# Chinook Salmon (*Oncorhynchus tshawytscha*) Spawning Ground Surveys in the South Fork Salmon River and Big Creek, 1996-2008



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# EXECUTIVE SUMMARY


The Nez Perce Tribe Department of Fisheries Resources Management conducted spawning ground surveys on the South Fork Salmon River (SFSR) and Big Creek (Middle Fork Salmon River tributary) from 1996 to 2008 to assess annual Chinook salmon (Oncorhynchus tshawytscha; Nacó'x in Nez Perce) spawning success. We conducted multiple-pass, ground count surveys of Chinook salmon redds and carcasses on 4 sections in the SFSR covering a total of 19.1 kilometers (km) and 2 sections in Big Creek covering a total of 10.3 km.

Performance measures derived from redd count data included 1) index of spawner abundance (redd counts); 2) spawner abundance; 3) progeny-per-parent ratio (derived from a ratio of return (progeny) redds to parent redds); 4) spawn timing and; 5) adult spawner distribution, estimated from the distribution of redds. Performance measures derived from carcass survey data included 1) adult spawner sex ratio; 2) age at return; 3) size-at-return; 4) hatchery fraction; 5) pre-spawn mortality and; 6) stray rate.

The index of spawner abundance averaged 322 (S.E. = 51) redds and ranged from 40 redds in 1996 to 715 redds in 2004 for the SFSR. Big Creek index of spawner abundance averaged 38 (S.E. = 9) redds and ranged from 2 in 1996 to 104 in 2001. Both rivers showed an overall increasing population trend over the survey time period. Spawner distribution and spawn timing were also relatively stable over that time period for both rivers. From 1996 – 2008 a total of 5,143 carcasses were recovered in the SFSR consisting of 2,568 females, 2,041 males, 404 jacks and 130 unknown sex. Big Creek recoveries totaled 191 carcasses consisting of 89 females, 82 males and 19 jacks. Within the SFSR, we identified significant differences in female prespawn mortality, age at return, size at return and adult spawner sex ratio for natural-origin (NOR) compared with hatchery-origin (HOR) Chinook salmon. Although these differences were small, they potentially indicated a slight life history divergence of the HOR fish resulting from management of the production hatchery program in the SFSR that did not include NOR fish in the broodstock.

We compared SFSR and Big Creek index of spawner abundance using a Pearson Correlation of redd counts from 1996 – 2008. Redd counts in Big Creek were highly correlated with both total SFSR redds and estimated NOR redds, suggesting that escapement to these spawning areas was heavily influenced by out of basin factors or common environmental factors.

We anticipate that SFSR escapement and spawner population estimates will be more precise in the future with the inclusion of two Passive Integrated Transponder (PIT) tag arrays that were installed below the study area in 2008 (Krassel Guard Station) and 2009 (Lower SFSR at the Guard Station Bridge). Estimating detection efficiency at these sites should allow us to estimate the escapement to the SFSR when combined with sport and Tribal harvest estimates and returns to the McCall Hatchery weir.

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ACKNOWLEDGMENTS

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## INTRODUCTION

The Nez Perce Tribe Department of Fisheries Resources Management conducted spawning ground surveys on the South Fork Salmon River (SFSR) and Big Creek (Middle Fork Salmon River tributary) from 1996 to 2008 to assess annual Chinook salmon (Oncorhynchus tshawytscha; Nacó'x in Nez Perce) spawning success. Chinook salmon redd counts and carcass surveys were conducted via a multiple ground count census on these salmon spawning aggregates. The purpose of the multiple census technique was to enumerate Chinook salmon redds as accurately as possible over time, to determine timing of peak spawning and completion of spawning, and to collect data from carcasses for age, sex and hatchery:natural composition, and straying information. This type of information was utilized as an index of relative abundance for each individual year's spawning run and used to examine trends in spawning escapements over time.

Big Creek Chinook salmon were selected for survey as they represented a reference population from an unsupplemented spawning aggregate in the Middle Fork Salmon River drainage. The Middle Fork Salmon River system has been managed as a wild fish management area and is referred to as a genetic refuge for all salmonids. Comparing trends in abundance of the supplemented SFSR with unsupplemented populations can be used to estimate the affect of supplementation for Chinook salmon recovery.

McCall Fish Hatchery, which was completed in 1980, is located in the Payette River drainage in McCall, Idaho. The Lower Snake River Compensation Plan (LSRCP) hatchery program has a smolt production goal of one million fish which is intended to return 8,000 adult salmon to the South Fork Salmon River (Hutchinson, 1982). Chinook salmon smolts reared at McCall Hatchery are direct stream released into the South Fork Salmon River drainage, at the Knox Bridge (river kilometer - 522.303.215.118), which is approximately one kilometer upstream of the adult fish weir and trap. Adult salmon returning from these releases are captured at the fish weir and used for broodstock, transported back downstream for sport and Tribal fisheries, enhancement, and distribution, or outplanted to various locations in the SFSR or the East Fork South Fork Salmon River (EFSR) to spawn naturally. Natural-origin (NOR) fish were passed above the weir or used for broodstock as part of the Idaho Salmon Supplementation Project (Bowles and Leitzinger, 1991).

Prior to the initiation of this study the magnitude of hatchery-origin (HOR) adult salmon spawning in the South Fork Salmon River downstream of the adult weir was unknown. Since the purpose of the Lower Snake River Compensation Plan hatchery program has been focused on preservation of these listed Chinook salmon, it has become increasingly important for managers to understand the contribution of HOR adults in the naturally spawning population. Our work on the upper mainstem South Fork Salmon River was intended to determine HOR and NOR adult salmon composition on the spawning grounds below the adult fish weir and estimate their contribution production of NOR adults in the SFSR.

## DESCRIPTION OF STUDY AREAS

The South Fork Salmon River is approximately 128 kilometer (km) in length and enters the Salmon River at river kilometer 222. The drainage encompasses an area of 3,382 square km (1,306 square miles). The primary spawning ground survey area is located above the confluence of the East Fork South Fork Salmon River and covered four stream reaches comprising a total of 19.1 kilometers of the mainstem South Fork Salmon River (Figure 1). These survey areas were established in 1991. SFSR sections counted annually included a 5.0 km section from McCall Hatchery weir to the confluence with Dime Creek (WD); a 6.3 km section from the confluence with Dime Creek to approximately 580 m above the confluence with Roaring Creek at GPS point N44.74033 W115.68914 (DC); a 1.1 km section encompassing the Poverty Flat area from the confluence with Blackmare Creek to where the river narrows at GPS point N44.83606 W115.70423 (PF) and; a 6.7 km section from Lodgepole campground to the Phoebe Creek bridge (LP). In addition, a single peak count survey was performed in 2000 – 2003, 2005 and 2007 on a section beginning at the end of the DC section at GPS point N44.74033 W115.68914 and ending at the confluence with Sisters Creek (GC).

Big Creek is approximately 67 km in length (Figure 2) and enters the Middle Fork Salmon River at river kilometer 28.9. The drainage encompasses an area of 1,217 square kilometers, a majority of which is located within the Frank Church River of No Return Wilderness area. Access to the system is limited to a road in the headwaters and a trail from the Smith Creek wilderness boundary trailhead to the mouth where it enters the Middle Fork Salmon River. Big Creek sections surveyed annually included a 4.7 km section from the bridge near the mouth of Jacobs Ladder Creek to the confluence with Logan Creek (JC) and a 5.6 km section from the confluence with Logan Creek to the confluence with Smith Creek (LC; Figure 2).

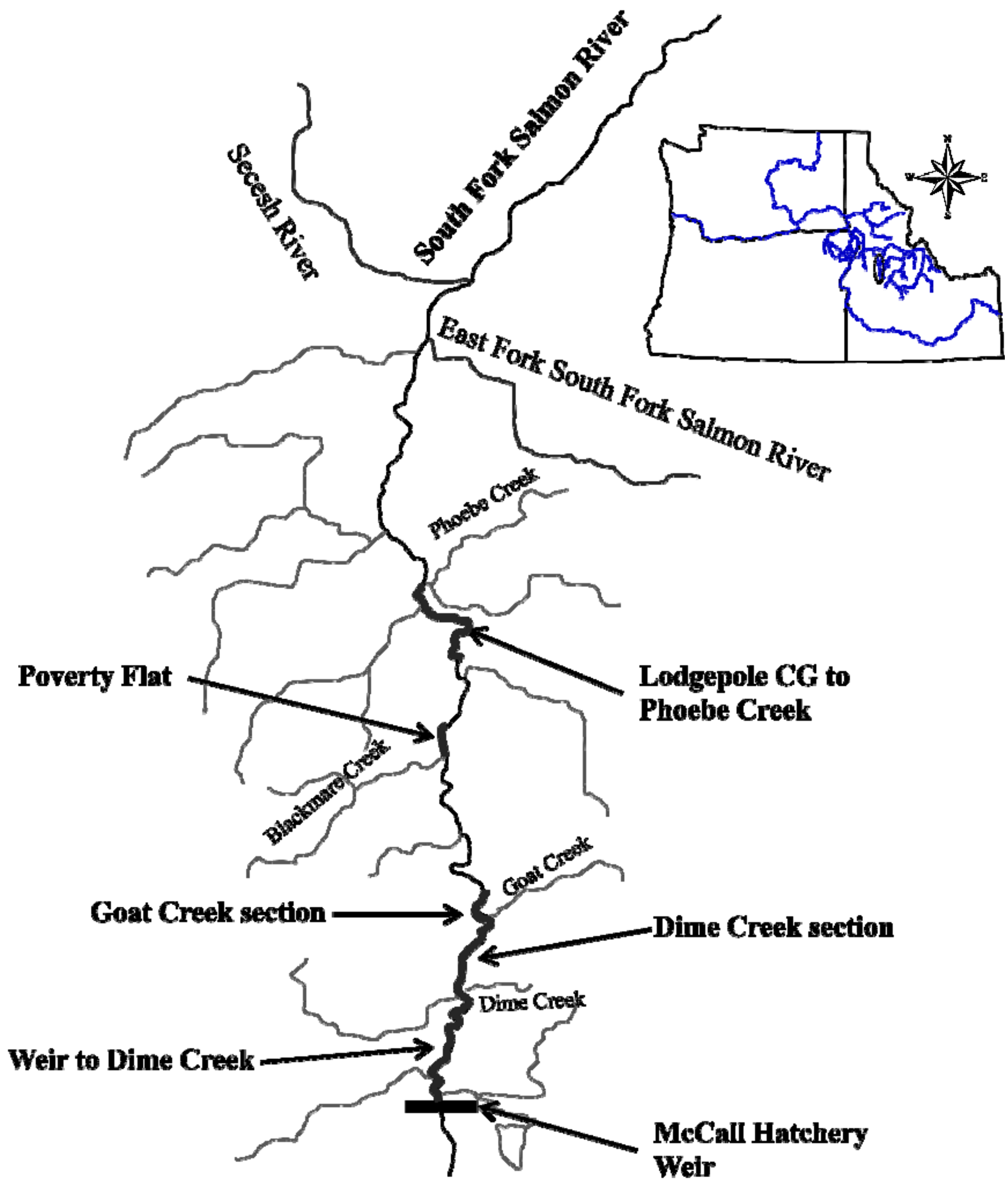



Figure 1. Map showing the South Fork Salmon River basin and stream sections surveyed during annual spawning ground surveys. Surveys where completed on four index areas; Weir to Dime Creek section (WD); Dime Creek section (DC); Poverty Flat (PF) and; Lodgepole Campground to Phoebe Creek (LP). The Goat Creek section (GC) was a supplemental area that was not surveyed every year.

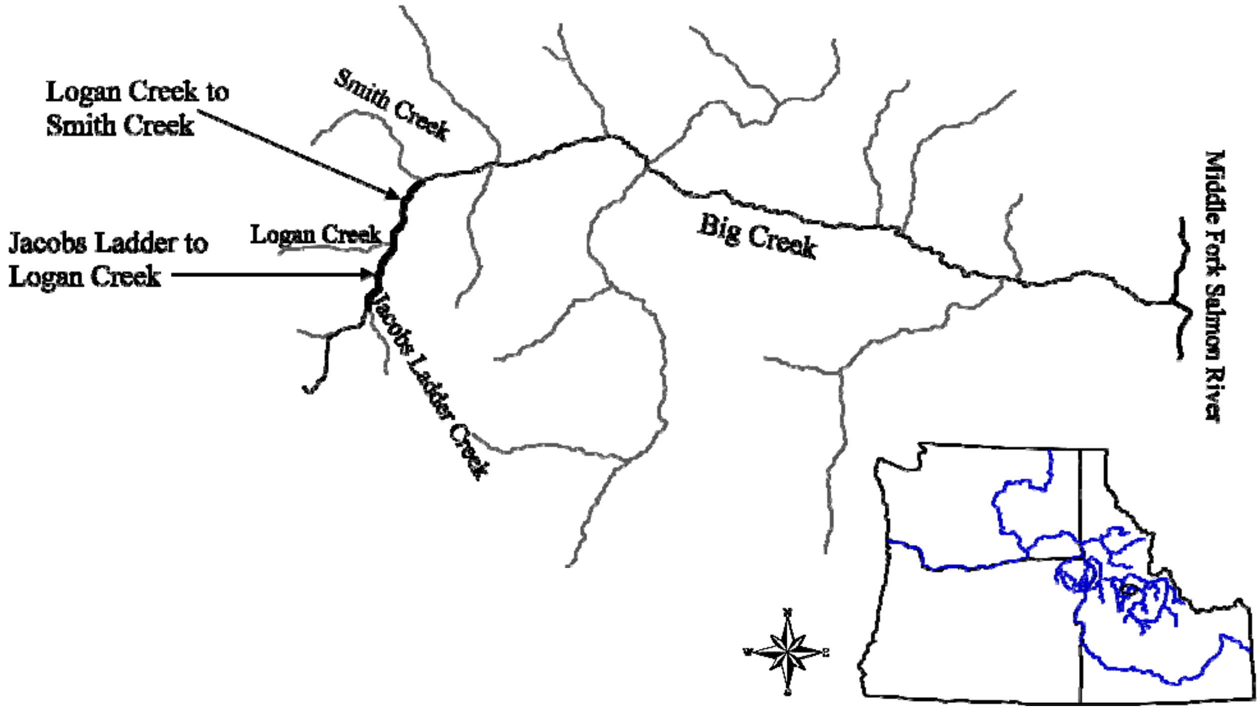



Figure 2. Map showing the Big Creek basin and stream sections surveyed during annual spawning ground surveys. Index area survey sections indicated included Jacobs Ladder to Logan Creek (JC) and Logan Creek to Smith Creek (LC).

## METHODS

### Spawning Ground Surveys

Data for this report were collected from multiple, ground-based spawning ground surveys in the South Fork Salmon River and Big Creek from 1996 – 2008. Generally, four surveys were completed on the SFSR and three were completed on Big Creek each year. The advantage of multiple-pass surveys was that they more accurately enumerated salmon redds, can be used as an index of relative abundance and effectively delineated spawn timing (Schwartzberg 1987). In addition, multiple-pass surveys allow enumeration and detailed biological assessments of carcass composition over the entire spawning period. Information collected included number of new redds, number of live adult salmon (including jacks) and carcasses and associated biological information in the respective survey reaches. Salmon carcass surveys were emphasized on the South Fork Salmon River to assess the hatchery:natural composition of adults on the spawning grounds.

From 1996 – 2005 redds were recorded but location was not marked with colored flagging. Since 2006 redd locations were marked with flagging that recorded the date observed and redd number. Different colored flagging was used during each subsequent survey period to aid in the determination of redd age. Flagging aided in redd identification especially when multiple closely-spaced redds were encountered, when stream flows changed and when rainstorm events caused heavy siltation making redds difficult to identify. Beginning in 2006 the location of all redds was marked with a Global Positioning System (GPS) waypoint in World Standard Group (WSG) 84 in degree decimal format.

Carcass surveys were performed in conjunction with extensive area, multiple pass redd counts, supplemented with additional carcass recovery surveys as needed. Data collected from carcass surveys included fork length, mid-eye-hypural length, presence/absence of fin clips, presence/absence of coded wire tags (generally only adipose fin-clipped hatchery) and sex (determined by cutting open and examining the gonads). In addition, scale samples and tissue samples (for DNA analysis) were collected from all NOR individuals. Scales were removed from a preferred area located two to three rows above the lateral line on a diagonal scale column running from the posterior base of the dorsal fin to the anterior base of the anal fin (Schwartzberg, 1987). All fish were scanned using a coded wire tag (CWT) detector and snouts were removed from all fish containing a CWT. Carcasses were cut open for positive identification of sex of the fish and to determine female percent spawned, and, caudal fin was removed from all worked up carcasses to prevent duplicative sampling.

## Chinook Salmon Age Determination

Adult Chinook salmon were aged using CWT tag codes, scale analysis and fork length. Scale analysis was conducted by Columbia River Intertribal Fish Commission (CRITFC) staff for samples collected from 1996 through 1999. Scales were selected, mounted and pressed according to methods described in (Jearld, 1983). Due to extensive scale resorption typical of scales samples collected from spawned-out salmon carcasses, accurate estimation of ocean ages was rarely possible. Typically, at least one ocean annuli was missing due to resorption of the outer portion of the scale. Ocean age was therefore estimated based on the degree of resorption observed, taking into account the fork length and sex of the fish in question. Scales from male Chinook salmon typically show greater resorption than those from female Chinook salmon.

## Performance Measure Calculations

Performance measures calculated from data collected from 1996 – 2008 followed definitions developed by the Collaborative Systemwide Monitoring and Evaluations Project (CSMEP; web site) and adopted by the Ad Hoc Supplementation Work Group (Beasely et al. 2008). Data collected from spawning ground surveys were limited to redd counts and adult spawner composition and this determined the performance measures that could be calculated. No juvenile or adult trapping or tagging was done under this project.

Performance measures derived from redd counts:

Performance measures calculated from redd counts included 1) index of spawner abundance; 2) progeny-per-parent ratio (derived from a ratio of return (progeny) redds to parent redds); 3) spawn timing (derived from timing of redd counts). Data collected for the calculation of these performance measures include total redds surveyed, total redds by section, Julian day that each redd was counted and location of each redd (including a GPS point for redds surveyed since 2006) and; 4) adult spawner distribution, estimated from the distribution of redds.

1) Index of spawner abundance was calculated from the raw measure of counts of redds in spawning areas using extensive area, multiple-pass surveys. Each section was surveyed a minimum of 3 times per year starting in late July or early August and

finishing in late August for Big Creek and starting in mid August and finishing in mid September for the SFSR. This generally encompassed the entire spawning period for each stream.

2) Progeny-per-parent ratio is a derived measure of Lamda, the median annual population growth rate and is estimated here using a raw measure of the median ratio of return redds to parent redds for complete brood years. The brood year of parent redds was determined by age composition of females recovered each year.
3) Spawn timing was estimated by four measures, 1) peak – date with the highest number of redds calculated based on a 10 day moving average summed across all years; 2) first-last – dates of the first and last redd counted based on all counts from 1996 – 2008 and; 3) date that the $10^{th}$ and $90^{th}$ percent of total redds were counted. Differences in spawn timing among sections were tested using a chi-square test with the null hypothesis that Julian day distributions were equal for redd counts from all sections.
4) Adult spawner distribution was estimated by examining redd count distribution by section over all years from 1996 – 2008. This was used to document major shifts in spawner distribution within each stream over the 13 year time frame.

Performance measures derived from carcass recoveries:

Performance measures calculated from carcass recoveries included; 1) adult spawner sex ratio; 2) age at return; 3) size-at-return; 4) hatchery fraction; 5) pre-spawn mortality and; 6) stray rate.

1) Adult spawner sex ratio was calculated as the proportion of female carcasses recovered from each stream, section and year. Comparisons among groups were made using a chi-square test with the null hypothesis of equal sex ratios.
2) Age-at-return for the SFSR was calculated as the age distribution of spawners determined by tags (CWT), the analysis of scales and fork length using an age distribution developed from hatchery returns to the McCall Hatchery trap. Age distribution from Big Creek was determined by fork length. Comparisons between NOR and HOR carcasses in the SFSR was tested using a t-test of means.
3) Size-at-return was calculated as the size distribution of spawners in each stream, section and by origin. Comparisons between NOR and HOR carcasses in the SFSR were made using at t-test of means.
4) Hatchery fraction was calculated by dividing the total number of HOR carcasses by the total number of carcasses for the entire stream and each section. Hatchery fraction for each section was compared using a chi-square test with the null hypothesis that the hatchery fraction was equal in all sections.
5) Pre-spawn mortality (females retaining > 75% of their eggs) was calculated by dividing the total number of females that retained > 75% of their eggs by the total number of female carcasses recovered, total by origin and by section (SFSR only). For the SFSR, significant differences in percent female pre-spawn mortality between HOR and NOR carcasses was tested using a two-way Analysis of Variance (ANOVA) with year and origin as factors. In addition, physical and biological factors that affected pre-spawn mortality were analyzed using linear regression analysis. Physical factors investigated included average August water temperature and the average August flow at the United States Geological Survey Krassel stream gage on the SFSR

(http://waterdata.usgs.gov/nwis/uv?13310700). Biological factors investigated included origin, size, presence of visible injuries and abundance.

6) Stray rate was calculated as the percent of HOR Chinook salmon in Big Creek and the presence of tagged fish from other basins in the SFSR. HOR strays to Big Creek were identified with an adipose fin clip. The McCall Hatchery has an ongoing hatchery production program that releases HOR smolts above the surveyed sections so it was not unexpected to detect large numbers of these fish in our carcass surveys. Stray hatchery fish from other basins were identified by CWT.

The performance measure *spawner abundance* was not estimated because it was impossible to directly enumerate the spawning populations in the SFSR or Big Creek. Expanding the number of redds by a standard value such as 2.31 (Plan for Analyzing and Testing Hypotheses; PATH; Beamesderfer et al. 1998) would provide an estimate for spawner abundance that was identical to that estimated from the redd count trend data (*Index of Spawner Abundance*). Consequently, it does not provide a direct measure Chinook salmon abundance in the SFSR. With the fall 2008 installation of a stream-wide Passive Integrated Transponder (PIT) tag detector below the spawning area in the SFSR (KRS PIT tag array; http://www.ptoccentral.org/cgi-bin/osmi.cgi?SI=KRS), in the future we may be able to estimate spawner abundance in these sections based on PIT tag detections at KRS, returns to the McCall Hatchery weir and an estimate of sport and Tribal harvest. In addition, the Integrated Status and Effectiveness Monitoring Program (ISEMP; http://www.nwfsc.noaa.gov/research/divisions/cbd/mathbio/isemp/index.cfm) will begin PIT tagging natural adult Chinook salmon and steelhead at Lower Granite Dam (2009), providing another method to estimate Chinook salmon and steelhead escapement to our survey area. These data along with that of the ongoing spawning ground surveys should provide a more accurate estimate of annual Chinook salmon spawner abundance in the SFSR and potentially Big Creek using the PIT tag array at Taylor Ranch (TAY). Beginning in 2010 the NPT Spawning Ground Survey Report includes estimates of spawner abundance in the SFSR based on PIT tag detections at KRS, the McCall Hatchery Weir, complemented with redd count and carcass survey data.

## RESULTS AND DISCUSSION

### South Fork Salmon River Chinook Salmon Redd Counts

*Index of spawner abundance*

Annual redd counts from four sections in the SFSR from 1996 – 2008 revealed high year-to-year variability with an increasing linear trend (Table 1; Figure 3; see Appendix A for detailed annual redd count data). Overall redd counts averaged 322 (S.E. = 51) with a minimum of 40 in 1996 and a peak of 715 in 2004. Examining redd count data by section revealed a similar pattern of large year–to-year redd count variability among the sections (Table 1).

Table 1. Redd counts from four sections in the South Fork Salmon River determined from

annual multiple-pass spawning ground surveys from 1996 – 2008. WD – weir to Dime Creek; DC – Dime Creek section; PF – Poverty Flat; LP – Logdepole Campground to Phoebe Creek.

| Year | WD | DC | PF | LP | Total |
|---|---|---|---|---|---|
| 1996 | 6 | 4 | 13 | 17 | 40 |
| 1997 | 59 | 71 | 51 | 72 | 253 |
| 1998 | 31 | 19 | 33 | 51 | 134 |
| 1999 | 18 | 18 | 17 | 44 | 97 |
| 2000 | 62 | 107 | 37 | 66 | 272 |
| 2001 | 108 | 134 | 74 | 130 | 446 |
| 2002 | 78 | 171 | 73 | 164 | 486 |
| 2003 | 81 | 85 | 58 | 146 | 370 |
| 2004 | 146 | 285 | 122 | 162 | 715 |
| 2005 | 67 | 195 | 44 | 60 | 366 |
| 2006 | 53 | 105 | 44 | 72 | 274 |
| 2007 | 47 | 118 | 41 | 38 | 244 |
| 2008 | 249 | 70 | 90 | 78 | 487 |
| Total | 1005 | 1382 | 697 | 1100 | 4184 |
| Mean | 77.31 | 106.31 | 53.62 | 84.62 | 321.85 |
| St. Dev. | 63.30 | 78.42 | 30.07 | 49.12 | 184.69 |
| C.V. | 0.82 | 0.74 | 0.56 | 0.58 | 0.57 |

We used the estimated female hatchery fraction from each section to calculate the proportion of redds constructed by NOR females after subtracting prespawn female mortality (Figure 4). Counts for the WD and DC sections and the PF and LP sections were combined because there were no significant differences in hatchery fraction for those sections (see *Hatchery Fraction*). The pattern and trend line over the years revealed that although the number of total redds in the WD and DC sections were increasing, this was largely a result of an increase in HOR redds. The slope of the trend line for the total redds in these combined sections was positive and significantly steeper than that for the estimated NOR redds (total redds slope = 19.71; estimated NOR slope = 4.29; Figure 4a). In contrast, total redds and estimated NOR redd count trend lines for the PF and LP sections were positive and showed a similar slope (total redds slope = 6.74; NOR redds slope = 6.78; Figure 4b).

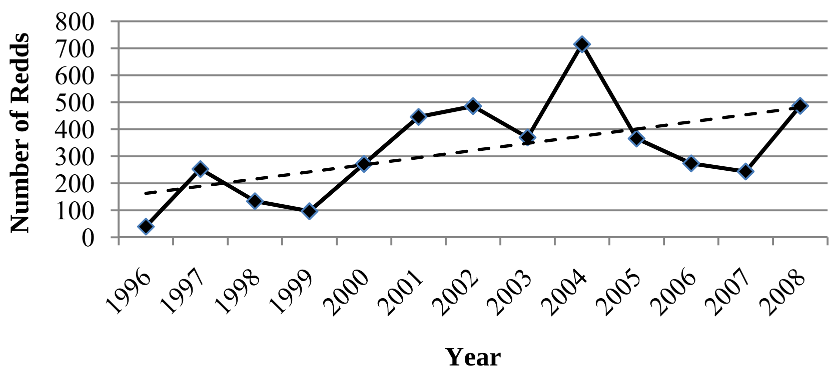
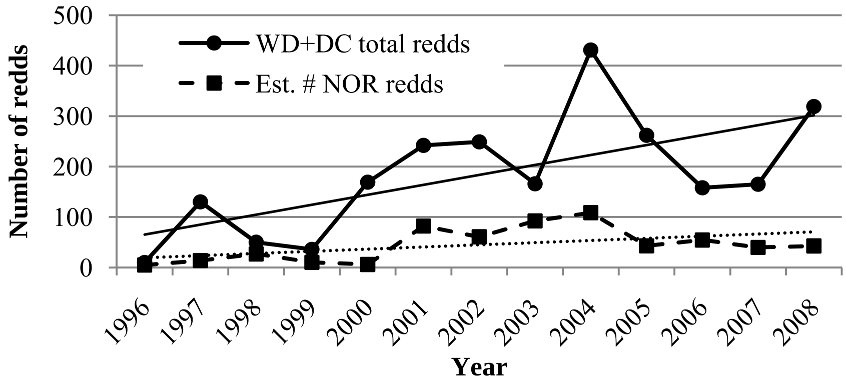


Figure 3. Total redds counted from four sections of the South Fork Salmon River below the McCall Hatchery Weir from 1996 – 2008. Dashed line demonstrates the linear trendline for the data series.

a.




b.

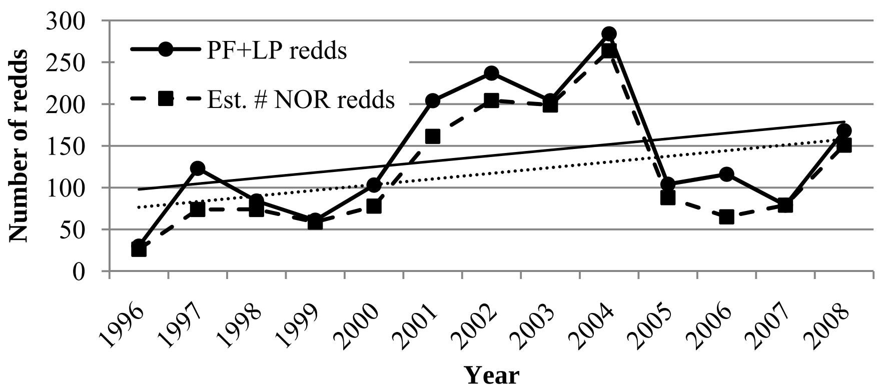



Figure 4. Total Chinook salmon redds (circles) and estimated number of Chinook salmon natural origin return (NOR) redds (squares) counted from 1996 – 2008. NOR redds were estimated using the proportion of NOR female carcasses recovered in each section after subtracting the HOR and NOR female prespawn mortalities. Solid and dashed trendlines demonstrate the linear trend line for total redds and NOR redds, respectively. 4a. Counts from the Weir to the confluence with Dime Creek (WD) and Dime Creek (DC) sections combined. 4b. Counts from the Poverty Flat (PF) and Lodgepole Campground to Phoebe Creek Bridge (LP) sections combined.

*Progeny-per-parent ratio*

Without a weir or video counting structure in the upper SFSR it was impossible to accurately enumerate Chinook salmon adult abundance. Therefore, progeny-per-parent ratio was calculated using the ratio of return redds to parent redds. The relatively large number of naturally-spawning HOR fish, especially in the upper two sections (see *"spawner distribution"*), would significantly affect the progeny-per-parent ratio estimate unless the redds constructed by the HOR females were removed from the estimate of the progeny, but not the parent redds. For parent redds, all females, regardless of origin, would produce offspring that would be counted as natural-origin adults in subsequent surveys. However, return or progeny redds only included redds constructed by NOR females from a given brood year, either 4 or 5 years later. An estimate of the number of NOR redds was calculated by multiplying the total number of redds by the proportion of NOR female carcasses recovered for a given year. Brood year origin was estimated using annual carcass recovery age data and the proportion of age 4 and age 5 females and these proportions were then used to estimate brood year origin of the return redds. Uncertain age determination (based on lengths; see below) and small female carcass sample sizes during some years was a concern. We used a t-test to confirm that the age composition of females returning to the McCall Hatchery trap was not significantly different compared to that of female carcass recoveries ($t = 0.549$, $P = 0.588$), indicating that our carcass recoveries represented the age composition of NOR females returning to the SFSR.

Return/parent redds were calculated annually and the median value provided an estimate of $\lambda$. Data was available from 1996 – 2008, providing return/parent redd estimates for brood years 1996-2003. Lambda estimates for NOR redds was 1.296 (Table 2) suggesting an increasing population. It could not be determined if this was a result of the contribution of HOR fish to the population growth rate or an increasing growth rate for NOR fish in the SFSR.

Table 2. Chinook salmon parent redds, return redds and return/parent ratio estimated using total parental redds and estimated natural origin return (NOR) return redds in the SFSR. NOR redds were estimated based on the proportion of female NOR carcasses recovered each year. Lamda ($\lambda$) was estimated as the median progeny-per-parent value.

| Brood year | Parent redds | Progeny redds | Progeny/ parent |
|---|---|---|---|
| 1996 | 40 | 92 | 2.297 |
| 1997 | 253 | 319 | 1.263 |
| 1998 | 134 | 345 | 2.572 |
| 1999 | 97 | 186 | 1.915 |
| 2000 | 272 | 362 | 1.330 |
| 2001 | 446 | 89 | 0.199 |
| 2002 | 486 | 175 | 0.360 |
| 2003 | 370 | 80 | 0.215 |
| | | $\lambda =$ | 1.296 |

*Spawn timing*

Chinook salmon redd count data from 1996 – 2008 was used to estimate spawn timing for four sections in the SFSR (Table 3). Median, 10$^{th}$ percentile and 90$^{th}$ percentile values indicated that the earliest spawn timing occurred in the WD section, with the other 3 sections showing similar timing for these measures. Peak counts, indicating the date with the highest count summed over all years, were earlier for the WD and DC sections compared to the PF and LP sections (Table 3). The other measures did not show differences. Graphing the cumulative redd counts pooled for years 1996 – 2008 (Figure 5) and chi-square analysis of all sections indicated that overall spawn timing was significantly different among the sections ($P < 0.001$). Pairwise comparisons indicated that cumulative spawn timing differed among each section, with WD having earliest and LP having the latest spawn timing.

Although the differences were not large, the slightly earlier spawning in the upper two sections may be the result of hatchery practices or physical environment. If spawn timing of HOR fish was altered by hatchery broodstock selection protocols (non random selection for early or late spawning individuals) then the significantly higher proportion of HOR fish in the upper two sections (WD and DC; see below) may have skewed the overall spawning timing earlier in those sections. Inadvertant hatchery selection has been demonstrated to significantly alter spawn timing in many salmonid species (Quinn et al. 2002). However, spawning of broodstock at the McCall Hatchery weir has not changed over the life of the program, with the first spawn occurring on the same approximate date from 1980 – 2007 (Hutchinson, 1982; McPherson et al. 2008). Additionally, the small magnitude of change between the groups suggest no significant alteration in spawn timing for HOR compared to NOR fish. There is evidence for altered spawn timing in another Snake River basin Chinook salmon population. HOR Chinook salmon in the Imnaha River spawn significantly later and predominantly down river compared to NOR fish and the authors suggested that inadvertant hatchery selection for later spawn timing was responsible (Hoffnagle, et al. 2008). A second and more likely reason was that spawn timing occurred earlier in upstream locations resulting from a physical temperature gradient forming throughout the system, with adults spawning later in the lower two sections (PF and LP) due to warmer water temperatures experienced during the spawning period. Our data did indicate that average August temperatures were higher as you move farther downstream from the McCall Hatchery weir (data not shown) and this may have contributed to to later spawn timing. The relationship between warmer temperatures and later spawn timing has been demonstrated for numerous salmon species (Quinn, 2005).

Table 3. Chinook salmon spawn timing for 4 sections of the South Fork Salmon River below the McCall Hatchery Trap from 1996 – 2008. Median, Peak, first-last, 10th percentile and 90th percentile are dates. Peak indicated the date with the highest number of redds summed over all years.

| Section | Median | Peak | First-last | 10th percentile | 90th percentile |
|---|---|---|---|---|---|
| WD | 9/1 | 9/3 | 8/15-9/18 | 8/27 | 9/7 |
| DC | 9/3 | 9/5 | 8/13-9/15 | 8/29 | 9/13 |
| PF | 9/4 | 9/9 | 8/18-9/20 | 8/30 | 9/14 |
| LP | 9/5 | 9/10 | 8/14-9/22 | 8/30 | 9/11 |

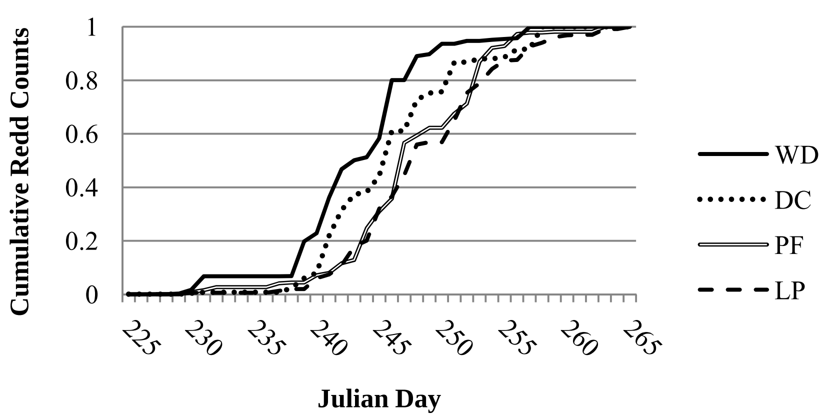


Figure 5. Cumulative Chinook salmon redd counts from four sections in the South Fork Salmon River determined from annual multiple-pass spawning ground surveys from 1996 – 2008. WD – weir to Dime Creek; DC – Dime Creek section; PF – Poverty Flat; LP – Lodgepole Campground to Phoebe Creek.

*Adult spawner distribution*

Chinook salmon adult spawner distribution was investigated by examining redd count distribution by section over all years. We combined the redd count distributions for the WD and DC sections (WD + DC group) and the PF and LP sections (PF + LP group) because of similar hatchery/natural fraction and geographic proximity. Graphing the proportion of redds in each group revealed a significant change in redd distribution over time, with an overall positive trend for the WD + DC group and a negative trend for the PF + LP group (Figure 6). Driving the trend have been a greater proportion of redds counted in the WD + DC sections from 2004 - 2008 whereas, prior redd distributions were approximately equally divided between the groups. Overall redd counts in the PF + LP group have been relatively stable (see *Index of spawner abundance* section), suggesting that the change in spawner distribution resulted from an increased number of HOR fish spawning in the WD + DC section since 2001 or 2002. A similar pattern was observed in the Imnaha River where HOR Chinook salmon tended to spawn below the weir in close proximity to the acclimation and release facility (Hoffnagle et al. 2008).

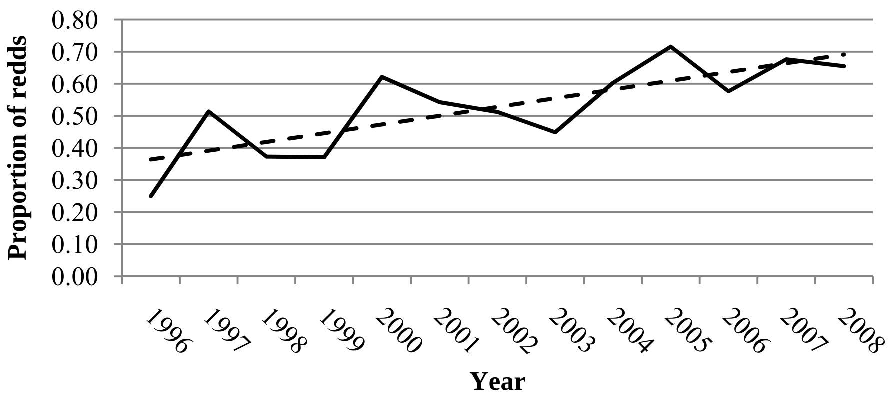



Figure 6. Estimated Chinook salmon spawner distribution determined by redd count proportions in the weir to Dime Creek and Dime Creek section from 1996 – 2008. Dashed line demonstrated the linear trend line over this time period.

South Fork Salmon River Carcass Surveys

*Sex ratios*

From 1996 – 2008 a total of 5,143 carcasses were recovered where sex could be determined including 2,568 females, 2,041 males and 404 jacks. Adult Chinook salmon sex ratios varied among the years (Figure 7), averaging 62% (S.E. = 15.4%) female for HOR carcasses and 51% (S.E. = 5.0%) female for NOR carcasses. For all carcasses, including jacks, adult Chinook salmon carcass recoveries comprised 56% (S.E. = 15.0%) female for HOR carcasses and 48% female (S.E. = 6.9%) for NOR carcasses. T-test revealed a significant difference between the proportion of HOR and NOR female carcasses when jacks were excluded (t = 2.47; P = 0.020) but no difference when jacks were included (t = 1.701; P = 0.101).

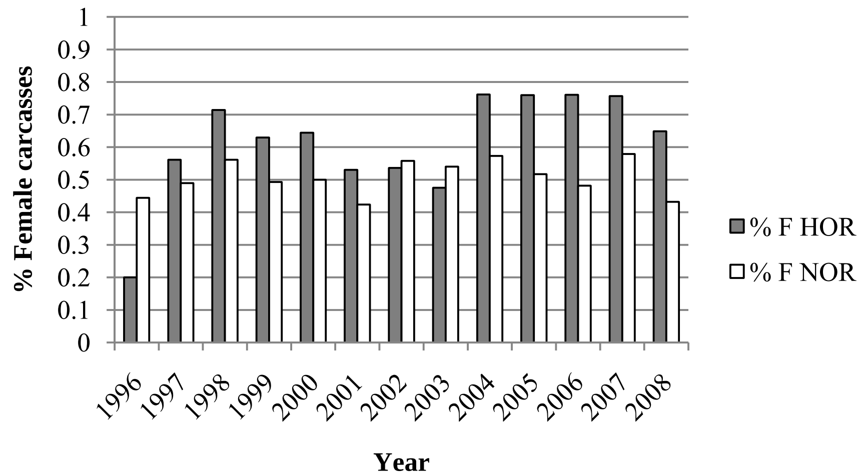



Figure 7. Percent female (F) hatchery-origin (HOR) and natural-origin (NOR) adult Chinook salmon carcasses recovered during South Fork Salmon River spawning ground surveys from 1996 – 2008.

The McCall Hatchery adult weir and trapping facility operated by the IDFG was installed to collect broodstock for a conventional hatchery program while allowing passage of NOR Chinook salmon to the spawning grounds in the Stolle Meadows area (Hutchinson, 1982). Comparing sex ratios of HOR and NOR adult carcasses (jacks excluded) with interrogations of fish at the McCall Hatchery trap (Table 4) revealed a significantly greater proportion of NOR Chinook salmon female carcasses were recovered on the spawning grounds (T-test; t = 3.106; P = 0.005). In contrast, there was no significant difference between carcass survey recoveries and weir interrogations for HOR Chinook salmon (T-test; t = 1.402; P = 0.173). Including jacks, female carcass recoveries for both HOR (T-test; t = 3.606; P = 0.001) and NOR (T-test; t = 3.257; P = 0.003) comparisons were significantly greater than that interrogated at the weir (data not shown).

Table 4. Annual percent female (F) Chinook salmon carcasses recovered during multiple pass spawning ground surveys below the weir and percent female Chinook salmon interrogated at the McCall Hatchery trap.

| | Carcass recoveries | | McCall Hatchery trap | |
|---|---|---|---|---|
| Year | % F HOR[1] | % F NOR[2] | % F HOR[1] | % F NOR[2] |
| 1996 | 20.0 | 44.4 | 40.0 | 27.4 |
| 1997 | 56.2 | 48.9 | 44.4 | 40.4 |
| 1998 | 71.4 | 56.1 | 55.9 | 64.3 |
| 1999 | 63.0 | 49.3 | 51.5 | 42.5 |
| 2000 | 64.4 | 50.0 | 53.7 | 42.2 |

| | | | | |
|---|---|---|---|---|
| 2001 | 53.0 | 42.4 | 87.3 | 37.1 |
| 2002 | 53.7 | 55.8 | 54.0 | 41.8 |
| 2003 | 47.5 | 54.0 | 48.6 | 45.6 |
| 2004 | 76.2 | 57.3 | 51.0 | 36.5 |
| 2005 | 76.0 | 51.7 | 54.4 | 52.5 |
| 2006 | 76.1 | 48.2 | 53.2 | 39.3 |
| 2007 | 75.7 | 57.9 | 48.7 | 46.5 |
| 2008 | 64.9 | 43.2 | 63.6 | 35.2 |
| Mean | 61.4 | 50.7 | 54.3 | 42.4 |
| C.V. | 0.259 | 0.105 | 0.210 | 0.211 |

[1]HOR – hatchery-origin
[2]NOR – natural-orign

*Age-at-return*

A total of 3,866 Chinook salmon carcasses were aged by three methods in the following order of priority, 1) CWT tag codes, 2) scale analysis and, 3) fork length. Combining males and females, the age distribution consisted of 10.1% age three, 68.8% age four, 21.1% age five and 0.026% age 6 (a single male determined by scale analysis). Separating age distribution by sex revealed 20.7% age three, 57.1% age four, 21.4% age five and 0.054% age 6 and 79.2% age four and 20.8% age five for males and females, respectively. Analyzing mean ages from all years revealed significant differences between HOR and NOR carcasses for age 3 but not age 4 or age 5 carcasses (Figure 8; T-test, age 3 – P = 0.048; age 4 – P = 0.943; age 5 – P = 0.345). In contrast, an age structure distribution comparison across years revealed significant differences between HOR and NOR carcasses for all age classes (chi-square analysis; age 3 – P = 0.005; age 4 – P < 0.001; age 5 – P < 0.001).

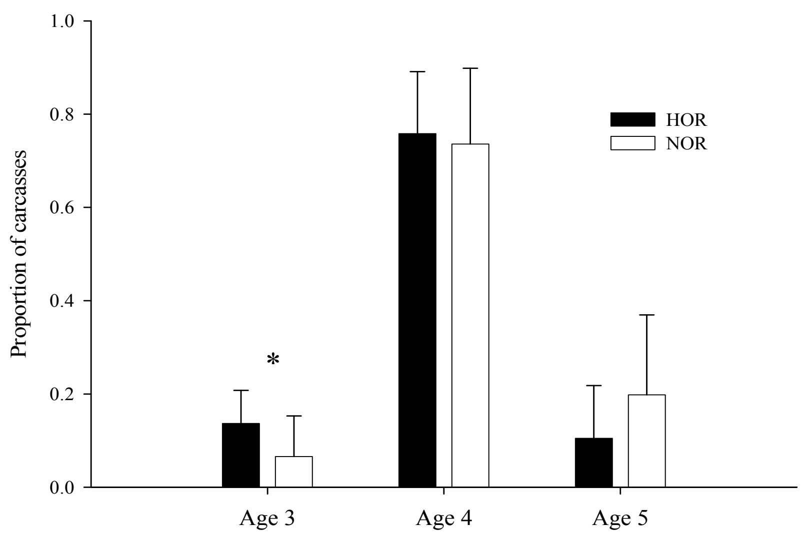
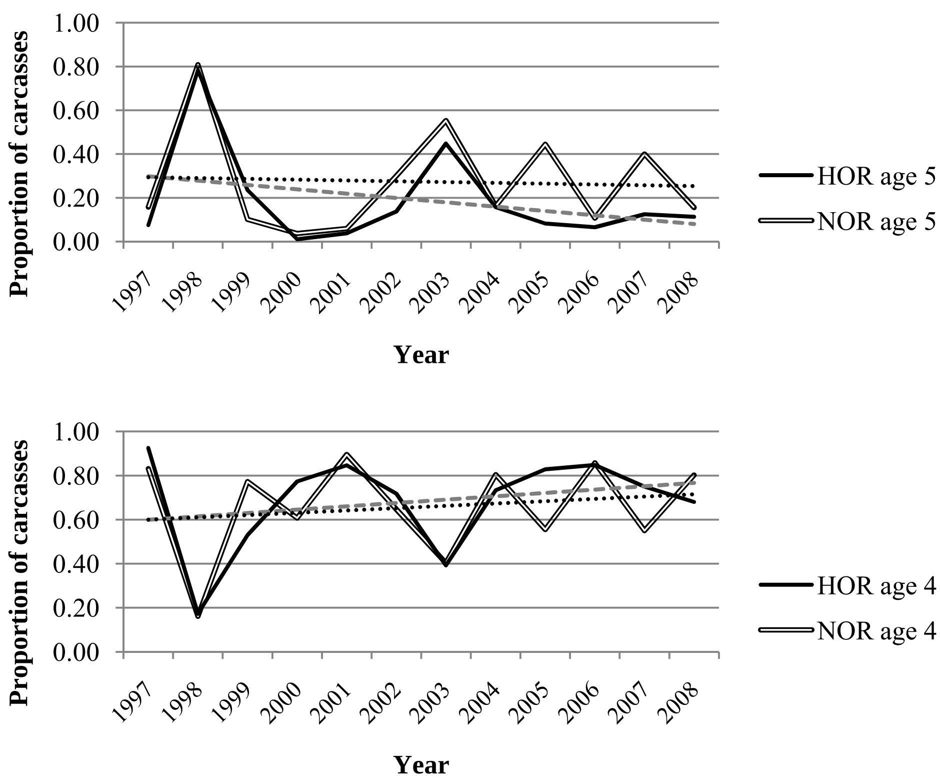



Figure 8. Age-at-return for hatchery-origin (HOR) and natural-origin (NOR) Chinook salmon carcasses recovered in the South Fork Salmon River from 1996 – 2008. *Significantly

different (P ≤ 0.05).

Analyzing trends in age-at-return from 1997 through 2008 revealed slight declines in the proportion of age 5 HOR and NOR carcasses and slight increased trends for age 4 carcasses (Figure 9). Data from 1996 was removed from the analysis because only 10 HOR carcasses were recovered that year. Overall trends were largely driven by the exceptionally large age 5 returns in 1998, comprising approximately 80% of the recovered carcasses. Two slight trend differences were present in the data from 1997 – 2008. First, there was a steeper decline in HOR compared to NOR for age 5 fish. Second, there was an inverse relationship between HOR and NOR age 3 trends. Both differences were relatively minor and suggest a potential change in age composition occurred in the HOR population compared to the NOR population.



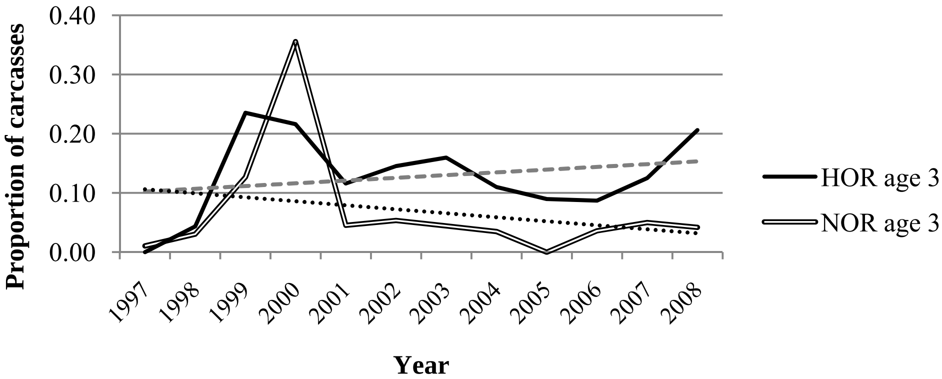



Figure 9. Annual age-at-return for hatchery-origin (HOR) and natural-origin (NOR) Chinook salmon carcasses recovered in the South Fork Salmon River from 1997 through 2008. Dotted and dashed lines demonstrate the linear trend line for NOR and HOR carcasses, respectively.

*Size-at-return*

Size-at-return was determined by fork length measurements from a total of 3,864 known-sex Chinook salmon carcasses that were recovered from 1996 – 2008, including 2,027 females, 1,433 males and 404 jacks. Not all carcasses were measured, during high return years a subset of untagged HOR carcasses were tallied by sex and percent spawned (females only). Thus, the total number of carcasses used in this analysis was less than the total used in other analyses. Mean fork lengths for female, male and jack Chinook salmon recovered from 1996 – 2008 are presented in Table 5. Combining carcass lengths from all years demonstrated that mean fork length measurements were significantly greater for NOR compared to HOR females (t-test, $P < 0.001$) and males (t-test, $P = 0.004$), but not jacks (t-test, $P = 0.634$). T-tests comparing HOR and NOR fork lengths from individual years revealed larger mean size-at-return for NOR compared to HOR Chinook salmon carcasses in 2001, 2002, 2005 and 2007 (Figure 10). The differences observed in 2001 and 2002 were not large and likely resulted from large sample sizes of carcasses with increased power to distinguish between relatively small differences. The differences observed in 2005 and 2007, and the combined year differences, likely resulted from significant age structure differences between the groups (see *age class structure* section).

Table 5. Number and mean size-at-return measured by fork length for hatchery-origin (HOR) and natural-origin (NOR) Chinook salmon carcasses recovered in the South Fork Salmon River, pooling data from 1996 – 2008. Mean and standard errors (S.E.) values are in millimeters (mm).

| | HOR | | | NOR | | |
|---|---|---|---|---|---|---|
| | Female | Male | Jack | Female | Male | Jack |
| N | 1098 | 541 | 274 | 929 | 892 | 130 |
| Mean | 805.64 | 836.97 | 578.91 | 835.04 | 851.93 | 576.35 |
| S.E. | 24.31 | 35.98 | 34.97 | 27.40 | 28.52 | 50.55 |

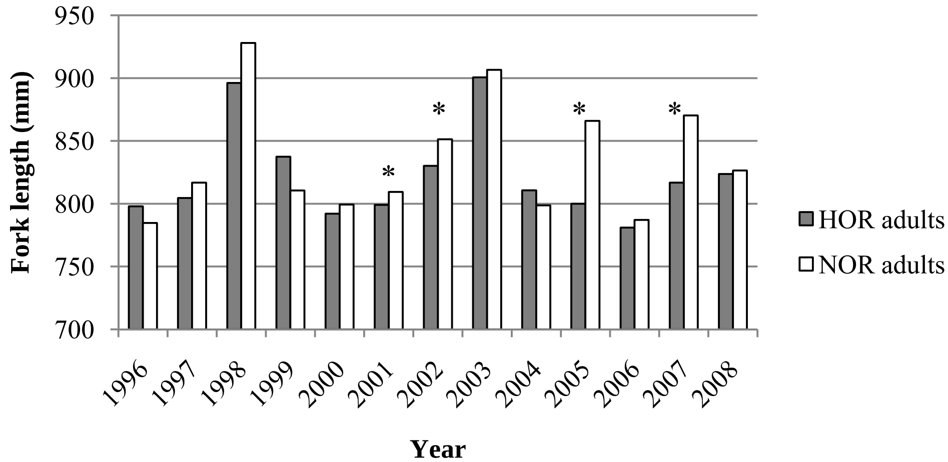



Figure 10. Size-at-return for hatchery-origin (HOR) and natural-origin (NOR) Chinook salmon carcasses recovered in the South Fork Salmon River from 1996 – 2008. All sizes are fork lengths measured in millimeters (mm). * Significantly different – $P \leq 0.05$.

*Hatchery fraction*

A total of 5,143 Chinook salmon carcasses were recovered from 1996 – 2008 including 2,973 HOR, 2,167 NOR and 3 of unknown origin. An analysis of HOR/NOR composition by section using a one-way ANOVA revealed significant differences between the upper sections (WD + DC group) and lower sections (PF + LP group), but no differences within the upper or lower sections (Table 6).

Table 6. Mean (S.E.) percent hatchery-origin (HOR) Chinook salmon carcasses recovered by section (in bold along the diagonal) from 1996 - 2008. Results of a multiple pair-wise comparisons using a one-way ANOVA Holm-Sidak method are shown with the t-value for each pair-wise comparison below the diagonal and the P-value above the diagonal. WD – weir to Dime Creek; DC – Dime Creek section; PF – Poverty Flat; LP – Lodgepole Campground to Phoebe Creek.

| Section | WD | DC | PF | LP |
|---|---|---|---|---|
| WD | **70.60** (3.83) | 0.634 | <0.001* | <0.001* |
| DC | 0.48 | **73.19** (3.64) | <0.001* | <0.001* |
| PF | 8.70 | 9.18 | **23.56** (4.14) | 0.096 |
| LP | 10.40 | 10.88 | 1.70 | **14.37** (3.68) |

*Indicated significant Holm-Sidak multiple pair-wise comparisons; critical P-value adjusted for multiple tests.

Hatchery fraction differences in the upper two sections compared to the lower two sections indicate that a majority of HOR fish spawn closer to the release site at Knox Bridge (approximately 1 km above the McCall Hatchery weir). HOR fish do spawn in the lower sections, but at a much lower rate, suggesting that the HOR fish were more likely to return to the sections close to the release point.

High returns of HOR fish to the SFSR, like those that have occurred since 2001, resulted in the outplanting of excess fish trapped at the McCall Hatchery weir to downstream sites for increased harvest opportunities and to augment natural spawning. All outplanted fish were marked with an opercle tag or punch so they could be identified at the weir or during carcass surveys. Fish that were outplanted multiple times were marked with additional opercle punches. The number and percentage of all opercle punched carcasses that were recovered from 1996 – 2008 are presented in Table 7. Over all years an average of 15.8% of recovered carcasses were outplanted fish, ranging from 0 (1998) to 42.8% (2000).

Table 7. Total carcasses, number opercle punched carcasses and percent carcasses exhibiting an opercle punched recovered during South Fork Salmon River Chinook salmon spawning ground surveys from 1996 – 2008. The number of right opercle punches (ROP) or left opercle punches (LOP) represented the number of punches which corresponds to the number of times the fish was captured at the weir and released downstream.

| Year | Total carcasses | Number Opercle Punched | Percent Opercle Punched | Mark type[1] |
|---|---|---|---|---|
| 1996 | 34 | 4 | 11.8 | ROT |
| 1997 | 284 | 97 | 34.2 | 1LOP, 1ROP, ROT |
| 1998 | 127 | 0 | 0 | |
| 1999 | 115 | 15 | 13.0 | 1LOP |
| 2000 | 530 | 228 | 43.0 | 1LOP, 1ROP, 2LOP, 2ROP |
| 2001 | 1128 | 69 | 6.1 | 1LOP, 1ROP, 2ROP |
| 2002 | 1004 | 220 | 21.9 | 1LOP, 1ROP |
| 2003 | 617 | 17 | 2.8 | 1ROP |
| 2004 | 369 | 94 | 25.4 | 1LOP, 1ROP, 2LOP, 2ROP, 3ROP |
| 2005 | 204 | 57 | 27.9 | 1LOP, 1ROP |
| 2006 | 106 | 11 | 10.4 | 1ROP |
| 2007 | 62 | 13 | 21.0 | 1LOP, 1ROP |
| 2008 | 563 | 52 | 9.2 | 1LOP |
| Averages | 395.6 | 67.5 | 17.4 | |

[1]ROT – right opercle tag; 1LOP – one left opercle punch; 1ROP – one right opercle punch; 2LOP – two left opercle punches; 2ROP – 2 right opercle punches; 3ROP – three right opercle punches.

*Female pre-spawn mortality*

All Chinook salmon carcasses were cut open to determine sex and, for females, percent spawned. Females judged to retain greater than 75% of their eggs were considered prespawn mortalities. Pre-spawn mortality varied significantly among years, ranging from zero (1996) to 35.0% in 2001 (Figure 11).

The highly variable rates of female prespawn mortality observed suggested that biological or physical factors may have affected adult female survival in the SFSR. Biological factors that may be associated with female prespawn mortality included origin, size, abundance and presence of visible injuries. Likely physical factors included water temperature and discharge. To test these variables we used statistical methods testing mean differences between groups and association test such as linear regression analysis to determine if there were significant relationships between these factors and female prespawn mortality. Although significant associations don't prove that these factors directly account for female prespawn mortality, they may direct additional research aimed at better understanding the causes of this mortality.

For combined years 1996 – 2008, we recovered significantly greater numbers of HOR compared to NOR female prespawn mortalities (Figure 11), with an average of 13.9% (S.E. = 0.039) for HOR females compared to an average of 3.8% (S.E. = 0.017) for NOR females. Two-way ANOVA revealed that differences in the mean values of origins (P = 0.003) and years (P = 0.016) were greater than would be expected by chance, indicating significant differences among these groups and among years.

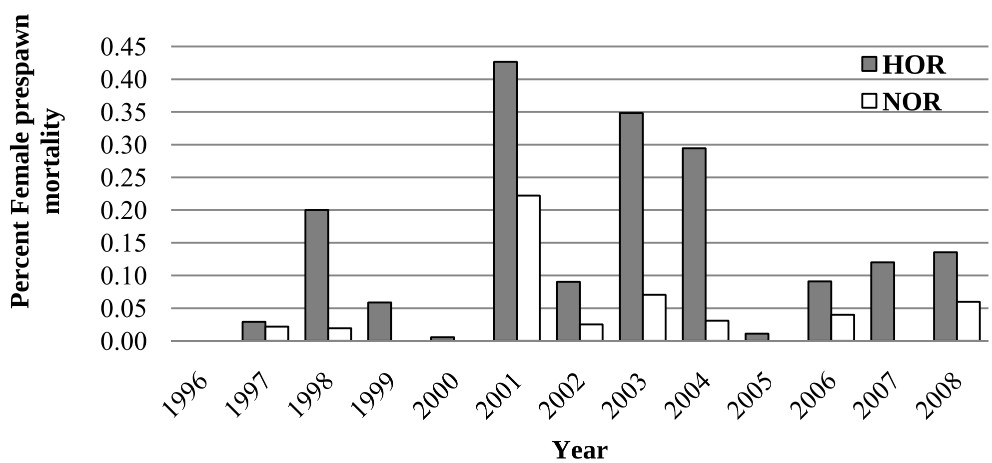



Figure 11. Percent female prespawn hatchery-origin (HOR) and natural-origin (NOR) mortalities from carcasses recovered from the South Fork Salmon River from 1996 – 2008.

Mean length of the 0 – 25% spawned group was 825.00 mm (S.E. = 4.40) compared to 819.26 mm (S.E. = 1.69) for the 26 - 100% spawned group and these differences were not statistically different (t-test; t = 1.447; P = 0.148). Thus, size did not appear to influence female prespawn mortalities.

Abundance was measured as the total number of Chinook salmon (HOR and NOR) trapped at the McCall Hatchery Weir (MHW). This measure was chosen because it is the only site in the SFSR that directly enumerates Chinook salmon. Linear regression analysis revealed a significant relationship between female prespawn mortality and total abundance at the MHW (Figure 12; $R^2 = 0.507$; $P = 0.009$). Regression analysis of HOR and NOR data separately were also both significant (HOR - $R^2 = 0.358$; $P = 0.040$ and; NOR - $R^2 = 0.499$; $P = 0.010$).

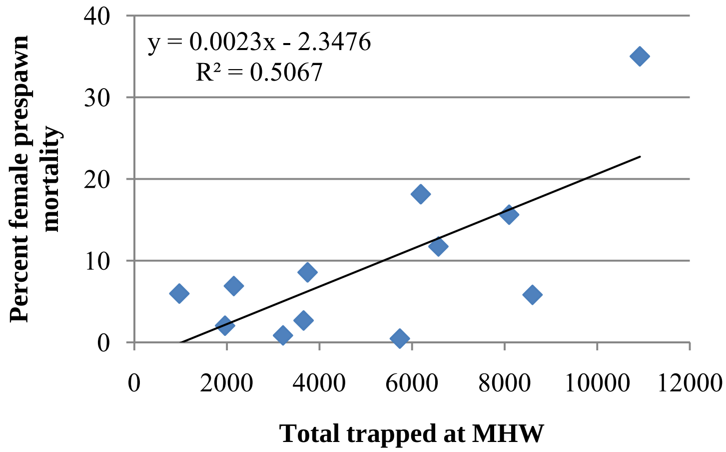



Figure 12. Scatter plot demonstrating the relationship between total Chinook salmon trapped at the McCall Hatchery Weir (MHW) and percent female prespawn mortality from 1997 - 2008.

In addition to general biological factors, fish experience in the SFSR may contribute to prespawn mortality. Two potential contributing factors unique to the SFSR include having been outplanted and the presence of a fishery related injury. A total of 17.4% of recovered HOR female carcasses exhibited opercule marks indicating that they had been captured at the McCall Hatchery weir and were outplanted downstream for harvest augmentation or to augment natural spawning (see "*Hatchery fraction*" section). Comparing prespawn mortality rates between outplanted and non-outplanted revealed that 9.5% of the outplanted females were prespawn mortalities and 24.3% of the non-outplanted females were prespawn mortalities, suggesting that being outplanted did not significantly influence the rate of prespawn mortality during the mid August to mid September spawning period.

A total of 47 of 2568 carcasses exhibited signs of injuries, many consistent with fishing activities such as puncture wounds, gashes, hooks in mouth or body and abrasions (Appendix 2). Of the 47 carcasses exhibiting injuries, 27 were female and 20 of these were prespawn mortalities. At this rate it was evident that visible injuries significantly increased the chances that a female carcass was a prespawn mortality. Although the rate of injuries noted over the years was minimal, it was possible that our survey schedule did not allow us to adequately enumerate prespawn mortality prior to spawning (our first survey did not occur until mid August). Main harvest activities generally occurred in July and it was possible that mortalities happened earlier in the summer and the resulting carcasses were eaten by scavengers or naturally decomposed before our surveys began. Similarly, significant portion of outplanting occurs in July and completing surveys during this time period may reveal higher prespawn mortality for these fish. Earlier surveys should be considered in the future.

The most likely physical factor affecting female prespawn mortality is water temperature experienced in the SFSR. Because our surveys generally began in mid August, we could only measure the effect of this variable just prior to and during spawning.

We used the average August temperature as a variable because a majority of females were beginning to spawn or are in the spawning area during this time period and therefore must tolerate potentially high temperatures. Linear regression analysis revealed a relationship between total female prespawn mortality and average August water temperature at Knox Bridge ($R^2 = 0.389$; $P = 0.023$). An analysis using average temperature during the last two weeks of August (Aug. 14-31) revealed a better fitting model suggesting that higher temperatures during the spawning period had a larger effect on female spawning success (Figure 13; $R^2 = 0.486$; $P = 0.012$). Regression analysis of HOR and NOR data separately also were both significant (HOR - $R^2 = 0.526$; $P = 0.013$ and; NOR - $R^2 = 0.372$; $P = 0.035$; data not shown).

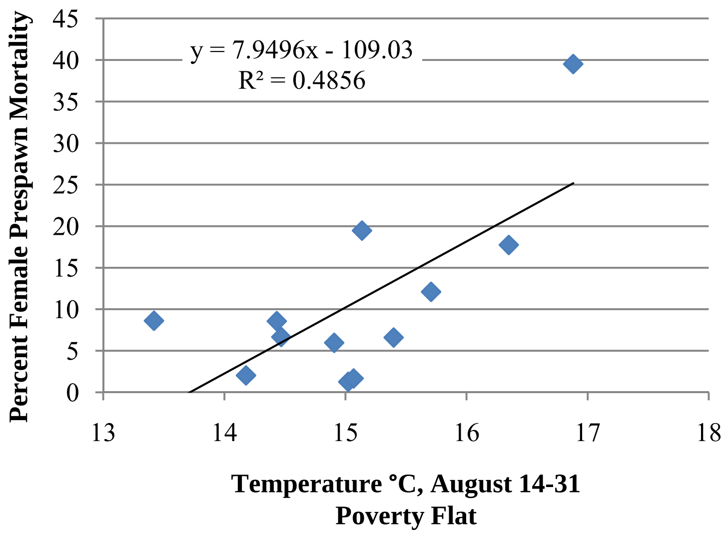



Figure 13. Scatter plot demonstrating the relationship between average August water temperature at the Knox Bridge thermograph and percent female prespawn mortality from 1997 - 2008.

Average August discharge from 1996 – 2008 was obtained from the USGS stream gage near the National Forest Krassel Guard Station on the SFSR (http://waterdata.usgs.gov/nwis/uv?13310700). Linear regression analysis of female prespawn mortality and average August discharge revealed no significant relationship ($P = 0.123$; $R^2 = 0.203$). Analyses looking at HOR and NOR fish separately were also not significant (data not shown).

These analyses suggest that both biological and physical factors influenced female prespawn mortality in the SFSR. The significantly higher rates in HOR compared to NOR females indicated a clear difference in survival during spawning. Additional research to determine the cause of this difference will be important given the large numbers of HOR fish that spawn naturally or are outplanted to other rivers with a goal of boasting natural returns. Female prespawn mortality was also positively associated with overall abundance and average August water temperature, especially during the last two weeks of August corresponding to the early spawning period. Although these two factors were thought to be responsible for high rates of prespawn mortality in sockeye salmon from Alaska, similar to this analysis, a clear cause and effect was not determined (Quinn et al. 2007). These results suggest that indirect effects such as altered energy balance or increased disease load may decrease survival with exposure to higher temperatures. High water temperatures near the threshold tolerance level appeared to adversely affected survival of migrating sockeye salmon in the Columbia River (Keefer, et. al. 2007; Naughton et. al. 2005).

*Stray rate*

In the SFSR the presence of HOR strays could only be determined from CWT, PIT or other tag recoveries, the origin of untagged HOR and NOR fish could not be determined. From 1996 – 2008 a total of 220 CWTs were recovered including 216 originating from McCall Hatchery releases, 3 originating from Lostine River releases and 1 originating from Grande Ronde River releases for an overall estimated stray rate of 1.85%. By year the estimated stray rate was zero (all years except 2003, 2005 and 2007), 3.3% in 2003 (1/49), 3.9% in 2005 (2/49) and 8.3% in 2007 (1/11). Only six PIT tags were recovered over this timeframe, with none being from out of basin fish.

## Big Creek Redd Counts

*Index of spawner abundance*

Annual redd counts from two sections in Big Creek from 1996 – 2008 revealed high year-to-year variability with an increasing linear trend (Figure 14). Overall redd counts averaged 37.9 (S.E. = 9.49) with a minimum of 2 in 1996 and a peak of 104 in 2001. Examining redd count data by section revealed a similar pattern of variability among the sections, with large year the year variability (Table 8). In all years except 1996 (only 2 redds were counted that year) the Jacobs Ladder Creek to Logan Creek section contained more redds than the Logan Creek to Smith Creek section.

Table 8. Redd counts from two sections in Big Creek determined from annual multiple-pass spawning ground surveys from 1996 – 2008. JC – Jacobs Ladder Creek to Logan Creek; LC – Logan Creek to Smith Creek.

| Year | JC | LC | Total redds |
|---|---|---|---|
| 1996 | 1 | 1 | 2 |
| 1997 | 26 | 0 | 26 |
| 1998 | 13 | 3 | 16 |
| 1999 | 4 | 0 | 4 |
| 2000 | 10 | 3 | 13 |
| 2001 | 95 | 9 | 104 |
| 2002 | 89 | 6 | 95 |
| 2003 | 63 | 15 | 78 |
| 2004 | 32 | 17 | 49 |
| 2005 | 11 | 10 | 21 |
| 2006 | 12 | 3 | 15 |
| 2007 | 18 | 7 | 25 |

| | | | |
|---|---|---|---|
| 2008 | 32 | 12 | 44 |
| Total | 406 | 86 | 492 |
| Averages | 31.2 | 6.6 | 37.8 |
| St Dev | 31.40 | 5.65 | 34.22 |
| CV | 1.01 | 0.85 | 0.90 |

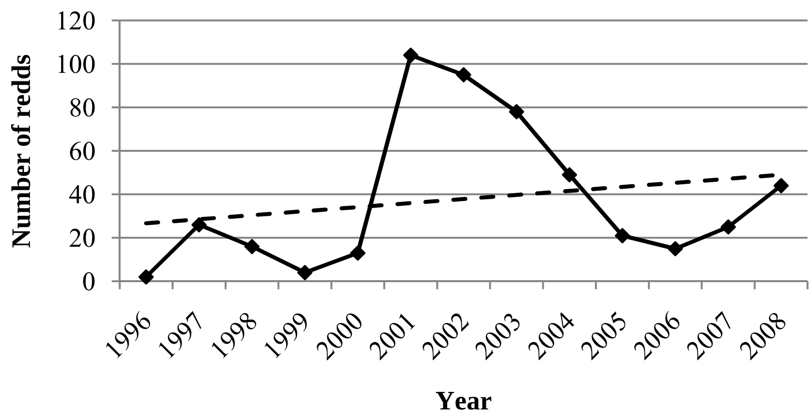



Figure 14. Total redds counted from two sections of Big Creek from 1996 – 2008. Dashed line demonstrates the linear trendline for the data series.

*Progeny-per-parent ratio*

Without an accurate method to determine adult abundance in Big Creek, progeny-per-parent ratio was calculated using the ratio of return (progeny) redds to parent redds. It was not possible to accurately estimated female age composition for a majority of years because only 4 of 12 years were greater than 10 carcasses recovered and 7 of 12 years fewer than five carcasses were recovered. So female age composition was determined from all carcass recoveries pooled across years and this was used to determine brood year origin of redds. For the combined years of 1996 - 2008 the proportion of female carcasses was composed of 0.642 age four and 0.358 age five. These proportions were used to estimate the parent redds for brood years 1996 through 2003. Return/parent redds were calculated annually and the median value provided an estimate of λ (Table 9).

The overall λ estimate from 8 broodyears was significantly greater than one indicating a rapidly expanding population. Five/eight brood years had return/parent redd ratios significantly greater than one with the largest ratios resulting from extremely small spawning populations observed in 1996 and 1999. In contrast λ estimates from brood years 2001 – 2003 were significantly less than one. Overall the population in Big Creek has undergone extreme variations in population size, from near extirpation to relatively high abundance, leading to the extremely wide range in λ estimates. Although the overall λ estimate was significantly greater than one, this measure can be very sensitive to starting and ending years. Our analysis began with brood year 1996 which corresponded to an extremely low population level with only 2 redds counted in the entire reach. From this level even a relatively modest increase in population size would result in a significantly positive λ. In reality, other than the short-lived peak in return from 2001 – 2003, the Chinook salmon population in Big Creek was relatively flat.

Table 9. Parent redds, return redds and return/parent ratio for all redds in Big Creek for brood years 1996 - 2003. Lamda (λ) was calculated as the median progeny-per-parent value.

| Brood year | Parent redds | Progeny redds | Progeny/parent redds |
|---|---|---|---|
| 1996 | 2 | 45.58 | 22.789 |
| 1997 | 26 | 100.78 | 3.876 |
| 1998 | 16 | 88.91 | 5.557 |
| 1999 | 4 | 67.62 | 16.905 |
| 2000 | 13 | 38.98 | 2.998 |
| 2001 | 104 | 18.85 | 0.181 |
| 2002 | 95 | 18.58 | 0.196 |
| 2003 | 78 | 31.80 | 0.408 |
| | | λ = | 3.437 |

*Spawn timing*

Spawn timing was investigated by estimating the median, peak, 10th percentile and 90th percentile redd counts for the JC and LC sections. Spawn timing was significantly earlier for the JC section, with the median being 10 days earlier and the peak count being 15 days earlier compared to the LC section (Table 10). Graphing the cumulative redd counts pooled for years 1996 – 2008 (Figure 15) and chi-square analysis of all sections indiated that overall spawn timing was significantly different among the sections ($P < 0.001$). Given that the peak spawn date for the LC section was the final pass, future surveys should provde an additional survey in September in that section.

Table 10. Spawn timing for two sections in Big Creek from 1996 – 2008 with median, peak, 10th percentile and 90th percentile dates. Peak indicated the date with the highest number of redds summed over all years.

| Section | Median | Peak | Range | 10th percentile | 90th percentile |
|---|---|---|---|---|---|
| JC | 8/12 | 8/12 | 7/18-8/31 | 7/30 | 8/26 |
| LC | 8/22 | 8/27 | 7/25-9/1 | 8/10 | 8/27 |

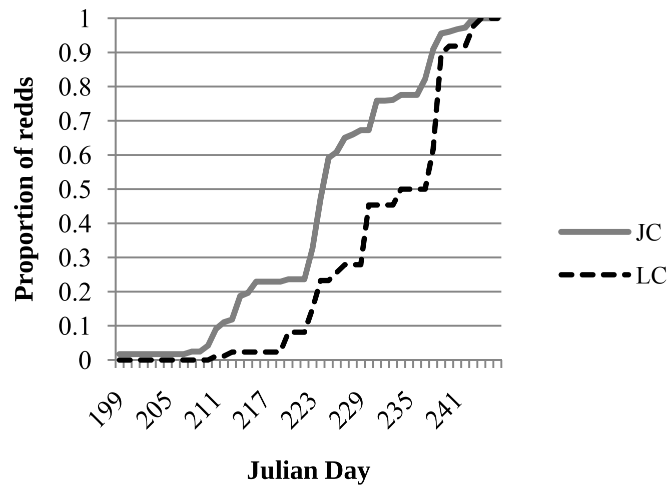



Figure 15. Cumulative redd counts from two sections in Big Creek determined from annual multiple-pass spawning ground surveys from 1996 – 2008. JC – Jacobs Ladder Creek to Logan Creek; LC – Logan Creek to Smith Creek.

*Adult spawner distribution*

Adult spawner distribution was investigated by comparing the redd count distribution in the JC section with that observed in the LC section. From 1996 - 2008 an average of 78.2% (S.E. = 0.044) of the redds were counted in the JC section. Graphing the proportion of redds in each section revealed a slight change in redd distribution over time, with an overall positive trend for the LC section and a negative trend for the JC section (Figure 16). Only two redds were counted in 1996, one in each section, and data from that year was dropped from the analysis.

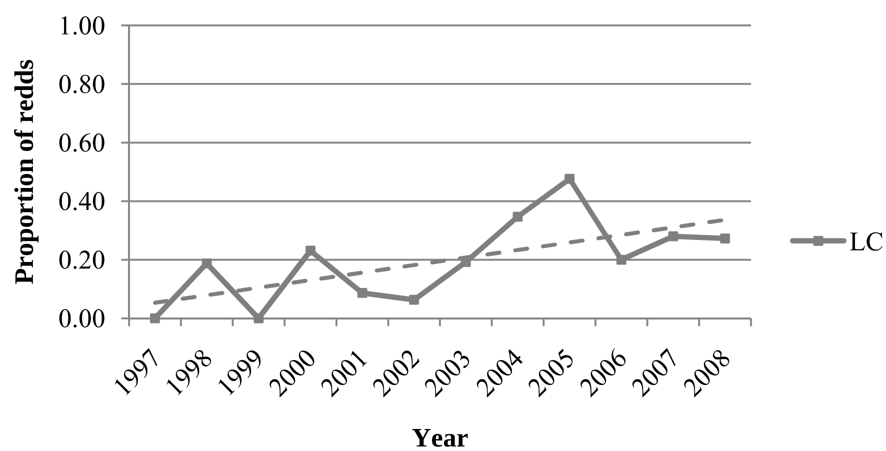


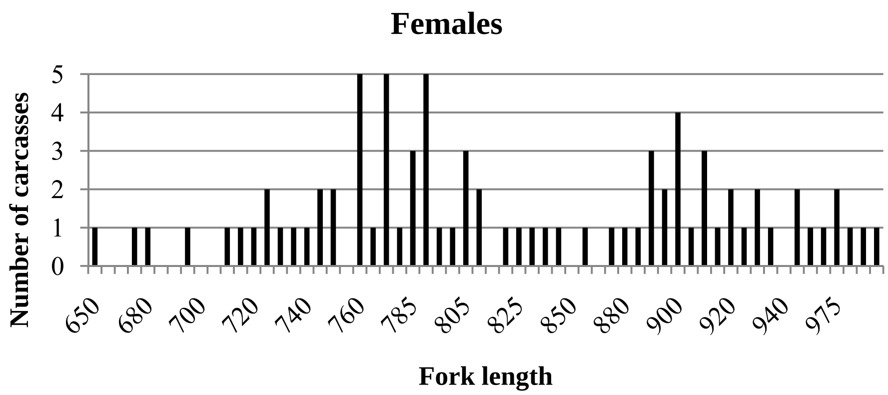

Figure 16. Proportion of redds counted in the Logan Creek to Smith Creek (LC) section of upper Big Creek from 1997 – 2008. Dashed line shows the linear trend for the data set. Data from 1996 was not shown because only two redds were counted that year.

*Sex ratios*

Sex ratios of carcasses are presented in Table 12. For the combined years of 1996 – 2008, 66.2% of the adult carcasses were female. Individual years ranged from 29.4% to 100% female however, for a majority of years very few carcasses were recovered, making it difficult to accurately determine annual sex ratios from carcass recoveries in Big Creek.

*Age-at-return*

Ages of Big Creek carcasses were determined by total fork length and length frequency analysis. A length frequency histogram of male and female carcasses is presented in Figure 17. Length breaks to estimate ages were determined by major breaks in the histograms. Females ≤ 885 were age 4, > 890 were age 5. For males ≤ 660 were age 3, 665 – 885 were age 4 and ≥ 890 were age 5. Analysis of age distribution revealed 17.6% age three, 72.2% age four and 10.2% age five males and 64.2% age four and 35.8% age five females. Combining males and females resulted in an age distribution that consisted of 10.1% age three, 68.8% age four and 21.1% age five.



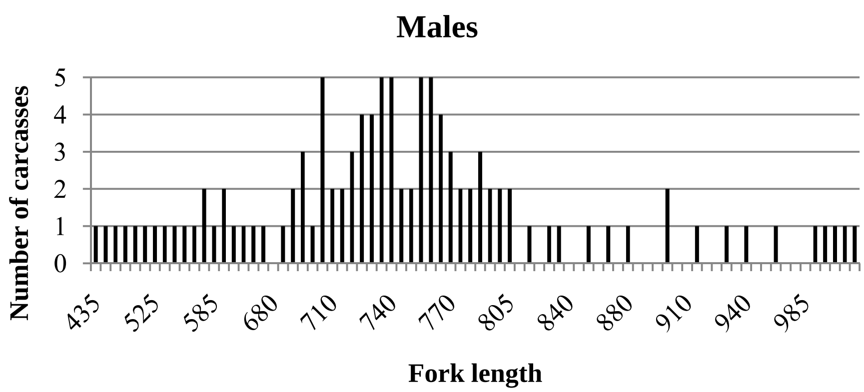




Figure 17. Fork length frequency histograms from Big Creek female and male carcasses recovered from 1996 – 2008. Fork lengths were measured in mm.

*Size-at-return*

Fork length measurements were obtained from all carcasses recovered in Big Creek from 1996 – 2008 (Table 11). For the combined years 1996 – 2008, mean adult carcass length (excluding jacks) was significantly greater for females compared to males ($P<0.001$). It was not possible to compare size at return from one year to the next because few carcasses were recovered for most years. Size differences may not be biologically significant because true age was not determined so it was not possible to distinguish true adults in the population.

Table 11. Number, mean (S.E.), range, minimum and maximum lengths determined from carcasses recovered in Big Creek from 1996 – 2008. All values were lengths in millimeters (mm).

| | Female | Male | Jack |
|---|---|---|---|
| N | 81 | 89 | 19 |
| mean<br>(S.E.) | 829.8<br>(9.66) | 779.3<br>(9.45) | 552.6<br>(16.26) |
| range | 360 | 405 | 225 |
| min | 650 | 675 | 435 |
| max | 1010 | 1080 | 660 |

*Hatchery fraction*

Big Creek has never been supplemented with hatchery fish so the majority of carcasses were NOR, with any HOR carcasses being from hatchery strays. For the combined years 1996 – 2008 a total of 191 carcasses were recovered, including 184 NOR and 7 HOR (Table 12). Over all years the proportion of HOR carcasses recovered was 3.7%, representing the hatchery fraction in Big Creek. Hatchery fraction for individual years ranged from zero (7 different years) to 50% HOR in 2006, although only 4 carcasses were recovered that year making interpretation of this result suspect.

Although HOR Chinook salmon straying into Big Creek was generally rare, it was surprising considering that there were not HOR fish released anywhere in the Middle Fork basin. Unfortunately, none of the HOR carcasses contained tags that could be used to determine the hatchery of origin.

Table 12. Hatchery/Natural composition, percent female carcasses and number and percent HOR carcasses recovered in Big Creek from 1997 through 2008. No carcasses were recovered in 1996.

| Year | Female HOR[1] | Female NOR[2] | Male HOR[1] | Male NOR[2] | Jack HOR[1] | Jack NOR[2] | Total | % HOR[1] | % Female[3] |
|---|---|---|---|---|---|---|---|---|---|
| 1997 | | 4 | | | | | 4 | 0.000 | 1.000 |
| 1998 | | 3 | | 3 | | | 6 | 0.000 | 0.500 |
| 1999 | | 2 | | 1 | | | 3 | 0.000 | 0.667 |
| 2001 | 1 | 28 | 1 | 47 | | 8 | 85 | 0.024 | 0.373 |
| 2002 | | 10 | | 24 | | 2 | 36 | 0.000 | 0.294 |
| 2003 | | 16 | 1 | 5 | 1 | 3 | 26 | 0.077 | 0.762 |
| 2004 | 1 | 5 | | 1 | | | 7 | 0.143 | 0.833 |
| 2005 | | 4 | | 1 | | 2 | 7 | 0.000 | 0.800 |
| 2006 | 2 | 1 | | | | 1 | 4 | 0.500 | 1.000 |
| 2007 | | 1 | | 1 | | | 2 | 0.000 | 0.500 |
| 2008 | | 5 | | 4 | | 2 | 11 | 0.000 | 0.556 |
| Total[4] | 4 | 78 | 2 | 87 | 1 | 18 | 191 | 0.037 | 0.662 |

[1]hatchery-origin
[2]natural-origin
[3]Percent female adult carcasses (excluded jacks).
[4]Total percent female was an average of the annual percentages.

*Female prespawn mortality*

For the combined years 1996 – 2008, we recovered only one female carcass that retained all of its eggs indicating that it was a prespawn mortality. This carcass was recovered in 2003 from the JC section. Of the remaining 82 female carcasses recovered, 75 were 100% spawned and 7 were unknown. These results demonstrated that female prespawn mortality was not a significant issue in Big Creek.

*Stray rate*

Only the presence of adipose fin-clipped HOR carcasses could be used to determine stray rate to Big Creek. It was not possible to estimate a NOR stray rate from carcass recoveries. Therefore, the overall stray rate was equal to the proportion of HOR carcasses recovered. See section "*Carcass surveys – hatchery fraction*" for an estimated stray rate in Big Creek.

Conclusions and Management Recommendations

*Index of spawner abundance, as measured by redd counts, in the SFSR and Big Creek were highly correlated from 1996 – 2008.*

We compared data and results from the SFSR with that collected from Big Creek, an unsupplemented stream with minimal management impacts, to better evaluate the status of the heavily managed SFSR. We compared SFSR and Big Creek index of spawner abundance using a Pearson correlation and linear regression analysis of redd counts from 1996 – 2008. Redd counts in Big Creek were highly correlated with both total SFSR redds (Pearson correlation coefficient = 0.661, P = 0.014) and estimated NOR redds (Figure 18; Pearson correlation coefficient = 0.789, P = 0.0014). High correlation coefficients and similar slopes for population abundance measures in these two geographically distinct basins (South Fork Salmon River and Middle Fork Salmon River basins) suggested that escapement to these spawning areas was heavily influenced by out of basin factors or similar environmental conditions across large geographic scales.

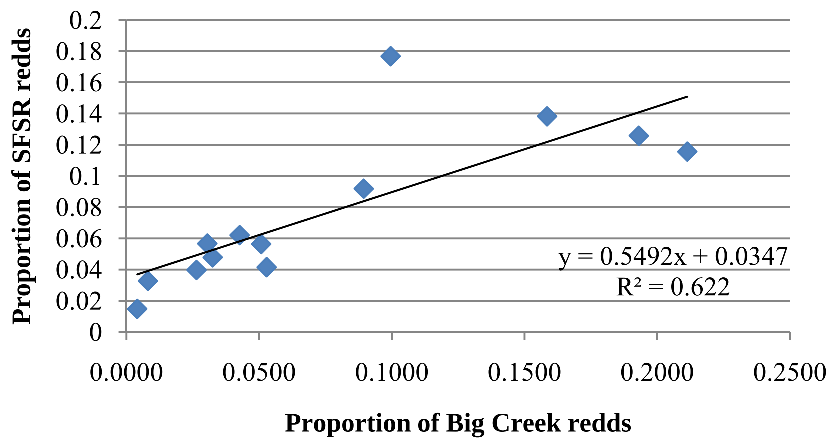



Figure 18. Annual redd counts measured as the proportion of redds counted each year in Big Creek and the South Fork Salmon River (SFSR) from 1996 – 2008. Dashed line demonstrates the linear trendline for the data series of the same color.

Comparing sex ratios, age and return, size and return and female prespawn mortality carcass recovery data indicated that the NOR population in the SFSR was more similar to the NOR population in Big Creek than that in the HOR population in the SFSR. This suggests that the NOR population in the SFSR retained the characteristics of a NOR population in spite of the large number of HOR fish on the spawning grounds. Assessing the SFSR NOR population based on these parameters does not indicate any loss of fitness or viability.

*Chinook salmon spawner distribution was changing in both the SFSR and Big Creek*

Spawner distribution changed from 1996 – 2008 in both the SFSR and Big Creek. In the SFSR a greater proportion of redds were enumerated in the upper two sections just below the McCall Hatchery Trap. This was likely a result of increased HOR abundance and spawning below the weir. Although the overall proportion of redds changed, the lower two sections still maintained significant numbers of NOR spawners with no change in HOR fraction, suggesting a stable NOR population in those areas.

In Big Creek, spawner distribution shifted to a greater proportion of redds in the lower section from 1996 – 2008. Generally, the lower section has very little suitable spawning habitat compared to the upper section, with most of the spawning in the lower section occurring within a kilometer of the confluence with Logan Creek at the upper end of the lower section. However, the Big Creek stream morphology is very dynamic and it is possible that suitable spawning habitat increased in the lower section over this time period, enabling greater number of adult spawners to utilize that area.

*Significant numbers of HOR Chinook salmon spawned below the MHT.*

HOR Chinook salmon in the SFSR spawned extensively below the MHT, especially in the two sections just below the trap (WD and DC), with HOR recoveries making up greater than 75% of the carcasses. A majority of these fish never made it to the trap, with approximately 17% having been outplanted from the MHT. As you move downstream from the trap the proportion of HOR carcasses recovered on the spawning grounds decreased, although it was still significant. In spite of the large proportion of HOR fish, NOR abundance was stable or slightly increasing in the SFSR below the weir. We should continue to monitor the impact of HOR/NOR interactions in the SFSR below the MHT and evaluate the status of the ESA-listed NOR component. Importance of including HOR fallout in to MH evaluations.

*SFSR HOR and NOR Chinook salmon population comparisons*

Comparing population parameters of HOR and NOR Chinook salmon in the SFSR revealed significant differences for sex ratios, age at return, size at return and female prespawn mortality. Most of these differences resulted from a younger average age for HOR compared to NOR fish, producing greater numbers of jacks in the HOR population. Reasons behind the significantly greater rates of female prespawn mortality in the HOR population were not evident but suggest decline in viability or in the inability to behaviorally locate thermally hospitable locations. These parameters will need to be monitored over time to assess major changes in life history attributes in the HOR or NOR populations.

## Recommended Future Activities

- Continue multiple-pass, extensive area spawning ground surveys in the SFSR and Big Creek.
- Continue to monitor redd count trends in SFSR and Big Creek to assess spawner abundance, timing and distribution.
- Continue carcass recoveries from SFSR and Big Creek to assess important Chinook salmon life history attributes.
- Monitor female prespawn mortality rates and investigate contributing factors.
- Utilize the currently functioning PIT tag arrays to better enumerate Chinook salmon escapement and spawning in the SFSR basin.

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**APPENDICIES**

Appendix A. Redd counts, number live fish, number of carcasses and redds per kilometer from mutliple-pass, extensive area spawning ground surveys in the South Fork Salmon River and Big Creek from 1996 – 2008.

Table A1. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 1996.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/19/96 | 1 | 0 | 0 | |
| | 9/3/96 | 2 | 1 | 1 | |
| | 9/10/96 | 3 | 0 | 4 | |
| | 9/16/96 | 0 | 1 | 0 | 1.2 |
| Dime Creek to unnamed trib. (6.3 km) | 8/19/96 | 1 | 0 | 0 | |
| | 9/3/96 | 2 | 3 | 0 | |
| | 9/10/96 | 1 | 6 | 5 | |
| | 9/16/96 | 0 | 1 | 7 | 0.6 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/20/96 | 0 | 0 | 0 | |
| | 9/3/96 | 8 | 16 | 0 | |
| | 9/9/96 | 5 | 7 | 3 | |
| | 9/18/96 | 0 | 0 | 2 | 11.8 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/20/96 | 0 | 0 | 0 | |
| | 9/4/96 | 13 | 20 | 1 | |
| | 9/9/96 | 2 | 24 | 1 | |
| | 9/18/96 | 2 | 4 | 10 | 2.5 |
| Total | | 40 | | 34 | |

Table A2. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 1996.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 8/21/96 | 1 | 0 | 0 | 0.2 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 8/5/96 | 0 | 0 | 0 | |
| | 8/20/96 | 1 | 0 | 0 | |
| | 9/10/96 | 0 | 0 | 0 | 0.2 |
| Total | | 2 | | 0 | |

Table A3. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 1997.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek | 8/18/97 | 10 | 31 | 1 | |
| (5 km) | 9/4/97 | 42 | 23 | 58 | |
| | 9/15/97 | 7 | 1 | 3 | 11.8 |
| Dime Creek to unnamed | 8/18/97 | 5 | 11 | 0 | |
| trib. (6.3 km) | 9/2/97 | 64 | 79 | 99 | |
| | 9/15/97 | 2 | 0 | 11 | 11.3 |
| Poverty Flat to 0.2 km | 8/19/97 | 6 | 20 | 0 | |
| below gauge (1.1 km) | 9/3/97 | 25 | 30 | 22 | |
| | 9/9/97 | 20 | 7 | 26 | |
| | 9/18/97 | 0 | 0 | 7 | 46.4 |
| Lodgepole CG to Phoebe | 8/18/97 | 5 | 2 | 1 | |
| Creek bridge (6.7 km) | 9/3/97 | 51 | 67 | 12 | |
| | 9/9/97 | NC | NC | 36 | |
| | 9/16/97 | 16 | 6 | 8 | 10.7 |
| Total | | 253 | | 284 | |

NC – No count

Table A4. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 1997.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan | 8/19/97 | 0 | 1 | 0 | |
| Cr. (4.7 km) | 9/4/97[1] | 0 | 0 | 0 | 0.0 |
| Logan Cr. To Jacobs | 8/4/97 | 8 | 11 | 0 | |
| Ladder (5.6 km) | 8/19,20/97 | 18 | 21 | 3 | |
| | 9/4/97 | 0 | 0 | 0 | 4.6 |
| Total | | 26 | | 4[2] | |

[1] – Ground count from Logan Creek downstream one mile.

[2] – One additional carcass was obtained during spawning ground training on 8/12/97.

Table A5. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 1998.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek | 8/19/98 | 0 | 17 | 2 | |
| (5 km) | 9/2/98 | 29 | 25 | 7 | |
| | 9/15/98 | 2 | 0 | 0 | 6.2 |
| Dime Creek to unnamed | 8/19/98 | 0 | 27 | 2 | |
| trib. (6.3 km) | 9/2/98 | 19 | 12 | 8 | |
| | 9/15/98 | 0 | 0 | 5 | 3.0 |
| Poverty Flat to 0.2 km | 8/19/98 | 0 | 2 | 0 | |
| below gauge (1.1 km) | 9/2/98 | 27 | 46 | 3 | |
| | 9/6,8/98 | NC | NC | 30 | |
| | 9/14/98 | 6 | 5 | 18 | 30.0 |
| Lodgepole CG to Phoebe | 8/19/98 | 0 | 11 | 2 | |
| Creek bridge (6.7 km) | 9/2/98 | 45 | 69 | 9 | |
| | 9/8/98 | NC | NC | 26 | |
| | 9/14/98 | 6 | 3 | 17 | 7.6 |
| Total | | 134 | | 127 | |

NC – No count

Table A6. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 1998.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan | 8/3/98 | 0 | 1 | 0 | |
| Cr. (4.7 km) | 8/18/98[1] | 2 | 0 | 1 | |
| | 8/31/98 | 1 | 0 | 1 | 0.6 |
| Logan Cr. To Jacobs | 8/3/98 | 4 | 3 | 3 | |
| Ladder (5.6 km) | 8/17/98 | 5 | 2 | 7 | |
| | 8/31/98 | 4 | 3 | 0 | 2.3 |
| Total | | 16 | | 12 | |

[1] – Ground count from Logan Creek downstream one mile.

Table A7. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 1999.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/18/99 | 2 | 4 | 0 | |
| | 9/1/99 | 11 | 9 | 3 | |
| | 9/7/99 | 1 | 2 | 8 | |
| | 9/14/99 | 3 | 11 | 4 | |
| | 9/20/99 | 1 | 0 | 1 | 3.6 |
| Dime Creek to unnamed trib. (6.3 km) | 8/18/99 | 0 | 0 | 2 | |
| | 9/1/99 | 12 | 23 | 4 | |
| | 9/7/99 | 6 | 4 | 11 | |
| | 9/14/99 | 0 | 0 | 3 | 2.8 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/17/99 | 0 | 0 | 0 | |
| | 8/31/99 | 9 | 8 | 6 | |
| | 9/8/99 | 8 | 4 | 8 | |
| | 9/14/99 | 0 | 3 | 3 | 15.4 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/17/99 | 1 | 5 | 0 | |
| | 9/1/99 | 25 | 34 | 2 | |
| | 9/8/99 | 15 | 60 | 9 | |
| | 9/13/99 | 3 | 23 | 28 | |
| | 9/20/99 | 0 | 2 | 23 | 6.6 |
| Total | | 97 | | 115 | |

Table A8. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 1999.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 8/16/99 | 0 | 0 | 0 | |
| | 8/30/99 | 0 | 0 | 1 | 0.0 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 8/16/99 | 4 | 5 | 1 | |
| | 8/30/99 | 0 | 0 | 1 | 0.7 |
| Total | | 4 | | 3 | |

Table A9. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2000.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | # of Live Fish | Number of Carcasses | Redds per kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/16/00 | 0 | 44 | 1 | |
| | 8/29-30/00 | 55 | 273 | 25 | |
| | 9/6/00 | 7 | 114 | 67 | |
| | 9/12/00 | 0 | 36 | 74 | 12.4 |
| Dime Creek to unnamed trib. (6.3 km) | 8/16/00 | 0 | 62 | 0 | |
| | 8/29-30/00 | 72 | 242 | 53 | |
| | 9/6/00 | 35 | 86 | 99 | |
| | 9/12/00 | 0 | 29 | 51 | 17.0 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/16/00 | 0 | 0 | 1 | |
| | 8/29/00 | 4 | 48 | 0 | |
| | 9/5/00 | 19 | 60 | 16 | |
| | 9/11,13/00 | 14 | 24 | 40 | |
| | 9/20/00 | NC | 0 | 6 | 33.6 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/16/00 | 0 | 0 | 0 | |
| | 8/29/00 | 8 | 68 | 1 | |
| | 9/5/00 | NC | NC | 3 | |
| | 9/11/00 | 58 | 60 | 28 | |
| | 9/19/00 | NC | 1 | 34 | 9.9 |
| unnamed tributary to below Goat Creek (3.5 km) | 8/29,31/00 | 20 | 77 | 24 | |
| | 9/13/00 | 17 | 0 | 7 | 10.6 |
| Total | | 309 | | 530 | |

NC – No count

Table A10. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2000.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 7/31/00 | 1 | 2 | 0 | |
| | 8/14/00 | 2 | 1 | 0 | |
| | 8/28/00 | 0 | 0 | 0 | 0.7 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 7/31/00 | 3 | 11 | 0 | |
| | 8/14/00 | 4 | 1 | 0 | |
| | 8/28/00 | 3 | 7 | 1 | 1.8 |
| Total | | 13 | | 1 | |

Table A11. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2001.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/16/01 | 0 | 772[1] | 16 | |
| | 8/28/01 | 31 | 630[1] | 100 | |
| | 9/5/01 | 77 | 442[1] | 169 | |
| | 9/11/01 | 0 | 136 | 92 | |
| | 9/18/01 | 0 | 7 | 31 | 21.6 |
| Dime Creek to unnamed trib. (6.3 km) | 8/15-16/01 | 0 | 602[1] | 20 | |
| | 8/28-29/01 | 27 | 492[1] | 122 | |
| | 9/5-6/01 | 107 | 240 | 166 | |
| | 9/11-12/01 | 0 | 112 | 152 | |
| | 9/18/01 | 0 | 7 | 28 | 21.3 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/15/01 | 0 | 2 | 1 | |
| | 8/29/01 | 2 | 21 | 6 | |
| | 9/4/01 | 28 | 123 | 14 | |
| | 9/10/01 | 44 | 141 | 17 | |
| | 9/17-19/01 | 0 | 15 | 26 | |
| | 9/24/01 | NC | 0 | 3 | 67.3 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/15/01 | 0 | 14 | 0 | |
| | 8/29/01 | 7 | 67 | 9 | |
| | 9/4,7/01 | 75 | 218 | 23 | |
| | 9/10/01 | 40 | 194 | 10 | |
| | 9/17,19/01 | 8 | 35 | 70 | |
| | 9/24/01 | 0 | 5 | 7 | 19.4 |
| unnamed tributary to below Goat Creek (3.5 km) | 8/29/01 | 10 | 33 | 33 | |
| | 9/12/01 | 13 | 5 | 9 | |
| | 9/18/01 | 0 | 0 | 3 | 6.6 |
| Total | | 469 | | 1,127 | |

[1] – Estimate only

Table A12. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2001.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 8/2/01 | 0 | 4 | 0 | |
| | 8/13/01 | NC | NC | NC | |
| | 8/27/01 | 9 | 4 | 7 | 1.9 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 8/2/01 | 28 | 105 | 3 | |
| | 8/13-14/01 | 48 | 187 | 19 | |
| | 8/21/01 | NC | NC | 35 | |
| | 8/27/01 | 19 | 14 | 22 | 17.0 |
| Total | | 104 | | 85 | |

NC – No count

Table A13. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2002.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/12/02 | 0 | 78 | 0 | |
| | 8/27/02 | 27 | 505 | 7 | |
| | 9/3-4/02 | 51 | 153 | 115 | |
| | 9/10/02 | 0 | 12 | 33 | 15.6 |
| Dime Creek to unnamed trib. (6.3 km) | 8/13/02 | 1 | 415 | 13 | |
| | 8/27/02 | 37 | 410 | 17 | |
| | 9/3-4/02 | 133 | 250 | 295 | |
| | 9/10/02 | 0 | 26 | 109 | 27.1 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 7/31/02 | NC | NC | 4 | |
| | 8/14/02 | 0 | 0 | 1 | |
| | 8/27/02 | 2 | 109 | 2 | |
| | 9/4/02 | 70 | 150 | 77 | |
| | 9/9-10/02 | 1 | 14 | 100 | |
| | 9/16/02 | 0 | 2 | 26 | 66.4 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/14/02 | 1 | 20 | 2 | |
| | 8/28/02 | 31 | 175 | 2 | |
| | 9/5/02 | 125 | 140 | 80 | |
| | 9/9/02 | 0 | 35 | 71 | |
| | 9/16/02 | 7 | 3 | 7 | 24.5 |
| unnamed tributary to below Goat Creek (3.5 km) | 8/14/02 | 0 | 12 | 5 | |
| | 8/28/02 | 9 | 33 | 0 | |
| | 9/5/02 | 9 | 11 | 37 | |
| | 9/17/02 | 0 | 2 | 1 | 5.1 |
| Total | | 504 | | 1,004 | |

NC – No count

Table A14. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2002.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 7/30/02 | 1 | 0 | 1 | |
| | 8/26/02 | 5 | 5 | 0 | 1.3 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 7/18/02 | 7 | 15 | 1 | |
| | 7/30/02 | 18 | 49 | 1 | |
| | 8/7-8/02 | NC | 47 | 5 | |
| | 8/12/02 | 47 | 82 | 14 | |
| | 8/20/02 | NC | NC | 7 | |
| | 8/26/02 | 18 | 13 | 7 | 15.9 |
| Total | | 96 | | 36 | |

NC – No count

Table A15. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2003.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/18/03 | 3 | 367 | 5 | |
| | 8/26/03 | 1 | 521 | 10 | |
| | 9/3-4/03 | 77 | 197 | 109 | |
| | 9/9-10/03 | 0 | 11 | 20 | 16.2 |
| Dime Creek to unnamed trib. (6.3 km) | 8/26/03 | 22 | 247 | 23 | |
| | 9/3-4/03 | 63 | 78 | 136 | |
| | 9/9/03 | 0 | 7 | 33 | 13.5 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/13/03 | 0 | 0 | 0 | |
| | 8/25/03 | 8 | 30 | 2 | |
| | 9/2/03 | 17 | 123 | 19 | |
| | 9/8-9/03 | 29 | 53 | 68 | |
| | 9/15/03 | 4 | 10 | 19 | 52.7 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/13/03 | 0 | 1 | 1 | |
| | 8/25/03 | 8 | 65 | 2 | |
| | 9/2/03 | 48 | 168 | 23 | |
| | 9/8,10/03 | 75 | 93 | 75 | |
| | 9/15/03 | 15 | 11 | 42 | 21.8 |
| unnamed tributary to below Goat Creek (3.5 km) | 8/26/03 | 4 | 13 | 4 | |
| | 9/10/03 | 6 | 0 | 1 | 2.9 |
| Total | | 380 | | 592 | |

Table A16. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2003.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 7/29/03 | 0 | 4 | 1 | |
| | 8/11/03 | 6 | 13 | 0 | |
| | 8/27/03 | 9 | 7 | 8 | 3.2 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 7/29/03 | 7 | 26 | 1 | |
| | 8/11/03 | 37 | 67 | 3 | |
| | 8/19/03 | NC | NC | 1 | |
| | 8/25/03 | 19 | 13 | 7 | |
| | 8/28/03 | NC | NC | 5 | 11.2 |
| Total | | 78 | | 26 | |

NC – No count

Table A17. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2004.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/18/04 | 2 | 284 | 4 | |
| | 8/30-31/04 | 106 | 235 | 13 | |
| | 9/8-9/04 | 38 | 28 | 36 | 29.2 |
| Dime Creek to unnamed trib. (6.3 km) | 8/18/04 | 0 | 8 | 1 | |
| | 8/30-31/04 | 132 | 217 | 62 | |
| | 9/8-9/04 | 153 | 31 | 96 | 45.2 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/16/04 | 0 | 0 | 2 | |
| | 9/1/04 | 82 | 144 | 9 | |
| | 9/10/04 | 40 | 21 | 39 | |
| | 9/14/04 | NC | NC | 4 | |
| | 9/21/04 | 0 | 0 | 1 | 110.9 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/16/04 | 0 | 3 | 1 | |
| | 8/31/04 | 76 | 92 | 1 | |
| | 9/9/04 | 77 | 46 | 39 | |
| | 9/14/04 | NC | NC | 4 | |
| | 9/22/04 | 9 | 0 | 0 | 24.2 |
| Total | | 715 | | 312 | |

NC – No count

Table A18. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2004.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 7/26/04 | 0 | 2 | 0 | |
| | 8/17/04 | 13 | 15 | 3 | |
| | 8/30/04 | 4 | 5 | 2 | 3.6 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 7/26/04 | 3 | 14 | 0 | |
| | 8/3/04 | 5 | 35 | 0 | |
| | 8/18/04 | 17 | 31 | 0 | |
| | 8/30/04 | 7 | 7 | 2 | 5.7 |
| Total | | 49 | | 7 | |

Table A19. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2005.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/17/05 | 0 | 16 | 0 | |
| | 8/31/05 | 34 | 91 | 18 | |
| | 9/15/05 | 33 | 3 | 39 | 13.4 |
| Dime Creek to unnamed trib. (6.3 km) | 8/17/05 | 0 | 52 | 0 | |
| | 8/31/05 | 81 | 155 | 33 | |
| | 9/15/05 | 114 | 4 | 87 | 31.0 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/16/05 | 0 | 0 | 0 | |
| | 8/30/05 | 6 | 34 | 0 | |
| | 9/14/05 | 25 | 10 | 10 | |
| | 9/21/05 | 13 | 1 | 1 | 40.0 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/16/05 | 0 | 2 | 0 | |
| | 8/30/05 | 11 | 64 | 0 | |
| | 9/14/05 | 49 | 17 | 12 | |
| | 9/21/05 | NC | 1 | 2 | 9.0 |
| unnamed tributary to below Goat Creek (3.5 km) | 9/1/05 | 5 | 8 | 2 | |
| | 9/16/05 | 5 | 0 | 0 | 2.9 |
| Total | | 376 | | 204 | |

NC – No count

Table A20. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2005.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 7/25/05 | 0 | 0 | 0 | |
| | 8/8/05 | 5 | 5 | 0 | |
| | 8/22/05 | 3 | 3 | 1 | |
| | 9/1/05 | 2 | 0 | 1 | 2.1 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 7/25/05 | 0 | 0 | 0 | |
| | 8/8/05 | 3 | 11 | 0 | |
| | 8/22/05 | 6 | 8 | 3 | |
| | 8/30/05 | 2 | 1 | 2 | 2.0 |
| Total | | 21 | | 7 | |

Table A21. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2006.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/15/06 | 1 | 8 | 0 | |
| | 8/29/06 | 47 | 42 | 3 | |
| | 9/5/06 | 2 | 18 | 11 | |
| | 9/13/06 | 3 | 3 | 2 | 10.6 |
| Dime Creek to unnamed trib. (6.3 km) | 8/15/06 | 0 | 12 | 1 | |
| | 8/29/06 | 37 | 27 | 1 | |
| | 9/5/06 | 27 | 84 | 8 | |
| | 9/13/06 | 41 | 4 | 17 | 16.7 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/30/06 | 19 | 31 | 6 | |
| | 9/6/06 | 20 | 25 | 10 | |
| | 9/13/06 | 5 | 4 | 6 | |
| | 9/19/06 | NC | NC | 2 | 40.0 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/30/06 | 27 | 36 | 2 | |
| | 9/6/06 | 10 | 30 | 16 | |
| | 9/12/06 | 35 | 9 | 20 | |
| | 9/19/06 | NC | NC | 1 | 10.7 |
| Total | | 274 | | 106 | |

NC – No count

Table A22. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2006.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 7/31/06 | 0 | 0 | 0 | |
| | 8/14/06 | 1 | 3 | 0 | |
| | 8/28/06 | 2 | 0 | 0 | 0.6 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 7/31/06 | 3 | 8 | 0 | |
| | 8/14/06 | 7 | 23 | 1 | |
| | 8/22/06 | NC | NC | 2 | |
| | 8/28/06 | 2 | 1 | 1 | 2.1 |
| Total | | 15 | | 4 | |

NC – No count

Table A23. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2007.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/29/07 | 32 | 72 | 9 | |
| | 9/5/07 | 11 | 16 | 5 | |
| | 9/12/07 | 4 | 2 | 2 | 9.4 |
| Dime Creek to unnamed tributary (6.3 km) | 8/29/07 | 83 | 130 | 22 | |
| | 9/5/07 | 27 | 4 | 13 | |
| | 9/12/07 | 8 | 0 | 2 | 18.7 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/28/07 | 19 | 32 | 5 | |
| | 9/11/07 | 22 | 2 | 2 | 37.3 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/28/07 | 14 | 19 | 1 | |
| | 9/20/07 | 24 | 1 | 1 | 5.7 |
| unnamed tributary to below Goat Creek (3.5 km) | 9/11/07 | 15 | 0 | 0 | 4.3 |
| Total | | 259 | | 62 | |

Table A24. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2007.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 7/31/07 | 0 | 0 | 0 | |
| | 8/14/07 | 1 | 7 | 0 | |
| | 8/27/07 | 6 | 9 | 0 | 1.5 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 7/31/07 | 5 | 4 | 0 | |
| | 8/15/07 | 13 | 5 | 0 | |
| | 8/27/07 | 0 | 1 | 2 | 3.2 |
| Total | | 25 | | 2 | |

Table A25. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in the South Fork Salmon River in 2008.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Fish Weir to Dime Creek (5 km) | 8/19/08 | 49 | 310 | 22 | |
| | 8/27/08 | 103 | NC | 72 | |
| | 9/3-4/08 | 89 | 110 | 208 | |
| | 9/10/08 | 8 | 10 | 84 | 49.8 |
| Dime Creek to unnamed tributary (6.3 km) | 8/19/08 | 4 | 6 | 3 | |
| | 8/27/08 | 14 | 80 | 5 | |
| | 9/3/08 | 35 | 51 | 30 | |
| | 9/10/08 | 17 | 5 | 29 | 11.1 |
| Poverty Flat to 0.2 km below gauge (1.1 km) | 8/20/08 | 5 | 31 | 1 | |
| | 8/26/08 | 10 | 37 | 3 | |
| | 9/4/08 | 48 | 70 | 31 | |
| | 9/9,11/08 | 25 | 19 | 31 | |
| | 9/17/08 | 2 | 0 | 2 | 81.8 |
| Lodgepole CG to Phoebe Creek bridge (6.7 km) | 8/20/08 | 0 | 5 | 2 | |
| | 8/26/08 | 7 | 50 | 0 | |
| | 9/2/08 | 38 | 73 | 10 | |
| | 9/9/08 | 33 | 34 | 28 | |
| | 9/17/08 | NC | 1 | 2 | 11.6 |
| Total | | 487 | | 563 | |

NC - No count

Table A26. Number of Chinook salmon redds, live fish, carcasses, and redds per kilometer observed in upper Big Creek in 2008.

| Stream Section Sampled | Date (mm/dd/yy) | New Redds | Number of Live Fish | Number of Carcasses | Redds per Kilometer |
|---|---|---|---|---|---|
| Smith Creek to Logan Cr. (4.7 km) | 7/29/08 | 0 | 0 | 0 | |
| | 8/11/08 | 7 | NC | 0 | |
| | 8/25/08 | 5 | 9 | 2 | 2.6 |
| Logan Cr. To Jacobs Ladder (5.6 km) | 7/29/08 | 2 | 8 | 0 | |
| | 8/11/08 | 13 | 28 | 2 | |
| | 8/25/08 | 17 | 13 | 7 | 5.7 |
| Total | | 44 | | 11 | |

NC - No count

Appendix B. Performance measure table for South Fork Salmon River and Big Creek Chinook salmon spawning aggregates.

Table B1. Performance measures for SFSR and Big Creek Chinook salmon spawning aggregates. Data was obtained from annual redd counts and carcass surveys from 1996 – 2008.

| | Performance Measure | SFSR | | | Big Creek |
|---|---|---|---|---|---|
| | | NOR | HOR | Combined | NOR |
| Abundance | Adult Escapement to Snake Basin | NA | NA | NA | NA |
| | Fish per Redd Estimate | NA | NA | NA | NA |
| | **Index of Spawner Abundance -** redd counts, 1996-2008<br>Mean (S.E.)<br>Range | **117.0 (19.75)**<br>**26.3 – 263.7** | **204.8 (34.18)**<br>**13.8 – 451.3** | **321.9 (51.22)**<br>**40 - 715** | **37.9 (9.49)**<br>**2 - 104** |
| | **Spawner Abundance**<br># redds x 2.31, 1996-2008<br>Mean (S.E.)<br>Range | **270.3 (45.62)**<br>**60.8 – 609.1** | **473.1 (78.96)**<br>**31.9 – 1042 5** | **743.5 (118.33)**<br>**92.4 – 1651.7** | **87.4 (21.93)**<br>**4.6 – 240.2** |
| | **Hatchery Fraction**<br>percent HOR, 1996-2008 | **NA** | **NA** | **WD = 70.6%**<br>**DC = 73.2%**<br>**PF = 23.6%**<br>**LP = 14.4%**<br>**All sections = 57.8%** | **Total = 3.66%** |
| | Ocean/Mainstem Harvest | NA | NA | NA | NA |
| | Harvest Abundance in Tributary | NA | NA | NA | NA |
| | Index of Juvenile Abundance (Density) | NA | NA | NA | NA |
| | Juvenile Emigrant Abundance | NA | NA | NA | NA |
| | Hatchery Production Abundance | NA | NA | NA | NA |
| | Smolt Equivalents | NA | NA | NA | NA |
| | Run Prediction | NA | NA | NA | NA |
| Survival - Productivity | Smolt-to-Adult Return Rate | NA | NA | NA | NA |
| | **Progeny-per- Parent Ratio**<br>Lamda-progeny redds/parent redds, 1996 – 2003 brood years | **2.82** | **Ukn** | **0.94** | **3.44** |
| | Recruit/spawner (Smolt Equivalents per Redd or female) | NA | NA | NA | NA |
| | **Pre-spawn Mortality**<br>Percentage of females 0-25% spawned, 1996-2008 | **6.56%** | **17.81%** | **13.13%** | **1.20%** |
| | Juvenile Survival to Lower Granite Dam | NA | NA | NA | NA |
| | Juvenile Survival to all Mainstem Dams | NA | NA | NA | NA |
| | In-hatchery Life Stage Survival | NA | NA | NA | NA |
| | Post-release Survival | NA | NA | NA | NA |
| | Relative Reproductive Success (Parentage) | NA | NA | NA | NA |

| | Performance Measure | SFSR | | | Big Creek |
|---|---|---|---|---|---|
| | | NOR | HOR | Combined | NOR |
| Distribution | **Adult Spawner Spatial Distribution**<br>Percentage of redds in each section, 1996-2008 | **WD&DC – 25.5%**<br>**PF&LP – 74.5%** | **WD&DC – 74.5%**<br>**PF&LP – 25.5%** | **WD&DC – 52.8%**<br>**PF&LP – 47.2%** | **JC – 78.2%**<br>**LC – 21.8%** |
| | **Stray Rate**[1]<br>Percentage of out of basin carcasses, 1996-2008 | **Ukn** | **1.85%** | **Unk** | **3.66%** |
| | Juvenile Rearing Distribution | NA | NA | NA | NA |
| | Disease Frequency | NA | NA | NA | NA |
| Genetics | Genetic Diversity | | | | |
| | Reproductive Success (Nb/N) | NA | NA | NA | NA |
| | Effective Population Size (Ne) | NA | NA | NA | NA |
| Life History | Age Class Structure | NA | NA | NA | NA |
| | **Age–at–Return**<br>Percentage of carcasses of each age class, 1996-2008 | **Males:**<br>**age 3 = 12.7%**<br>**age 4 = 63.3%**<br>**age 5 = 23.9%**<br>**age 6 = 0.01%**<br>**Females:**<br>**age 4 = 70.2%**<br>**age 5 = 29.8%** | **Males:**<br>**age 3 = 33.9%**<br>**age 4 = 52.6%**<br>**age 5 = 13.5%**<br>**Females:**<br>**age 4 = 89.2%**<br>**age 5 = 10.8%** | **Males:**<br>**age 3 = 20.7%**<br>**age 4 = 57.1%**<br>**age 5 = 21.4%**<br>**age 6 = 0.05%**<br>**Females:**<br>**age 4 = 79.2%**<br>**age 5 = 20.8%** | **Males:**<br>**Age 3 = 17.6%**<br>**Age 4 = 72.2%**<br>**Age 5 = 10.2%**<br>**Females:**<br>**Age 4 = 64.2%**<br>**Age 5 = 35.8%** |
| | Age–at-Emigration | NA | NA | NA | NA |
| | **Size-at-Return**<br>Mean mm (S.E.), 1996-2008 | **Jack = 576.4 (50.55)**<br>**Male = 851.9 (28.52)**<br>**Female = 835.0(27.40)** | **Jack = 578.9 (34.97)**<br>**Male = 837.0 (35.98)**<br>**Female = 805.6(24.31)** | **Jack = 578.1 (2.51)**<br>**Male = 846.3 (2.54)**<br>**Female =819.1(1.51)** | **Jack = 552.6 (16.26)**<br>**Male = 779.3 (9.45)**<br>**Female = 829.8 (9.66)** |
| | Size-at-Emigration | NA | NA | NA | NA |
| | Condition of Juveniles at Emigration | NA | NA | NA | NA |
| | **Adult Spawner Sex Ratio**<br>Percent adult females, 1996-2008 | **50.7%** | **61.4%** | **55.7%** | **66.2%** |
| | Fecundity by Age | NA | NA | NA | NA |
| | Adult Run-timing | NA | NA | NA | NA |
| | **Spawn-timing**<br>Peak date<br>Range, 1st – last redd<br>10th percentile<br>90th percentile | **Ukn** | **Ukn** | **9/3**<br>**8/12 – 9/24**<br>**8/29**<br>**9/11** | **8/12**<br>**7/18 – 9/11**<br>**8/1**<br>**8/27** |
| | Juvenile Emigration Timing | NA | NA | NA | NA |
| | Mainstem Arrival Timing (Lower Granite) | NA | NA | NA | NA |
| Habitat | Instream Flow | NA | NA | NA | NA |
| | Water Temperature | NA | NA | NA | NA |

[1]HOR stray rate was the proportion of out of basin CWTs divided by the total CWT recoveries; Big Creek stray rate was the proportion of adipose fin clipped carcasses recovered.

Appendix C. Injuries noted from carcasses collected in the SFSR from 1996 - 2008.

Table C1. South Fork Salmon River carcasses recovered that exhibited of visible injuries. Data includes the section, year, sex, percent spawned, origin and a description of the injuries.

| Section[1] | Year | Sex | Percent spawned[2] | Origin[3] | Remarks |
|---|---|---|---|---|---|
| WD | 1997 | F | 100 | H | single hook in mouth |
| WD | 1997 | F | 100 | N | Trebel hook in side |
| LP | 1998 | F | 100 | N | Puncture wound |
| DC | 1998 | F | 0 | H | Open flesh on dorsal; not puncture wound |
| WD | 1998 | J | | N | Large stick through mouth |
| DC | 2001 | F | 0 | H | 1/2" puncture wound left side by dorsal |
| DC | 2001 | F | 0 | H | Abrasion right side |
| WD | 2001 | F | 0 | H | Picket marks on body |
| DC | 2001 | F | 0 | H | Deep abrasions on right side |
| DC | 2001 | F | 0 | N | 3 Puncture wound right side |
| DC | 2001 | F | 0 | N | Large chunk out of dorsal, gash by right opercle |
| DC | 2001 | M | | N | Puncture wound right side |
| WD | 2001 | M | | N | Puncture wound |
| DC | 2001 | M | | N | Fishing line in mouth |
| LP | 2001 | M | | N | 2 Puncture wound right side |
| DC | 2001 | M | | H | Gaff wound right hand side |
| DC | 2001 | M | | H | puncture wound right side |
| DC | 2002 | F | 0 | H | Puncture wound above ventral fin |
| DC | 2002 | F | 0 | H | Puncture wound |
| PF | 2002 | F | 0 | N | Several puncture wounds on left side |
| DC | 2002 | F | 0 | H | Puncture wound |
| PF | 2002 | F | 0 | N | Puncture wound (2" hole) on right side |
| DC | 2002 | F | 0 | H | Puncture wound |
| WD | 2002 | F | 100 | H | Hook in mouth |
| WD | 2002 | J | | H | Abrasion right side |
| DC | 2002 | M | | H | Puncture wound |
| PF | 2002 | M | | H | Puncture wounds on left side |
| DC | 2002 | M | | N | Puncture wound |
| WD | 2002 | M | | H | Gash on right side |
| WD | 2003 | F | 0 | N | Puncture wound |
| LP | 2003 | F | 0 | N | Entire belly bruised swollen |
| WD | 2003 | F | 100 | N | Puncture wound right side |
| PF | 2003 | F | 0 | H | 4 deep abrasions on tail |
| GC | 2003 | F | 0 | H | Puncture wound |
| LP | 2003 | M | | N | 2 open wounds/tumors on side below dorsal fin |
| WD | 2003 | M | | H | 2 Large circular abrasions |
| DC | 2003 | M | | H | Hook in side and other puncture wounds |

| | | | | | |
|---|---|---|---|---|---|
| DC | 2004 | F | 50 | H | Wound on side |
| PF | 2004 | M | | N | Bite wound |
| DC | 2004 | M | | H | Gash on head |
| WD | 2005 | F | 100 | H | Puncture wound |
| WD | 2008 | F | 0 | H | gaff wound |
| WD | 2008 | F | 0 | H | gaff wound |
| WD | 2008 | F | 0 | H | gaff wound |
| WD | 2008 | M | | N | gaff wound |
| WD | 2008 | M | | H | wound |
| WD | 2008 | M | | H | gaff wound |

[1]Sections: WD – McCall Hatchery weir to Dime Creek; DC – Dime Creek to 1 km below Mirror Creek; PF – Poverty Flats; LP – Lodgepole Campground to Phoebe Creek.
[2]Percent spawned was estimated from females only.
[3]Origin: H – hatchery-origin; N – natural-origin.