

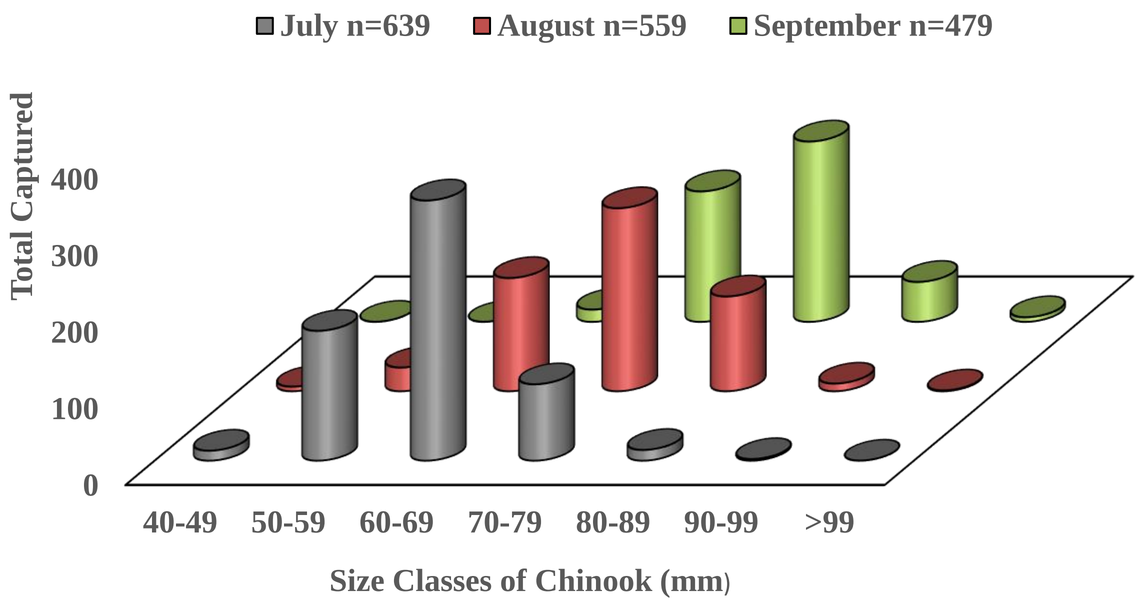


Figure 24. Seasonal growth of juvenile spring Chinook salmon captured during monthly sampling for July, August, September at the footbridge site (rkm 10.5), BY 2005-2016.

Precocious Chinook

There was only 2 BY 2015 NOR precocious juveniles caught in the screw trap during 17 July through 30 June 2018. There were also 2 adipose clipped precocious juveniles that must have moved upstream from the LH and then down again looking for potential mates. Each year several 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 low number of precocious fish captured this season is likely due to the fact that the screw trap was pulled from 21 August to 6 September due to the aforementioned mortality event, and then again from 10 September to 16 September due to LH road construction and a lack of access. This time frame is when adult Chinook are spawning and the majority of precocials are captured in the rotary trap. The numbers of precocious juveniles Burck (1993) reported in the bypass trap ranged from 158-575 annually, 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. It is of note that there were a larger percentage of precocious fish observed while snorkeling for the summer parr group and monthly sampling events. If they were captured they were scanned for a PIT tag, and a length, weight, and genetic sample were collected.

Summer Parr Sampling

A total of 994 BY 2016 parr where collected using snorkel/seine methods on 31 July 2017 (Figure 25). These fish were collected from the upper rearing areas of LGC in the upper portion of section 3L and the lowest section of 3U between rkm 8.9 and 12.0 (Figure 26). The CTUIR tagged these fish and returned them to the stream reach from which they were collected. Fork lengths were taken from 225 of these at the time of tagging (Figure 27). The vast majority of the tagged fish were between 60-75 mm (81%).

Figure 25. Snorkel/seining of juvenile spring Chinook for the summer parr group collected in unit 3U and 3L.

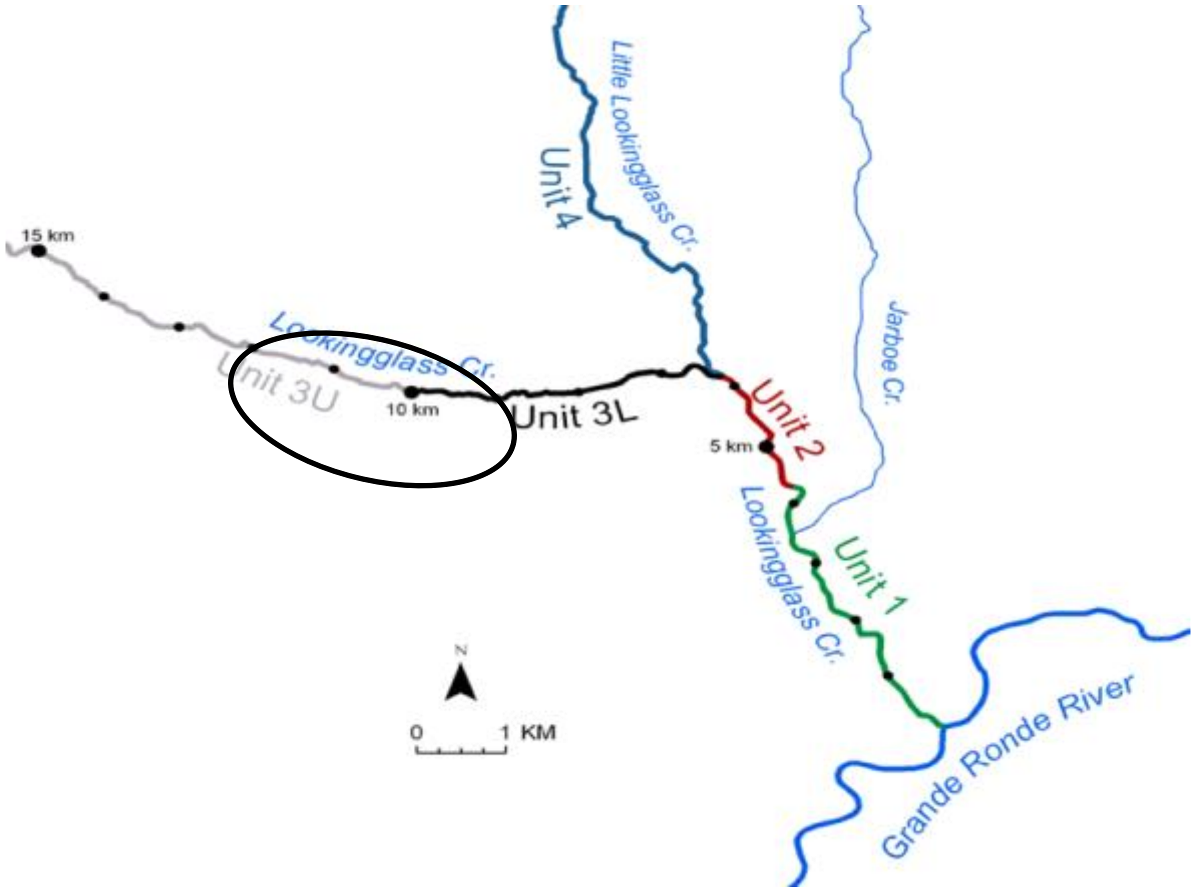


Figure 26. Circled area indicated the location of fish collection during the summer parr group sampling.

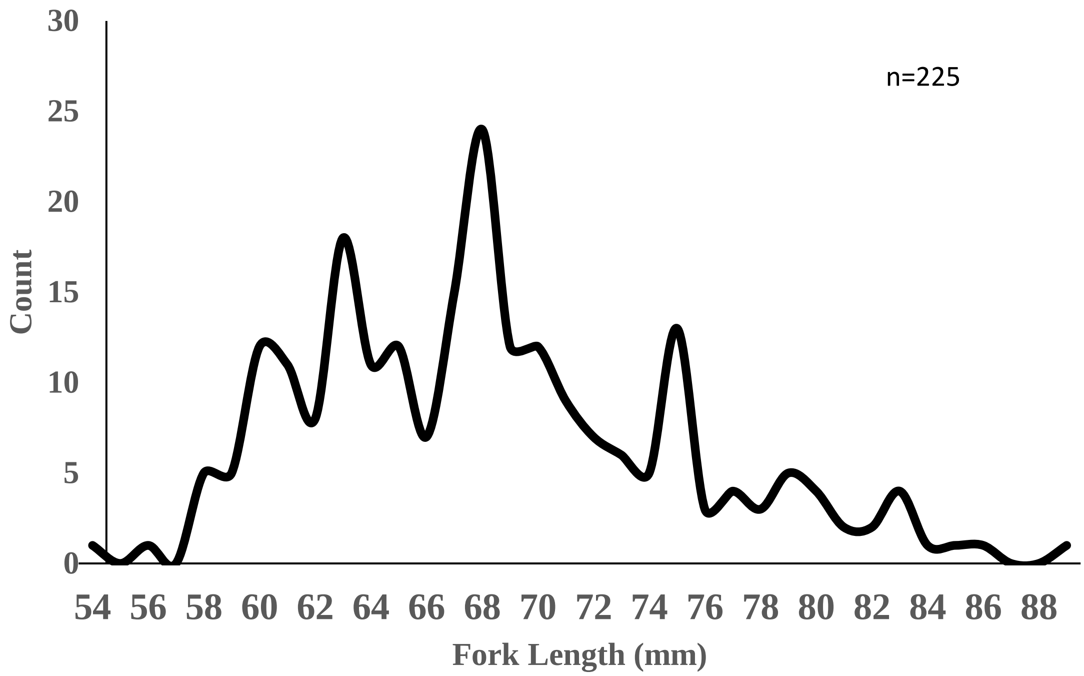


Figure 27. Size of summer parr spring Chinook salmon tagged in early August 2017, (BY 2016) during the summer parr collection effort.

Of the 994 summer parr tagged 1-3rd August, there were 129 captured in the screw trap, with 19% (24 fish) of these captures occurring in August 2017, possibly as a result of the disturbance during tagging. The majority of the summer parr group emigrated during the fall and winter months between release date of 4 August and 31 December (89%). This movement corresponded to the natural outmigration of parr captured in the screw trap.

1.6 Adaptive Management

Natural origin adult returns in recent years have displayed an upward trend, but are still below the minimum threshold numbers for recovery (Zimmerman & Patterson, 2002). However, 2017 and 2018 marked record low numbers for both HOR and NOR returns. This was true for the entire Grande Ronde Basin and not specific to LGC. Despite the low numbers in 2018, there was a tribal and recreational harvest on LGC. The lower ladder was used in conjunction with the upper ladder once harvest had ended. There was a large number of fish captured in the lower ladder late in the season which enabled the broodstock needs to be met.

There were several anomalies of age 4 “mini jacks” that returned to LGC and were recovered below the weir. No scales were taken from these due to the fact that they had a CWT, however scales will be taken in the future since these fish came back as verified age 4 returns. There were only 24 total jack returns this year (8%), compared to 42% of total returns in 2017. Increases in maturation rates could indicate poor ocean conditions as described by (Siegel, et al., 2017).

Pre-spawn mortality was greatly reduced this year. Releasing adults directly upstream near the water intake building into a deep pool or just upstream likely played a factor in reducing handling related stress and mortality. The number of redds below the weir in 2018 were 52% of the total redds observed, higher than both the endemic and Rapid River eras. The high density of redds below the weir is likely causing a lack of viability of some redds due to superimposition.

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 & 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), (Independant 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 purchasing of the (formerly) Nielson property (Figure 28, Figure 29) 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 re-introduction 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 years of pre-restoration data readily available enables us to observe and quantify fish use and response to habitat restoration. Restoration efforts may address the smaller mean size and survival estimates currently observed in outmigrating spring Chinook in higher redd years. Improving this section of the stream will expectantly provide for the needs of Chinook salmon in all life stages. Beginning in 2018 (BY 17), we also began looking at stable isotopes of juvenile Chinook salmon, benthic invertebrates, leaf litter, and periphtyon present during our monthly sampling efforts during the months of July-September. The lower site (standard) is within the CTUIR property where we plan to do the habitat reconstruction and use as the "treatment" site, and the upper site (footbridge) will remain untouched and be used as our "control". This also affords us a chance to elucidate what is available for fish consumption during these periods of time, prior to restoration and after, as well as how that compares to other streams in the basin.

The current Lookingglass Management Plan is in Section 1.8 of this report. However co-managers have met to alter this plan due to the additional operation of the lower ladder and the continued low numbers of returns in an effort to ensure broodstock objectives are met. The updated version will not be in place until 2019 and will be discussed in a future report.

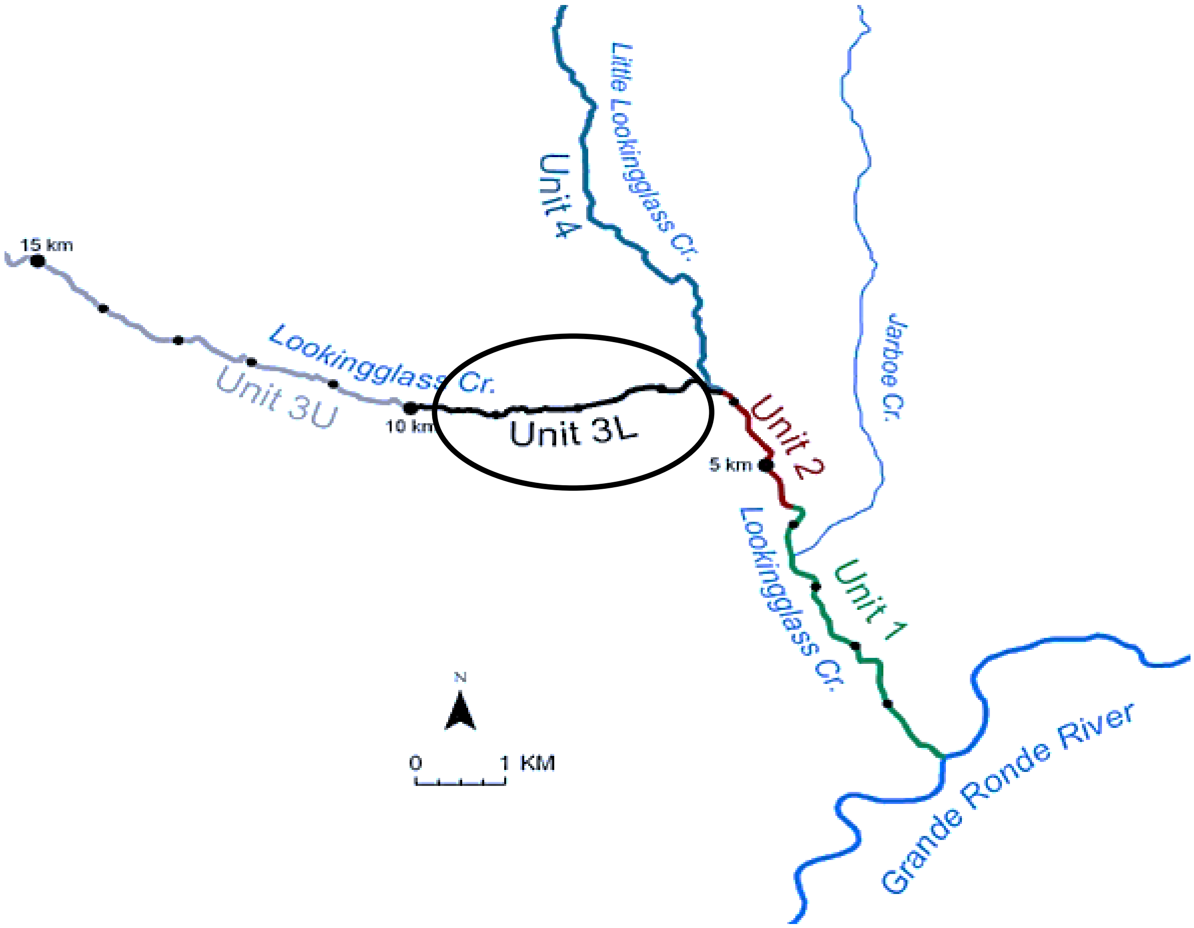


Figure 28. Lookingglass Creek section breaks for spawning surveys. The circled area indicates the acquired conservation property slated for restoration work in the future.

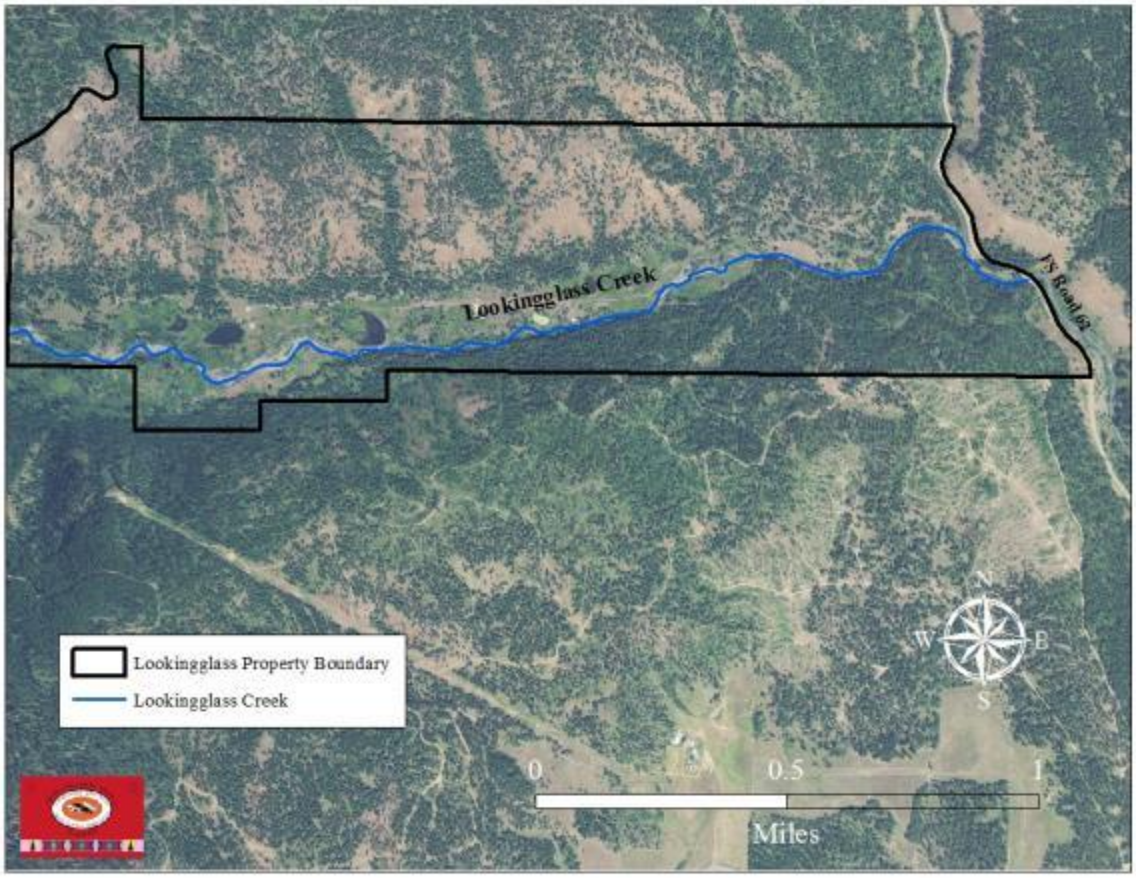


Figure 29. The conservation property recently purchased by CTUIR in 2015.

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 re-introduced 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. It is unlikely that without the continued HOR component to this program that the NOR would be able to self-propagate and increase each year, as well as provide tribal harvest.

1.8 Management Plan

The goal of the LGC spring Chinook hatchery program is to reintroduce spring Chinook into LGC using CC stock to support tributary harvest, natural population restoration, and maintenance of a gene bank for the CC stock. Current production targets for CC and LGC production, per the *2008-2017 United States v. Oregon* Management Agreement are outlined in Table 18.

Table 18. Current LGC management plan outlined in B1 of the *2008-2017 United States vs Oregon* Management Agreement.

Release Site	Rearing Facility	Stock	Life Stage	Target Release Number	Primary Program Purpose	Funding
LGC	LGC/Capt. Br	CC	Smolt	250,000	Fishery/Reintro	LSRCP/BPA
CC	LGC/Capt. Br	CC	Smolt	150,000	Suppl/ Fishery	LSRCP/BPA

LGC=Lookingglass Creek
CC=Catherine Creek

Disposition of these adults will be determined in early July according to the guidelines in Table 19, and adults designated to be passed upstream will be released. Disposition of LGC adults arriving after July 4 will be based on the percentages outlined in Table 19. All adults passed upstream will have genetic samples taken.

Table 19. Disposition of LGC adult spring Chinook salmon arriving at the LH weir.

Escapement Level	% Pass Above	% Keep for Brood
150	67	33
200	60	40
250	55	45
300*	50	50

**if greater than 300, adjustments will be made based on brood needs. If brood need has been met, remainder to be released upstream.*

An estimated 158 adults (47 NOR and 111 HOR) are required to meet 250,000 smolt production levels. Broodstock for the program will be collected from returns to either the LH weir or the CC weir. Either conventional or captive hatchery adults may be used for brood. The goal for broodstock composition will be to incorporate 30% NOR adults, with no more than 25% of the returning NOR Chinook retained for brood. If a shortage of NOR adults occurs, then additional HOR adults will be collected to meet the brood target.

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2.1 Appendices of Water Temperatures and Diurnal Fluctuations

Based on Figure 31 and Figure 33, LLGC is on average a couple of degrees cooler than the mainstem at the screw trap site. The LLGC probe site is roughly 5.5 km upstream from the screw trap site which likely explains the cooler temperature. Since 2013, zero contiguous hours were logged on the LLGC culvert probe that were ≥20°C, and only 3 hours were logged ≥ 20°C for the LGC Screw Trap probe (minus 2016 data for lost probe). The diurnal fluctuation is greater for the LGC site, in particular during the months of July-September (Figure 30, Figure 32).

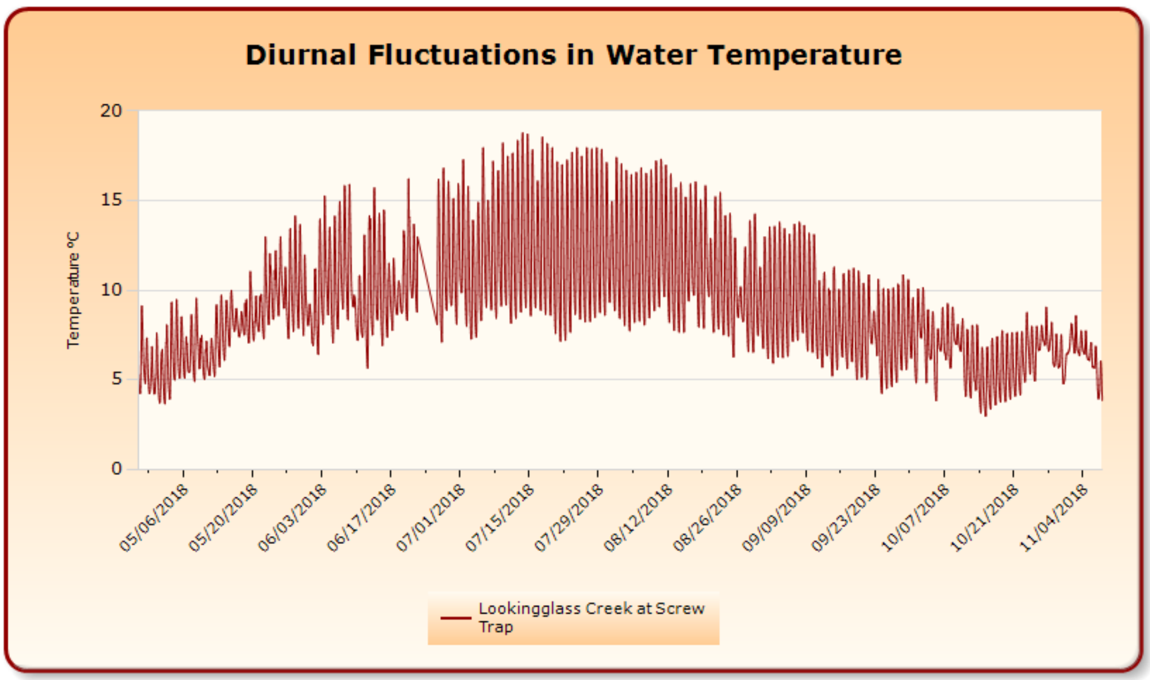

Figure 30. Diurnal fluctuations at the Lookingglass Creek screw trap site, 2018. There was a small period in June where the temperature probe was out of the water and that data has been removed.

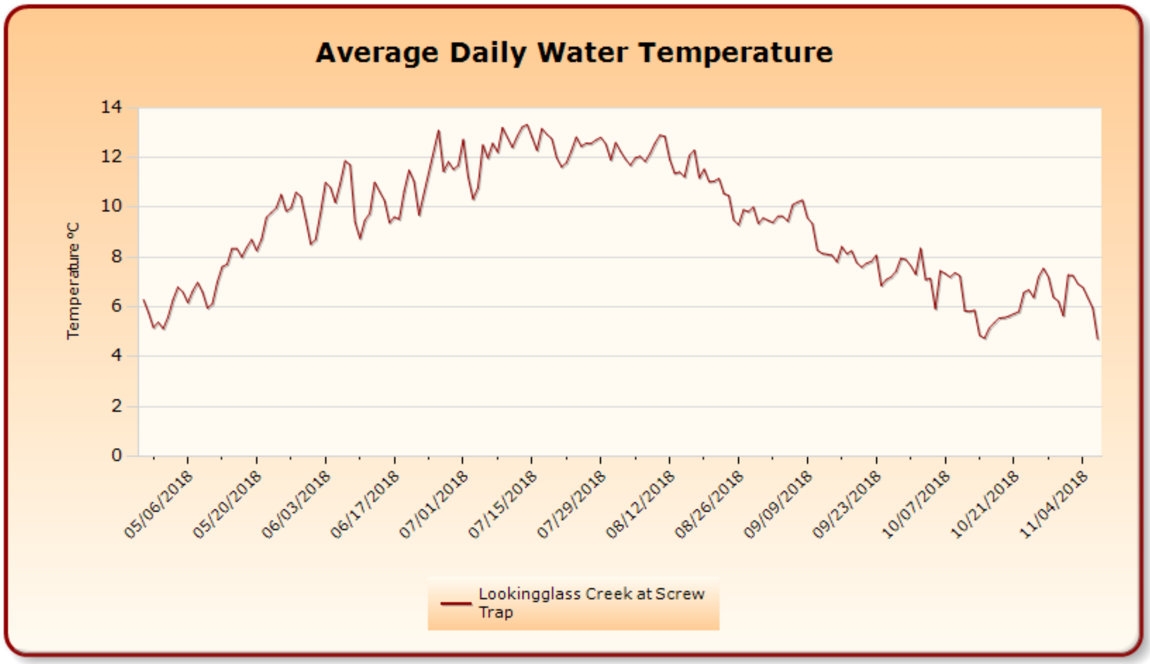

Figure 31. Average daily water temperature at the Lookingglass Creek screw trap site, 2018.

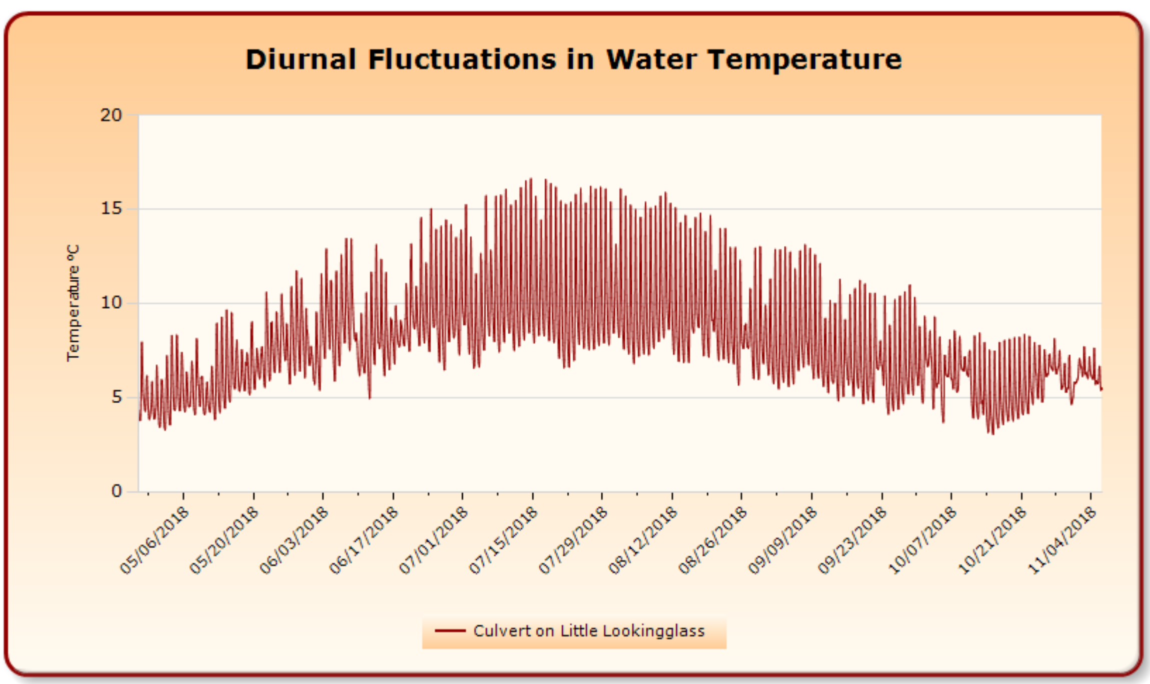

Figure 32. Diurnal fluctuations at the Little Lookingglass Creek culvert site, 2018.

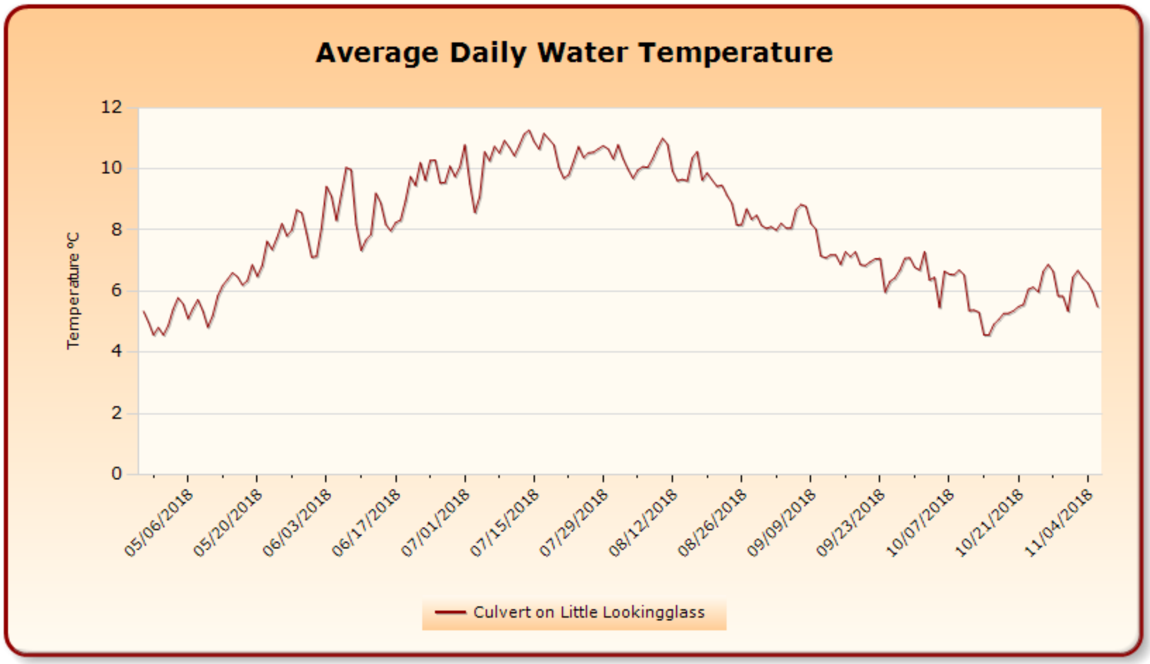

Figure 33. Average daily water temperature at the Little Lookingglass Creek culvert site, 2018.

2.2 Appendices of Data Used for Wilcoxon Statistical Analysis

Table 20. Percentage of redds by unit for RY 2009-2018. Data in table are used in Wilcoxon Rank Sum analysis on page 23 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
Mean %	37	7	23	26	7	

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 incorrect, 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 21. 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 22. Previous method of calculating Fish/redd and prespawn mortality for naturally spawning spring Chinook salmon above the LH weir, 2004-2015.

Year	Fish/redd		Prespawning mortality
	Adults only	Jacks and Adults	
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 23. 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 2017 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 October 2017.

We assisted Bonneville Power Administration (BPA) funded projects with data collection in 2017. 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 in Unit 3L (Figure 34). 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. 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. We counted 14 completed lamprey redds during these surveys (Figure 35). The observed lamprey redds were counted in areas where we currently see large numbers of Chinook redds also. Two surveys were conducted on LLGC due to some being released at the culvert, and 2 redds were counted. There will 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 34. Approximately 151 adult lamprey were released into Lookingglass and Little Lookingglass Creek in 2018.

Figure 35. Location of the observed lamprey redds, 2018.

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, Margaret Anderson, and Renee Heeren 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, Dora Sigo (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 redd density maps. Gene Shippentower (CTUIR) reviewed previous drafts of this report. The Bureau of Reclamation provided support for this project in the amount of approx. $50,000 for seasonal help to complete field work, and equipment purchases. Tim Hoffnagle and Joseph Feldhaus (ODFW) provided their methodology for calculating population estimates detailed in Appendices 2.2 that enabled us to be consistent with our partner agencies.