# Chinook Salmon Productivity and Escapement Monitoring in the John Day River Basin

Annual Technical Report

July 1, 2013–June 30, 2014

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Funded by:

Oregon Watershed Enhancement Board
775 Summer Street NE, Suite 360
Salem, OR  97301-1290

OWEB Contract Number: 212-909

June 2014

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*Objectives*

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2. Estimate age composition and proportion of hatchery-origin spawners for three John Day River spring Chinook salmon populations.

3. Estimate productivity metrics including smolts per redd for three John Day River spring Chinook populations.

*Accomplishments and Findings*

Spawning ground surveys for spring Chinook salmon were conducted in the John Day River basin from 5 August through 2 October 2013. We observed 916 spring Chinook redds while surveying 301.9 km of potential spawning habitat (189.6 km of census, 78.2 km of index, and 34.0 km of random reaches). We estimated 79 redds were constructed in the 10.7 km of stream where we were denied access in the Mainstem John Day River. A total of 995 spring Chinook redds were constructed in the John Day River basin, 44% fewer than the previous year, at an overall density of 3.7 redds/km for the survey area. Redd abundance decreased from 2012 within all three populations. Redd count in the Mainstem declined 4%, the Middle Fork redd count dropped 77%, and North Fork redd total was down 45% from 2012. The 2013 Middle Fork redd total of 113 was the second lowest observed since 2000 (85 redds were observed in 2007), both years experienced a pre-spawn mortality event associated with high stream temperatures.

Estimated spring Chinook escapement for 2013 was 4,905 fish (using a ratio of 4.93 adults and jacks per redd estimated at the Catherine Creek weir in the Grande Ronde River basin). We recovered 818 Chinook carcasses (17% of the estimated total spawners), 756 (92%) of which had an adipose fin and were assumed to be of wild origin, 7 (1%) had a clipped adipose fin and were assumed to be of hatchery origin, and the remaining 55 could not be identified.

Stock-recruit analyses for the Mainstem and Middle Fork John Day populations indicate that smolts produced per redd decreases as the number of redds increases, indicating that rearing habitat may be limiting freshwater production. The Mainstem stock-recruit curve shows the strongest density-dependence, with production decreasing when escapement exceeds 400 redds. Conversely, an adult-to-adult recruitment curve for the North Fork suggests no decrease in production at higher escapements. Average sustainable yield in the Middle Fork appears to be lower than the Mainstem.

# ACKNOWLEDGEMENTS

We acknowledge the assistance and cooperation of private landowners throughout the John Day River basin that allowed us to survey on their property. We thank Jeff Neal and Brent Smith for providing assistance and advice. We also thank the countless volunteers for helping conduct field surveys. Stephanie Gunckel and Kanani Bowden provided assistance and advice on scale analysis. Susan Benda analyzed kidney samples. This project was funded by Pacific Coastal Salmon Recovery Funds distributed through the Oregon Watershed Enhancement Board, Contract Number 212-909. We thank Tom Stahl and Greg Sieglitz for assistance with contract administration.

## INTRODUCTION

The John Day River basin supports three wild populations of spring Chinook salmon. Distinct populations are present in the upper Mainstem, Middle Fork, and North Fork of the John Day River (Narum et al. 2008). These populations remain depressed relative to historic levels. Numerous habitat protection and rehabilitation projects have been implemented in the basin to improve salmonid freshwater production and survival. Often, these projects lack effectiveness monitoring (Bayley and Li 2008). While our monitoring efforts outlined here do not specifically measure the effectiveness of any individual project, they will provide much needed programmatic or watershed-scale (status and trend) information to help evaluate project-specific effectiveness monitoring efforts as well as meet the data needs as index stocks. Our continued monitoring efforts to estimate salmonid abundance, age structure, smolts per redd, freshwater habitat use, and distribution of critical life stages will allow managers to assess the long-term effectiveness of habitat projects.

Because Columbia River basin managers have identified the John Day River basin spring Chinook population aggregate as an index population for assessing the effects of alternative future management actions on salmon stocks in the Columbia River basin (Schaller et al. 1999), we continue our ongoing studies. This project is high priority based on the level of emphasis by the Northwest Power and Conservation Council (NWPCC) Fish and Wildlife Program, Independent Scientific Advisory Board (ISAB), Independent Scientific Review Panel (ISRP), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), and the Oregon Watershed Enhancement Board (OWEB). Each of these groups has placed priority on monitoring and evaluation to provide the real-time data to guide restoration and adaptive management in the region.

## STUDY AREA

The John Day River drains 20,300 $km^2$ of east central Oregon, the third largest drainage area in the state (Figure 1). From its source in the Strawberry Mountains at an elevation near 1,800 m, the John Day River flows 457 km to the Columbia River at an elevation near 90 m. It enters the Columbia River at river kilometer (rkm) 351. The basin is bounded by the Columbia River to the north, the Blue Mountains to the east, and the Ochoco Mountains to the west.

Spring Chinook salmon primarily spawn in the upper Mainstem John Day River (hereafter called Mainstem; Figure 2) upstream from Indian Creek, in the Middle Fork John Day River (hereafter called Middle Fork; Figure 3) upstream of Armstrong Creek, and the North Fork John Day River (hereafter called North Fork; Figure 3) upstream of Camas Creek. Important spawning tributaries of the North Fork include Granite Creek and its tributaries (Clear Creek and Bull Run Creek; hereafter called Granite Creek System) and Desolation Creek (Figure 3). Spawning has also occurred in the South Fork

John Day River (hereafter called South Fork; Figure 4), the North Fork tributaries Camas and Trail creeks, and the Mainstem tributaries Deardorff, Reynolds, and Bridge creeks.

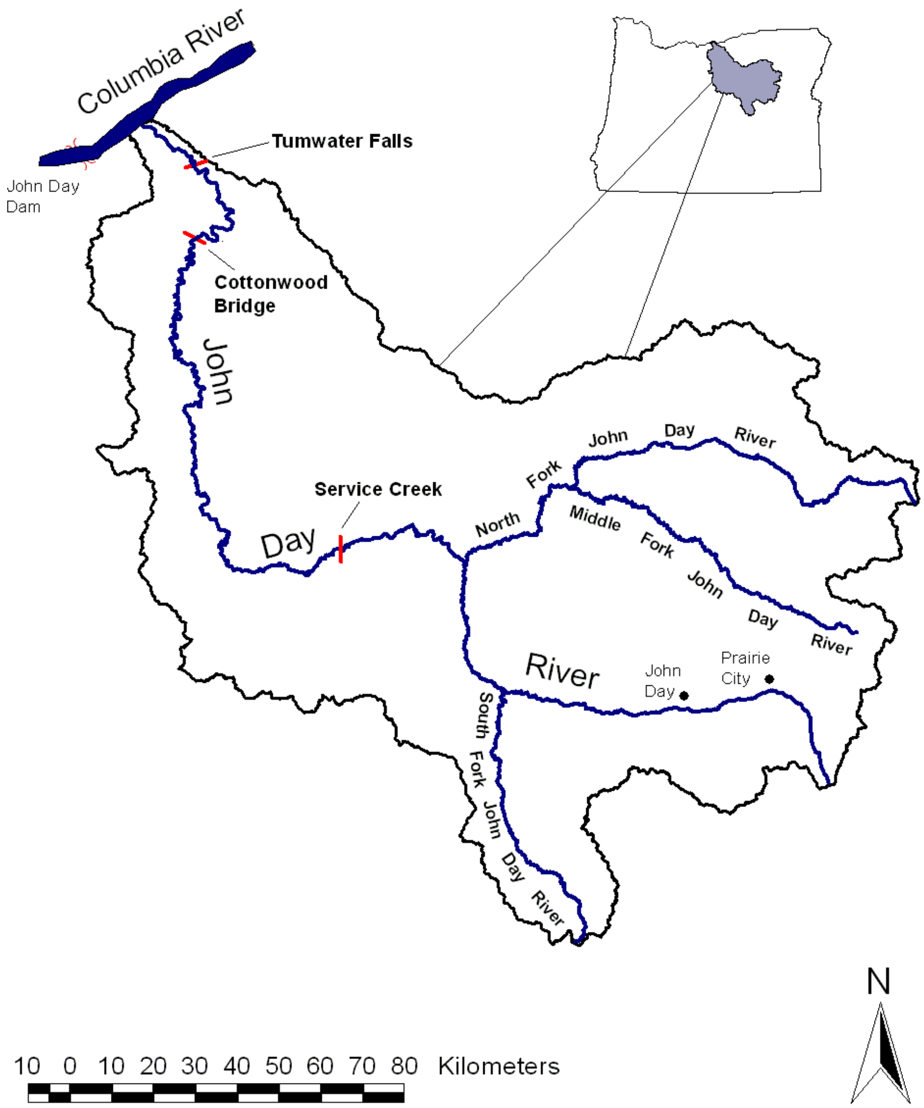


Figure 1. Map of the John Day River basin.

# METHODS

## Sampling Design

Spring Chinook salmon spawning surveys were conducted during August and September to encompass the temporal distribution of Chinook spawning in the John Day River basin. These surveys included index, census, and random sections. Index sections were defined as locations where redd counts have occurred annually since 1964. Census sections were defined as any location where spring Chinook redds have been previously documented. Random surveys (2 km in length) were defined as surveys located outside of the known spawning universe. The intent of random surveys was to check for range expansion. Our random sampling universe extended 20 km downstream from the most downstream redd observed in each Hydrologic Unit Code (4th level HUC; Mainstem, Middle Fork, and North Fork). A second sampling universe extended 4 km upstream from the most upstream redd observed. Survey sections were selected with a random number generator based on river kilometer. For every one site selected upstream from the census section, two sites were selected downstream from the census section. If redds were observed in a random site, that survey section was added to the census universe for all following years. The index, census, and random sections were collectively assumed to provide a census count of spring Chinook salmon redds (hereafter referred to as "total").

Index surveys were scheduled to occur at the peak of spawning in each of the three populations (Mainstem, Middle Fork, and North Fork). Pre-index surveys were conducted one week prior to the index surveys and post-index surveys were conducted one week after the index surveys to account for temporal variation in spawning. However, post-index counts were treated as census counts and not included in the overall index count. During 2013, with the exception of wilderness areas, we surveyed census sections three times on the same dates as the pre-index, index, and post-index surveys. We conducted random surveys on the Mainstem, Middle Fork, North Fork, and South Fork on the day of the index or post-index surveys for their respective streams.

## Spawning Surveys

Spawning surveys were conducted on foot, and ranged in length from 0.01 to 13.3 km depending on accessibility and difficulty. Typically, teams of two surveyors walked the stream, with one surveyor on each bank to ensure detection and accuracy when distinguishing redds. In each section, surveyors recorded the number of new redds, live fish (on- or off-redd), and carcasses. During index and census surveys, the first team marked redds with numbered flagging placed near each redd or group of redds. During subsequent surveys, teams re-identified flagged redds and recorded any new redds. During the last survey in each reach, surveyors geo-referenced redds with a global positioning system receiver and removed all flags.

Every carcass we observed was examined unless decomposition or scavenging damage disallowed accurate measures. Medial eye to posterior scale length (MEPS) was measured to the nearest millimeter and carcasses were dissected to verify sex. Volume (to the nearest 59 ml) of eggs retained was noted for every female. Every carcass was scanned for the presence of a passive integrated transponder (PIT tag) unless there were fewer PIT scanners than survey crews.  Tag codes from recaptured PIT tags were queried for their tagging and observation history using PTAGIS (data available online at: www.ptoccentral.org).  Kidney samples were collected from recently deceased spring Chinook in each of the main spawning areas to determine concentration and prevalence of *Renibacterium salmoninarum* (Rs) antigen, the causative agent of bacterial kidney disease (BKD), in the spawning population.  Surveyors selected carcasses with intact organs and membranes and non-glazed eyes, indicative of recent mortality, as donors for kidney tissue analysis.  Clean disposable plastic knives and spoons were used to collect a 1–2 g sample of kidney tissue from each carcass.  Samples were placed in sterile 1-ounce Whirl-pack™ bags and stored in a cooler until they could be transferred to a freezer.  The enzyme-linked immunosorbent assay (ELISA) was used to obtain optical density (OD) values according to methodology adapted from Pascho and Mulcahy (1987).  The Rs antigen level is an indication of bacterial infection load of *R. salmoninarum*.  Table 1 summarizes the optical density value ranges and standard infection level categories used for BKD.

Table 1. Summary of ELISA optical density value ranges, designated Rs antigen category, and significance of result with respect to adult Chinook salmon.

| **Optical Density value ($OD_{405}$)** | **Rs antigen category** | **Significance to adult Chinook** |
|---|---|---|
| ≤ 0.100 | Negative or Very Low | Infection not detected by ELISA |
| 0.100–0.299 | Low Positive | Not a factor in death, did not have BKD |
| 0.300–0.699 | Moderate Positive | Beginning of significant infection, signs of disease absent, rarely a factor in death |
| 0.700–0.999 | High Positive | Gross signs rare, could be a factor in death |
| ≥ 1.000 | Clinical | Signs of disease usually present, death probable, fish had BKD |

Surveyors collected scale samples from the first fifteen carcasses encountered on each survey section as well as all adipose-clipped fish.  Scales were cleaned and mounted on gummed cards, imprinted on acetate using a hydraulic press fitted with hot plates, and subsequently viewed through a microfiche reader by two different people to determine age.  We visually determined both freshwater and saltwater age for all scales without regeneration in either region.  Fish with a freshwater annulus were classified as yearling smolts (approximately 18 month freshwater residence period post egg deposition, “stream-type” life history, Lichatowich and Mobrand 1995) and fish without a freshwater annulus were classified as sub-yearling smolts (less than 12 month freshwater residence period post egg deposition, “ocean-type” life history, Lichatowich and Mobrand 1995).  We summarized age structure at the population scale.

Carcasses of hatchery fish were identified by an adipose fin clip and subsequently had their snout removed to determine the presence of a coded wire tag (CWT).  Snouts were bagged with a numbered identification card and frozen. In the laboratory, snouts were dissected and CWTs were located using a magnetic detector. If a tag is detected, it is excised and visually decoded under magnification. The tag code is then entered into the Oregon Department of Fish and Wildlife (ODFW) database and hatchery of origin is queried using the Pacific States Marine Fisheries Commission (PSMFC) database. We used a chi-square statistic to test if frequencies of hatchery fish differed among populations.

We marked carcasses that were in good condition (i.e., intact and body cavity not breached) with a uniquely numbered black cable tie passing through the mouth and under the operculum and returned the marked carcasses to their original position in the stream. Tails were removed from carcasses with breached body cavities to prevent repeat sampling. During subsequent surveys, carcasses with cable tie marks were recorded by surveyors. We used these mark-recovery data to estimate carcass detection probability for three size classes ($\leq$ 499 mm, 500–599 mm, and $\geq$ 600 mm) and at the population scale. We used binomial logistic regression to model the influence of potential explanatory variables such as carcass size and population on carcass detection probability. After constructing candidate regression models, we used Akaike's information criterion, corrected for small sample size ($AIC_c$), to rank each candidate model.

**Redd Count Escapement Estimation**

All spring Chinook redds in the basin were visually counted with the exception of areas in the Mainstem and Clear Creek (Granite Creek System, GCS) where landowners denied access. A Geographic Information System (GIS) incorporating a 1:100,000 digital stream network was used to estimate stream reach and total reach lengths. We expanded our redd density estimate to non-surveyed reaches by multiplying adjacent-reach mean density by the length of the reach where we were denied access.

We evaluated the relationship between index and total (total = index + census + random) redd counts at the population level. We used linear regression to determine if the census redd counts for 2000 to 2013 were significantly related to total redd counts. Next, we plotted the residuals from each of these three regressions against streamflow (Service Creek gauging station) to evaluate whether deviations were related to streamflow. Finally, we developed a linear regression for the 2000 to 2012 index:total data and used this equation to predict the 2013 total count based on the 2013 index count. The predicted total count was then compared with the observed total count to evaluate the necessity of census surveys.

Absence of weirs in the John Day River basin prevents basin-specific fish/redd estimates. Therefore, we estimated spawner escapement by using the following equation.

$$\widehat{N}_p = r_p \cdot \hat{f}$$

where:

$\widehat{N}_p$ = Estimated number of spawners in the population
$r_p$ = Number of redds observed in the population
$\hat{f}$ = Estimated fish per redd above Catherine Creek weir located in the adjacent Grande Ronde River basin (ODFW unpublished data)

**PIT Tag Detection-Recapture Escapement Estimation**

Mark-recapture analysis using PIT-tagged fish provides an alternate method for estimating the abundance of adult Chinook returning to the John Day River basin. Several thousand Chinook smolts are intra-peritoneally PIT tagged annually when emigrating from the John Day River basin (DeHart et al. 2012). Tagged Chinook are subsequently detected at Bonneville Dam when returning as adults. Chinook salmon have a homing fidelity rate that typically exceeds 95% (Quinn 2005). Empirical evidence from the John Day River basin corroborates this. Lindsay et al. (1986) tagged juvenile Chinook in the three John Day populations and observed homing to natal spawning areas. Similarly, Narum et al. (2008) analyzed genetic evidence from the three populations and also concluded that homing dominated among these populations. Thus, we assumed a 100% homing rate between Bonneville Dam and spawning grounds for Chinook originally PIT tagged in the John Day River.

Following this assumption, John Day spring Chinook detection-recapture data were deemed applicable to a mark-recapture analysis (J. Peterson, Oregon State University, personal communication). When John Day Chinook crossed Bonneville Dam, some of these adults were "marked" at Bonneville Dam via passive detection of the PIT tags they carried. The detections we acquired each spring at Bonneville Dam (data available online at: www.ptoccentral.org) were analogous to operating a trap in the Lower John Day River that captured, PIT tagged, and released upstream migrating adults. Tagging a small portion (2–5%) of the population migrating upstream is sufficient, provided that a larger portion (> 15%) of the population is recovered as carcasses and examined for marks. This methodology is commonly used in the Pacific Northwest for estimating adult salmon escapement (e.g., Parsons and Skalski 2010).

Mortality may occur en route between Bonneville Dam and the spawning grounds, but we assumed the mortality to be equal between tagged and untagged Chinook, hence there was no change to the tagged:untagged ratio. PIT tags have been inside the body cavity of the fish since smoltification, so we assumed no tag loss during the upstream migration. On spawning ground surveys, the tags cannot be observed externally by the surveyor, thus eliminating the possibility of bias toward detection of a marked carcass. All carcasses that were physically intact (scavenged carcasses were excluded) were used for this estimate. There is evidence that female Chinook frequently expel an intra-peritoneally implanted PIT tag during spawning. For example, Prentice et al. (1986) observed 100% retention of PIT tags when hand spawning male Atlantic salmon (*Salmo salar*), but only 83% retention of PIT tags during hand spawning of female Atlantic salmon. We corrected for this tag loss by summing the spawning ground recaptures of males only, and then dividing by the fraction of males observed in our carcass recoveries to estimate the number of females that had PIT tags prior to expulsion.

We estimated the number of John Day origin spring Chinook to Bonneville Dam with the Petersen estimator (White et al. 1982):

$$\hat{N} = \frac{(M+1)(C+1)}{(\hat{R}+1)} - 1$$

where:

$\hat{N}$ = Number of returning adult Chinook crossing Bonneville Dam that originated from the John Day River

*M* = Number of returning adult Chinook that were originally PIT tagged when emigrating from the John Day River and subsequently detected crossing Bonneville Dam

*C* = Number of intact carcasses scanned for a PIT tag on spawning ground surveys (inclusive of both males and females)

$\hat{R}$ = Number of fish in group *M* that were recovered on spawning ground surveys, after correcting for female tag shed by assuming an equal rate of tag presence between males and females

**Pre-spawning Mortality Monitoring**

In response to a rapid rise in stream temperature and the presence of salmon carcasses, a survey effort was immediately conducted in the Middle Fork to quantify pre-spawning mortality. All survey reaches were located upstream of a PIT array, which detects upstream migrating PIT tagged adult salmon. All carcasses recovered on our surveys were scanned for PIT tags, measured for MEPS length, had scales collected, and were checked for origin and sex. We estimated the number of Chinook salmon in the Middle Fork upstream from the Middle Fork PIT array using Chapman's modification of the Petersen estimate (as described above) where:

$\hat{N}$ = Number of adult Chinook salmon upstream of the Middle Fork PIT array

*M* = Number of PIT tagged adults detected migrating upstream past the Middle Fork PIT array

*C* = Number of intact carcasses recovered on July 3

$\hat{R}$ = Number of fish in group *M* that were recovered on pre-spawning mortality survey

An additional estimate of total adult Chinook salmon abundance upstream of the Middle Fork array was generated using PIT detection data from the July 3 survey data combined with spawning ground survey PIT detection data collected in September.

To estimate mortality, we used carcass detection probability data gathered during 2012 spawning ground surveys (Bare et al. 2013). The logistic regression model fit to these data suggested that a better estimate may be generated if a covariate for size class was included. Therefore, we grouped the pre-spawn carcasses into size classes and divided the sum in each class by the corresponding detection probability from the 2012 spawning ground logistic regression model.

**Population Productivity Analyses**

We assessed covariation of total redd count among three John Day populations and other streams studied by ODFW's Northeast-Central Oregon research and monitoring program (NECORM) using Pearson correlation. Additionally, we evaluated the correlation between total redd count for each John Day population and an indicator of ocean productivity. The ocean indicator we selected was Pacific Decadal Oscillation (PDO; data available online at: http://jisao.washington.edu/pdo/PDO.latest) for the summer (May to September mean) that age-4 Chinook (the dominant age class in all three populations) entered the ocean. Negative values of the PDO indicate cooler sea surface temperatures and more productive ocean conditions for juvenile salmonids entering the ocean from the Columbia River.

Productivity of the three populations was assessed at two life history stages: smolt recruitment and adult recruitment. The smolt recruitment metric was an estimate of the number of out-migrant yearling smolts produced per redd. This metric was only available for the Mainstem and Middle Fork populations. The second metric was adult female to adult female (redd to redd) stock-recruitment curves. We fit these recruitment curves for each of the populations.

To estimate smolts per redd, yearling spring Chinook migrants were captured at two rotary screw trap (RST) sites. The RST sites are located downstream of all known spring Chinook spawning habitat within their respective subbasin, with the exception of Bridge Creek that is included in the Mainstem population. A 1.52 m or 2.44 m diameter RST was fished at the Mainstem (rkm 352) trap site depending on water conditions to optimize capture efficiency. Two 1.52 m RSTs were fished at the Middle Fork (rkm 24) trap site. Trapping efficiency was estimated separately at each RST site by releasing marked yearling chinook upstream of the trap(s) at civil twilight to mimic natural migration patterns (Tattam et al. 2013). A complete description of smolt collection methods is described by DeHart et al. (2012). Data collected from each of the RSTs were then used to estimate smolt abundance for the Mainstem and Middle Fork populations.

Adult to adult recruitment rates for each population were modeled with Ricker stock-recruitment curves fit to the total redd abundance dataset from 2000 to present. We analyzed the 2000 to 2008 brood years separately for each population. Total redd counts were partitioned based on the age structure of female Chinook recovered on spawning ground surveys in each population. This allowed us to determine the number of redds produced by each brood year. For instance, the "redd to redd" productivity of the Middle Fork population during brood year 2000 was estimated as:

$$\frac{(\text{2004 redds} \cdot (\text{proportion Age 4 females})) + (\text{2005 redds} \cdot (\text{proportion Age 5 females}))}{\text{Total Year 2000 redds}}$$

The natural log of recruit redds per brood year redds was regressed against brood year redds to parameterize a Ricker stock-recruitment curve for each population.

Salmonid populations frequently exhibit density-dependence during freshwater rearing (Achord et al. 2003; Milner et al. 2003). That is, the rate of per-capita production (which we measure as recruit redds per brood year redd) decreases with increasing brood year redd abundance. Thus, we expect lower productivity values at higher levels of brood year redd abundance and vice versa. This regression models density dependence by predicting lower recruitment rates at higher brood year redd abundances. The residuals from this regression measure the deviation between observed recruitment and the recruitment rates predicted after adjusting for density-dependence. A positive residual indicates higher than expected productivity, whereas a negative residual indicates lower than anticipated productivity. We plotted the residuals against brood year to evaluate temporal trends in productivity. Residuals from a stock-recruitment relationship can thus be used to investigate changes in productivity over time without the confounding effects of parental stock abundance (e.g., Peterman et al. 1998, Mueter et al. 2007).

## RESULTS

### Redd Counts

We surveyed 301.9 km of potential Chinook spawning habitat within the John Day River basin in 2013 (Table 2; Figures 2, 3, and 4). A total of 78.2 km of spawning habitat was surveyed within the index area, excluding 6.3 km where we were denied access, and 189.6 km of spawning habitat was surveyed within the census area, 12.0 km of which we were denied access. We conducted random surveys on the Mainstem, Middle Fork, North Fork, and South Fork for a total length of 34.0 km of stream.

Table 2. Access status (Y = Yes, N = No), survey type, and reach length (km) for 2013 spawning survey reaches in the John Day River basin.

| | | Survey Type | | |
|---|---|---|---|---|
| **Stream Name** | **Access Status** | **Census** | **Index** | **Random** |
| **Mainstem** | | | | |
| Bridge Creek | Y | 5.9 | | 5.8 |
| Canyon Creek | Y | | | 2.0 |
| Deardorff Creek | Y | 2.0 | | |
| John Day River | *N* | *6.7* | *6.3* | |
| John Day River | Y | 7.3 | 11.4 | 6.4 |
| Reynolds Creek | *N* | *4.1* | | |
| **South Fork** | | | | |
| S.F. John Day River | Y | 17.3 | | 3.2 |
| **Middle Fork** | | | | |
| Bridge Creek | Y | 2.9 | | |
| Clear Creek | Y | 4.1 | | 2.0 |
| Granite Boulder Creek | Y | 2.3 | | |
| M.F. John Day River | Y | 27.7 | 19.8 | 6.4 |
| Vinegar Creek | Y | 0.6 | | |
| **North Fork** | | | | |
| Baldy Creek | Y | 1.1 | | |
| Big Creek | Y | 0.1 | | |
| Camas Creek | Y | 0.8 | | 3.2 |
| Crane Creek | Y | | | 1.6 |
| Crawfish Creek | Y | 0.2 | | |
| N.F. John Day River | Y | 63.2 | 28.5 | 3.2 |
| Trail Creek | Y | 3.0 | | |
| **Granite Creek System** | | | | |
| Bull Run Creek | Y | 2.3 | 4.9 | |
| Clear Creek | *N* | *1.2* | | |
| Clear Creek | Y | 4.3 | 4.7 | |
| Granite Creek | Y | 7.5 | 9.0 | |
| **Desolation Creek** | | | | |
| Desolation Creek | Y | 35.3 | | |
| S.F. Desolation Creek | Y | 1.8 | | |
| **Total** | | **189.6** | **78.2** | **34.0** |

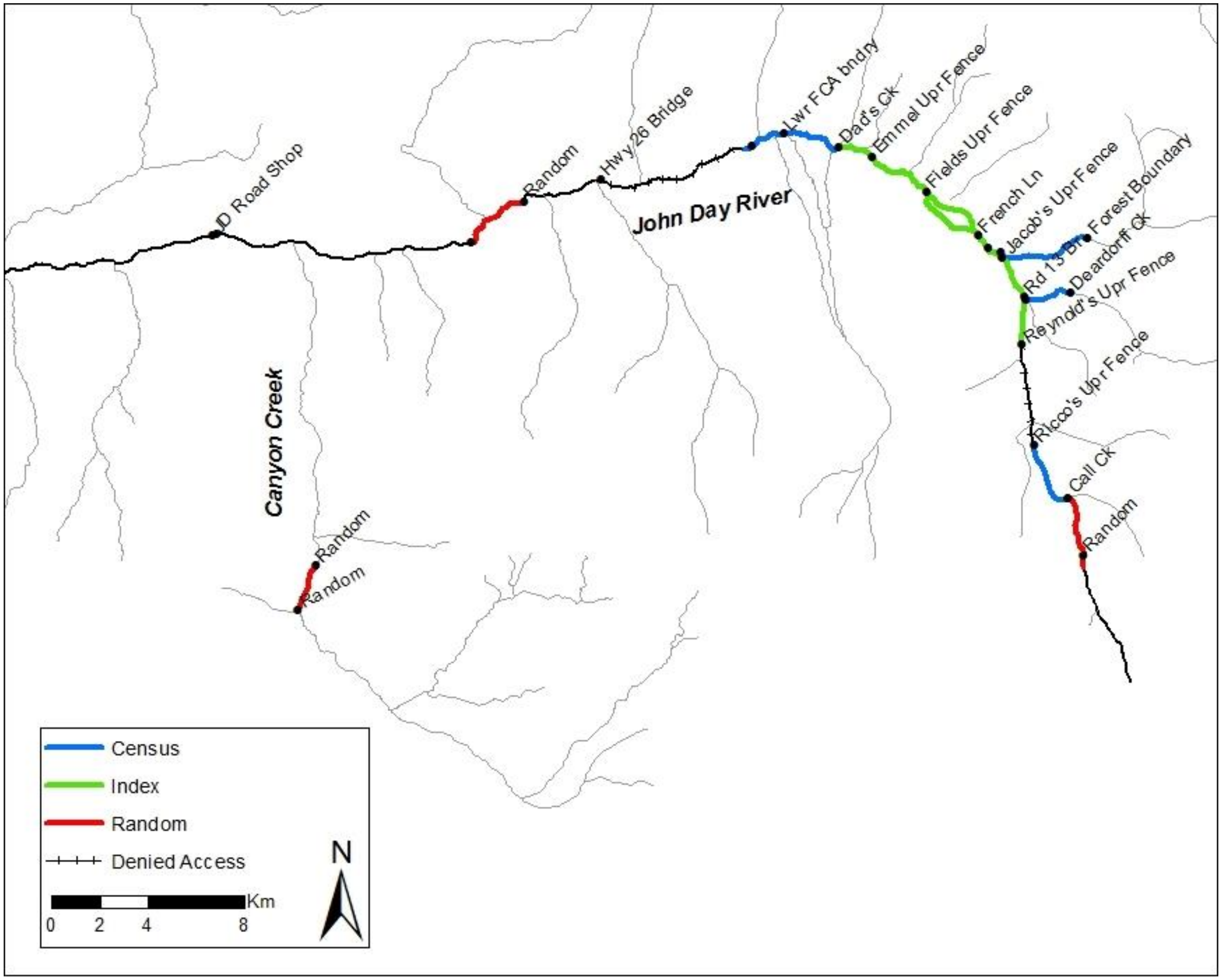


Figure 2. Map of the Mainstem spring Chinook spawning ground survey sections.

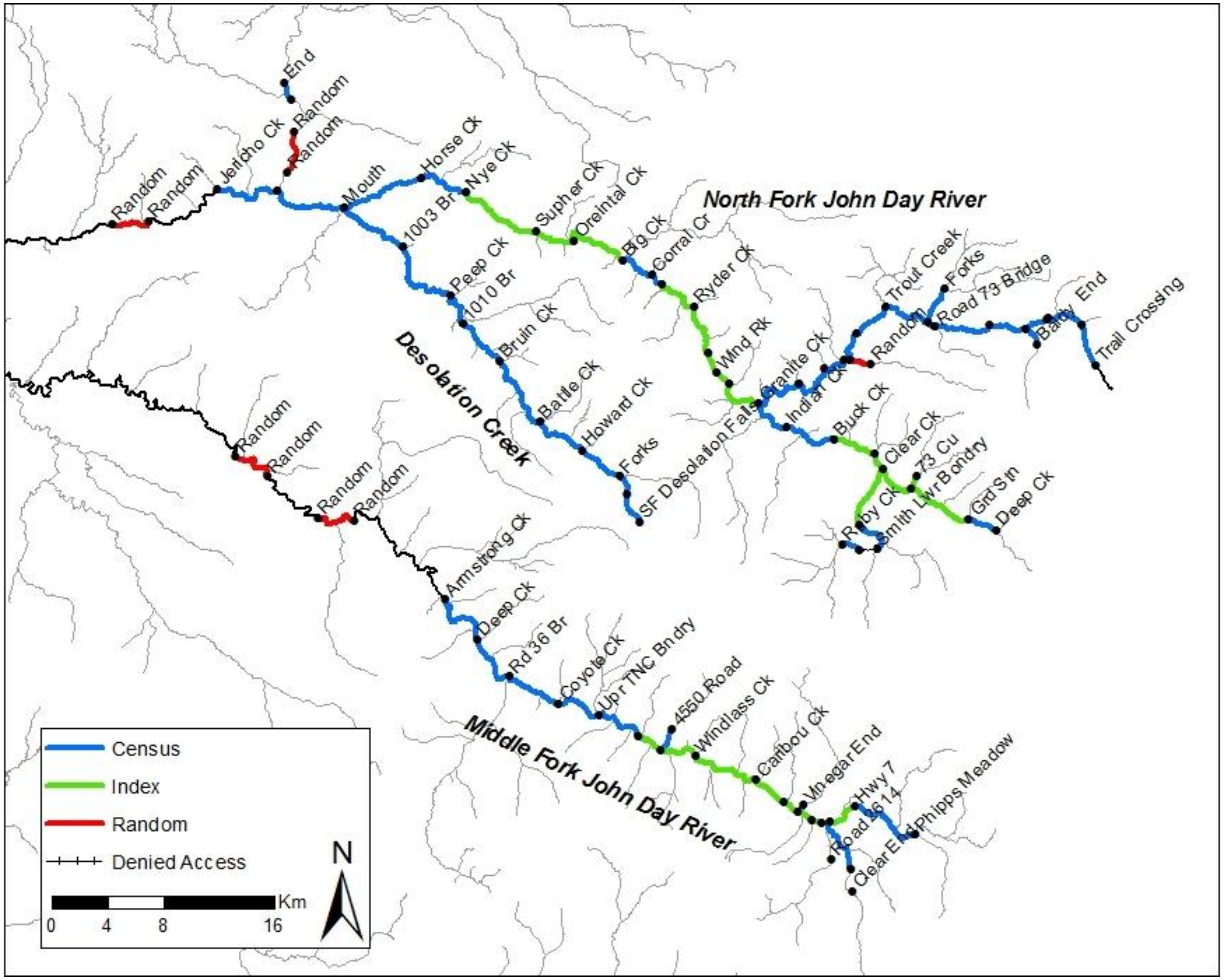


Figure 3. Map of the Middle Fork and North Fork spring Chinook spawning ground survey sections.

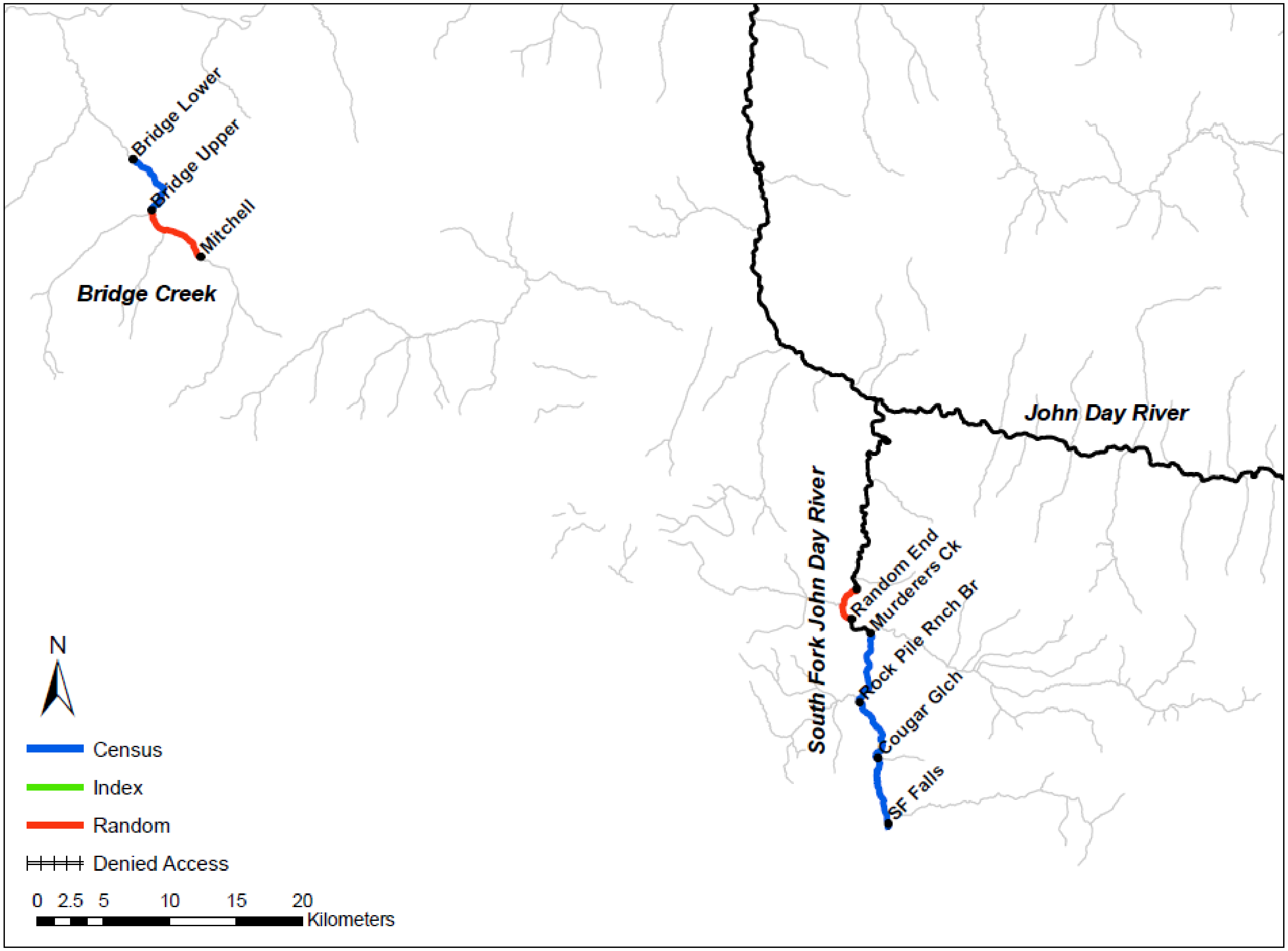


Figure 4. Map of the South Fork and Bridge Creek spring Chinook spawning ground survey sections.

We observed 916 spring Chinook redds within the John Day River basin in 2013 (Tables 3 and 4). In the 18.2 km of combined census and index reaches where we were denied access, we estimated a total of 79 redds in the Mainstem and 0 redds in Clear Creek, GCS. This resulted in a total estimated 995 spring Chinook redds in the John Day River basin in 2013. We estimated an overall density of 3.7 redds/km for the entire survey area, excluding random reaches where spawning was not present (Table 3). Of the 995 total redds, 670 were in index reaches at a density of 8.6 redds/km. The ratio of index to census redd counts, with post-index redds counted as census redds, was 1.3. Since 2000, the contribution of index counts to the total count has declined (Figure 5). No redds were observed in random reaches. The Mainstem accounted for 39.0% of the total redds observed in 2013, the Middle Fork had 11.4%, and the North Fork had 49.6%. We did not observe any redds in the South Fork. The Mainstem had the highest density of redds with 14.6 redds/km, followed by the Middle Fork with 2.0 redds/km, and the North Fork with 3.0 redds/km (Figures 6, 7, and 8).

Table 3. Distance surveyed, total unique redds observed, redd density, fish per redd estimates generated at the Catherine Creek weir, adult escapement, and total escapement for spring Chinook spawners in the John Day River basin from 2000–2013.

| Year | Distance (km) | Redds | Redds/km | Adults/Redd | Jacks and Adults/Redd | Adult Escapement | Total Escapement |
|---|---|---|---|---|---|---|---|
| 2000 | 236.1 | 1,869 | 7.9 | 1.54 | 1.69 | 2,875 | 3,163 |
| 2001 | 243.2 | 1,863 | 7.7 | 2.92 | 4.19 | 5,447 | 7,808 |
| 2002 | 255.9 | 1,959 | 7.7 | 2.71 | 2.90 | 5,299 | 5,689 |
| 2003 | 243.0 | 1,354 | 5.6 | 2.76 | 2.92 | 3,742 | 3,955 |
| 2004 | 260.0 | 1,531 | 5.9 | 2.13 | 2.24 | 3,257 | 3,437 |
| 2005 | 267.5 | 878 | 3.3 | 1.92 | 2.07 | 1,683 | 1,817 |
| 2006 | 264.6 | 909 | 3.4 | 2.29 | 2.41 | 2,079 | 2,190 |
| 2007 | 267.5 | 746 | 2.8 | 2.77 | 2.93 | 2,068 | 2,186 |
| 2008 | 264.6 | 963 | 3.6 | 1.99 | 2.15 | 1,916 | 2,072 |
| 2009 | 265.9 | 1,221 | 4.6 | 2.24 | 3.23 | 2,737 | 3,944 |
| 2010 | 268.2 | 1,440 | 5.4 | 2.55 | 2.71 | 3,671 | 3,905 |
| 2011 | 287.7[a] | 1,846 | 6.4 | 2.63 | 3.93 | 4,852 | 7,247 |
| 2012 | 276.7[a] | 1,787 | 6.5 | 2.90 | 3.02 | 5,187 | 5,391 |
| 2013 | 267.9[a] | 995 | 3.7 | 4.01 | 4.93 | 3,994 | 4,905 |

[a] *excludes random sites where redds were not observed*

Table 4. Total number of redds and carcasses observed during spring Chinook salmon spawning surveys in the John Day River basin, 2013.

| Stream Name | Redds (n) | | | Carcasses (n) | | |
|---|---|---|---|---|---|---|
| | **Census** | **Index** | **Random** | **Wild** | **Hatchery** | **Unknown** |
| Mainstem John Day | | | | | | |
| Deardorff Creek | 1 | | | 2 | | |
| Mainstem John Day River | 135 | 243 | | 231 | 4 | 10 |
| Reynolds Creek | 9 | | | | | |
| Middle Fork John Day | | | | | | |
| Bridge Creek | | | | | | |
| Clear Creek | 2 | | | 1 | | |
| Middle Fork John Day River | 30 | 81 | | 249 | 1 | 25 |
| North Fork John Day | | | | | | |
| Baldy Creek | 1 | | | | | |
| Bull Run Creek | 3 | 4 | | 3 | | 2 |
| Clear Creek | 22 | 15 | | 37 | | 1 |
| Desolation Creek | 44 | | | 25 | 2 | 2 |
| Granite Creek | 16 | 37 | | 76 | | 1 |
| North Fork John Day River | 178 | 174 | | 178 | | 21 |
| **Total** | **441** | **554** | **0** | **802** | **7** | **62** |

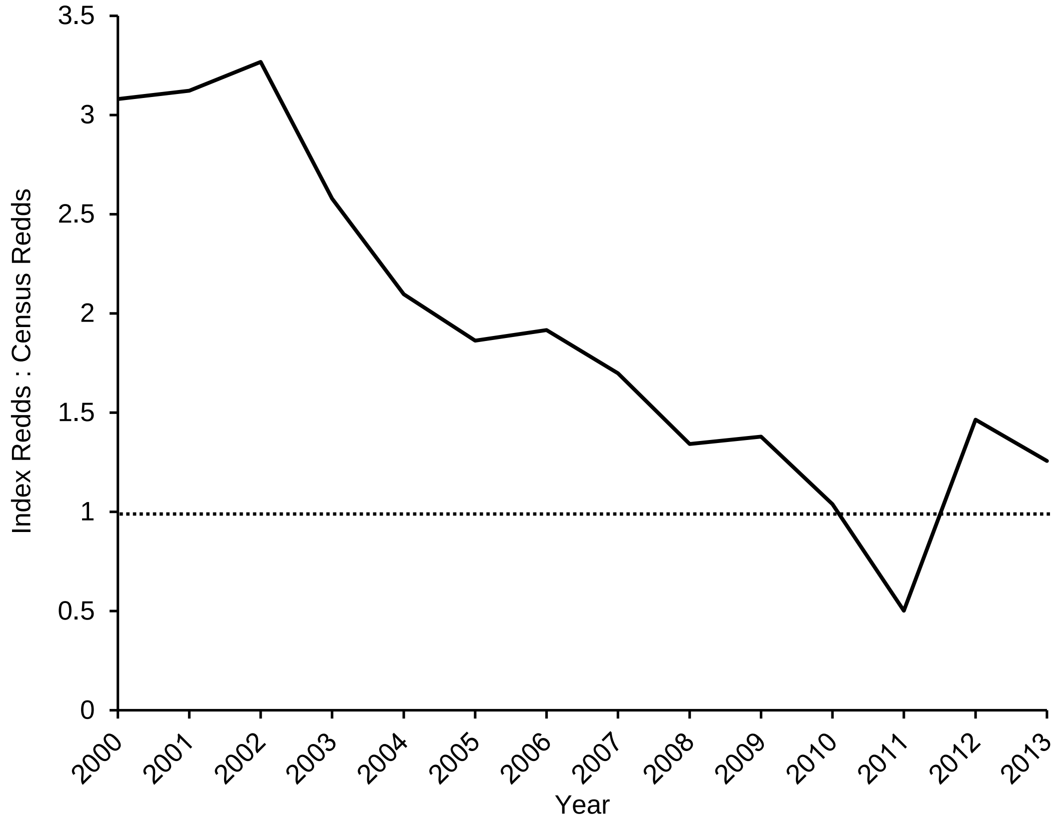


Figure 5. Ratio of index to census redd count totals from 2000–2013 for the John Day River basin. The dotted line indicates a ratio of 1:1 between the number of index redds and the number of census redds.

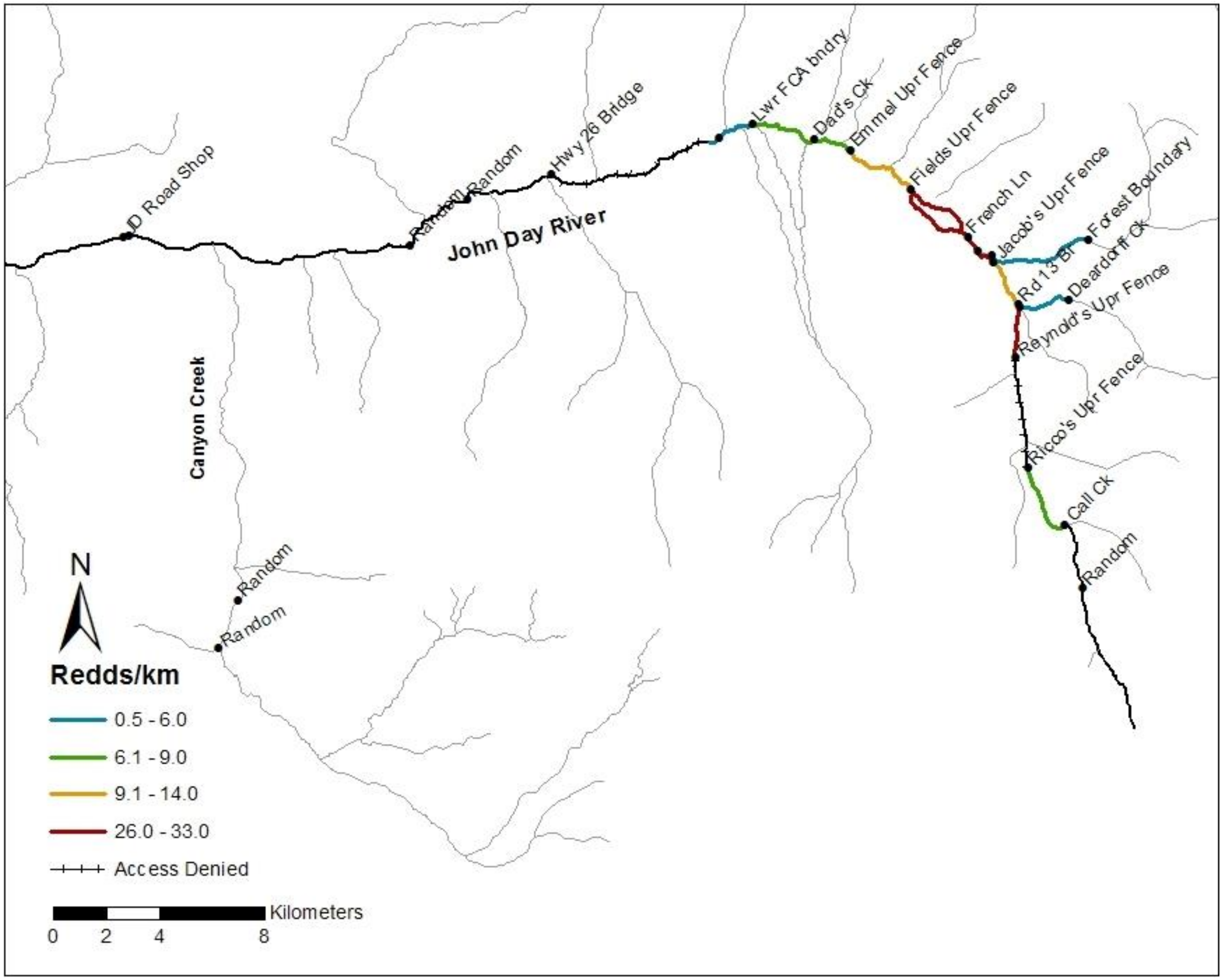


Figure 6. 2013 spring Chinook spawning survey sites and redd densities in the Mainstem John Day River.

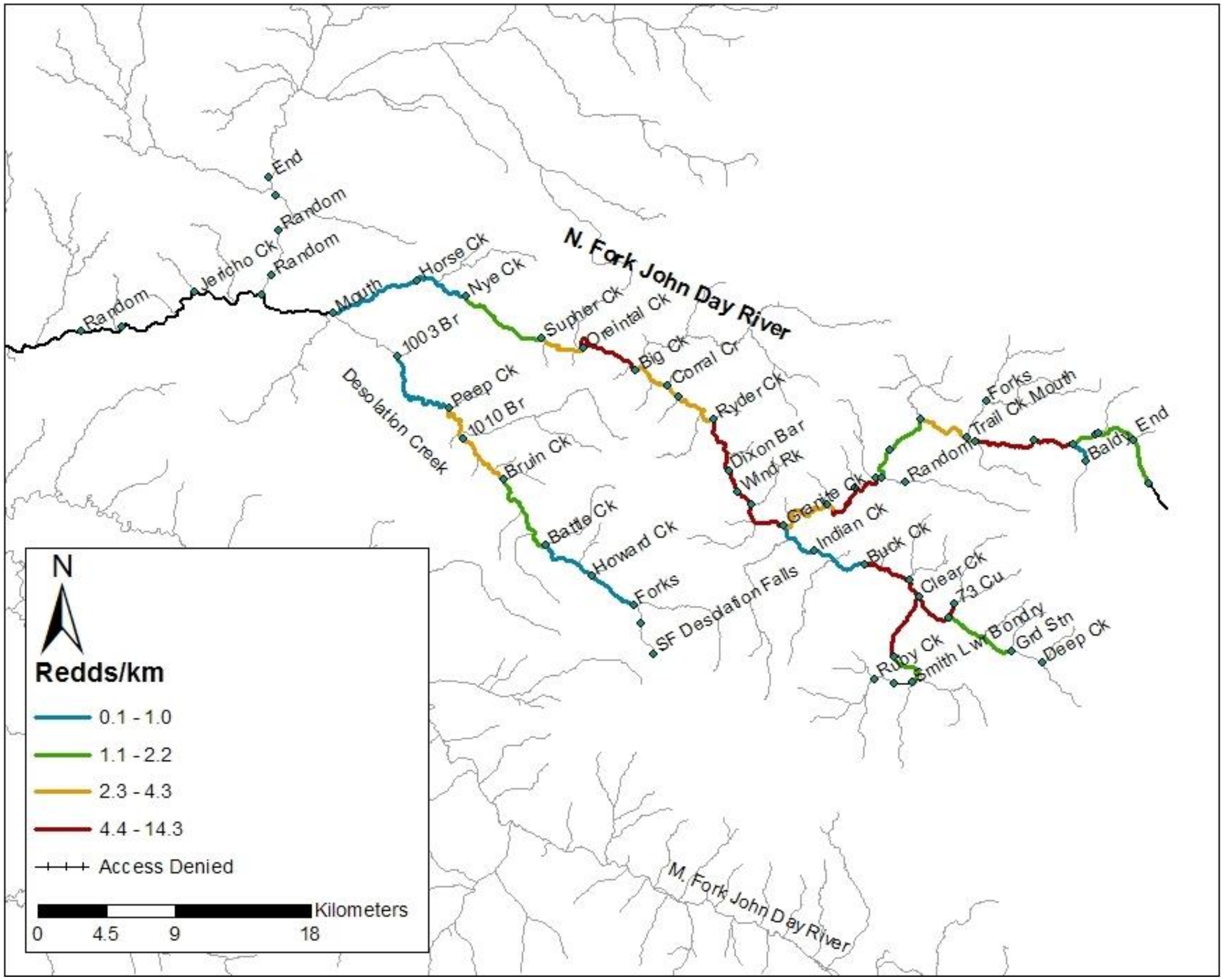


Figure 7. 2013 spring Chinook spawning survey sites and redd densities in the North Fork John Day River.

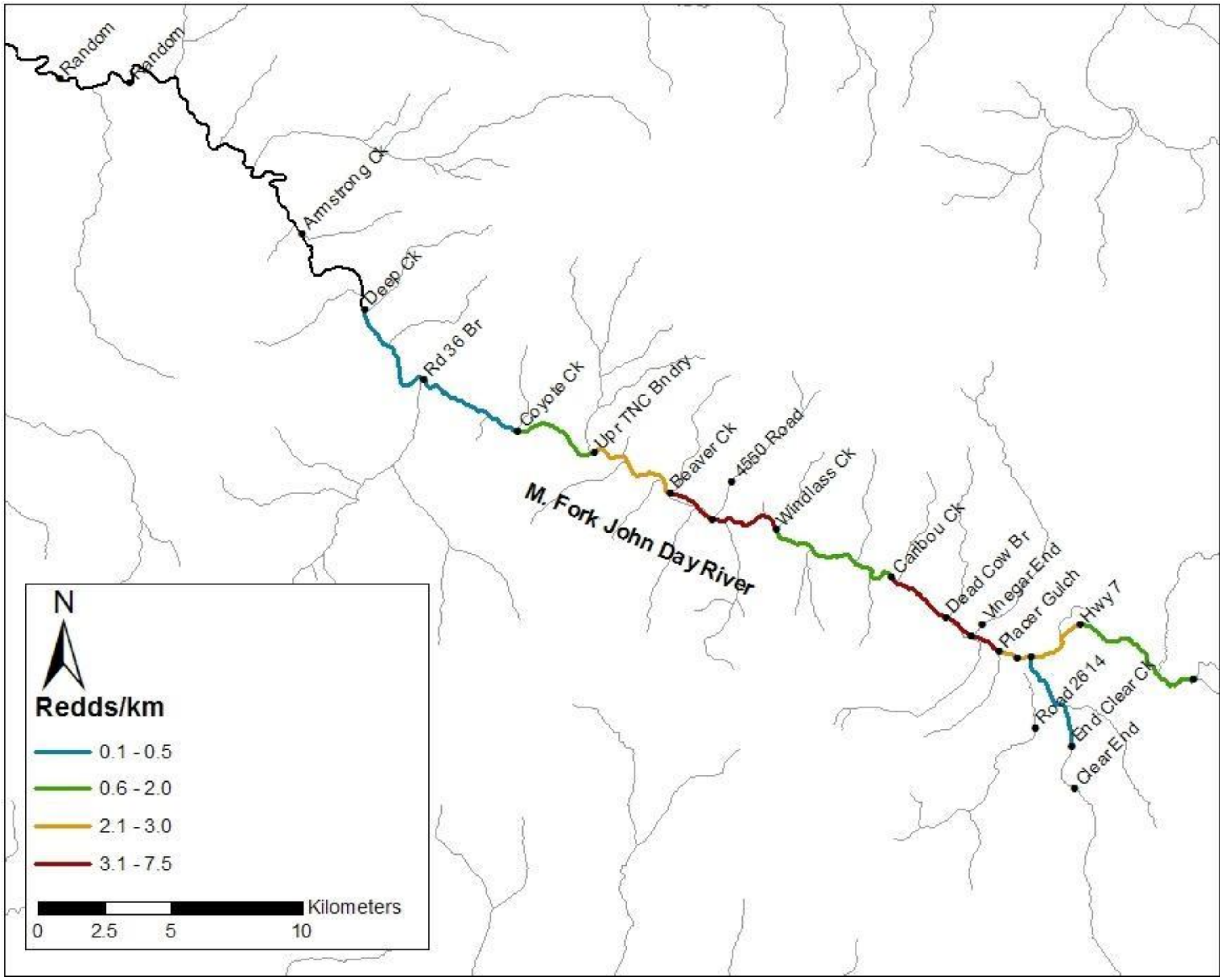


Figure 8. 2013 spring Chinook spawning survey sites and redd densities in the Middle Fork John Day River.

We found significant correlations between index and total redds (total = index + census + random) for all three John Day populations (Mainstem $r = 0.93$, $P < 0.01$, Middle Fork $r = 0.96$, $P < 0.01$, and North Fork $r = 0.95$, $P < 0.01$; Figure 9). Plotting the residuals against mean daily discharge in August for the John Day River at Service Creek (rkm 252) suggests discharge may influence redd distribution, particularly in the Mainstem and North Fork populations (Figure 9). We also found a significant correlation between basinwide total and index counts for 2000 to 2012 ($r = 0.80$, $P < 0.01$). Applying the regression equation between index and total redd counts for survey years 2000–2012 to the 2013 index count predicted a total redd count of 1,119. This prediction overestimated the actual total redd count by 12%.

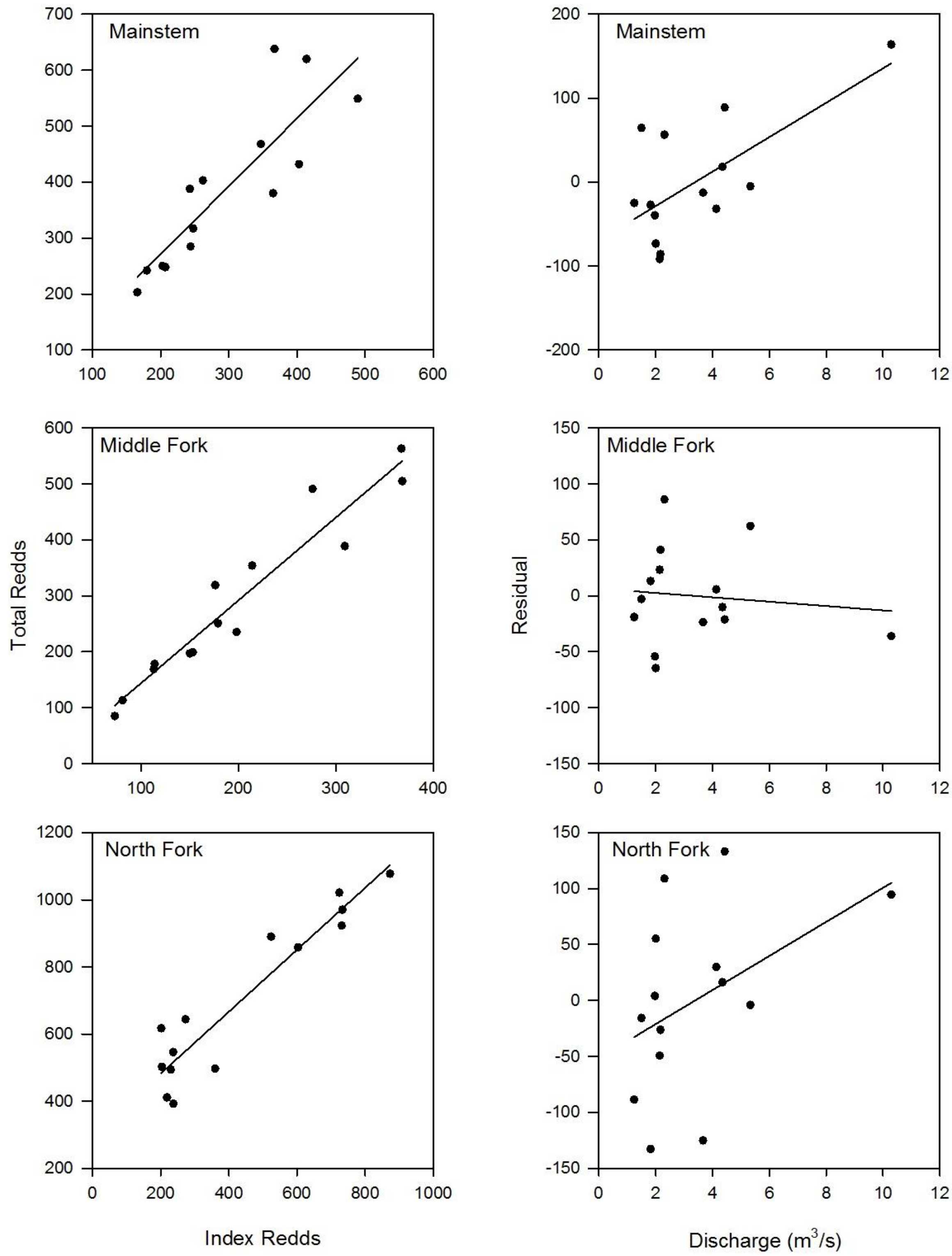


Figure 9. Regression between index and total redd counts from 2000–2013 spawning ground surveys and the residuals from these regressions plotted against August discharge of the John Day River for spawning populations in the Mainstem, Middle Fork, and North Fork of the John Day River.

**Redd Count Expansion Escapement Estimation**

The 4.93 fish per redd ratio generated from Catherine Creek spawning surveys in 2013 is the highest since the monitoring began; 76% higher than the mean jacks and adults per redd observed from 2000 through 2012. Applying the ratio to the John Day River basin, we estimated an escapement of 4,905 spring Chinook spawners in the John Day River basin for 2013 (Table 3). We estimated 1,913 fish spawned in the Mainstem, 557 spawned in the Middle Fork, and 2,435 spawned in the North Fork.

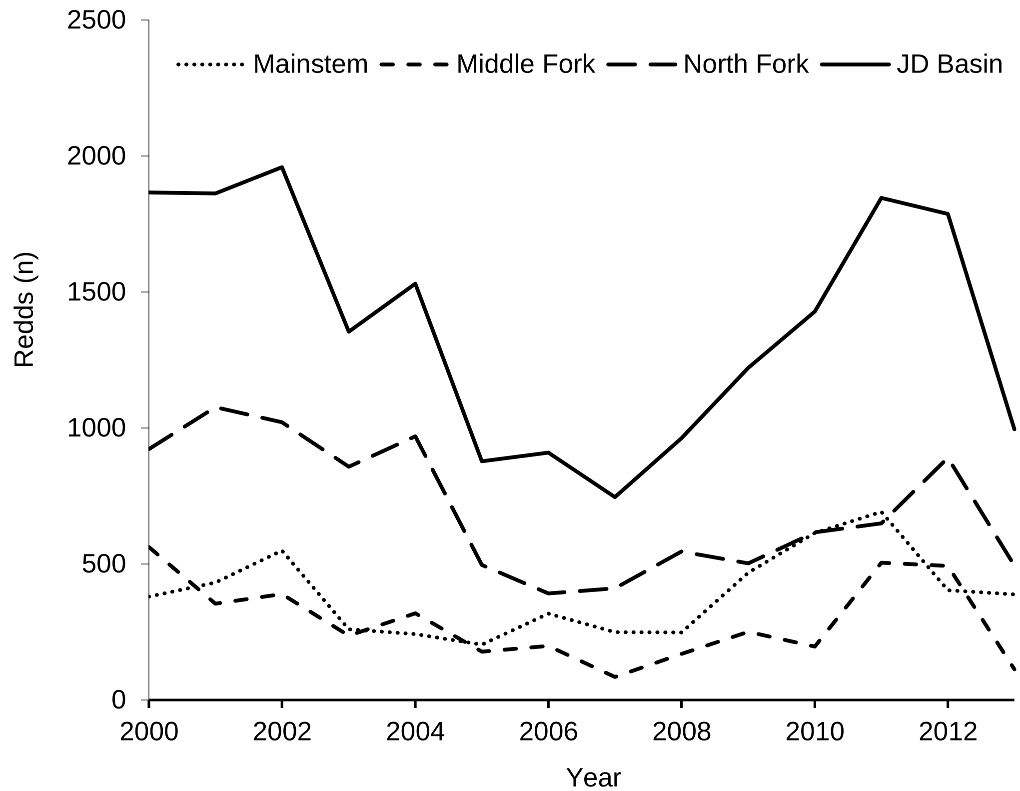


Figure 10. Redd totals from 2000–2013 for three John Day River basin spring Chinook salmon populations and the basinwide total.

Redd abundance at the John Day River basin scale during 2013 was nearly half that of 2012 (Figure 10). At the population scale, the Mainstem population showed a 4% decline, the North Fork dropped 45%, and the Middle Fork dropped the most with 77% fewer redds in 2013 than we observed in 2012. Redd counts in other northeast Oregon river basins (e.g., Grande Ronde and Imnaha) also decreased in 2013 (Figure 11); Grande Ronde River basin redd counts dropped 61% and Imnaha River basin redds declined 38% from 2012 to 2013. Annual Middle Fork and North Fork redd counts are significantly correlated with each other (Table 5), however, the Mainstem is not significantly correlated with either the Middle Fork or North Fork. Redd counts for the Mainstem were significantly correlated to both Grande Ronde and Imnaha river populations, however, the Middle Fork and North Fork were not correlated with either the Grande

Ronde or Imnaha basins (Table 5, Appendix Table VII). Redd counts for every population except the Middle Fork were either significantly or suggestively correlated with PDO values during the summer two years prior to the redd count (Table 5, Figure 12). Much of the unexplained variation (residuals) in the linear regression of Middle Fork redd count versus PDO can be explained through a negative linear relationship with stream temperature ($r = -0.720$; $P = 0.07$) (Figure 13).

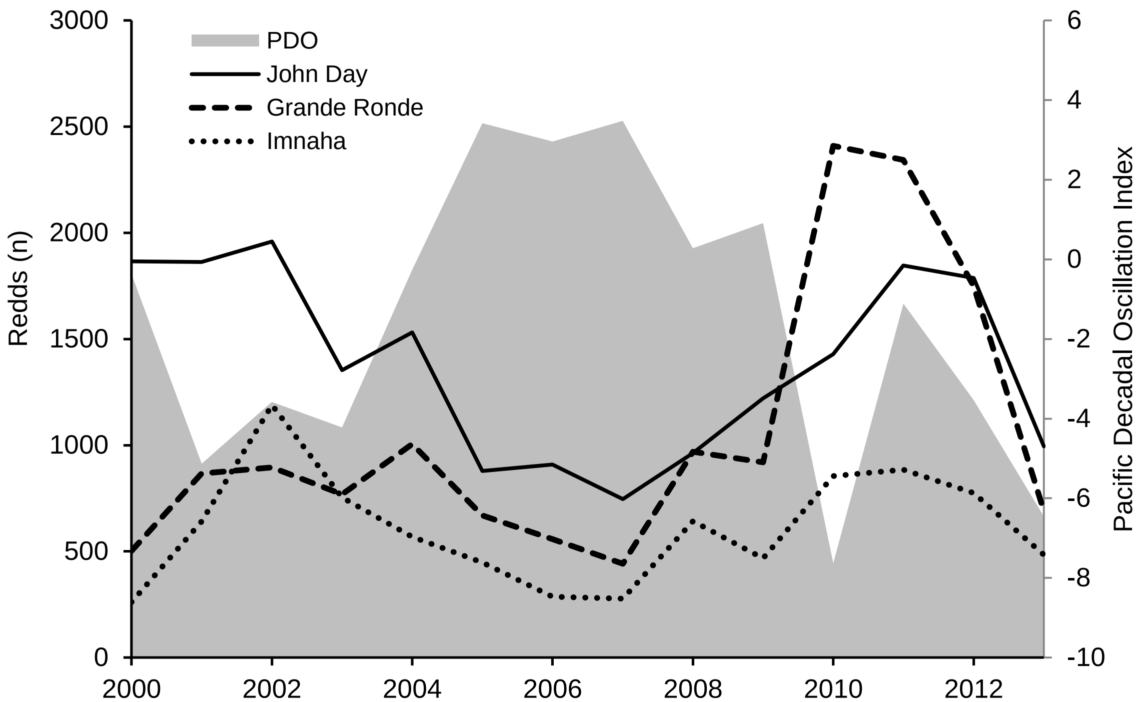


Figure 11. Redd totals from 2000–2013 for the John Day, Grande Ronde, and Imnaha river basins plotted with summer values of the Pacific decadal oscillation index. Pacific decadal oscillation index values are for the summer of entry for age-4 Chinook.

Table 5. Matrix of correlation coefficients (Pearson's r) between Mainstem John Day, Middle Fork John Day, North Fork John Day, Imnaha, and Grande Ronde rivers Chinook redd counts from 2000–2013 and Pacific Decadal Oscillation (PDO) values observed during the summer two years prior to the redd count year (Imnaha and Grande Ronde data provided by J. Feldhaus, ODFW). Significant correlations (P < 0.05) are indicated in bold, nearly significant (P < 0.10) are indicated by italics.

| | Middle Fork Redd Count | North Fork Redd Count | Grande Ronde Redd Count | Imnaha Redd Count | Summer Entry PDO |
|---|---|---|---|---|---|
| Mainstem Redd Count | *0.46* | 0.17 | **0.73** | **0.59** | *-0.50* |
| Middle Fork Redd Count | - | **0.68** | 0.33 | 0.31 | -0.16 |
| North Fork Redd Count | - | - | 0.09 | *0.49* | *-0.46* |
| Grande Ronde Redd Count | - | - | - | **0.61** | *-0.46* |
| Imnaha Redd Count | - | - | - | - | **-0.59** |

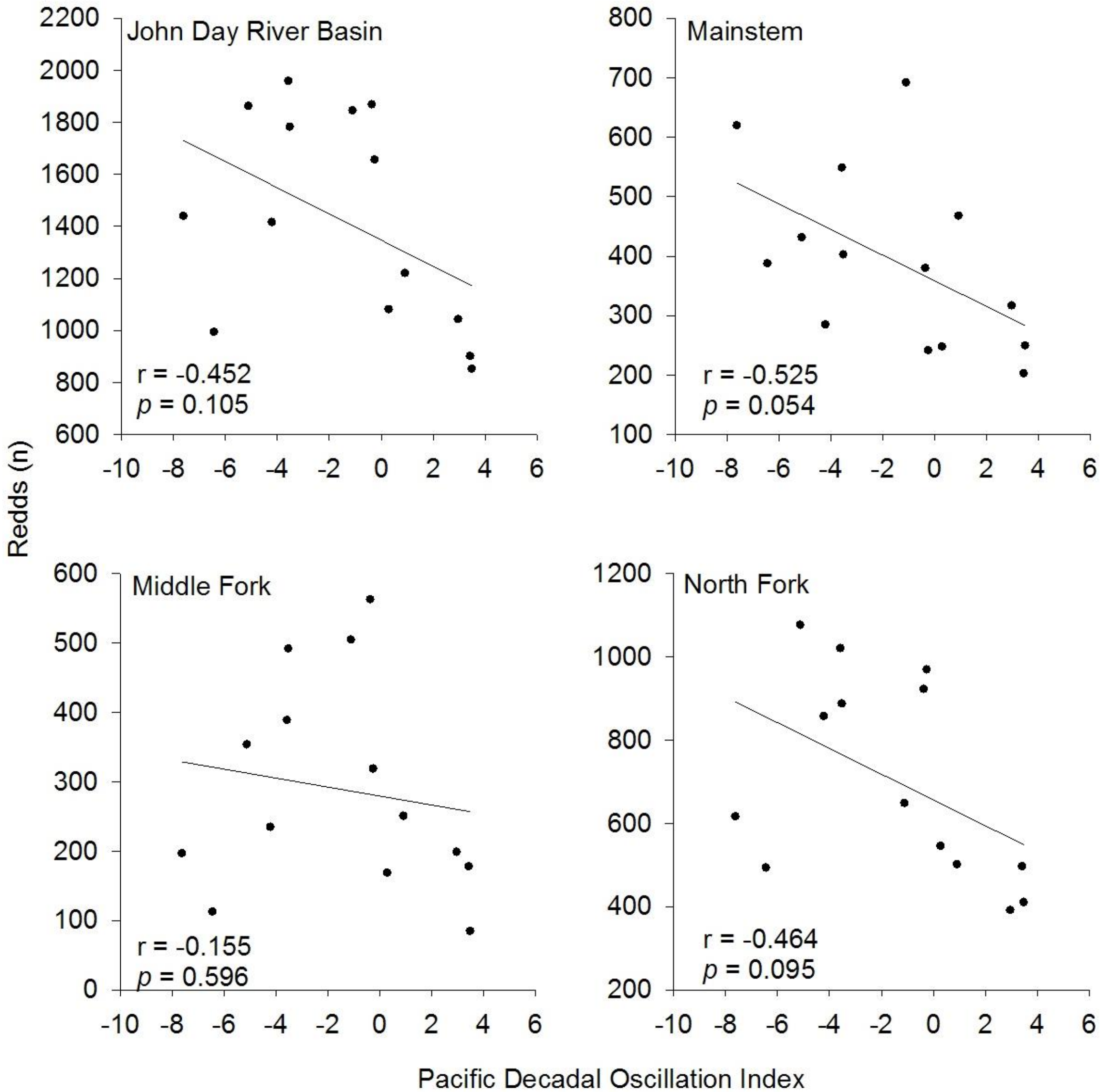


Figure 12. Correlation between Pacific Decadal Oscillation values and total redd counts from 2000 to 2013 spawning ground surveys in the Mainstem, Middle Fork, and North Fork of the John Day River.

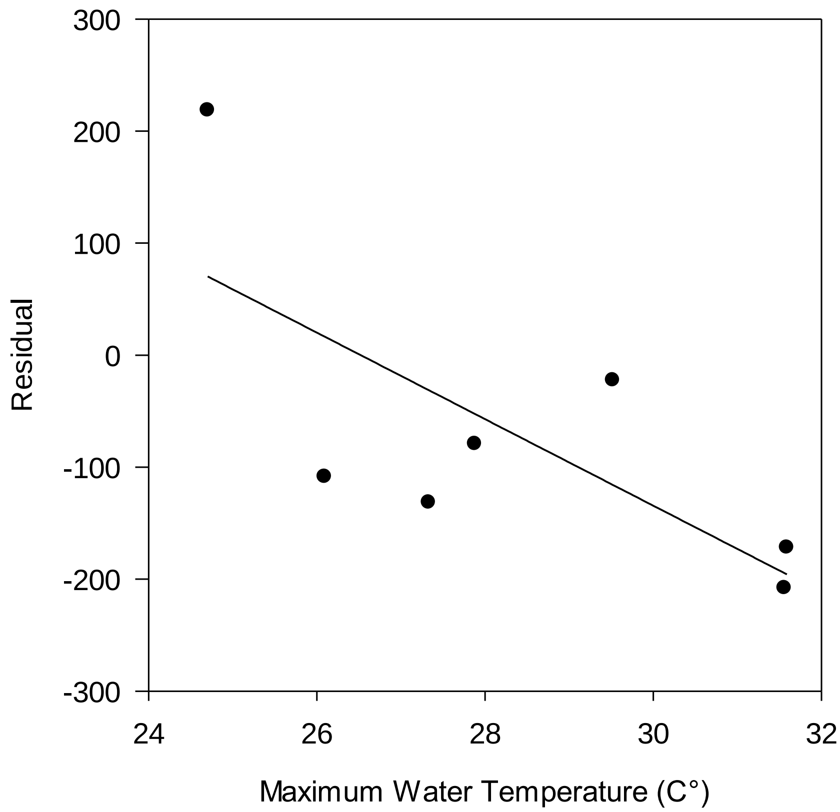


Figure 13. Correlation between the residuals from a linear regression of Middle Fork redd counts versus Pacific Decadal Oscillation values and maximum water temperature during July 1 through Aug 10 of 2005–2013 (excluding 2006 and 2012) in the Middle Fork John Day River.

**Carcass Recovery**

In 2013, we recovered 818 carcasses throughout the John Day River basin (Table 6). We were able to determine origin of 763 carcasses. Of the 7 fish that had clipped adipose fins, four were recovered in the Mainstem, one in the Middle Fork, and two in the North Fork population. The proportion of adipose-clipped carcasses observed in 2013 (0.9%) was within the range reported since 1998, which has ranged from a low of <1% in 1998 to a high of 5% in 2007. We did not detect a significant difference in the presence of hatchery fish among populations ($X^2_2 = 0.304$). We did not recover any CWTs from the snouts of hatchery fish. We determined the sex of 719 carcasses, 403 (56.1%) were males and 316 (43.9%) were females. We determined age for 527 carcasses using scale pattern analysis. There was a total of 87 age-3 (16.5%), 324 age-4 (61.5%), and 116 age-5 (22%) fish (Figure 14; Tables 6 and 7). Six of the age-3 Chinook carcasses recovered were female. One adult Chinook was tentatively identified as a sub-yearling smolt during their freshwater rearing phase. The remainder of the non-regenerated scales indicated a yearling smolt life history pattern. Laboratory analysis of 82 kidney samples to determine Rs antigen levels revealed 12 samples were negative or very low (BKD infection was not detected), 66 samples were low positive (it was not a factor in death, fish did not have BKD), and a single Age-4 wild post-spawn female in the Mainstem population had a high positive (gross signs of BKD are rare, it could have been a factor in death) (Appendix Table VIII). Of the 171 female carcasses for which we estimated egg retention, 125 (73%) were completely spawned. The 46 females that were partially spawned contained an average of 422 ml (SD = 340) of eggs.

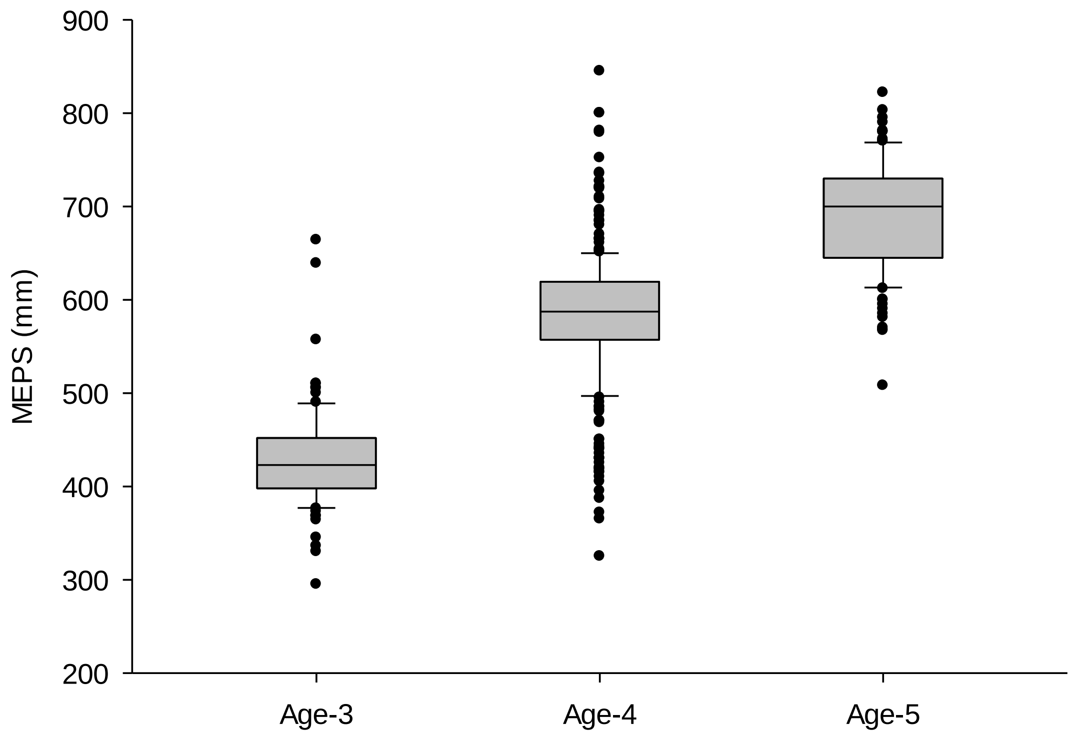


Figure 14. Age versus MEPS length for Chinook carcasses recovered in 2013 (n = 530). Boxes indicate 25th percentile, median, and 75th percentile. Error bars indicate 10th and 90th percentiles.

Table 6. Age, mean MEPS length (mm), standard error (SE), sample size (n), range (mm), and percentage of total known-sex aged Chinook from 2013 carcass recovery.

| | Male | | | | | Female | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age** | **Length (mm)** | **SE** | **n** | **Range (mm)** | **%** | **Length (mm)** | **SE** | **n** | **Range (mm)** | **%** |
| 3 | 423.8 | 5.5 | 81 | 295–639 | 15% | 486.5 | 38.7 | 6 | 405–664 | 1% |
| 4 | 579.9 | 6.5 | 171 | 325–845 | 32% | 588.5 | 3.9 | 153 | 442–779 | 28% |
| 5 | 717.5 | 10.7 | 32 | 612–822 | 6% | 682.5 | 6.1 | 84 | 508–780 | 16% |

Table 7. Percentage of known-sex aged Chinook carcasses by population for 2013.

| | | % Males by Age | | | | % Females by Age | | |
|---|---|---|---|---|---|---|---|---|
| | **n** | **3** | **4** | **5** | **n** | **3** | **4** | **5** |
| Mainstem | 67 | 46.3 | 52.2 | 1.5 | 62 | 8.1 | 79.0 | 12.9 |
| Middle Fork | 98 | 23.5 | 62.2 | 14.3 | 63 | 1.6 | 65.1 | 33.3 |
| North Fork | 119 | 22.7 | 63.0 | 14.3 | 118 | 0.0 | 53.4 | 46.6 |
| **Basin Total** | 284 | 28.5 | 60.2 | 11.3 | 243 | 2.5 | 63.0 | 34.6 |

### PIT Tag Detection-Recapture Escapement Estimation

A total of 769 carcasses, including those that had been scavenged, were scanned for PIT tags during the spawning ground surveys and 15 tags were recovered (Table 8). Three PIT-tagged carcasses were female and 12 were male, all of them were of wild origin. Two carcasses originally tagged as juveniles in the Middle Fork were recovered in the Middle Fork, two carcasses were tagged as juveniles and recovered in the Upper Mainstem, and two fish tagged as juveniles in the lower Mainstem John Day River (below the confluence with the North Fork) were recovered separately in the Middle Fork and North Fork subbasins. Seven fish were tagged as adults during April and May of 2013 at the adult fish facility of Bonneville Dam (rkm 234). A recapture in the Middle Fork was tagged at the juvenile bypass of the John Day Dam (rkm 347) in May of 2010. Another fish was tagged in the Snake River at Lower Granite Dam (rkm 522.173) with subsequent barge transportation from the facility in April of 2011 and was recovered in the Middle Fork.

Table 8. Spring Chinook passive integrated transponder (PIT) tags recovered on John Day River spawning ground surveys during 2009–2013. U = unknown sex.

| | Intact Wild Carcasses Scanned | | | Carcasses with John Day Origin PIT Tags[b] | | | Carcasses with Out of Basin Origin PIT Tags | | |
|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Male** | **Female** | **U** | **Male** | **Female** | **U** | **Male** | **Female** | **U** |
| 2009 | 114 | 137 | 2 | 3 | 1 | 0 | 1 | 0 | 0 |
| 2010 | 259 | 233 | 24 | 7 | 0 | 1 | 3 | 1 | 0 |
| 2011 | 746 | 759 | 42 | 31 | 4 | 0 | 6 | 5 | 0 |
| 2012 | 228 | 318 | 619 | 8 | 1 | 5 | 3 | 6 | 5 |
| 2013 | 319 | 245 | 4 | 6 | 0 | 0 | 6 | 3 | 0 |

[b] *Only includes PIT-tagged individuals that were detected at Bonneville Dam*

Detections at Bonneville Dam indicated that 70 John Day origin PIT-tagged Chinook passed the dam in 2013. Spawning surveys scanned a total of 568 intact wild origin carcasses (Table 8). We recaptured five John Day basin origin males and were unable to detect a PIT tag in any of the female carcasses. We estimated the number of recaptured John Day origin PIT-tagged females to be four, producing a total of 9 recaptured adults. Estimated wild spawner abundance was 4,039 (95% CI: 1,846−6,232) (Figure 15).

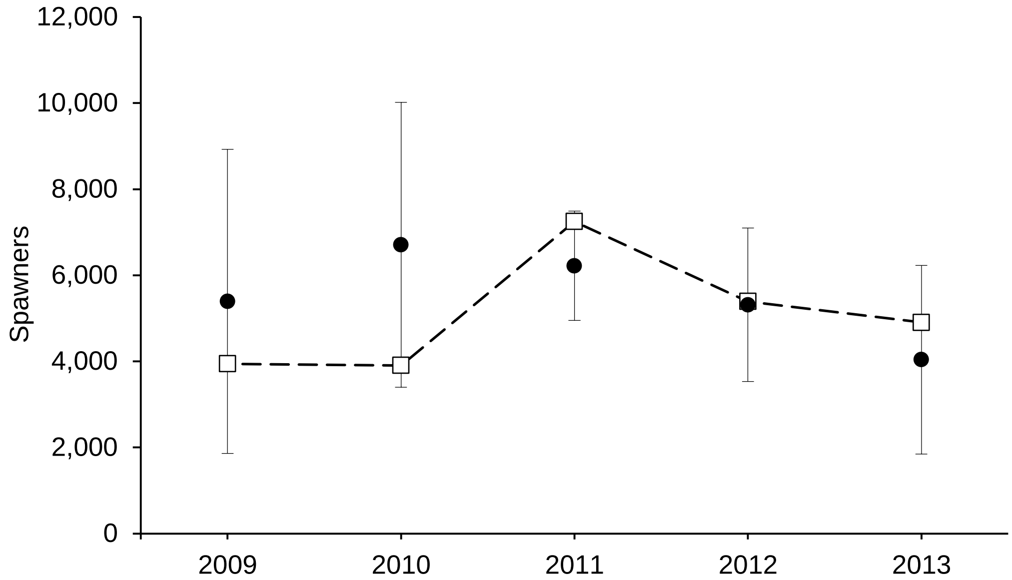


Figure 15. Mark-recapture abundance estimates (black circles) with 95% confidence intervals and redd count escapement estimates (white squares) for spawning years 2009–2013.

**Carcass Detection Probabilities**

We marked 163 carcasses with uniquely numbered cable-ties. We recovered 58 of these marked carcasses on subsequent surveys. The probability of a marked carcass being recovered was 0.43 in the Middle Fork, 0.32 in the North Fork and 0.24 in the Mainstem. Information theoretic selection of four candidate logistic regression models (Table 9) indicated that the intercept model (a null model with no explanatory variables) and population model were competing models (Delta AICc < 2). Models incorporating size, or size in combination with population, did not fit the data as well as the population and null models (Table 9).

Table 9. Akaike's information criterion (AICc) model selection results for binomial logistic regressions of marked carcass recoveries versus different explanatory variables. Explanatory variables included: population and size. The intercept model is a null model with no explanatory variables.

| Model | K | $AIC_c$ | $\Delta AIC_c$ |
|---|---|---|---|
| Intercept | 1 | 34.91 | 0.00 |
| Population | 3 | 35.77 | 0.86 |
| Size | 3 | 38.57 | 3.67 |
| Size + Population | 5 | 39.64 | 4.73 |

**Pre-spawning Mortality Monitoring**

Lower than average discharge and a sudden rise in air temperature caused the water temperature in the Middle Fork to increase suddenly and remain elevated for several days (Figure 16). The stressful conditions resulted in pre-spawning mortality for some of the Middle Fork salmon. On July 3, survey crews walked approximately 37 km of the Middle Fork, observed 113 live fish, and physically recovered 82 carcasses. After expanding for carcasses that were not detected by surveyors, we estimated that183 Chinook salmon died on or before July 3. Based on the number of PIT tagged fish detected (i.e., marked) passing the array ($M$ = 25) and the ratio of captured:marked carcasses recovered ($C$ = 70, $R$ = 5), we estimated in July that 307 Chinook (95% C.I.: 115−498) were present upstream of the Middle Fork PIT array. The post-spawning estimate in October, which utilized pre- as well as post-spawning data, increased the estimate to 460 fish (95% C.I.: 247−674) ($M$ =28, $C$ = 158, $R$=9).

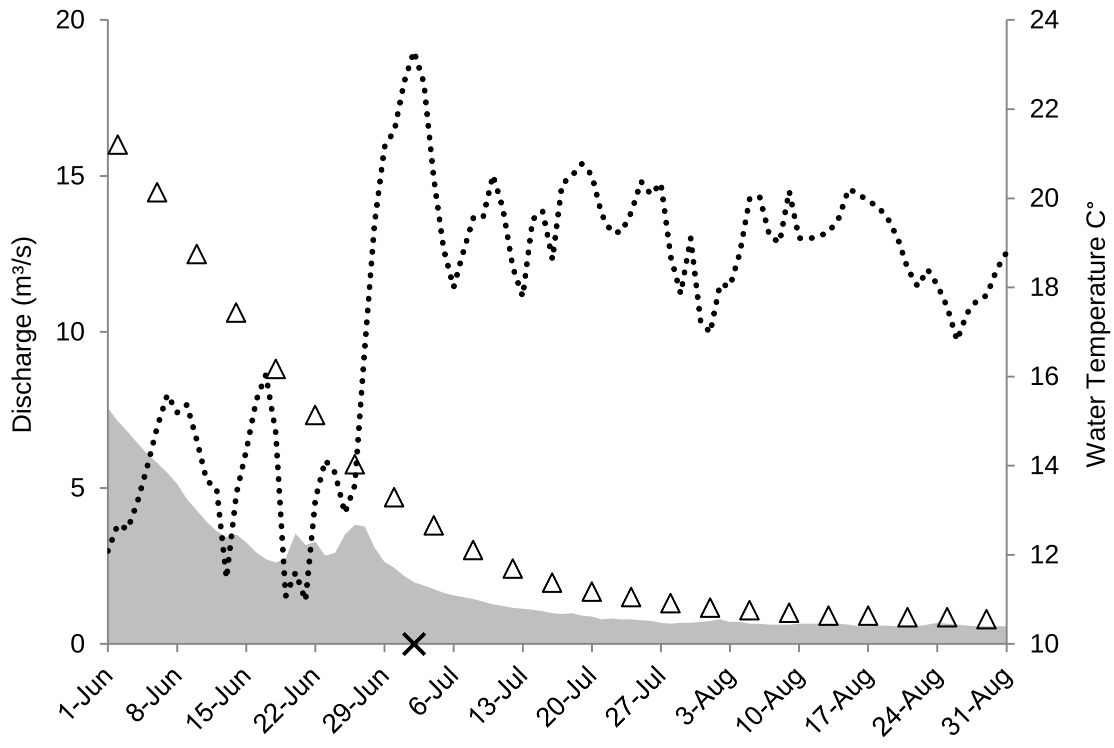


Figure 16. Middle Fork John Day River discharge ($m^3/s$) in solid gray, with 84-year average daily stream flow (open triangles) for June through August and corresponding daily mean water temperature during 2013 (dotted line). The fish kill, believed to occur on July 2, is indicated by the “X” on the x-axis.

**Population Productivity Analyses**

We estimated that freshwater productivity for the 2011 brood year was 90 smolts per redd (95% CI: 79–101) in the Mainstem and 63 smolts per redd (95% CI: 58−71) in the Middle Fork. The estimated number of smolts produced per redd declined with increasing redd abundance for both the Mainstem and Middle Fork populations (Figures 17 and 18).

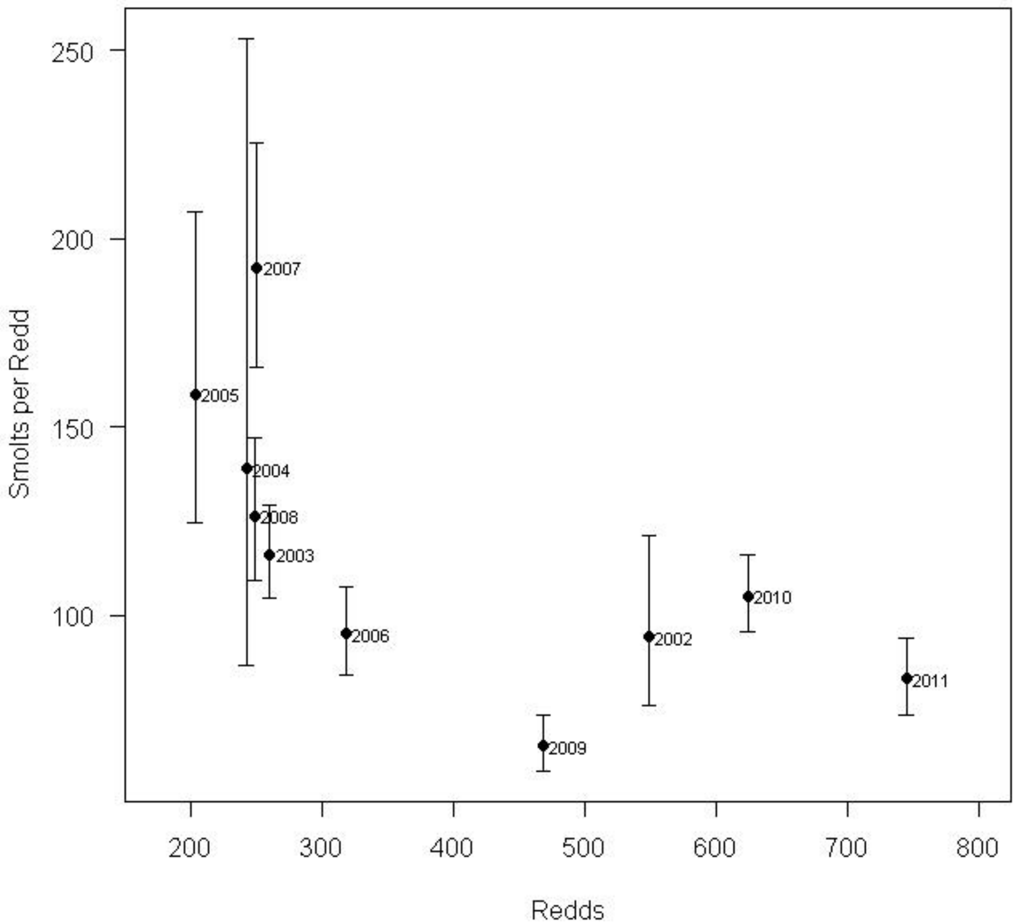


Figure 17. Estimated yearling spring Chinook salmon smolts produced per redd for brood years 2002 through 2011 for the Mainstem John Day population. Error bars are 95% Confidence Intervals.

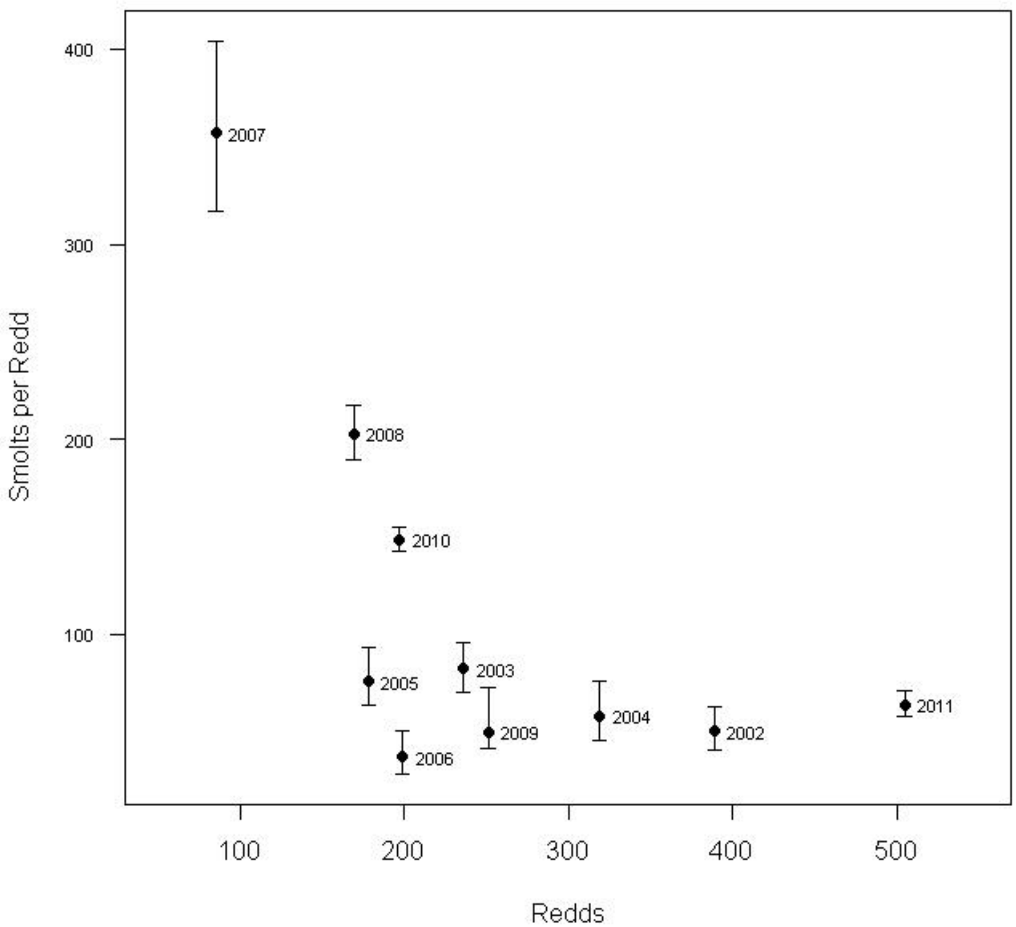


Figure 18. Estimated yearling spring Chinook salmon smolts produced per redd for brood years 2002 through 2011 for the Middle Fork John Day population. Error bars are 95% Confidence Intervals.

Stock-recruitment analysis for the Mainstem population suggests a replacement level (unexploited equilibrium) of 350 redds. Maximum sustained production for the Mainstem population occurs at 230 redds (Figure 19a). The Middle Fork population appears to have a replacement level of 250 redds and maximum sustained production for the Middle Fork is achieved at 243 redds (Figure 19c). Replacement level for the North Fork population is 560 redds. Unlike the Mainstem and Middle Fork populations, maximum sustained production for the North Fork population is currently estimated to occur at an escapement of 730 redds, which is greater than the replacement level for this population (Figure 19e).

Plots of residuals from the stock-recruitment regressions suggest an upward trend for the Mainstem population. Four of the first five brood years for the Mainstem had negative residuals. Conversely, the most recent four brood years had positive residuals (Figure 19b). Residuals for the Middle Fork (Figure 19d) and North Fork (Figure 19f) do not appear to share this pattern. Residuals for both of these populations appear symmetrically distributed about zero, with no discernible trend over time.

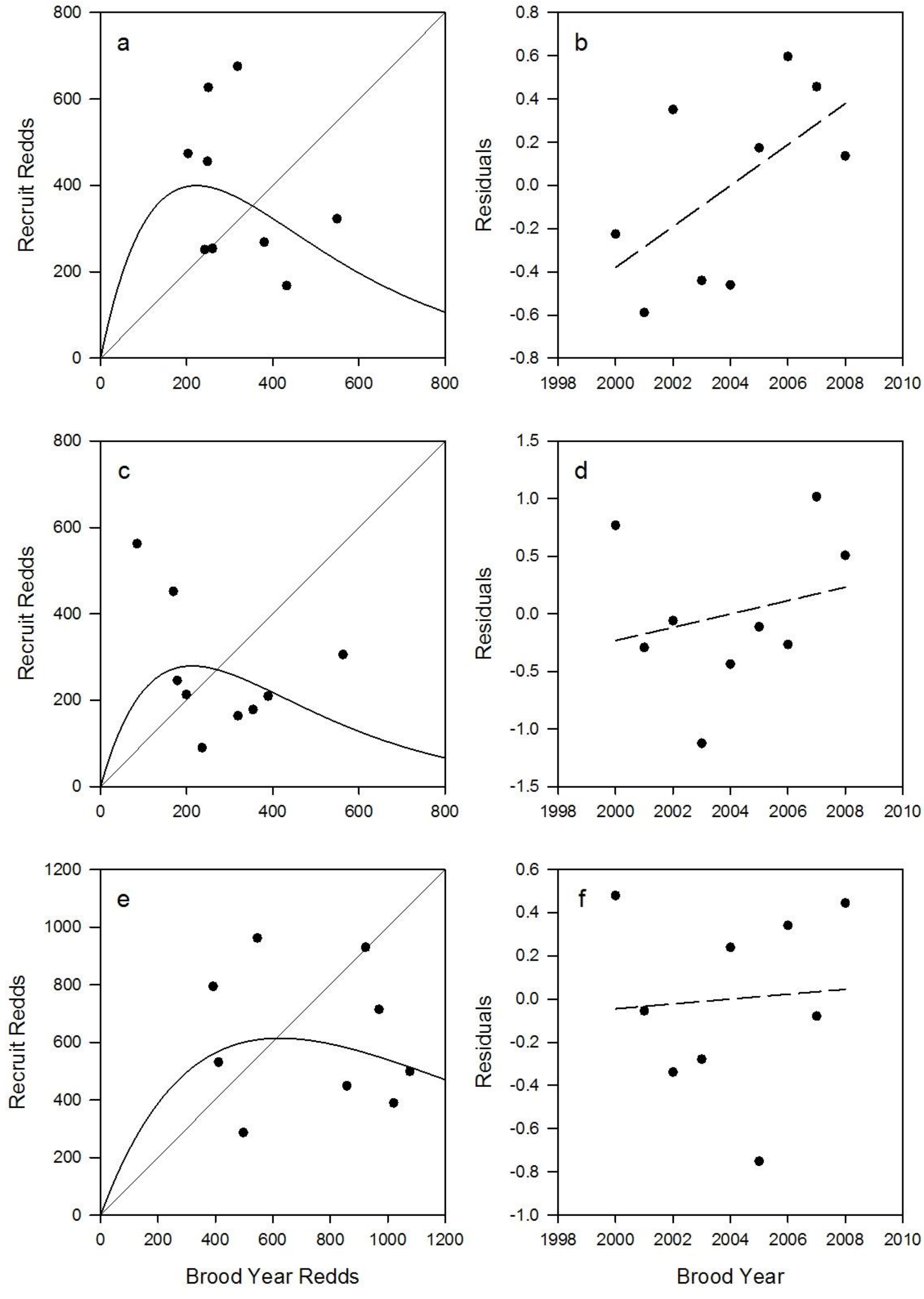


Figure 19. Comparison of Ricker stock-recruitment curves for 2000 through 2008 brood years and associated residual versus brood year plots for Chinook spawning populations in the Mainstem (a and b), Middle Fork (c and d), and North Fork (e and f) of the John Day River. Diagonal lines in panels a, c, and e are 1:1 replacement lines. Dashed lines in panels b, d, and f are linear regression lines fit to the residuals to illustrate trends over time.

## DISCUSSION

### Status of John Day River Spring Chinook Salmon

Adult Chinook abundance estimates for the John Day River basin declined substantially from 2012 to 2013. This may be partially attributable to below average saltwater survival. During migration year 2011, the most recent year for which we are able to estimate smolt to adult ratio (SAR), we observed the lowest SAR of the monitoring period for Chinook (Banks et al., 2013). Middle Fork and North Fork escapement experienced large declines, dropping to some of the lowest levels observed since 2000. In contrast to this decrease, Mainstem redd counts only dropped 4% from redd counts observed in 2012. In addition to 2013 producing the lowest number of spring Chinook returns to Bonneville Dam in the past five years, the Middle Fork population experienced a pre-spawn mortality event resulting from a rapid increase in stream temperature in early July.

The Middle Fork post-spawning mark-recapture estimate of 460 Chinook, which incorporated captures and recaptures from both pre- and post-spawning survey data, provides the best estimation of what escapement was prior to pre-spawning mortality. During July, we estimated a pre-spawning mortality total of 183 Chinook (i.e., 40% mortality). However, using the detection probability values from September spawning ground surveys may overestimate mortality. In July, pre-spawning fish died recently (i.e., within one or two days of surveying) and the probability of detection may have been higher because scavenger opportunity and carcass decomposition were limited. Using the 13-year mean fish per redd value (2.80) from Catherine Creek data, Middle Fork spawner escapement during 2013 would be 316 spawners. This estimate suggests 144 Chinook salmon (31% of the salmon present in the Middle Fork during summer 2013) died prior to spawning in 2013. Our best post-season estimation is that 31% of adult Chinook salmon died prior to spawning in the Middle Fork John Day during 2013. In future years we will improve our pre-spawning mortality estimates through more precise estimation of July carcass recovery probability.

The 2013 Middle Fork fish kill was not the first adult Chinook mortality event associated with warm temperatures observed in recent years. In 2007, similar hot air temperatures and low water levels simultaneously occurred during early July on the Middle Fork, and we observed 118 Chinook salmon carcasses. Further, it was estimated that 50% of the total adult Chinook that made it to the Middle Fork that year died during the hot weather experienced in early July. The events of 2007 and 2013 demonstrate that a combination of low stream flow and hot air temperatures during early July have the potential to kill over 25% of the adult Chinook salmon in the Middle Fork. These events are likely to be lethal for other fishes in these habitats as well. This evidence illustrates the importance of restoration actions that address both summer water flow and temperature.

John Day spring Chinook populations show trends in abundance similar to other northeast Oregon populations and appear to be affected by density-independent factors.

The large decreases in John Day redd counts in 2013 were mirrored by 61% and 37% declines in Grande Ronde and Imnaha basin redd counts, respectively. Covariation among redd counts in northeast Oregon populations suggests a large-scale environmental effect is occurring across these populations. Such ecological responses to large-scale changes in the physical environment are known to occur with Pacific salmon (Hare et al. 1999). Although, low ocean-entry PDO values associated with adults returning in 2013 predicted higher escapement numbers than were actually observed, significant and nearly significant inverse relationships between PDO values during the summer of smolt ocean-entry and adult returns to all but one northeast Oregon population suggest that ocean conditions may be a driving factor. The Middle Fork is the only population where redd count is not related to ocean conditions. We suggest that this relationship is obscured by inter-annually variable pre-spawn mortality which occurs at a greater magnitude in the Middle Fork than neighboring populations.

Despite the likely effect that ocean conditions have on redd abundance, trends in freshwater productivity provide a more appropriate measure of population status than simple adult abundance (e.g., Lawson 1993). Mainstem and Middle Fork smolts produced per redd decreased as the number of redds increased, indicating that juvenile rearing areas are fully seeded at recent escapement levels and rearing habitat may be limiting freshwater production. Stock-recruit analyses for the John Day populations illustrate the effect of density-dependence. The Mainstem stock-recruit curve shows the strongest density-dependent effect, production decreases rapidly once escapement exceeds 400 redds. Conversely, the curve for the North Fork indicates no immediate concern about decreased production at higher escapements. In the Mainstem population there is also a broad range of escapement which produced a positive sustainable yield and a large yield when brood redds approach 200. Average sustainable yield in the Middle Fork, however, is low and extends over a shorter range of brood year redds. In the North Fork, sustainable yield is roughly constant for a comparatively broader range of brood year redds.

A review of the residuals from the Mainstem stock recruitment curve suggests non-stationarity because a positive slope is apparent through the years (see Figure 15). The environment in the Mainstem may be changing to the benefit of Chinook productivity. Since this pattern is not reflected in the Middle and North Fork populations, it appears to be specific to the Mainstem environment. Spatial connectivity may explain the trends we see in productivity. Many habitat improvement projects have been completed in the upper Mainstem subbasin in recent years, which have increased fish passage and juvenile rearing habitat (J. Neal, ODFW, personal communication). Removing barriers and allowing juvenile and adult Chinook access to additional spawning and rearing habitat is an approach to increasing yearling smolt production through freshwater habitat restoration (Sharma and Hilborn 2001). Our data suggest that habitat actions in the upper Mainstem may be contributing to apparent increases in productivity.

Straying of adipose-clipped hatchery Chinook into the John Day River basin remains low; less than one percent of our recovered carcasses were adipose-clipped hatchery fish and we were unable to detect a statistically significant difference in hatchery carcass recoveries among the populations. Genetic analysis of carcasses recovered from 2004 to 2006 found the North Fork population had a higher rate of out-of-basin strays, both adipose-clipped and unmarked (identified as wild on spawning surveys), compared to the Mainstem or Middle Fork (Narum et al. 2008). Past recoveries of adipose-clipped carcasses, which have occurred more frequently in the North Fork population corroborate these results. Narum et al. (2008) also suggested that wild strays may be more prevalent than hatchery strays in the John Day River basin. Numerous wild Chinook juveniles in Snake and Upper Columbia River populations are marked with PIT tags, creating the possibility of redetection in the John Day River. Despite the high number of PIT tagged adults at large, we recovered only one Chinook that was PIT tagged as a juvenile outside the John Day River basin. We will place continued emphasis on scanning carcasses for PIT tags to improve our understanding of straying by wild Chinook.

**Survey Methodology**

Continuing to monitor index reaches allows us to see trends in redd abundance. Index reaches, however, were not chosen using a non-biased random process. Furthermore, index sites are based on redd distributions that were established five decades ago in reaches that may no longer provide the most suitable spawning habitat nor the highest redd densities. Although our census area has expanded over time, our analyses suggest spawner distribution shifts toward census reaches as run size increases, possibly resulting from competition for spawning gravel among adult females. Our data also suggest a greater percentage of fish utilize census areas during higher flow conditions. This may be the result of managers in the 1950's selecting index sites based on redd distribution during normal flow conditions, thereby excluding spawning reaches made available by above average discharge. Hence, our data indicate that index counts alone are not an accurate method for estimating escapement. Although it is necessary to continue monitoring index reaches to maintain long-term trend data, it is also necessary to monitor census sites to account for inter-annual variation in spawning distribution.

2013 was the second consecutive year that we conducted a carcass detection study. Similar to 2012 results, our carcass detection probability data indicate that carcasses were more readily recovered in the Middle Fork, nearly half of the carcasses were detected multiple times. Factors contributing to higher recovery probability in the Middle Fork may include: stream banks with sparse brush and shading, low stream flow, narrow stream width, limited undercut banks and large woody debris jams, and less evidence of scavenging. Our 2013 detection probability in the Mainstem increased by an order of magnitude from the previous year, although it remains lower than the probability observed in the Middle and North forks. Lower carcass detection in the Mainstem was perhaps due to the dense riparian cover, higher turbidity, log jams, undercut banks, and moderate amounts of scavenging. In the North Fork population, scavenging appears to be a major limitation to carcass recovery; fresh bear tracks and feces were abundant on streambanks within roadless reaches. While we were able to observe higher redd densities in wilderness sections of the North Fork, very few carcasses were available for inclusion in the study. Despite the limitations, marking and re-sighting carcasses throughout the spawning grounds improved our understanding of factors influencing carcass recovery probability. We intend to continue monitoring carcass detection probability with the unique marking scheme of numbered cable ties in place of operculum punches.

Mark-recovery data from PIT tags implanted into John Day River Chinook provided an independent alternative to estimating John Day River spawner abundance as the product of redd count and the out-of-basin fish per redd estimate. Catherine Creek (Grande Ronde River basin) fish-per-redd estimates are used for John Day escapement estimation because a similar weir-based fish count station does not exist in the John Day basin. Despite John Day basin redd counts correlating with those of Catherine Creek, we currently have no way of determining if fish-per-redd values are correlated between the two basins. The unusually high fish per redd estimate in 2013 demonstrates the possible variation an external fish-per-redd value incorporates into escapement estimates. Conversely, the PIT tag mark-recovery escapement estimation relied solely on John Day spring Chinook data. Although results from our 2011 and 2012 data suggest that this approach is feasible, the 2013 mark-recovery escapement estimate demonstrates that a minimum number of returning marked fish is necessary to generate an estimate with acceptable confidence. The concordance of escapement estimates generated by these discrete methodologies increases our confidence in the suitability of both methods for estimating John Day spring Chinook salmon escapement. We intend to continue both estimations for immediate future years.

**Management Implications**

Similar to 2012, less than 1% of the spawning adult spring Chinook salmon exhibited a sub-yearling smolt life history pattern. While it is uncertain whether these few adults originated from the John Day River, we have identified sub-yearling smolts migrating past our traps and into the Columbia River. During 2013 we also conducted Fall Chinook salmon surveys on the Lower John Day River (Appendix Table X). Fall Chinook, which are typically sub-yearling smolts (Quinn 2005), have had consistently low abundance (no confirmed redds in 2013) in the Lower John Day River. The lack of a self-sustaining fall Chinook population suggests possible selection against sub-yearling smolts in the John Day River. Abundance and survival of sub-yearling Chinook salmon smolts will be an important component of future research, as production potential of sub-yearling smolts is less limited by freshwater rearing habitat constraints. We intend to continue monitoring the occurrence of sub-yearling smolts via scales recovered from adult Chinook carcasses.

Adult escapements in recent years have been at or above the current capacity of freshwater habitat to produce yearling smolts. While escapement in 2013 was below carrying capacity, the density-dependent relationships we have described suggest we will likely see above average smolt per redd recruitment during the 2015 migration year. Continuing to manage for escapement equal to the replacement level (Figure 19) is a cautious approach which should allow for sufficient production of all juvenile life-history types. Improvements to rearing habitat for yearling smolts and improvements in survival for sub-yearling smolts would increase the potential for future fisheries targeting these wild populations. Recreational fisheries targeting wild salmonids are currently scarce in the Columbia River basin.

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**APPENDIX**

Appendix Table I. Spring Chinook total redd counts in the John Day River basin, 2000–2013. Includes redds observed in index, census and random sections, and redds estimated where permission to survey was denied.

| | | | | North Fork Subbasin | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Granite Creek System | | | | |
| Year | Mainstem | South Fork | Middle Fork | North Fork | Granite Creek | Clear Creek | Bull Run Creek | Desolation Creek | Basin Total |
| 2000 | 380 | 3 | 563 | 612 | 198 | 96 | 12 | 5 | 1,869 |
| 2001 | 432 | 0 | 354 | 803 | 126 | 80 | 45 | 23 | 1,863 |
| 2002 | 549 | 0 | 389 | 707 | 163 | 64 | 31 | 56 | 1,959 |
| 2003 | 260 | 0 | 236 | 668 | 118 | 32 | 1 | 39 | 1,354 |
| 2004 | 242 | 0 | 319 | 806 | 72 | 38 | 8 | 46 | 1,531 |
| 2005 | 203 | 0 | 178 | 420 | 43 | 15 | 4 | 15 | 878 |
| 2006 | 318 | 0 | 199 | 262 | 55 | 28 | 14 | 33 | 909 |
| 2007 | 250 | 0 | 85 | 358 | 19 | 9 | 2 | 23 | 746 |
| 2008 | 248 | 0 | 169 | 432 | 57 | 16 | 10 | 31 | 963 |
| 2009 | 468 | 0 | 251 | 360 | 47 | 53 | 4 | 38 | 1,221 |
| 2010 | 624 | 2 | 197 | 386 | 93 | 50 | 18 | 70 | 1,440 |
| 2011 | 692 | 0 | 505 | 475 | 67 | 44 | 14 | 49 | 1,846 |
| 2012 | 403 | 0 | 493 | 595 | 139 | 69 | 37 | 51 | 1,787 |
| 2013 | 388 | 0 | 113 | 494 | 53 | 37 | 7 | 44 | 995 |

Appendix Table II. Census and index survey lengths (km) for spring Chinook salmon spawning surveys in the John Day River basin, 2000–2013. Includes stream lengths in areas where we were denied access.

| | | | | North Fork Subbasin | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Granite Creek System | | | | |
| **Year** | **Mainstem** | **South Fork** | **Middle Fork** | **North Fork** | **Granite Creek** | **Clear Creek** | **Bull Run Creek** | **Desolation Creek** | **Basin Total** |
| 2000 | 32.2 | 17.3 | 51.5 | 83.9 | 16.5 | 7.6 | 5.7 | 21.4 | 236.1 |
| 2001 | 32.2 | 17.3 | 51.5 | 83.9 | 16.5 | 7.6 | 5.7 | 28.5 | 243.2 |
| 2002 | 32.2 | 17.3 | 51.5 | 86.9 | 16.5 | 10.3 | 7.2 | 34.0 | 255.9 |
| 2003 | 32.2 | 0.2 | 51.5 | 86.9 | 16.5 | 10.3 | 7.2 | 38.2 | 243.0 |
| 2004 | 34.3 | 17.3 | 51.5 | 88.3 | 16.5 | 10.3 | 7.2 | 34.6 | 260.0 |
| 2005 | 34.3 | 17.3 | 51.5 | 92.2 | 16.5 | 10.3 | 7.2 | 38.2 | 267.5 |
| 2006 | 34.3 | 17.3 | 51.5 | 92.2 | 16.5 | 10.3 | 7.2 | 35.3 | 264.6 |
| 2007 | 34.3 | 17.3 | 51.5 | 92.2 | 16.5 | 10.3 | 7.2 | 38.2 | 267.5 |
| 2008 | 34.3 | 17.3 | 51.5 | 92.2 | 16.5 | 10.3 | 7.2 | 35.3 | 264.6 |
| 2009 | 34.3 | 17.3 | 51.5 | 94.8 | 16.5 | 10.2 | 7.2 | 34.0 | 265.9 |
| 2010 | 34.3 | 17.3 | 51.5 | 97.5 | 16.5 | 10.2 | 7.2 | 34.0 | 268.6 |
| 2011 | 43.9 | 17.3 | 57.4 | 95.8 | 16.5 | 10.3 | 7.2 | 37.1 | 285.6 |
| 2012 | 45.3 | 17.3 | 59.4 | 96.0 | 16.5 | 10.3 | 7.2 | 37.1 | 290.8 |
| 2013 | 43.6 | 17.3 | 59.4 | 96.7 | 16.5 | 10.3 | 7.2 | 37.1 | 287.2 |

Appendix Table III. Spawning density (redds/km) in the John Day River basin, 2000–2013. Includes density estimates for areas where we were denied access.

| | | | | North Fork Subbasin | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Granite Creek System | | | | |
| Year | Mainstem | South Fork | Middle Fork | North Fork | Granite Creek | Clear Creek | Bull Run Creek | Desolation Creek | Basin Total |
| 2000 | 11.8 | 0.2 | 10.9 | 7.3 | 12.0 | 12.6 | 2.1 | 0.2 | 7.9 |
| 2001 | 13.4 | 0.0 | 6.9 | 9.6 | 7.6 | 10.5 | 7.9 | 0.8 | 7.7 |
| 2002 | 17.0 | 0.0 | 7.6 | 8.1 | 9.9 | 6.2 | 4.3 | 1.6 | 7.7 |
| 2003 | 8.1 | 0.0 | 4.6 | 7.7 | 7.2 | 3.1 | 0.1 | 1.0 | 5.6 |
| 2004 | 7.1 | 0.0 | 6.2 | 9.1 | 4.4 | 3.7 | 1.1 | 1.3 | 5.9 |
| 2005 | 5.9 | 0.0 | 3.5 | 4.6 | 2.6 | 1.5 | 0.6 | 0.4 | 3.3 |
| 2006 | 9.3 | 0.0 | 3.9 | 2.8 | 3.3 | 2.7 | 1.9 | 0.9 | 3.4 |
| 2007 | 7.3 | 0.0 | 1.7 | 3.9 | 1.2 | 0.9 | 0.3 | 0.6 | 2.8 |
| 2008 | 7.2 | 0.0 | 3.3 | 4.7 | 3.5 | 1.6 | 1.4 | 0.9 | 3.6 |
| 2009 | 13.6 | 0.0 | 4.9 | 3.8 | 2.8 | 5.2 | 0.6 | 1.1 | 4.6 |
| 2010 | 18.2 | 0.1 | 3.8 | 4.0 | 5.6 | 4.9 | 2.5 | 2.1 | 5.4 |
| 2011 | 15.8 | 0.0 | 7.8 | 5.0 | 4.1 | 4.3 | 1.9 | 1.3 | 6.3 |
| 2012 | 12.4 | 0.0 | 8.3 | 6.2 | 8.4 | 6.7 | 5.1 | 1.4 | 6.1 |
| 2013 | 8.9 | 0.0 | 1.9 | 3.6 | 3.2 | 3.6 | 1.0 | 1.2 | 3.9 |

Appendix Table IV. Mainstem and Middle Fork John Day River smolt/redd ratios based on estimates of smolt abundance and redd counts for spring Chinook salmon, 2002–2011 brood years.

| | | Mainstem | | | | Middle Fork | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 95% CI | | | | 95% CI | |
| Brood Year | Smolt Year | Redds (n) | Smolts/ redd | Lower | Upper | Redds (n) | Smolts/ redd | Lower | Upper |
| 2002 | 2004 | | 100 | 81 | 129 | 389 | 61 | 50 | 78 |
| 2003 | 2005 | 549 | 130 | 117 | 144 | 236 | 93 | 79 | 108 |
| 2004 | 2006 | 260 | 139 | 87 | 253 | 319 | 58 | 45 | 76 |
| 2005 | 2007 | 242 | 267 | 209 | 349 | 178 | 95 | 80 | 117 |
| 2006 | 2008 | 203 | 146 | 129 | 164 | 199 | 37 | 28 | 50 |
| 2007 | 2009 | 318 | 296 | 255 | 346 | 85 | 453 | 402 | 514 |
| 2008 | 2010 | 250 | 223 | 193 | 260 | 169 | 211 | 198 | 227 |
| 2009 | 2011 | 248 | 176 | 158 | 198 | 251 | 85 | 71 | 104 |
| 2010 | 2012 | 468 | 105 | 96 | 116 | 197 | 148 | 142 | 155 |
| 2011 | 2013 | 692 | 90 | 79 | 101 | 505 | 63 | 58 | 71 |

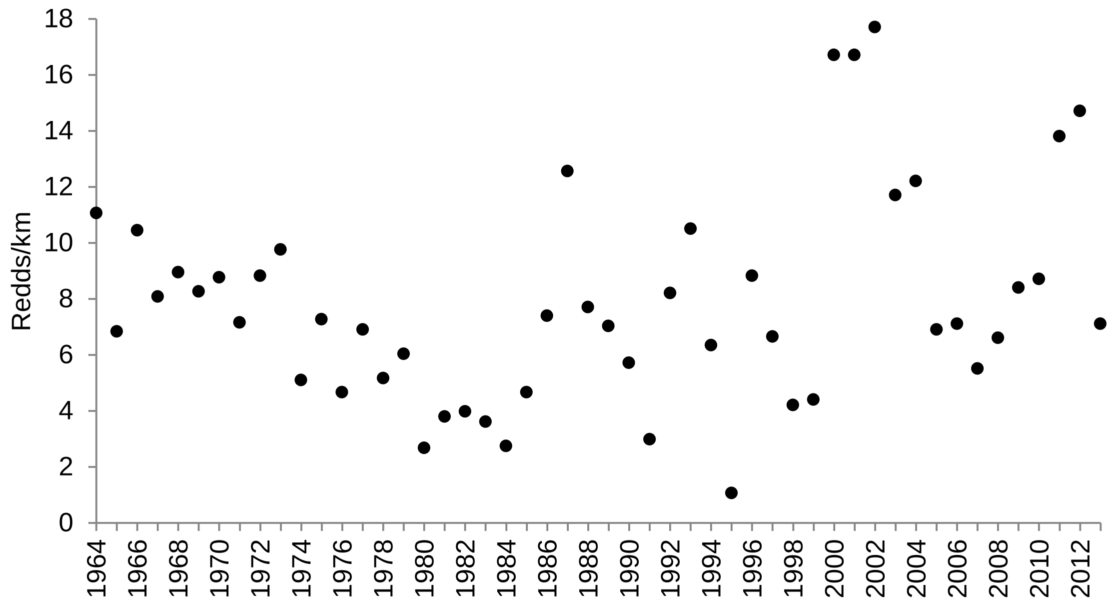
[a] Mainstem trap was moved upstream of the confluence with the South Fork. Estimated abundance from Mainstem and South Fork traps were henceforth combined.

Appendix Table V. Egg retention and ELISA optical density values for adult spring Chinook kidneys sampled from carcasses in the John Day River basin, 2013.

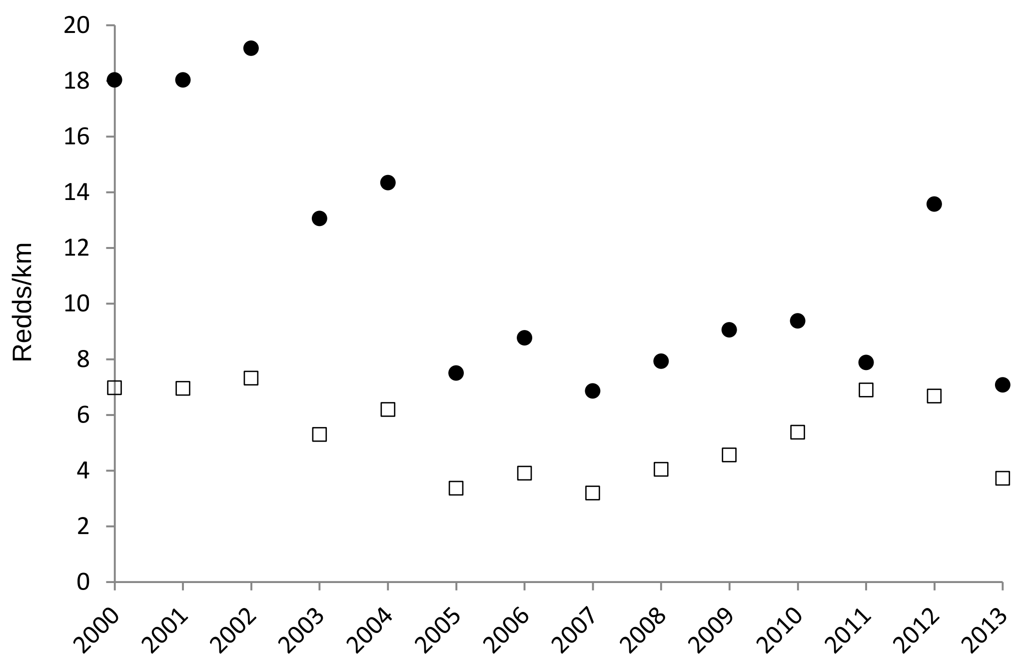
| Population | Egg Retention (ml) | Optical Density ($OD_{405}$) |
|---|---|---|
| Mainstem John Day River | 237 | 0.081 |
| Mainstem John Day River | | 0.089 |
| Mainstem John Day River | 0 | 0.091 |
| Mainstem John Day River | | 0.092 |
| Mainstem John Day River | 59 | 0.099 |
| Mainstem John Day River | | 0.101 |
| Mainstem John Day River | | 0.105 |
| Mainstem John Day River | | 0.110 |
| Mainstem John Day River | | 0.111 |
| Mainstem John Day River | | 0.112 |
| Mainstem John Day River | | 0.112 |
| Mainstem John Day River | | 0.114 |
| Mainstem John Day River | 0 | 0.117 |
| Mainstem John Day River | | 0.117 |
| Mainstem John Day River | | 0.119 |
| Mainstem John Day River | | 0.124 |
| Mainstem John Day River | | 0.127 |
| Mainstem John Day River | | 0.129 |
| Mainstem John Day River | | 0.134 |
| Mainstem John Day River | | 0.140 |
| Mainstem John Day River | 0 | 0.145 |
| Mainstem John Day River | | 0.156 |
| Mainstem John Day River | 0 | 0.157 |
| Mainstem John Day River | 1,065 | 0.172 |
| Mainstem John Day River | | 0.184 |
| Mainstem John Day River | 0 | 0.705 |
| Mainstem John Day River | 0 | |
| Mainstem John Day River | | |
| Middle Fork John Day River | | 0.095 |
| Middle Fork John Day River | | 0.099 |
| Middle Fork John Day River | 0 | 0.103 |
| Middle Fork John Day River | | 0.103 |
| Middle Fork John Day River | 0 | 0.116 |
| Middle Fork John Day River | | 0.129 |
| Middle Fork John Day River | | 0.131 |
| Middle Fork John Day River | 0 | 0.132 |
| Middle Fork John Day River | | 0.132 |
| Middle Fork John Day River | 0 | 0.136 |
| Middle Fork John Day River | | 0.140 |
| Middle Fork John Day River | | 0.143 |
| Middle Fork John Day River | | 0.153 |

Appendix Table V. Continued.

| Population | Egg Retention (g) | Optical Density ($OD_{405}$) |
|---|---|---|
| Middle Fork John Day River | | 0.160 |
| Middle Fork John Day River | | 0.169 |
| Middle Fork John Day River | 0 | 0.218 |
| Middle Fork John Day River | | 0.256 |
| Middle Fork John Day River | | |
| North Fork John Day River | 0 | 0.069 |
| North Fork John Day River | 710 | 0.076 |
| North Fork John Day River | 1,301 | 0.080 |
| North Fork John Day River | 237 | 0.094 |
| North Fork John Day River | | 0.099 |
| North Fork John Day River | 0 | 0.102 |
| North Fork John Day River | | 0.102 |
| North Fork John Day River | | 0.102 |
| North Fork John Day River | 828 | 0.103 |
| North Fork John Day River | | 0.104 |
| North Fork John Day River | 0 | 0.107 |
| North Fork John Day River | 30 | 0.107 |
| North Fork John Day River | | 0.108 |
| North Fork John Day River | 0 | 0.110 |
| North Fork John Day River | | 0.110 |
| North Fork John Day River | | 0.114 |
| North Fork John Day River | | 0.114 |
| North Fork John Day River | | 0.115 |
| North Fork John Day River | 0 | 0.117 |
| North Fork John Day River | | 0.118 |
| North Fork John Day River | 0 | 0.120 |
| North Fork John Day River | 0 | 0.121 |
| North Fork John Day River | | 0.124 |
| North Fork John Day River | 0 | 0.127 |
| North Fork John Day River | | 0.129 |
| North Fork John Day River | 0 | 0.130 |
| North Fork John Day River | | 0.131 |
| North Fork John Day River | | 0.137 |
| North Fork John Day River | 0 | 0.141 |
| North Fork John Day River | 237 | 0.141 |
| North Fork John Day River | | 0.146 |
| North Fork John Day River | 0 | 0.153 |
| North Fork John Day River | | 0.153 |
| North Fork John Day River | 78 | 0.166 |
| North Fork John Day River | | 0.171 |
| North Fork John Day River | | 0.225 |




Appendix Figure I. Spring Chinook index redd densities in the John Day River basin, 1964–2013. Densities include estimated redd counts in areas where we were denied access. Data from 1959–1963 are not presented because they do not cover the same spatial extent.




Appendix Figure II. Spring Chinook index (black circles) and census (open squares) redd densities in the John Day River basin, 2000–2013. Densities include estimated redd counts in areas where we were denied access.

Appendix Table VI. Index redd density (redds/km) in the John Day River basin 1998–2013. Includes estimated redd densities in areas where we were denied access. GCS = Granite Creek system (tributary to North Fork John Day).

| Year | Mainstem | Middle Fork | North Fork | GCS | Total |
|---|---|---|---|---|---|
| 1998 | 6.1 | 8.2 | 3.8 | 3.1 | 4.2 |
| 1999 | 3.3 | 4.0 | 4.2 | 4.7 | 4.4 |
| 2000 | 19.0 | 5.3 | 16.7 | 13.0 | 16.7 |
| 2001 | 21.6 | 18.0 | 21.3 | 11.9 | 16.7 |
| 2002 | 27.1 | 10.1 | 18.0 | 10.6 | 17.7 |
| 2003 | 13.6 | 15.6 | 16.9 | 4.4 | 11.7 |
| 2004 | 9.7 | 9.3 | 21.1 | 4.4 | 12.2 |
| 2005 | 8.8 | 8.9 | 9.5 | 2.2 | 6.9 |
| 2006 | 12.5 | 5.8 | 5.6 | 3.4 | 7.1 |
| 2007 | 9.9 | 7.7 | 6.9 | 1.1 | 5.5 |
| 2008 | 11.7 | 3.7 | 6.1 | 3.4 | 6.6 |
| 2009 | 18.4 | 5.7 | 4.5 | 4.1 | 8.4 |
| 2010 | 21.9 | 7.6 | 2.8 | 6.3 | 8.7 |
| 2011 | 26.6 | 18.6 | 7.5 | 4.5 | 13.4 |
| 2012 | 29.6 | 15.2 | 12.8 | 6.4 | 15.8 |
| 2013 | 13.8 | 4.1 | 6.1 | 3.0 | 6.6 |

Appendix Table VII.  2013 spring Chinook spawning survey section locations and coordinates (DD.DD, NAD 1983 Oregon Lambert).

| System | Description | Start | | End | |
|---|---|---|---|---|---|
| | | Latitude | Longitude | Latitude | Longitude |
| Mainstem John Day River | Indian Creek to Prairie Wood Products | 44.443455 | -118.797648 | 44.454705 | -118.717714 |
| Mainstem John Day River | Prairie Wood to Forrest Conservation Area | 44.453559 | -118.72218 | 44.459277 | -118.701083 |
| Mainstem John Day River | Forrest Conservation Area to Dad's Creek | 44.459277 | -118.701083 | 44.453506 | -118.672481 |
| Mainstem John Day River | Dad's Creek to Emmel Upper Fence | 44.453506 | -118.672481 | 44.449536 | -118.655137 |
| Mainstem John Day River | Emmel Upper Fence to Field Upper Fence | 44.449536 | -118.655137 | 44.435896 | -118.627021 |
| Mainstem John Day River | Field Upper Fence to French Lane | 44.435896 | -118.627021 | 44.419336 | -118.600508 |
| Mainstem John Day River | French Lane to Jacobs Upper Fence | 44.419336 | -118.600508 | 44.410514 | -118.588248 |
| Mainstem John Day River | Jacob's Upper Fence to Rd 13 Bridge | 44.410514 | -118.588248 | 44.39564 | -118.577286 |
| Mainstem John Day River | Rd 13 Bridge to Reynolds Fence | 44.39564 | -118.577286 | 44.377879 | -118.579106 |
| Mainstem John Day River | Reynold's Fence to Ricco Upper Fence | 44.377879 | -118.579106 | 44.340011 | -118.574012 |
| Mainstem John Day River | Ricco Upper Fence to Call Creek | 44.340011 | -118.574012 | 44.320119 | -118.55734 |
| Mainstem John Day River | Call Creek to 2 mi upstream (Random) | 44.320119 | -118.55734 | 44.298501 | -118.549733 |
| Mainstem John Day River | Near Grant Road Shop, city of John Day | 44.425048 | -119.001531 | 44.425384 | -118.999349 |
| Mainstem John Day River | RM254 (Random) | 44.420586 | -118.865736 | 44.435556 | -118.837848 |
| Canyon Creek | Canyon Creek (Random) | 44.300513 | -118.950313 | 44.284264 | -118.960479 |
| Reynolds Creek | Mouth to U.S. Forest Boundary | 44.412546 | -118.588818 | 44.417049 | -118.543229 |
| Deardorff Creek | Mouth to 2.0 km upstream | 44.394786 | -118.576509 | 44.396724 | -118.553344 |
| Bridge Creek (LMJD) | Woodward fence to Mitchell | 44.605424 | -120.218222 | 44.573504 | -120.171854 |
| Bridge Creek (LMJD) | Fossil Beds to Woodward fence | 44.640008 | -120.236093 | 44.605424 | -120.218222 |
| Middle Fork John Day River | Armstrong Creek to Deep Creek | 44.743248 | -118.851359 | 44.716848 | -118.821969 |
| Middle Fork John Day River | Deep Creek to Road 36 Bridge | 44.716848 | -118.821969 | 44.692588 | -118.794073 |
| Middle Fork John Day River | Road 36 Bridge to Coyote Creek | 44.692588 | -118.794073 | 44.674525 | -118.75024 |
| Middle Fork John Day River | Coyote Creek to Upper TNC Boundary | 44.674525 | -118.75024 | 44.666466 | -118.713502 |
| Middle Fork John Day River | Upper TNC Boundary to Beaver Creek | 44.666466 | -118.713502 | 44.652418 | -118.677977 |
| Middle Fork John Day River | Beaver Creek to Windlass Creek | 44.652418 | -118.677977 | 44.638962 | -118.627342 |

Appendix Table VII. Continued.

| System | Description | Start | | End | |
|---|---|---|---|---|---|
| | | Latitude | Longitude | Latitude | Longitude |
| Middle Fork John Day River | Windlass Creek to Caribou Creek | 44.638962 | -118.627342 | 44.622012 | -118.573089 |
| Middle Fork John Day River | Caribou Creek to Dead Cow Bridge | 44.622012 | -118.573089 | 44.607644 | -118.547349 |
| Middle Fork John Day River | Dead Cow Bridge to Placer Gulch | 44.607644 | -118.547349 | 44.595637 | -118.522586 |
| Middle Fork John Day River | Placer Gulch to Highway 7 | 44.595637 | -118.522586 | 44.603958 | -118.48325 |
| Middle Fork John Day River | Highway 7 to Phipps Meadow | 44.603958 | -118.48325 | 44.5845 | -118.429986 |
| Middle Fork John Day River | RM 32 (Random) | 44.797713 | -118.965596 | 44.795695 | -118.932061 |
| Middle Fork John Day River | RM 26 (Random) | 44.83884 | -119.038544 | 44.824943 | -119.010646 |
| Granite Boulder Creek - MFJDR | Mouth to 4550 Road | 44.647386 | -118.665057 | 44.6558 | -118.647961 |
| Vinegar Creek | Mouth upstream 0.62km | 44.601232 | -118.535686 | 44.604931 | -118.530114 |
| Bridge Creek | Mouth to Road 2614 | 44.593407 | -118.513618 | 44.569226 | -118.506281 |
| Clear Creek | Mouth to 1.6 km upstream of Hwy 26 Bridge | 44.593743 | -118.506834 | 44.562465 | -118.488907 |
| Clear Creek | Road 180 to 2.0 km upstream | 44.562895 | -118.489093 | 44.548271 | -118.488078 |
| North Fork John Day River | Trail Crossing to Cunningham Creek | 44.88506 | -118.254856 | 44.910764 | -118.266677 |
| North Fork John Day River | Cunningham Creek to Baldy Creek | 44.910764 | -118.266677 | 44.909619 | -118.317805 |
| North Fork John Day River | Baldy Creek to Road 73 Bridge | 44.909619 | -118.317805 | 44.912888 | -118.400227 |
| North Fork John Day River | Road 73 Bridge to Trout Creek | 44.912888 | -118.400227 | 44.926657 | -118.444597 |
| North Fork John Day River | Trout Creek to Crane Creek | 44.926657 | -118.444597 | 44.893568 | -118.477699 |
| North Fork John Day River | Crane Creek to Trail Crossing | 44.893568 | -118.477699 | 44.87456 | -118.520736 |
| North Fork John Day River | Trail Crossing to Granite Creek | 44.87456 | -118.520736 | 44.865611 | -118.562299 |
| North Fork John Day River | Granite Creek to Wind Rock | 44.865611 | -118.562299 | 44.885947 | -118.599879 |
| North Fork John Day River | Wind Rock to Ryder Creek | 44.885947 | -118.599879 | 44.929562 | -118.618474 |
| North Fork John Day River | Ryder Creek to Cougar Creek | 44.929562 | -118.618474 | 44.944108 | -118.647593 |
| North Fork John Day River | Cougar Creek to Big Creek | 44.944108 | -118.647593 | 44.960194 | -118.682884 |
| North Fork John Day River | Big Creek to Oriental Creek | 44.960194 | -118.682884 | 44.973791 | -118.726782 |
| North Fork John Day River | Oriental Creek to Sulphur Creek | 44.973791 | -118.726782 | 44.980441 | -118.761786 |
| North Fork John Day River | Sulphur Creek to Nye Creek | 44.980441 | -118.761786 | 45.006291 | -118.824657 |

Appendix Table VII.  Continued.

| System | Description | Start Latitude | Start Longitude | End Latitude | End Longitude |
|---|---|---|---|---|---|
| North Fork John Day River | Nye Creek to Horse Canyon | 45.006291 | -118.824657 | 45.016381 | -118.865414 |
| North Fork John Day River | Horse Canyon to Desolation Creek | 45.016381 | -118.865414 | 44.997921 | -118.935827 |
| North Fork John Day River | Desolation Creek to Camas Creek | 44.997921 | -118.935827 | 45.01021 | -118.99595 |
| North Fork John Day River | Camas Creek to Jericho Creek | 45.01021 | -118.99595 | 45.011857 | -119.051625 |
| North Fork John Day River | RM 48 (Random) | 44.990133 | -119.147983 | 44.991729 | -119.114258 |
| Camas Creek | RM 2 (Random) | 45.021557 | -118.867 | 45.033849 | -118.980739 |
| Camas Creek | 0.4 km above and below Fivemile Creek | 45.079725 | -118.987687 | 45.068389 | -118.982212 |
| Big Creek | Footbridge to mouth | 44.960922 | -118.68239 | 44.960194 | -118.682884 |
| Trail Creek | Mouth to Forks | 44.915541 | -118.40631 | 44.820401 | -118.689409 |
| Baldy Creek | Mouth to 1 mi upstream | 44.909619 | -118.317805 | 44.899615 | -118.307586 |
| Crane Creek | Mouth to 1 mi upstream (Random) | 44.893568 | -118.477699 | 44.889431 | -118.459152 |
| Granite Creek | 73 Road Culvert to Ten Cent Creek | 44.816141 | -118.420549 | 44.83107 | -118.458033 |
| Granite Creek | Ten Cent Creek to Buck Creek | 44.83107 | -118.458033 | 44.841373 | -118.494582 |
| Granite Creek | Buck Creek to Indian Creek | 44.841373 | -118.494582 | 44.850403 | -118.537324 |
| Granite Creek | Indian Creek to Mouth of Granite Creek | 44.850403 | -118.537324 | 44.865611 | -118.562299 |
| Clear Creek | Ruby Creek to Alamo Road | 44.77295 | -118.48848 | 44.7696 | -118.473293 |
| Clear Creek | Alamo Road to Smith Lower Boundary | 44.7696 | -118.473293 | 44.769969 | -118.457903 |
| Clear Creek | Smith Lower Boundary to Old Road Crossing | 44.769969 | -118.457903 | 44.785595 | -118.472676 |
| Clear Creek | Old Road Crossing to Clear Creek Mouth | 44.785595 | -118.472676 | 44.821483 | -118.450278 |
| Bull Run Creek | Deep Creek to the Guard Station | 44.779916 | -118.348625 | 44.787182 | -118.374203 |
| Bull Run Creek | Guard Station to Mouth | 44.787182 | -118.374203 | 44.807964 | -118.425153 |
| Desolation Creek | Road 45 Culvert to Falls | 44.809318 | -118.683428 | 44.791032 | -118.673187 |
| Desolation Creek | Culvert downstream to Forks | 44.809318 | -118.683428 | 44.820401 | -118.689409 |
| Desolation Creek | Forks to Howard Creek | 44.820401 | -118.689409 | 44.838014 | -118.724023 |
| Desolation Creek | Howard Creek to Battle Creek | 44.838014 | -118.724023 | 44.856763 | -118.761268 |

Appendix Table VII.  Continued.

| System | Description | Start | | End | |
|---|---|---|---|---|---|
| | | **Latitude** | **Longitude** | **Latitude** | **Longitude** |
| Desolation Creek | Battle Creek to Bruin Creek | 44.856763 | -118.761268 | 44.896974 | -118.796166 |
| Desolation Creek | Bruin Creek to Road 1010 Bridge | 44.896974 | -118.796166 | 44.921231 | -118.829258 |
| Desolation Creek | Road 1010 Bridge to Peep Creek | 44.921231 | -118.829258 | 44.940121 | -118.839682 |
| Desolation Creek | Peep Creek to Road 1003 Bridge | 44.940121 | -118.839682 | 44.971799 | -118.882862 |
| Desolation Creek | Road 1003 Bridge to Mouth | 44.971799 | -118.882862 | 44.997921 | -118.935827 |
| South Fork John Day River | Murderers Creek To Rock Pile Ranch Bridge | 44.314554 | -119.539573 | 44.267652 | -119.550757 |
| South Fork John Day River | Rock Pile Ranch Bridge to Cougar Gulch | 44.267652 | -119.550757 | 44.229578 | -119.533785 |
| South Fork John Day River | Cougar Gulch to Izee Falls | 44.229578 | -119.533785 | 44.185104 | -119.524821 |
| South Fork John Day River | RM 14 (Random) | 44.344717 | -119.552153 | 44.324062 | -119.557311 |

Appendix Table VIII. Correlation matrix for census John Day River population Chinook redd counts from 2000 to 2013 and Chinook redd counts observed in other northeast Oregon streams. Significant correlations (α = 0.05) are indicated in bold.

| John Day Population | Catherine Creek | Lookingglass Creek | Minam River | Wallowa-Lostine System | Wenaha River | Imnaha River | Grande Ronde River |
|---|---|---|---|---|---|---|---|
| Mainstem | **0.772** | 0.501 | **0.855** | **0.692** | **0.592** | **0.602** | 0.508 |
| Middle Fork | 0.309 | 0.452 | 0.325 | 0.232 | **0.566** | 0.358 | 0.124 |
| North Fork | 0.058 | 0.059 | 0.261 | -0.035 | **0.692** | **0.547** | -0.011 |

Appendix Table IX. Summary of Chinook coded wire tag recoveries by John Day River population from 2000 to 2013.

| Year | Population | Tags (n) | Hatchery | Release Location |
|---|---|---|---|---|
| 2000 | Middle Fork | 1 | Round Butte, Oregon | West Fork Hood River |
| | North Fork | 2 | Lookingglass, Oregon | Grande Ronde River |
| | North Fork | 2 | Rapid River, Idaho | Rapid River |
| | North Fork | 1 | McCall, Idaho | South Fork Salmon River |
| 2001 | North Fork | 1 | Lookingglass, Oregon | Imnaha River |
| | North Fork | 1 | Rapid River, Idaho | Rapid River |
| 2002 | | | *No Recoveries* | |
| 2003 | North Fork | 1 | Lookingglass, Oregon | Catherine Creek |
| 2004 | Mainstem | 1 | Lookingglass, Oregon | Imnaha River |
| | Middle Fork | 1 | Lookingglass, Oregon | Grande Ronde River |
| | North Fork | 6 | Lookingglass, Oregon | Grande Ronde River |
| | North Fork | 1 | Lookingglass, Oregon | Catherine Creek |
| | North Fork | 1 | Lookingglass, Oregon | Lostine River |
| | North Fork | 2 | Rapid River, Idaho | Rapid River |
| 2005 | Mainstem | 1 | Lookingglass, Oregon | Grande Ronde River |
| | Mainstem | 1 | Round Butte, Oregon | Deschutes River |
| 2006 | Middle Fork | 1 | McCall, Idaho | South Fork Salmon River |
| | North Fork | 1 | McCall, Idaho | South Fork Salmon River |
| | North Fork | 1 | Lookingglass, Oregon | Grande Ronde River |
| 2007 | North Fork | 1 | Rapid River, Idaho | Rapid River |
| 2008 | North Fork | 1 | Lookingglass, Oregon | Lookingglass Creek |
| | North Fork | 1 | Lookingglass, Oregon | Catherine Creek |
| 2009 | North Fork | 1 | Lookingglass, Oregon | Catherine Creek |
| | North Fork | 1 | Wallowa, Oregon | Grande Ronde River |
| 2010 | North Fork | 2 | Rapid River, Idaho | Rapid River |
| 2011 | Middle Fork | 1 | Lostine, Oregon | Lostine River |
| | North Fork | 1 | | Grande Ronde River |
| 2012 | North Fork | 2 | Lookingglass, Oregon | Lookingglass Creek |
| | North Fork | 3 | | Grande Ronde River |
| 2013 | | | *No Recoveries* | |

Appendix Table X. Summary of 2013 fall Chinook spawning surveys conducted in the lower John Day River.

| | | | | Fish | |
|---|---|---|---|---|---|
| **Date** | **Survey Reach** | **Length (km)** | **Redds** | **Live** | **Dead** |
| 05-Nov-13 | RKM 64 to RKM 35 | 29 | 0 | 0 | 0 |
| 13-Nov-13 | RKM 64 to RKM 35 | 29 | 0 | 0 | 0 |
| 20-Nov-13 | RKM 64 to RKM 35 | 29 | 0 | 0 | 0 |
| 21-Nov-13 | RKM 35 to RKM 17 | 18 | 0 | 0 | 0 |