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

Annual Technical Report

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Objectives

1. Estimate number and distribution of spring Chinook salmon *Oncorhynchus tshawytscha* redds and spawners for three John Day River populations.

2. Estimate age composition and proportion of hatchery-origin spawners (PHoS) 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 6 August through 3 October 2014. We observed 2,084 spring Chinook redds while surveying 291 km of potential spawning habitat (190 km of census, 78 km of index, and 23 km of random reaches). We estimated 111 redds were constructed in the 17km of stream where we were denied access in the Mainstem John Day River. A total of 2,195 spring Chinook redds were constructed in the John Day River basin, more than double the 995 redds counted in the previous year, at an overall density of 7.5 redds/km for the survey area. Relative to 2013, redd count increased 214% in the Mainstem, 458% in the Middle Fork , and 172% in the North Fork. The 2014 Mainstem redd total of 829 was the highest observed since census monitoring began in 2000 (the second highest total of 638 redds was observed in 2011). The Middle Fork redd total of 518 was the second highest observed since 2000, when we counted 563 redds.

Estimated spring Chinook escapement estimate for 2014 was 6,349 fish (using a ratio of 2.89 adults and jacks per redd estimated at the Catherine Creek weir in the Grande Ronde River basin). We recovered 1,436 Chinook carcasses (23% of the estimated total spawners), 1,396 (97%) of which had an adipose fin and were assumed to be of wild origin. Six carcasses (PHoS = 1%) had a clipped adipose fin and were assumed to be of hatchery origin, and origin of the remaining 34 could not be determined.

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. Kanani Bowden and Ben Clemens of the Fish Life History and Analysis Project provided assistance and advice on scale analysis. Susan Benda of the Fish Pathology Laboratory analyzed kidney and intestine 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.

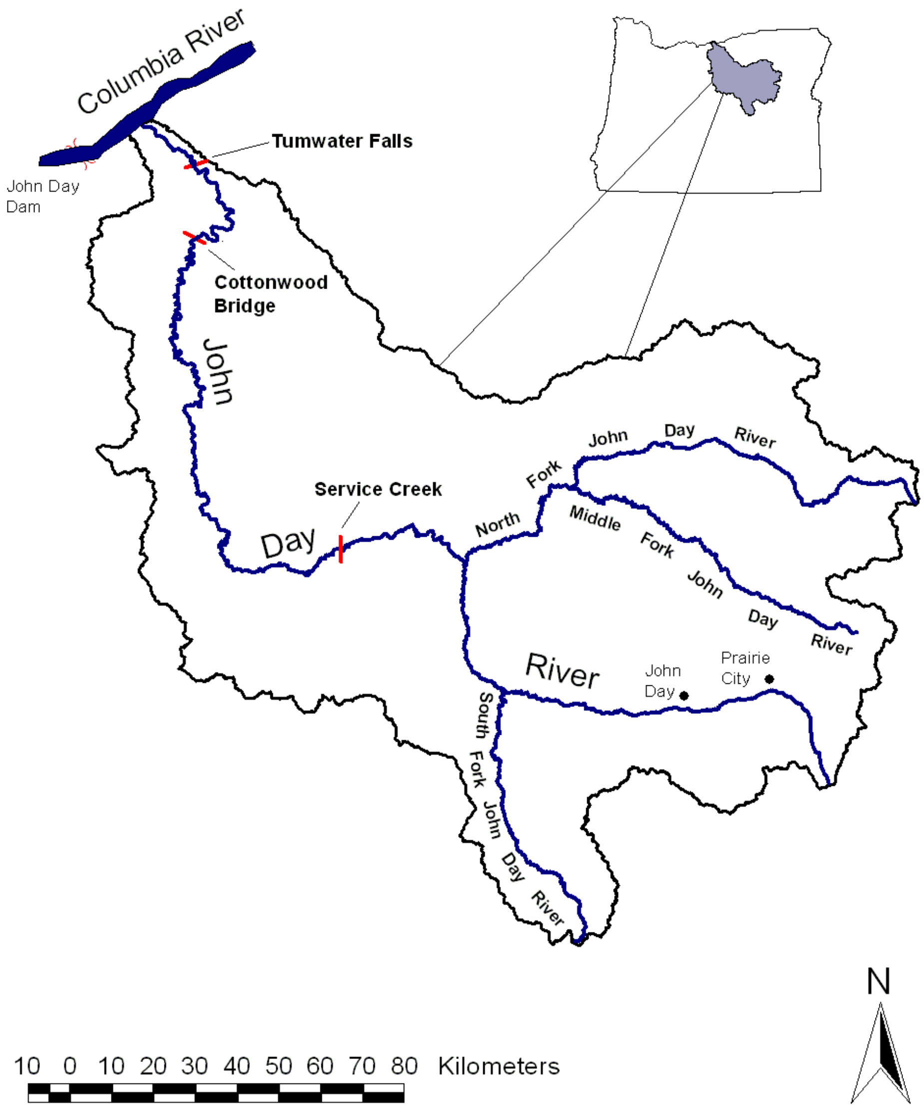

Figure 1. Map of the John Day River basin.

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 2014, 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 (in milliliters) 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). Intestine and kidney samples were collected from recently deceased spring Chinook in each of the main spawning areas to determine presence of *Ceratonova shasta*, also known as enteronecrosis or gut-rot disease, and 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 intestine and kidney tissue analyses. Clean disposable plastic knives and spoons were used to collect 1–2 g samples of intestine and/or 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 or PIT-tagged 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 recovered 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 applied a chi-square test of frequencies to detect differences in the presence of hatchery fish 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 at the population scale for three size classes ($\leq$ 499 mm, 500–599 mm, and $\geq$ 600 mm). 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 2014 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 2013 index:total data and used this equation to predict the 2014 total count based on the 2014 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

A PIT tag array on the Middle Fork John Day River (rkm 68) allows for an independent mark-recapture abundance estimate to be generated for that population. As described above, we also estimate the number of Chinook salmon in the Middle Fork using Chapman's modification of the Petersen estimate where:

$\hat{N}$ = Number of returning adult Chinook crossing the PIT array on the Middle Fork John Day River 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 Middle Fork PIT array
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

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 2009 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 290.9 km of potential Chinook spawning habitat within the John Day River basin in 2014 (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 23.0 km of stream.

Table 2. Access status (Y = Yes, N = No), survey type, and reach length (km) for 2014 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			1.5
Deardorff Creek	Y	2.0		
John Day River	*N*	*6.7*	*6.3*	
John Day River	Y	7.3	11.4	2.0
Reynolds Creek	*N*	*4.1*		
South Fork				
S.F. John Day River	Y	17.3		2.0
Middle Fork				
Bridge Creek	Y	2.9		
Clear Creek	Y	4.1		
Granite Boulder Creek	Y	2.3		
M.F. John Day River	Y	27.7	19.8	5.2
Vinegar Creek	Y	0.6		
North Fork				
Baldy Creek	Y	1.1		
Big Creek	Y	0.1		
Camas Creek	Y	0.8		1.5
Crane Creek	Y			1.6
Crawfish Creek	Y			1.4
N.F. John Day River	Y	63.2	28.5	2.0
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**	**23.0**

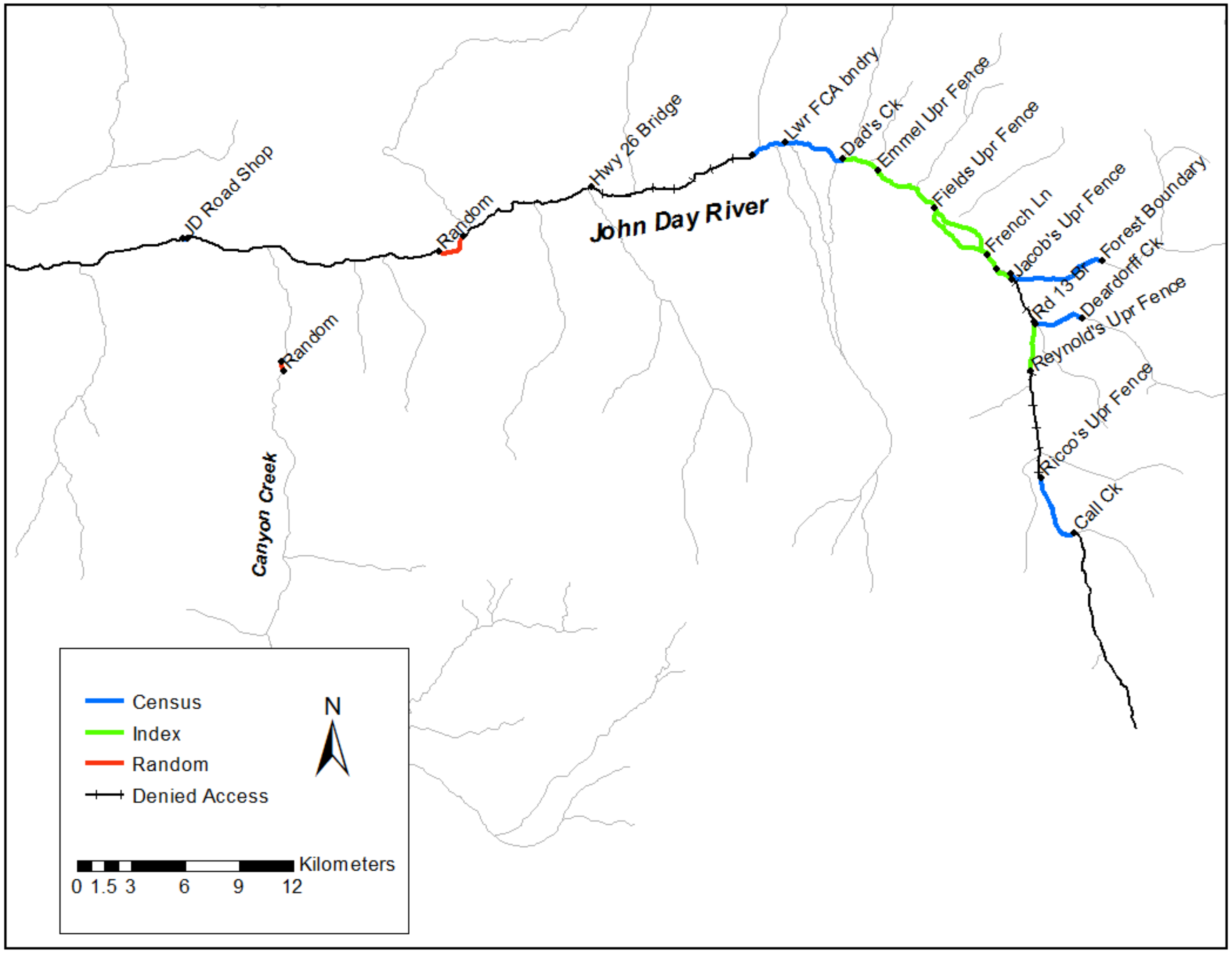

Figure 2. Map of the 2014 Mainstem spring Chinook spawning ground survey sections.

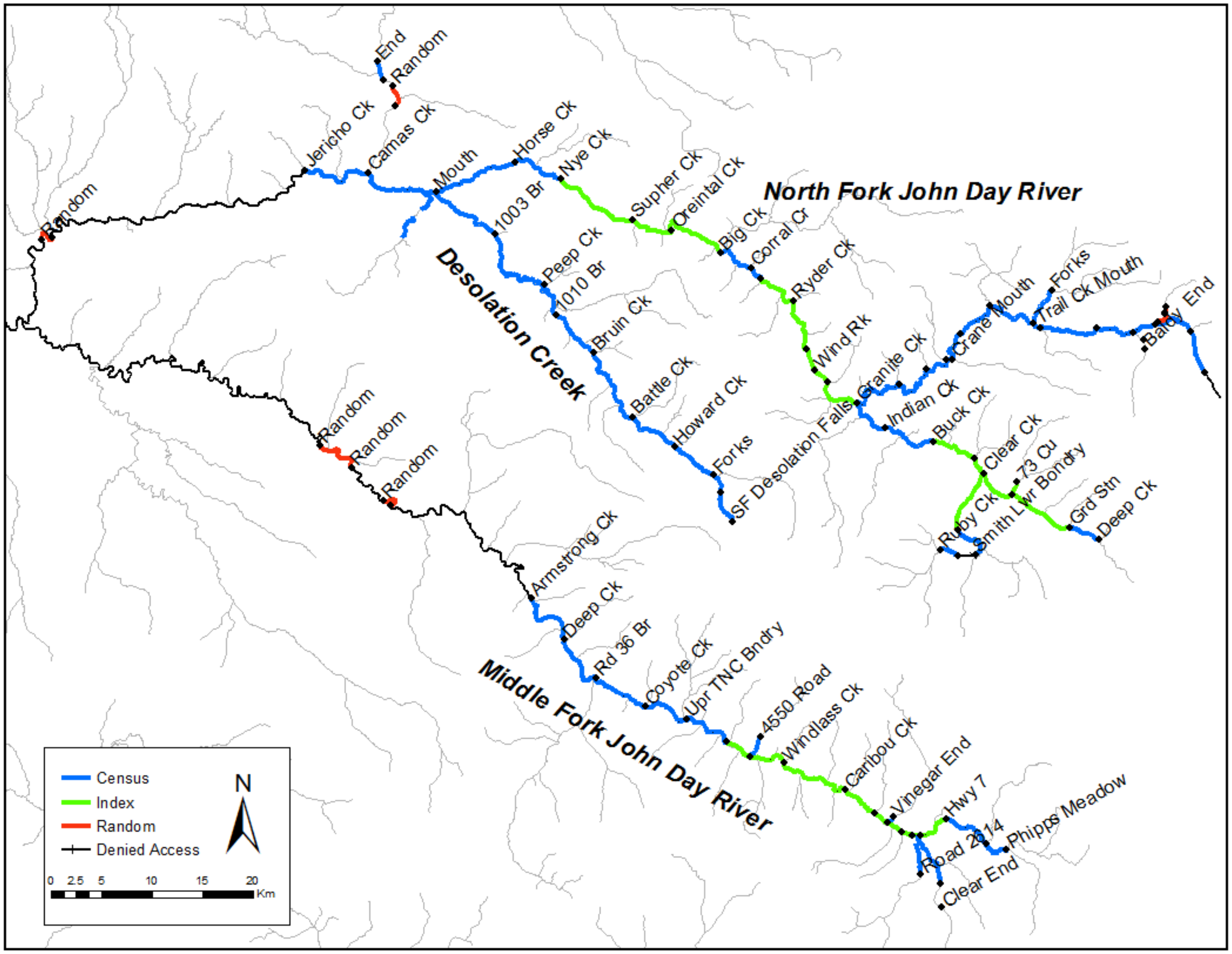

Figure 3. Map of the 2014 Middle Fork and North Fork spring Chinook spawning ground survey sections.

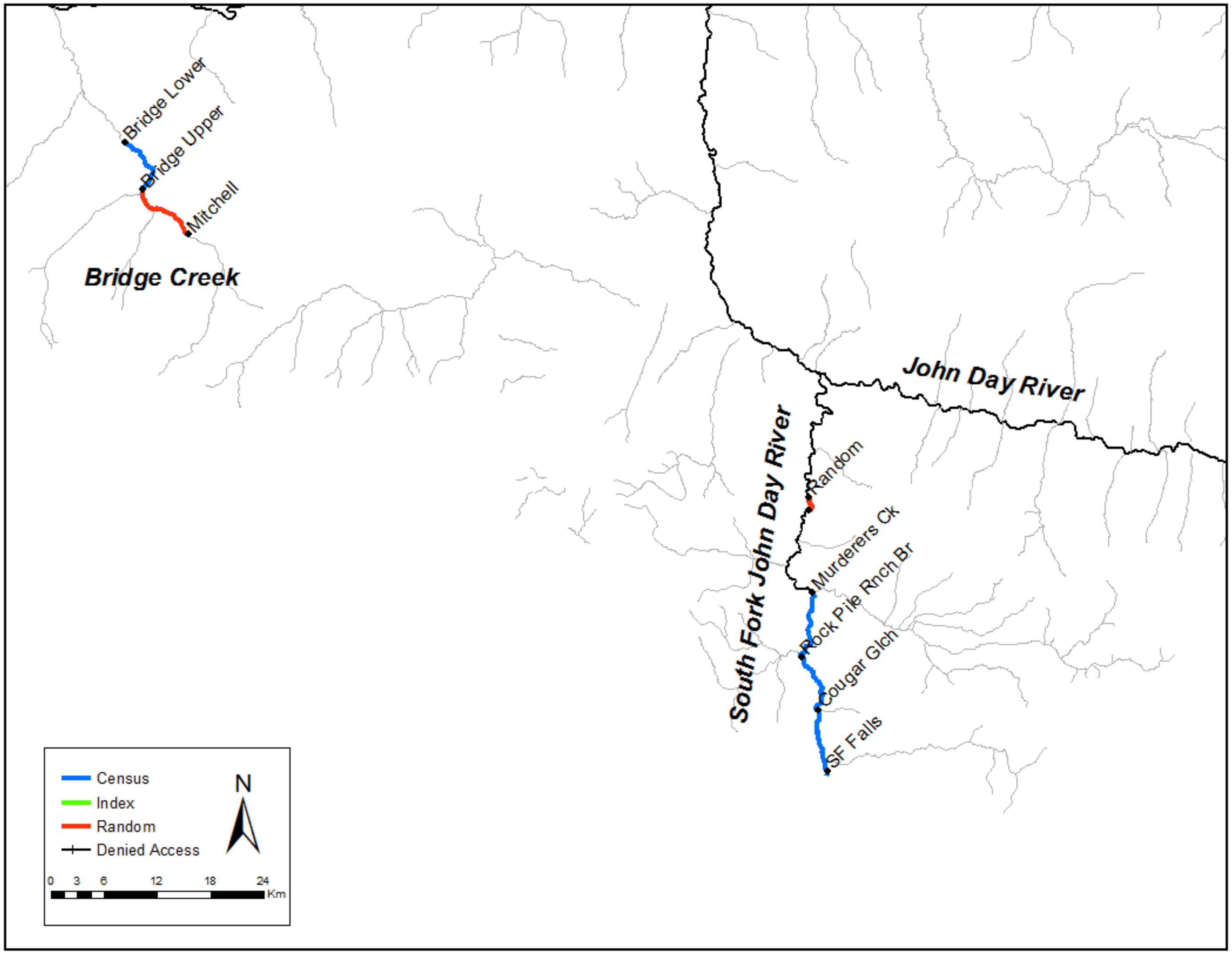

Figure 4. Map of the 2014 South Fork and Bridge Creek spring Chinook spawning ground survey sections.

We observed 2,084 spring Chinook redds within the John Day River basin in 2014 (Tables 3 and 4). In the 17 km of combined census and index reaches where we were denied access, we estimated a total of 111 redds in the Mainstem. This resulted in a total estimated 2,195 spring Chinook redds in the John Day River basin in 2014. We estimated an overall density of 7.6 redds/km for the entire survey area, excluding random reaches where spawning was not present (Table 3). Of the 2,195 total redds, 1,361 were observed during index surveys at a density of 18.2 redds/km. The ratio of index to census redds, with post-index redds treated as census redds, was 1.6. Since 2000, the contribution of index counts to the total count has declined (Figure 5). No redds were observed in any of the random reaches for 2014. The Mainstem accounted for 37.8% of the total redds observed in 2014, the Middle Fork had 23.6%, and the North Fork had 38.6%. We did not observe any redds in the South Fork. The Mainstem had the highest density of redds with 19.0 redds/km, followed by the Middle Fork with 8.7 redds/km, and the North Fork with 5.1 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 2000–2014.

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	2.62	3.90	4,844	7,205
2012	276.7[a]	1,787	6.5	2.91	3.01	5,202	5,384
2013	267.9[a]	995	3.7	3.81	4.68	3,795	4,663
2014	267.9[a]	2,195	7.6	2.70	2.89	5,920	6,349

[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, 2014.

Stream Name	Redds (n)			Carcasses (n)		
	Census	**Index**	**Random**	**Wild**	**Hatchery**	**Unknown**
Mainstem John Day						
Deardorff Creek	6			1		
Mainstem John Day River	236	439		287		7
Reynolds Creek	37					
Middle Fork John Day						
Bridge Creek						
Clear Creek	2			5		
Middle Fork John Day River	179	337		615	2	16
North Fork John Day						
Baldy Creek	4					
Bull Run Creek	33			33		
Clear Creek	16	87		63		4
Desolation Creek	77			21		
Granite Creek	25	99		127	1	2
North Fork John Day River	170	336		247	3	15
Total	**765**	**1,319**	**0**	**1,399**	**6**	**44**

Figure 5. Ratio of index to census redd count totals from 2000–2014 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.

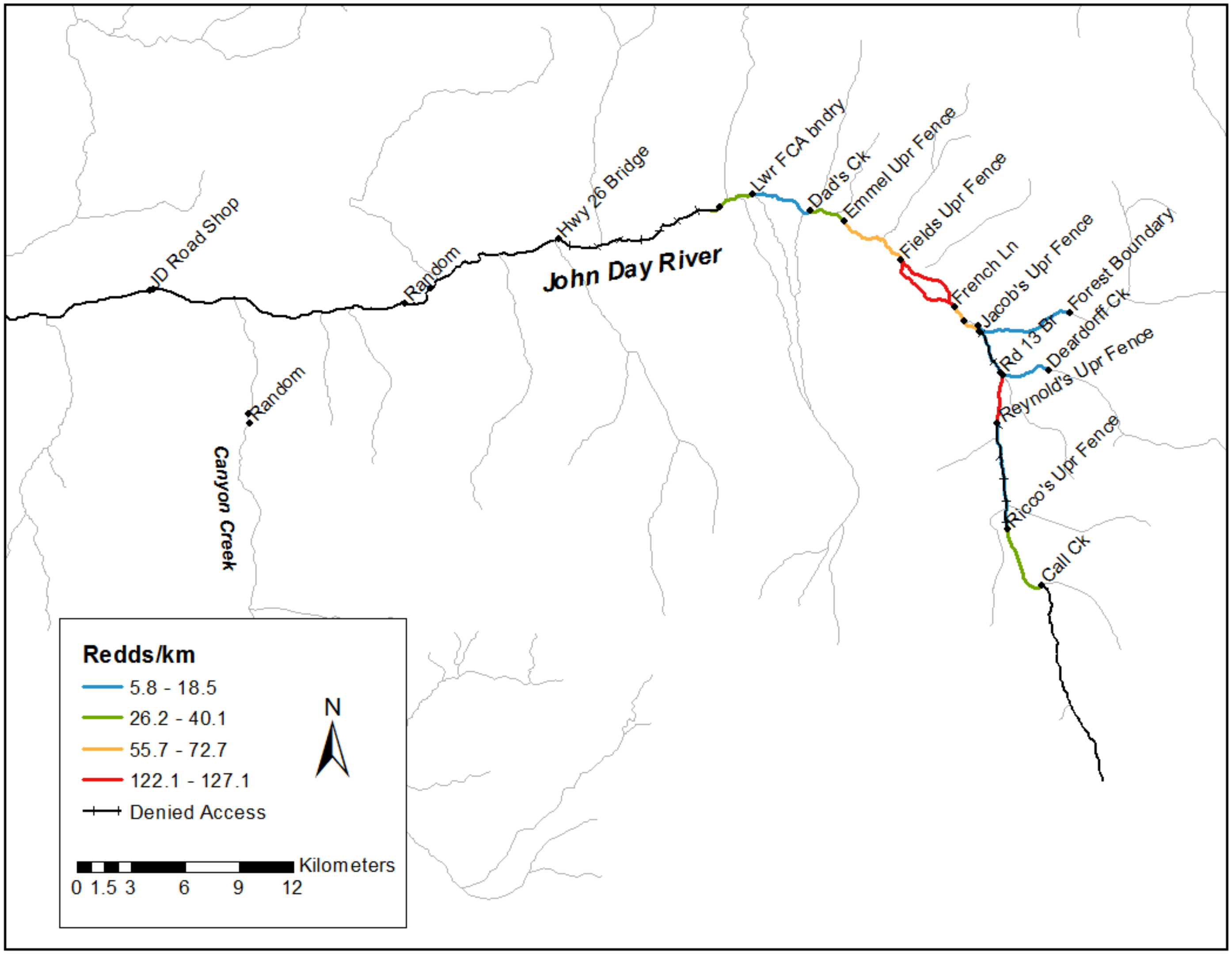

Figure 6. 2014 spring Chinook spawning survey sites and redd densities in the Mainstem John Day River.

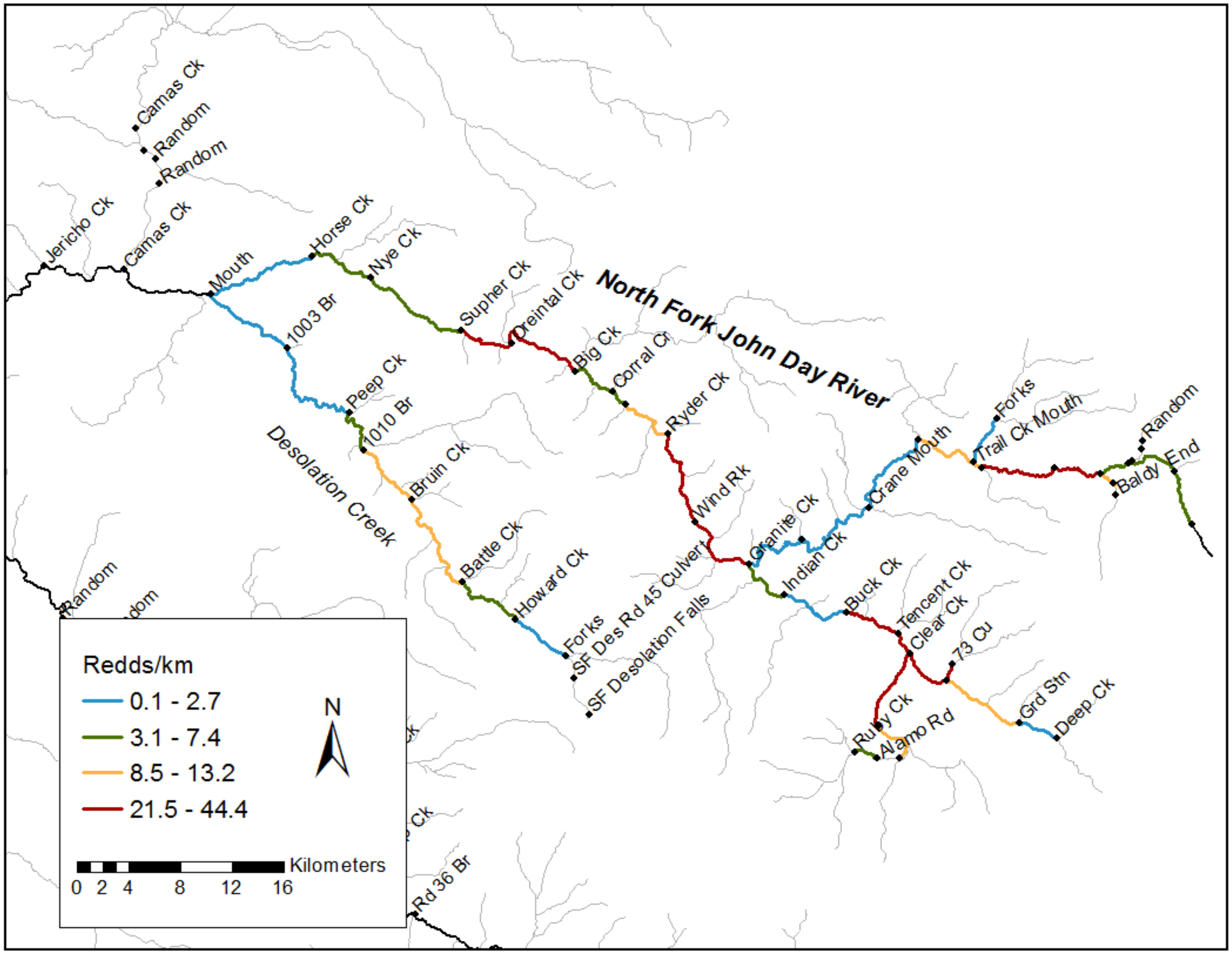

Figure 7. 2014 spring Chinook spawning survey sites and redd densities in the North Fork John Day River.

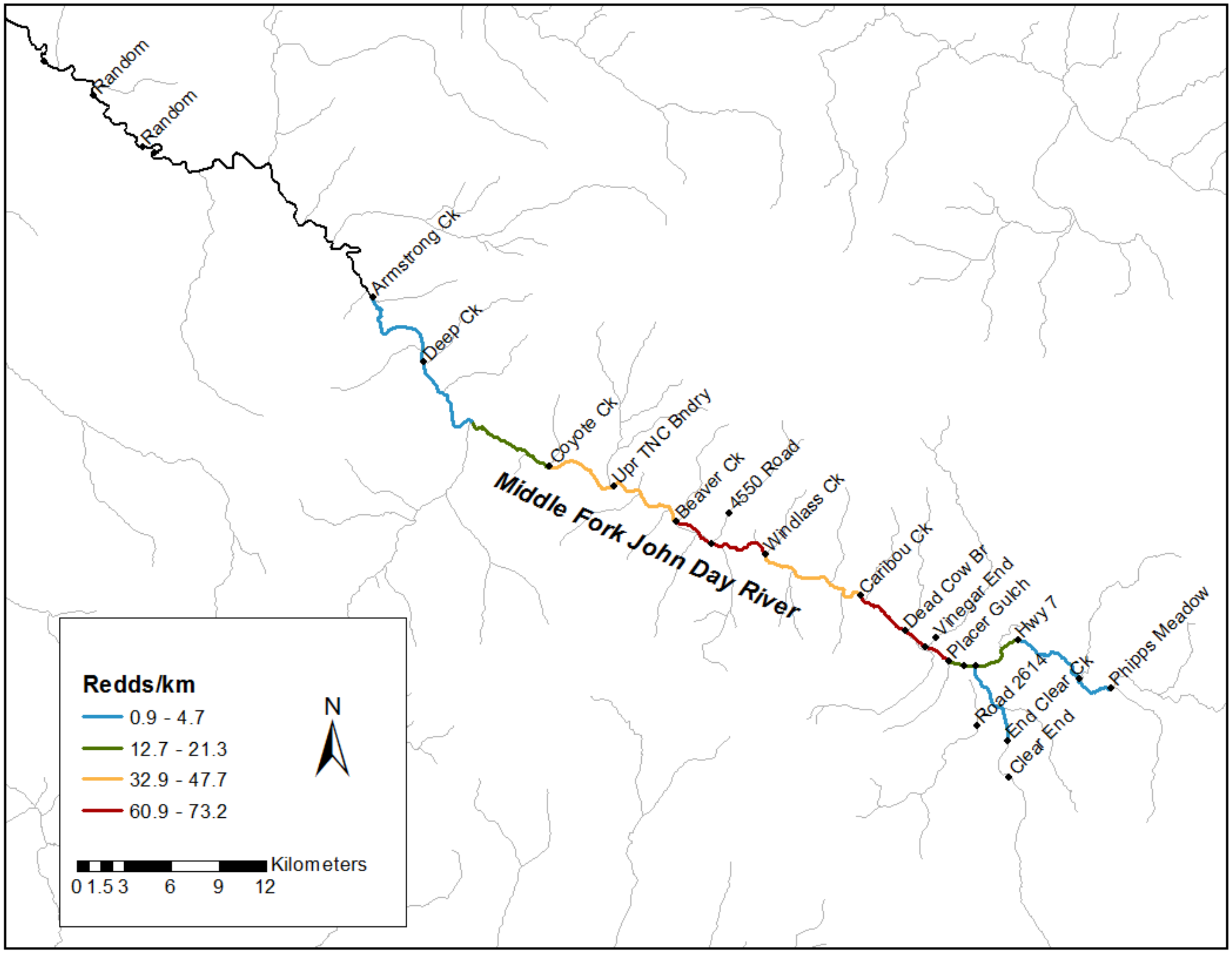

Figure 8. 2014 spring Chinook spawning survey sites and redd densities in the Middle Fork John Day River.

Significant correlations exist between index and total redds (total = index + census + random) for all three John Day populations (Mainstem $r = 0.88$, $P < 0.01$, Middle Fork $r = 0.97$, $P < 0.01$, and North Fork $r = 0.94$, $P < 0.01$; 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 2014 ($r = 0.94$, $P < 0.01$). Applying the regression equation between index and total redd counts for survey years 2000–2013 to the 2014 index count predicted a total redd count of 1,901. This prediction underestimated the actual total redd count by 13%.

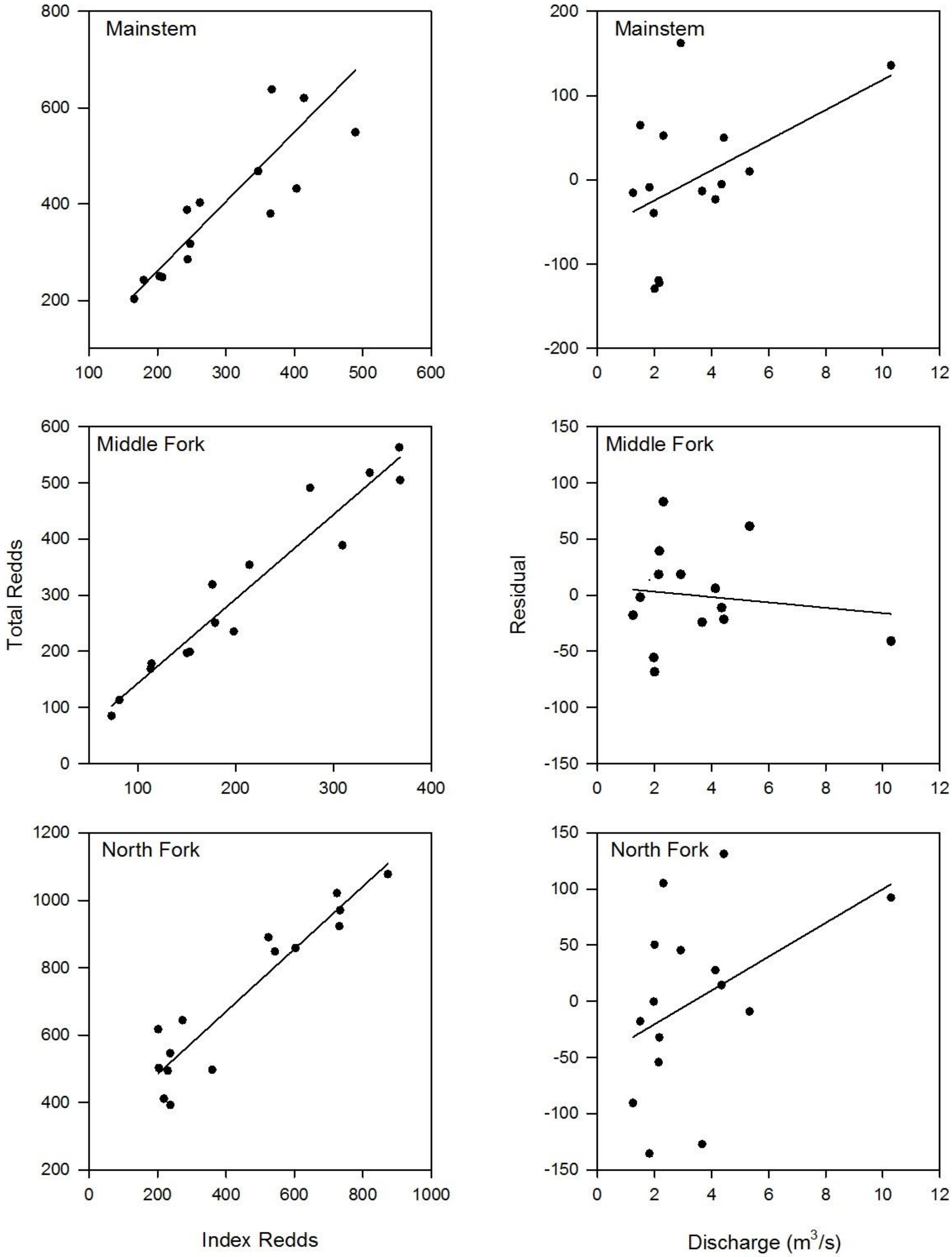

Figure 9. Regression between index and total redd counts from 2000–2014 spawning ground surveys and the residuals from these regressions plotted against mean August discharge of the John Day River for spawning populations in the Mainstem, Middle Fork, and North Fork of the John Day River.

Redd Count Expansion Escapement Estimation

The 2.89 fish per redd ratio generated from Catherine Creek spawning surveys in 2014 is similar to the fourteen year average (2.93). Applying this ratio to the John Day River basin, we estimated a spawning escapement of 6,349 spring Chinook jacks and adults in the John Day River basin for 2014 (Table 3). We estimated 2,398 fish spawned in the Mainstem, 1,498 spawned in the Middle Fork, and 2,453 spawned in the North Fork.

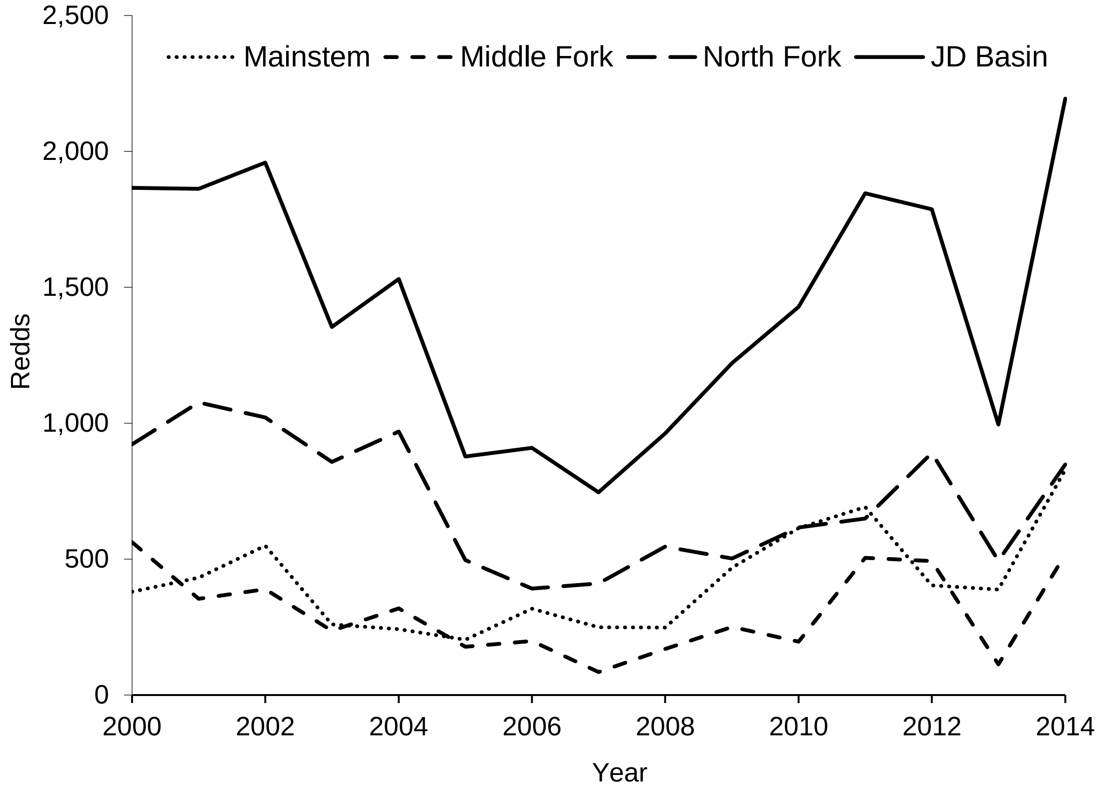

Figure 10. Redd totals from 2000–2014 for three John Day River basin spring Chinook salmon populations and the basinwide total.

Redd abundance at the John Day River basin scale during 2014 was more than double that of 2013 (Figure 10), surpassing 2,000 redds for the first time since basinwide monitoring began in 2000. At the population scale, the Mainstem showed a 114% increase, the North Fork increased 72%, and the Middle Fork climbed the most with 358% more redds in 2014 than we observed in 2013. Redd counts in other northeast Oregon river basins (e.g., Grande Ronde and Imnaha) also increased in 2014 (Figure 11); Grande Ronde River basin redd counts jumped 229% and Imnaha River basin redds went up 58% from 2013 to 2014. Annual Middle Fork redd counts are significantly correlated with counts in both Mainstem and North Fork populations (Table 5), however, the Mainstem is not significantly correlated with the North Fork. Redd counts for the Mainstem were significantly correlated to both Grande Ronde and Imnaha river populations. The Middle Fork showed a nearly significant correlation with the Grande Ronde (p-value = 0.096) and the North Fork was significantly correlated with Imnaha counts (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).

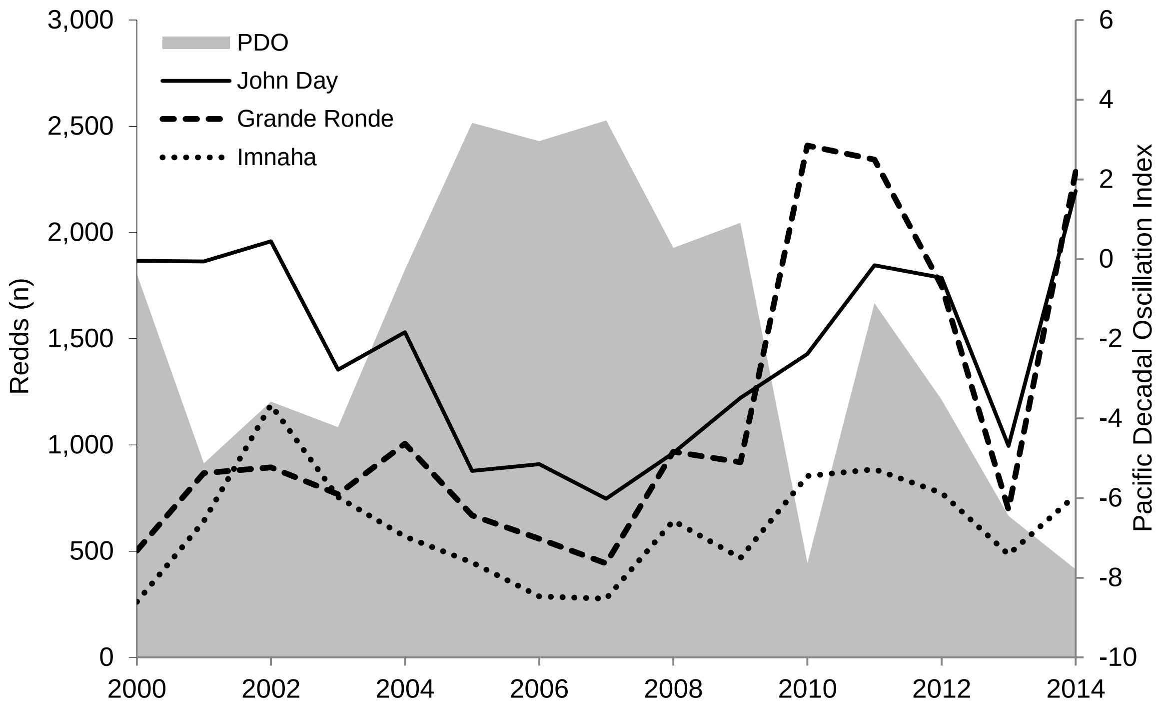

Figure 11. Redd totals from 2000–2014 for the John Day, Grande Ronde, and Imnaha river basins plotted with summer values of the Pacific decadal oscillation index. Pacific decadal oscillation index values are for the summer of entry for age-4 Chinook.

Table 5. Matrix of correlation coefficients (Pearson's r) between Mainstem John Day, Middle Fork John Day, North Fork John Day, Grande Ronde, and Imnaha rivers Chinook redd counts from 2000–2014 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	**0.55**	0.25	**0.78**	**0.58**	**-0.66**
Middle Fork Redd Count	-	**0.68**	*0.45*	0.39	-0.29
North Fork Redd Count	-	-	0.14	**0.56**	*-0.48*
Grande Ronde Redd Count	-	-	-	**0.58**	**-0.56**
Imnaha Redd Count	-	-	-	-	**-0.65**

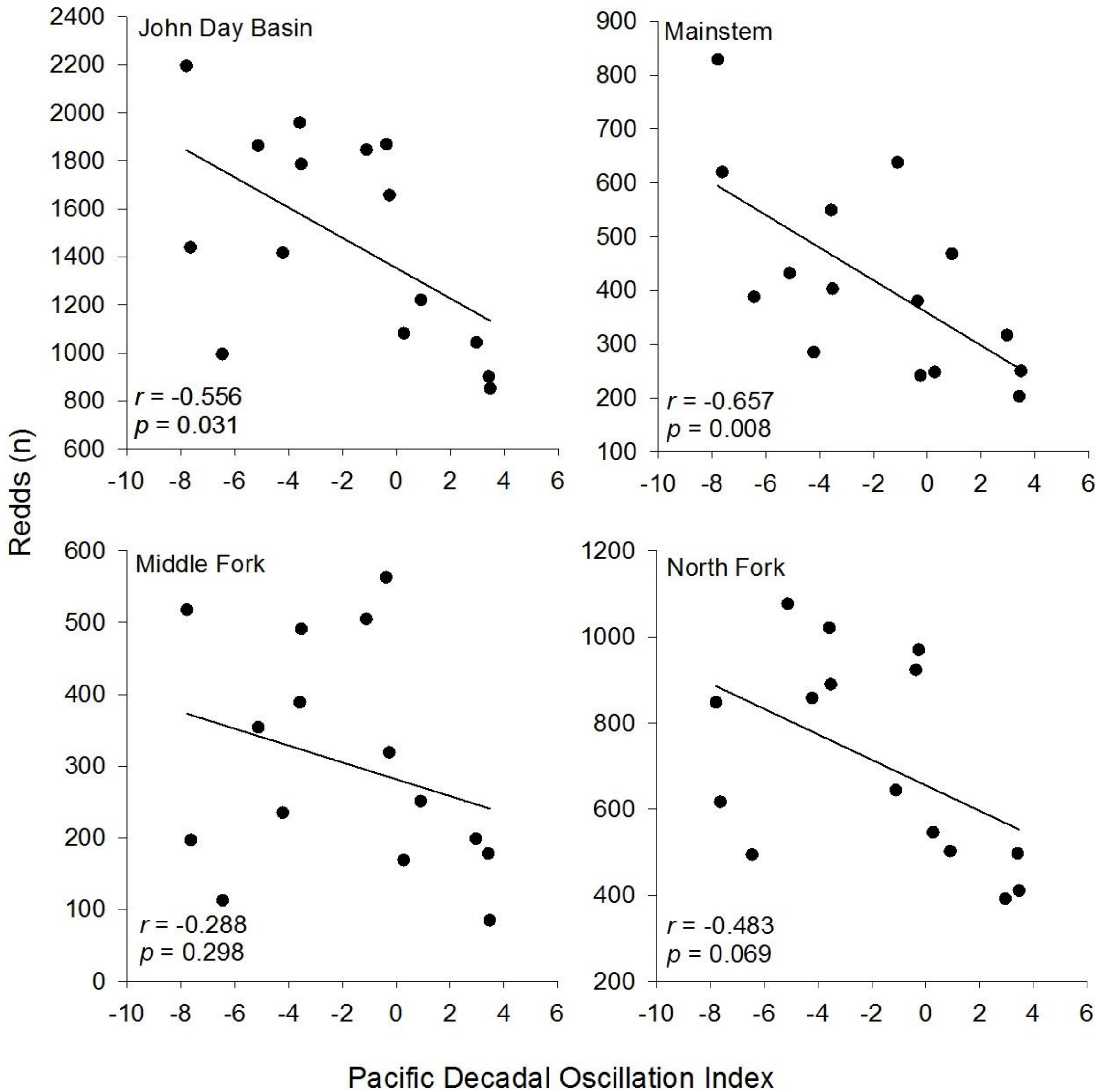

Figure 12. Correlation between Pacific Decadal Oscillation values and total redd counts from 2000–2014 spawning ground surveys in the Mainstem, Middle Fork, and North Fork of the John Day River.

Carcass Recovery

In 2014, we recovered 1,449 carcasses throughout the John Day River basin (Table 6). We were able to determine origin of 1,405 carcasses. Of the six fish that had clipped adipose fins, four were recovered in the North Fork and the other two were recovered in the Middle Fork. The PHoS observed in 2014 (0.4%) 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 = 0.214). We recovered one CWT from the snout of hatchery fish found in the North Fork that was released as a juvenile to the Grande Ronde River (Appendix Table IX). We determined the sex of 928 carcasses, 418 (45.0%) were male and 510 (55.0%) were female. We determined age for 774 carcasses using scale pattern analysis. There was a total of 27 age-3 (3.5%), 688 age-4 (88.9%), and 59 age-5 (7.6%) fish (Figure 13; Tables 6 and 7). All of the age-3 Chinook carcasses recovered were male.

Laboratory analysis produced optical density values for kidney samples taken from 107 carcasses and Rs antigen levels revealed 12 samples were negative or very low, 88 samples were low positive, six samples were moderate positive, and one Age-4 wild post-spawn female in the Mainstem population had a high positive (Appendix Table VIII). Of the 362 female carcasses for which we estimated egg retention, 320 (88%) were completely spawned. The 46 females that were partially spawned contained an average of 422 ml (SD = 341) of eggs.

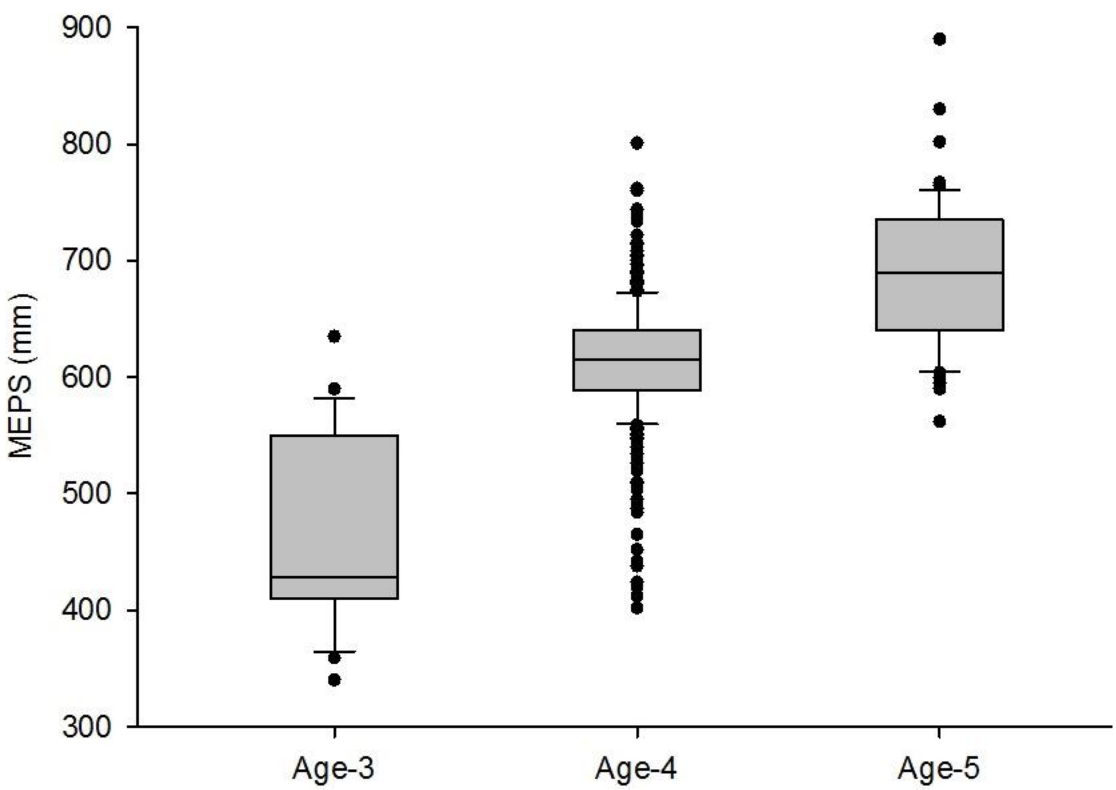

Figure 13. Age versus MEPS length for Chinook carcasses recovered in 2014 (n: Age-3 = 27; Age-4 = 692; Age-5 = 59). Boxes indicate 25th percentile, median, and 75th percentile. Error bars indicate 10th and 90th percentiles.

Table 6. Age, mean MEPS length (mm), standard error (SE), sample size (n), range (mm), and percentage of total known-sex aged Chinook from 2014 carcass recovery. Thirteen fish of unknown sex were also aged.

	Male					Female				
Age	**Length (mm)**	**SE**	**n**	**Range (mm)**	**%**	**Length (mm)**	**SE**	**n**	**Range (mm)**	**%**
3	456.7	15.4	27	340 - 635	3%			0		0%
4	615.4	3.4	280	402 - 801	36%	614.2	2.0	395	465 - 740	51%
5	702.3	14.9	15	590 - 802	2%	684.3	9.8	44	562 - 890	6%

Table 7. Percentage of known-sex aged Chinook carcasses by population for 2014.

		% Males by Age				% Females by Age		
	n	**3**	**4**	**5**	**n**	**3**	**4**	**5**
Mainstem	65	15.4	83.1	1.5	111	0.0	98.2	1.8
Middle Fork	112	6.3	88.4	5.4	159	0.0	90.6	9.4
North Fork	145	6.9	87.6	5.5	169	0.0	84.0	16.0
Basin Total	322	8.4	87.0	4.7	439	0.0	90.0	10.0

PIT Tag Detection-Recapture Escapement Estimation

A total of 1,272 carcasses, including those that had been scavenged, were scanned for PIT tags during the spawning ground surveys and 21 tags were recovered (Table 8). All of the recaptured fish were of wild origin. Thirteen of the PIT-tagged carcasses were male and nine were female. Seven of the nine females were tagged as adults in the Columbia River. Four carcasses originally tagged as juveniles in the Middle Fork were recovered in the Middle Fork, one carcass was tagged as a juvenile and recovered in the Upper Mainstem, and of three fish tagged as juveniles in the lower Mainstem John Day River (below the confluence with the North Fork), two were recovered in the Middle Fork and one was recovered in Granite Creek of the North Fork subbasin. Ten fish were tagged as adults during April and May of 2014 at the adult fish facility of Bonneville Dam (rkm 234). Another recaptured fish in the Middle Fork was tagged in the Snake River at Lower Granite Dam (rkm 522.173) in June of 2014. We also recovered two PIT-tagged fish, one in the Middle Fork and another in the Mainstem, that were marked at trawling sites from the Columbia River mouth to Three Tree Point, Washington (rkm 0-49).

Table 8. Spring Chinook passive integrated transponder (PIT) tags recovered on John Day River spawning ground surveys during 2009–2014. 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
2014	479	619	14	7	1	0	6	7	0

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

Detections at Bonneville Dam indicated that 172 John Day origin PIT-tagged Chinook passed the dam in 2014. Spawning surveys scanned a total of 1,112 intact wild origin carcasses (Table 8). We recaptured seven John Day basin origin males and one female. We estimated the number of recaptured John Day origin PIT-tagged females to be 8.6, producing a total of 15.6 recaptured adults. Estimated wild spawner abundance was 11,619 (95% CI: 6,489−16,749) (Figure 14).

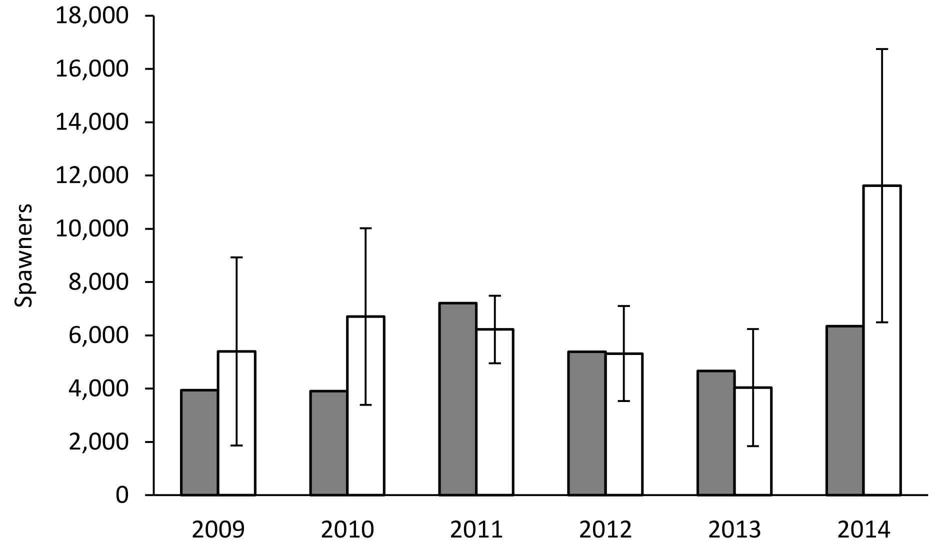

Figure 14. John Day River basin redd count escapement estimates (gray) and mark-recapture abundance estimates (white) with 95% confidence intervals for spawning years 2009–2014.

In the Middle Fork, 58 PIT tagged adult spring Chinook were detected (i.e., marked) as they swam past the array on their way to the spawning grounds. Subsequent spawning ground surveys scanned (i.e., captured) 514 carcasses, and 16.7 fish (estimated based on number of males recovered) were recaptured. The mark-recapture abundance estimate of 1,719 (95% CI: 1,077−2,361) spawners is significantly higher than those generated in the two previous years (Figure 15).

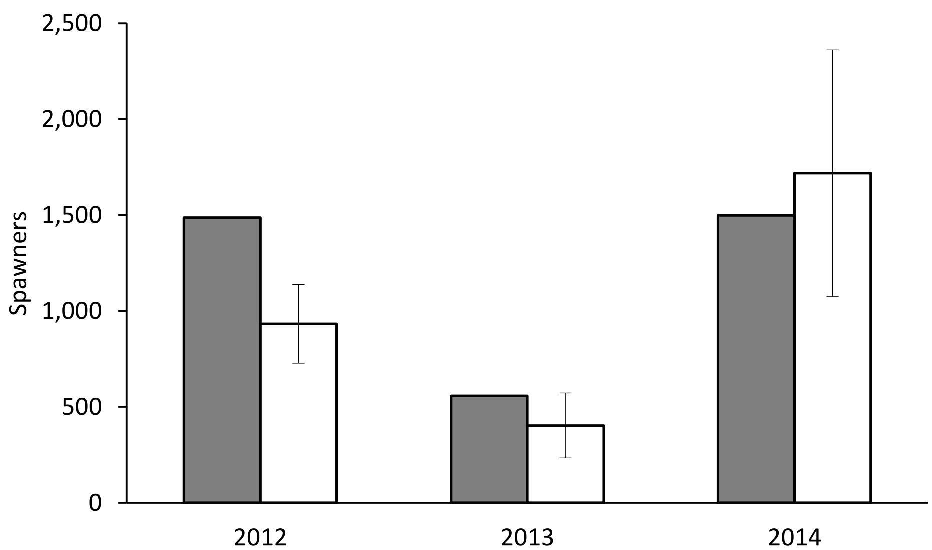

Figure 15. Middle Fork John Day River basin redd count escapement estimates (gray) and mark-recapture abundance estimates (white) with 95% confidence intervals for spawning years 2012–2014.

Carcass Detection Probabilities

We marked 541 carcasses with uniquely numbered cable-ties, 517 of which had their MEPS length recorded. We recovered 271 of these marked carcasses on subsequent surveys. The probability of a marked carcass being recovered was highest in the Middle Fork (0.64; n = 302), intermediate in the North Fork (0.39; n = 174) and lowest in the Mainstem (0.17; n = 41). Information theoretic selection of four candidate logistic regression models (Table 9) indicated that “size + population” and “population” were competing models (Delta AICc < 2), but the “population” model was the most parsimonious explanation of carcass recovery probability. Logistic regression models which incorporated size alone, or no explanatory variables (i.e., intercept), did not fit the data as well.

Table 9. Akaike’s information criterion (AICc) model selection results for binomial logistic regressions of marked carcass recoveries in 2014 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**	**ΔAIC_c**	**w_i**
Size + Population	5	42.54	0.00	0.61
Population	3	43.42	0.88	0.39
Size	3	89.47	46.93	0
Intercept	1	93.17	50.63	0

Population Productivity Analyses

We estimated that freshwater productivity for the 2012 brood year was 103 smolts per redd (95% CI: 85–125) in the Mainstem and 37 smolts per redd (95% CI: 25−56) 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 16 and 17).

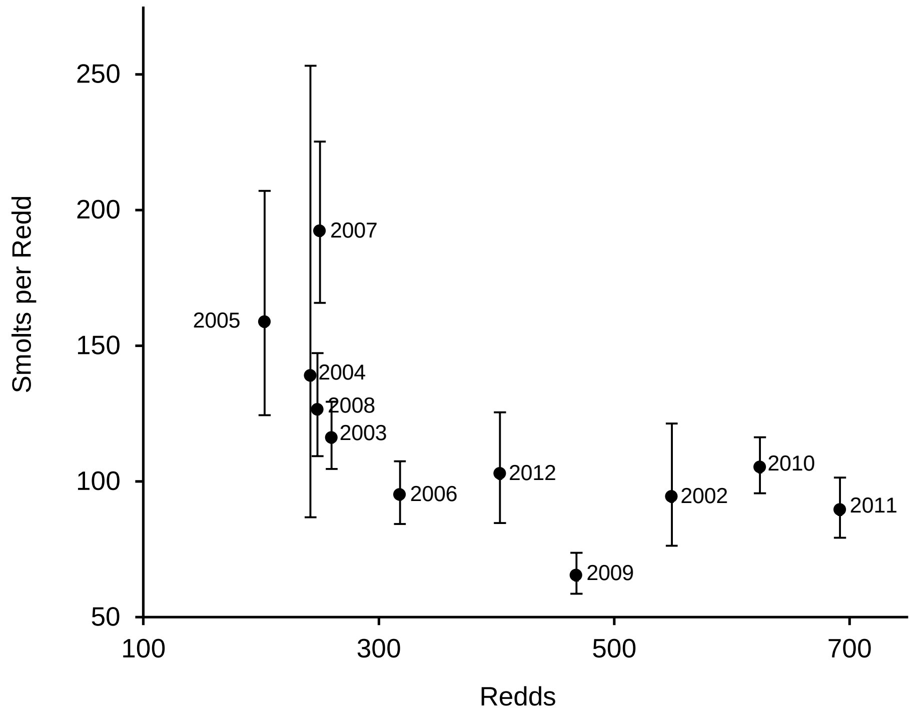

Figure 16. Estimated yearling spring Chinook salmon smolts produced per redd for brood years 2002 through 2012 for the Mainstem John Day population. Error bars are 95% Confidence Intervals.

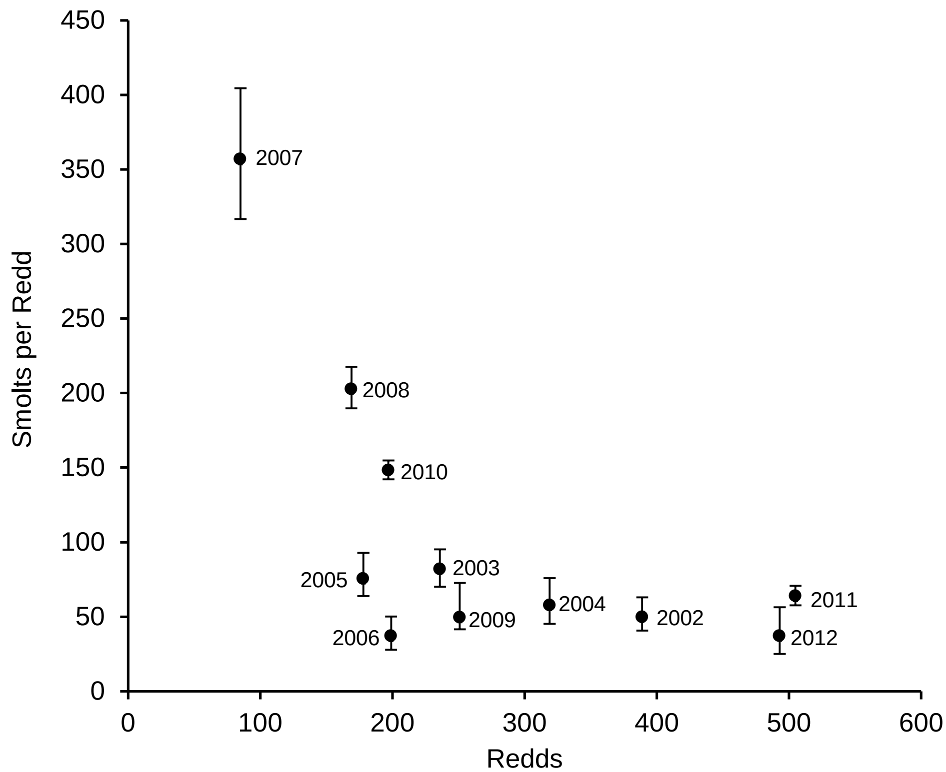

Figure 17. Estimated yearling spring Chinook salmon smolts produced per redd for brood years 2002 through 2012 for the Middle Fork John Day population. Error bars are 95% Confidence Intervals.

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 18a). 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 18c). 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 18e).

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 five brood years had positive residuals (Figure 18b). Residuals for the Middle Fork (Figure 18d) and North Fork (Figure 18f) do not appear to share this pattern. Residuals for both of these populations appear symmetrically distributed about zero, with no discernible trend over time.

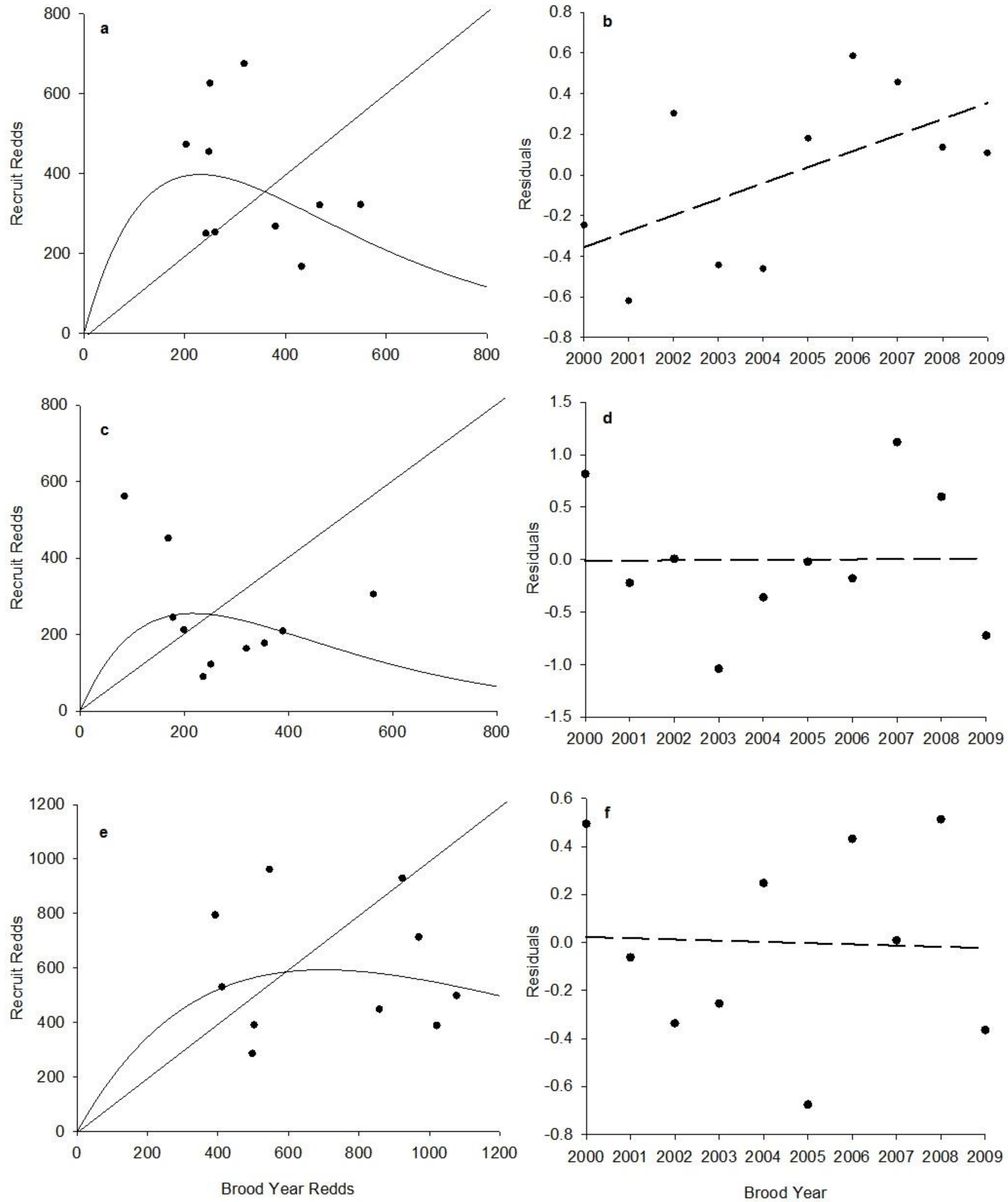

Figure 18. Comparison of Ricker stock-recruitment curves for 2000 through 2009 brood years and associated residual versus brood year plots for Chinook spawning populations in the Mainstem (a and b), Middle Fork (c and d), and North Fork (e and f) of the John Day River. Diagonal lines in panels a, c, 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

The significant increase in John Day River basin adult Chinook abundance increased from 2013 to 2014 may be partially attributable to favorable saltwater conditions. Low PDO values were observed for the summer entry of age-4 Chinook (migration year 2012). Conversely, during migration year 2011, which produced the majority of adults spawning in 2013, we observed the lowest SAR's of the monitoring period for Chinook (Banks et al., 2013). Much of 2014's increased redd count was attributable to the increased density in the Mainstem. Fall parr emigration estimates from the Mainstem during 2011 were an order of magnitude higher than in prior years (DeHart et al. 2012). Conversely, spring smolt migrant estimates have been relatively consistent through time. Our 2014 redd counts suggest that many of the fall parr migrants did survive to adult return.

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 increases in John Day redd counts in 2014 were mirrored by 229% and 58% increases 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). Once again, low ocean-entry PDO values appear to correspond with higher escapement numbers in 2014. Significant and nearly significant inverse relationships between PDO values during the summer of smolt ocean-entry and adult returns to most of the northeast Oregon populations suggest that ocean conditions may be a driving factor of adult abundance. An exception to this trend exists in the Middle Fork. Our data from prior years suggest that high stream temperatures occurring during late June and early July create higher pre-spawn mortality rates in this population than others in the region. These episodic pre-spawning mortality events, which we documented in 2007 and 2013, decouple Middle Fork redd counts from ocean productivity.

Given the 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 that 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 time (see Figure 18). 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. 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). We must, however, be cautious when interpreting trends in a short time series of data. Productivity of neighboring salmonid populations can oscillate in an asynchronous fashion in the absence of habitat perturbations (Hilborn et al. 2003). Such an oscillation could be occurring in our monitoring time-series. Although we can't identify causal mechanisms, our data demonstrate that in recent years, productivity in the upper Mainstem is increasing relative to the other two John Day populations.

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. The miniscule number of hatchery carcasses recovered limited our statistical power and precluded our ability to detect a statistically significant difference in PHoS among the populations. Visual recognition of hatchery fish may underestimate straying if hatchery smolts are either poorly fin-clipped or not fin-clipped. Genetic analysis and PIT tag recovery provide alternative methods to characterize both PHoS and the proportion of naturally produced strays escaping to spawn in the John Day River basin. 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 and present 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. During 2014, despite interrogating 20% of the estimated total escapement for PIT tags, we did not recover any Chinook that were PIT tagged as a juvenile outside of the John Day River basin and could hence be classified a wild or hatchery stray. Our lack of PIT tag recoveries corroborated our carcass recovery data during 2014, and combined indicate negligible current straying by hatchery or wild adults into the John Day River. Installation of PIT detection arrays on the North Fork and Upper Mainstem (planned for 2015) John Day will further improve our ability to detect stray wild adults.

Survey Methodology

Continuing to monitor index reaches allows us to see trends in redd abundance from 1964 to present, yet these reaches only comprise a portion of the spawning range in the basin. Index reaches were not chosen using an unbiased 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 index counts constituted 62% of redds observed in 2014, our more extensive census efforts reveal an overall downward trend in index representation since 2000 (Figure 5). For example, the 2011 index:census redd count ratio equaled 0.5 (index representation of 33%). 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 1950s 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.

The 2014 spawning season was the third consecutive year that we conducted a carcass detection study. Similar to 2012 and 2013 results, our 2014 carcass detection probability data indicate that carcasses were more readily recovered in the Middle Fork, where more than half of marked carcasses were subsequently detected. 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. The 2014 detection probability in the Mainstem decreased from the previous year, and remains lower than the recovery probability observed in the Middle and North forks. Lower carcass detections in the Mainstem are perhaps due to the dense riparian cover, higher turbidity, more frequent log jams, undercut banks, and moderate amounts of scavenging. In the North Fork population, scavenging appears to be a major limitation to carcass recovery; evidence of bear activity is abundant on streambanks within roadless reaches. While we were able to mark more carcasses in wilderness sections of the North Fork, relatively few of them were recovered on subsequent surveys. Despite the limitations, marking and re-sighting carcasses throughout the spawning grounds improved our understanding of factors influencing carcass recovery probability.

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 measuring the correlation of fish-per-redd values between the two basins. As demonstrated during the 2013 spawning season, when rain events resulted in turbidity that affected the final redd count, survey conditions in Catherine Creek may not reflect those encountered in the John Day basin and can result in fish per redd estimates that are not representative. Such occasions demonstrate the need for additional means of estimating escapement.

The PIT tag mark-recovery escapement for 2014 was significantly different from the redd expansion estimate for the first time in the five years that we have utilized this estimate. One possible explanation is that this estimation was overly sensitive to stochastic variation created by the small number of marked recovered fish during 2014. Therefore, a minimum number of returning marked fish is necessary to generate an accurate and precise estimate with acceptable confidence. With only 8 PIT tag recoveries in 2014, we may have had insufficient PIT tags available in the population to adequately implement this estimate. However, the dramatic increase in redd abundance in the Mainstem we observed during 2014 also suggests a possible alternate explanation. Given the high density of spawners, it is possible that redd superimposition occurred in the Mainstem, which could have biased our redd counts low. Hence, it is possible that we underestimated escapement in the Mainstem via the redd expansion, and correctly estimated escapement through the PIT detection-recapture estimation. The presence of a PIT array in the Middle Fork has allowed us to generate separate abundance estimates for the past three years. These estimates, independent of a fish per redd expansion, corroborate the trend in redd expansion estimates. During 2015, we will install another PIT array in the Mainstem John Day near Dayville (downstream of spawning reaches, but upstream of the North Fork confluence). Detection data from this site will provide more precise Mainstem specific detection-recapture population estimates and a better evaluation of redd undercounting due to superimposition during high density spawning years.

Management Implications

As a result of 2014 producing more than double the redds that were observed in 2013, we anticipate below average smolt per redd production from this brood. Monitoring smolt and adult production from the 2014 brood will help define the current capacity of freshwater habitat and refine our estimate of the replacement level for each population. Setting escapement goals equal to the replacement level (Figure 19) is a cautious approach which allows for production of all juvenile life-history types. Managing for replacement levels of escapement will provide “cushion” in the event of unanticipated ocean or freshwater environmental changes. Improvements to the rearing habitat would increase the potential for future recreational fisheries targeting wild populations, which are scarce for Columbia River Chinook.

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APPENDIX

Appendix Table I. Spring Chinook total redd counts in the John Day River basin, 2000–2014. 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
2014	829	0	518	848	124	103	33	77	2,195

Appendix Table II. Census and index survey lengths (km) for spring Chinook salmon spawning surveys in the John Day River basin, 2000–2014. 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
2014	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, 2000–2014. 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
2014	19.0	0.0	8.7	5.1	7.5	10.0	4.6	2.1	7.6

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, 2002–2012 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	549	94	76	121	389	50	41	63
2003	2005	260	116	105	129	236	82	70	95
2004	2006	242	139	87	253	319	58	45	76
2005	2007	203	159	124	207	178	76	64	93
2006	2008	318	95	84	107	199	37	28	50
2007	2009	250	192	166	225	85	357	317	404
2008	2010	248	126	109	147	169	203	190	218
2009	2011	468	65	59	74	251	50	42	73
2010	2012	624	105	96	116	197	148	142	155
2011	2013	692	90	79	101	505	64	58	71
2012	2014	403	103	85	125	493	37	25	56

[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, 2014.

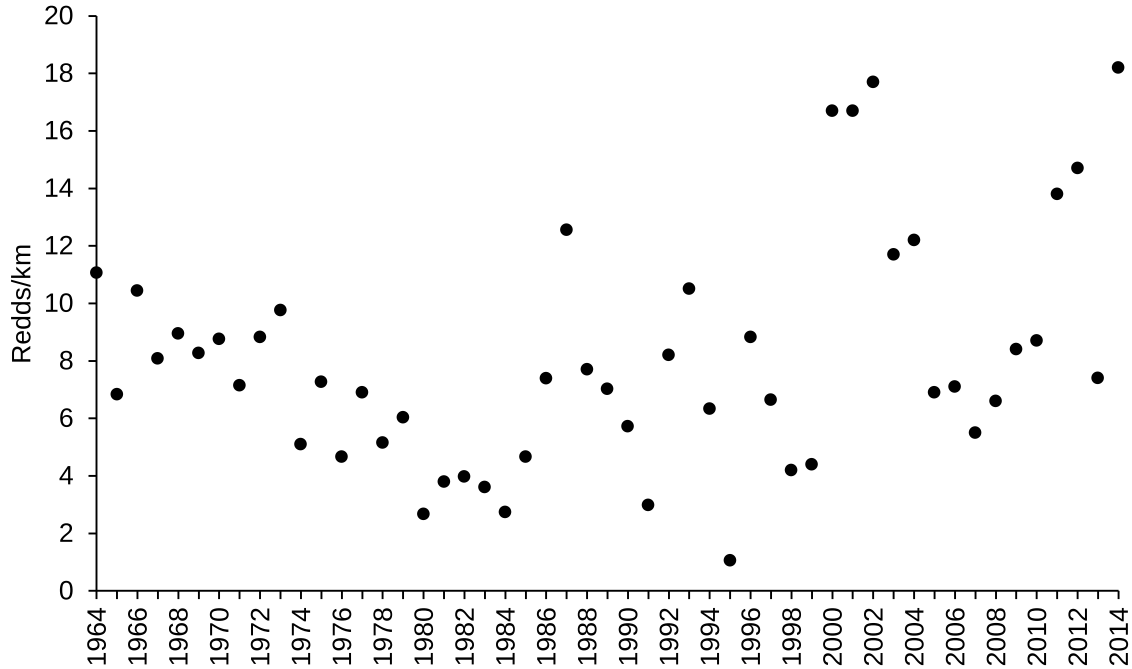
Population	Egg Retention (ml)	Optical Density (OD_{405})
Mainstem John Day River	50	1.917
Mainstem John Day River		0.178
Mainstem John Day River		0.169
Mainstem John Day River	0	0.168
Mainstem John Day River	0	0.157
Mainstem John Day River		0.136
Mainstem John Day River		0.130
Mainstem John Day River		0.129
Mainstem John Day River	0	0.125
Mainstem John Day River		0.125
Mainstem John Day River	0	0.124
Mainstem John Day River	0	0.123
Mainstem John Day River		0.119
Mainstem John Day River	0	0.118
Mainstem John Day River		0.116
Mainstem John Day River	0	0.109
Mainstem John Day River	0	0.109
Mainstem John Day River		0.109
Mainstem John Day River	0	0.108
Mainstem John Day River		0.107
Mainstem John Day River	175	0.106
Mainstem John Day River		0.105
Mainstem John Day River	575	0.102
Mainstem John Day River		0.098
Mainstem John Day River		0.095
Mainstem John Day River	700	0.093
Mainstem John Day River		0.091
Middle Fork John Day River	0	0.545
Middle Fork John Day River		0.282
Middle Fork John Day River	0	0.276
Middle Fork John Day River	60	0.257
Middle Fork John Day River	0	0.252
Middle Fork John Day River	0	0.212
Middle Fork John Day River	0	0.208
Middle Fork John Day River	0	0.207
Middle Fork John Day River	0	0.192
Middle Fork John Day River		0.190
Middle Fork John Day River		0.185
Middle Fork John Day River	600	0.179
Middle Fork John Day River	0	0.172
Middle Fork John Day River		0.164

Appendix Table V. Continued.

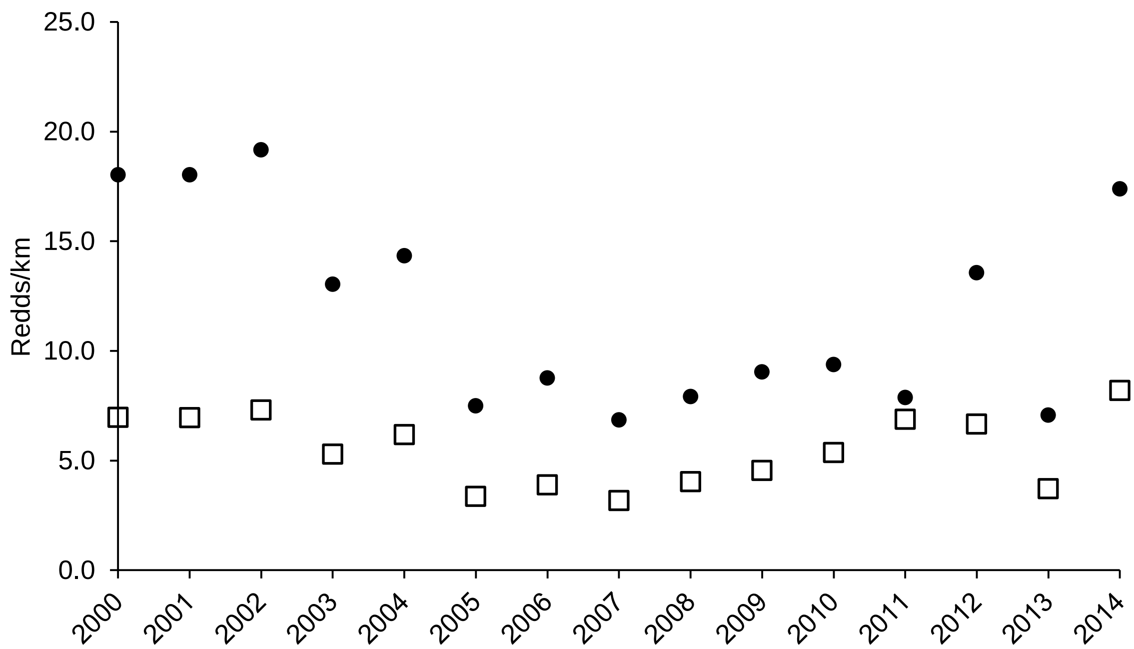
Population	Egg Retention (g)	Optical Density (OD_{405})
Middle Fork John Day River	230	0.163
Middle Fork John Day River		0.156
Middle Fork John Day River		0.152
Middle Fork John Day River		0.148
Middle Fork John Day River	0	0.142
Middle Fork John Day River		0.132
Middle Fork John Day River	0	0.131
Middle Fork John Day River		0.131
Middle Fork John Day River	10	0.129
Middle Fork John Day River		0.093
North Fork John Day River	0	0.573
North Fork John Day River		0.259
North Fork John Day River		0.233
North Fork John Day River	0	0.210
North Fork John Day River	0	0.193
North Fork John Day River	0	0.187
North Fork John Day River		0.175
North Fork John Day River		0.162
North Fork John Day River		0.162
North Fork John Day River		0.162
North Fork John Day River		0.158
North Fork John Day River	0	0.158
North Fork John Day River	0	0.157
North Fork John Day River	0	0.154
North Fork John Day River	0	0.153
North Fork John Day River	10	0.148
North Fork John Day River		0.146
North Fork John Day River	275	0.140
North Fork John Day River	0	0.137
North Fork John Day River		0.132
North Fork John Day River		0.132
North Fork John Day River		0.132
North Fork John Day River		0.129
North Fork John Day River	0	0.126
North Fork John Day River	0	0.125
North Fork John Day River	125	0.122
North Fork John Day River	0	0.121
North Fork John Day River		0.119
North Fork John Day River		0.116
North Fork John Day River		0.113
North Fork John Day River		0.112
North Fork John Day River	100	0.106
North Fork John Day River		0.096

Appendix Table V. Continued.

Population	Egg Retention (g)	Optical Density (OD_{405})
North Fork John Day River	0	0.094
North Fork John Day River		0.092
North Fork John Day River		0.092
North Fork John Day River		0.087
Unknown	N/A	0.437
Unknown	N/A	0.423
Unknown	N/A	0.402
Unknown	N/A	0.320
Unknown	N/A	0.269
Unknown	N/A	0.260
Unknown	N/A	0.210
Unknown	N/A	0.204
Unknown	N/A	0.204
Unknown	N/A	0.177
Unknown	N/A	0.174
Unknown	N/A	0.173
Unknown	N/A	0.145
Unknown	N/A	0.125
Unknown	N/A	0.120
Unknown	N/A	0.108
Unknown	N/A	0.081
Unknown	N/A	0.078



Appendix Figure I. Spring Chinook index redd densities in the John Day River basin, 1964–2014. 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, 2000–2014. 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 1998–2014. 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
2014	27.3	17.0	14.5	11.0	16.1

Appendix Table VII. 2014 spring Chinook spawning survey section locations and coordinates (DD.DD, NAD 1983 Oregon Lambert).

		Start		End	
System	**Description**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
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	Near Grant Road Shop, city of John Day	44.425048	-119.001531	44.425384	-118.999349
Mainstem John Day River	RM253 (Random)	44.425845	-118.861605	44.420566	-118.874140
Canyon Creek	Canyon Creek (Random)	44.375308	-118.954346	44.366545	-118.956446
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
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	-118.627342	44.622012	-118.573089
Middle Fork John Day River	Dead Cow Bridge to Placer Gulch	44.607644	-118.547349	44.595637	-118.522586

Appendix Table VII. Continued.

System	Description	Start Latitude	Start Longitude	End Latitude	End Longitude
Middle Fork John Day River	Placer Gulch to Highway 7	44.595637	-118.522586	44.603958	-118.483250
Middle Fork John Day River	Highway 7 to Phipps Meadow	44.603958	-118.483250	44.584500	-118.429986
Middle Fork John Day River	RM 30 (Random)	44.801673	-118.975865	44.804117	-118.982658
Middle Fork John Day River	RM 26 (Random)	44.838794	-119.038505	44.824894	-119.010555
Granite Boulder Creek - MFJDR	Mouth to 4550 Road	44.647386	-118.665057	44.655800	-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	44.874560	-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
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	45.010210	-118.995950

Appendix Table VII. Continued.

System	Description	Start Latitude	Start Longitude	End Latitude	End Longitude
North Fork John Day River	Camas Creek to Jericho Creek	45.01021	-118.99595	45.011857	-119.051625
North Fork John Day River	RM 38 (Random)	44.969424	-119.275803	44.968239	-119.285186
Camas Creek	RM 4 (Random)	45.052161	-118.971949	45.064404	-118.974060
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
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
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	Battle Creek to Bruin Creek	44.856763	-118.761268	44.896974	-118.796166

Appendix Table VII. Continued.

System	Description	Start Latitude	Start Longitude	End Latitude	End Longitude
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 10 (Random)	44.374033	-119.544030	44.383549	-119.543760

Appendix Table VIII. Correlation matrix for census John Day River population Chinook redd counts from 2000 to 2014 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	**0.822**	**0.585**	**0.911**	**0.718**	**0.714**	**0.575**	**0.628**
Middle Fork	0.425	**0.520**	0.470	0.327	**0.642**	0.393	0.266
North Fork	0.122	0.107	0.300	0.020	**0.669**	**0.559**	0.059

Appendix Table IX. Summary of Chinook coded wire tag recoveries by John Day River population from 2000 to 2014.

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*			
2014	North Fork	1	Lookingglass, Oregon	Grande Ronde River

Appendix Table X. Summary of 2014 fall Chinook spawning surveys conducted in the lower John Day River.

				Fish	
Date	**Survey Reach**	**Length (km)**	**Redds**	**Live**	**Dead**
06-Nov-14	RKM 64 to RKM 35	29	1	0	0
25-Nov-14	RKM 35 to RKM 17	18	0	0	0
10-Dec-14	RKM 64 to RKM 35	29	0	0	0