

**FISH RESEARCH PROJECT
OREGON**

**STEELHEAD ESCAPEMENT MONITORING IN THE UPPER
GRANDE RONDE RIVER AND JOSEPH CREEK BASINS**

ANNUAL TECHNICAL REPORT

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EXECUTIVE SUMMARY

Objectives

1. Estimate redd density and spawner escapement of summer steelhead in the Upper Grande Ronde River basin.
2. Estimate redd density and spawner escapement of summer steelhead in the Joseph Creek basin, a tributary to the Lower Grande Ronde River.
3. Estimate spawners:red ratio above adult weir collection points.

Accomplishments and findings

We conducted 117 surveys in the Upper Grande Ronde River (UGRR) basin and 109 surveys in the Joseph Creek basin from 14 March through 08 June 2016 to determine summer steelhead *Oncorhynchus mykiss* redd abundance and adult escapement for these two populations. We sampled 29 random, spatially-balanced sites throughout the UGRR basin encompassing 58.2 km (65%) of an estimated 892 km of available steelhead spawning habitat. In Joseph Creek, we surveyed 26 sites encompassing 52.7 km (13.7%) of the 384 km of available spawning habitat. During these surveys we observed 128 steelhead redds and three live steelhead in the UGRR basin and 177 redds and 18 live steelhead in the Joseph Creek basin. We observed zero carcasses in UGRR basin and one carcasses in the Joseph Creek basin.

On 18.7 km of Deer Creek, 63 redds, nine live steelhead, and zero carcasses were observed while surveying. However, we encountered 31 steelhead carcasses at the weir and 22 kelts that were passed downstream of the weir. Of these 53 adult steelhead all were marked with a left operculum punch (LOP) received in the Big Canyon fish trap. A total of 82 wild-origin adult steelhead were passed above a permanent weir on Deer Creek, resulting in 1.3 fish:red ratio for the 2016 spawning season. Using the fish:red ratio extrapolated from Deer Creek surveys, adult steelhead escapement estimates for the UGRR and Joseph Creek basins were 2,572 (95% C.I.: 1,548–3,596) and 1,663 (95% C.I.: 924–2,402) respectively.

Management recommendations

1. Using the current data of steelhead spawning distribution and geographic landscape variables, refine the sampling universe for the Upper Grande Ronde River and Joseph Creek populations to improve our knowledge of steelhead spawning distribution.
2. Estimate the biologically and statistically significant level of change in steelhead escapement for determining short- and long-term population changes.
3. Improve current methods for standardizing escapement estimates.
4. Manage the Upper Grande Ronde River and Joseph Creek populations exclusively for wild-origin steelhead and determine the extent and distribution of hatchery steelhead in the basin through observations of hatchery fish during the spawning season.

ACKNOWLEDGMENTS

We would like to acknowledge the assistance and cooperation of the many private landowners throughout the area who allowed us access to their property. The cooperation of private landowners was essential in meeting our project objectives. Additionally, we thank the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) for providing data from weir collections on Catherine and Lookinglass creeks and the UGRR. The Nez Perce Tribe provided data from weir collections on Joseph Creek. Further, we would like to acknowledge our field crew members Shannon Power, Justin Zapata, Shiann Micka and Joe Whittle for their assistance as well as Jeff Yanke and Kyle Bratcher for their expertise and assistance.

INTRODUCTION

Summer steelhead in the Grande Ronde River basin fall within the Snake River Distinct Population Segment (DPS) and are listed as threatened under the Endangered Species Act (62 FR 43937; August 18, 1997). The Upper Grande Ronde River (UGRR) and Joseph Creek basins support two of the four populations in the Grande Ronde Major Population Group (MPG). These populations are segregated based on topographic, genetic, and behavioral evidence of interactions. Historically, the Grande Ronde River was one of the more significant anadromous fish producing rivers in the Columbia River basin. Despite recovery efforts, these populations remain depressed relative to historic levels.

The goal of this project is to annually evaluate summer steelhead population abundance for the UGRR, and recently Joseph Creek, by conducting surveys of redds and spawning activity. These surveys provide those data needed to estimate adult steelhead escapement, improve our understanding of habitat utilization, and contribute to productivity and survival estimates for these populations.

Study area

The Grande Ronde River flows generally northeast 341 km from its origin in the Elkhorn Mountain range to join the Snake River at river kilometer (rkm) 271, about 32 rkm upstream of Asotin, WA and 793 rkm from the mouth of the Columbia River. The UGRR basin (Figure 1) includes the Grande Ronde River and its tributaries from the headwaters to the confluence with the Wallowa River (rkm 131). Major tributaries of the UGRR include Sheep Creek (rkm 312), Meadow Creek (rkm 290), Catherine Creek (rkm 225), and Lookinglass Creek (rkm 138). The UGRR drains approximately 4,200 km² and contains 1,475 km of streams (892 km of anadromous salmonid habitat). Elevations in the basin range from 705 m at the confluence of the Grande Ronde and Wallowa rivers to over 2,646 m in the headwater mountains. Stream physiography in headwater areas is similar to other western, inter-mountain systems, with forested uplands, perched meadows, and high to moderate stream gradients. However, the mid-portion of the UGRR flows through large historic wetland complex (approximately 56 x 24 km at its greatest extent), bounded by a geologic pinch point at the downstream end (Rinehart Gap). The main portion of this valley is extremely flat (stream gradient <0.1%), leading to increased stream sinuosity and decreased water velocity. Gradient increases after the UGRR passes downstream through Rinehart Gap (near the town of Elgin) and enters a canyon-dominated landscape. Land use in the headwaters is a mix of timberlands and cattle grazing, while the main

valley is in irrigated crop production. Agricultural land use is relatively light downstream of Elgin.

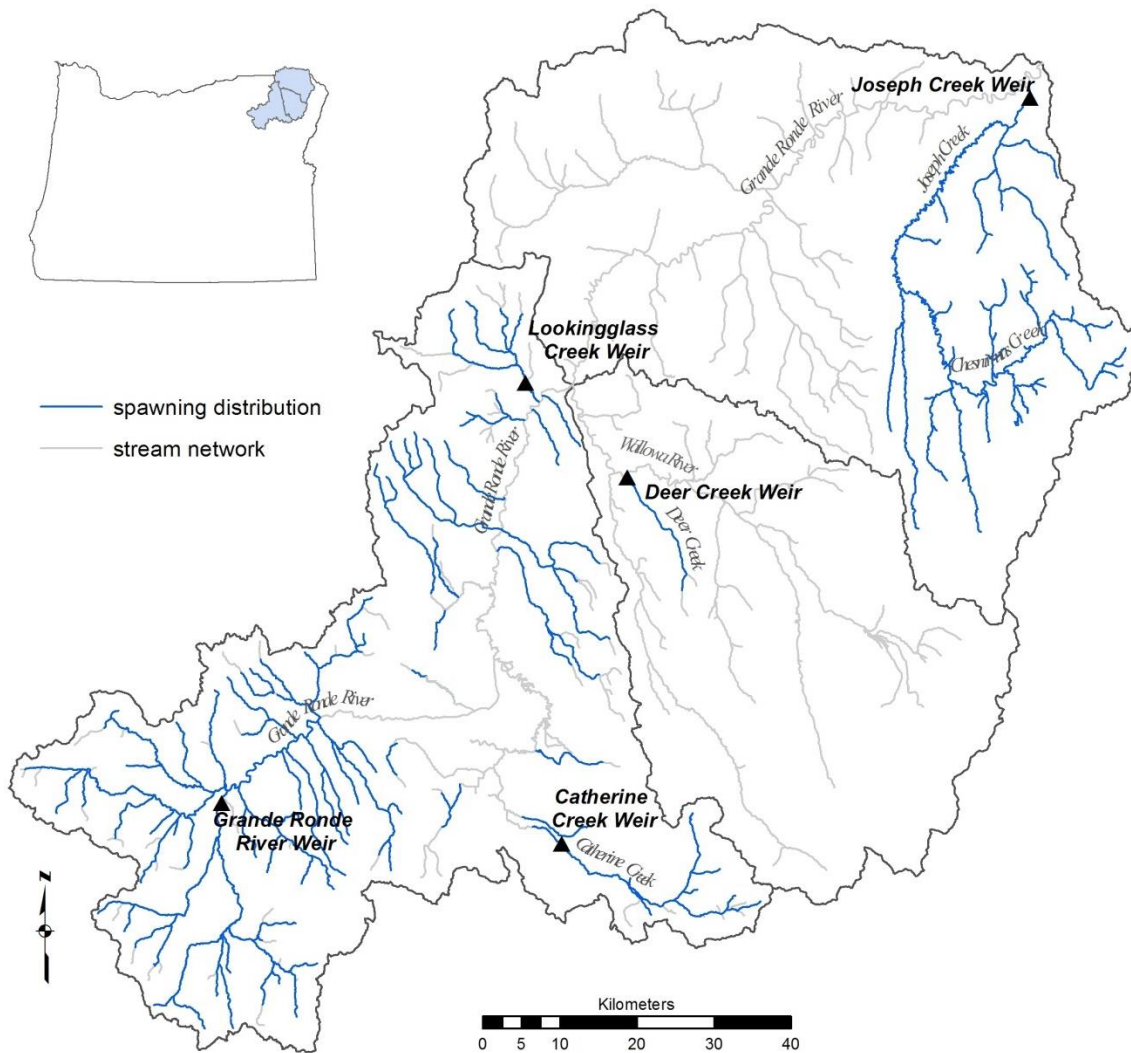


Figure 1. Sampling domains (blue) fall within the current spawning distribution of summer steelhead in Upper Grande Ronde River (UGRR) and Joseph Creek basins. Deer Creek and weir locations are also shown.

Joseph Creek is the most downstream tributary of the Grande Ronde River, entering approximately 7 km upstream of its mouth. Joseph Creek and its tributaries drain 1,420 km² originating on a plateau north of the upper Willowa River valley, and flowing generally north into Washington (Wallace 2011). The Joseph Creek basin contains 536 km of streams, 384 km of which are estimated to be part of steelhead spawning distribution (Figure 1). Major tributaries include Crow and Chesnimnus creeks (which meet forming Joseph Creek at rkm 79), Swamp Creek (rkm 54), and Cottonwood Creek (rkm 7). Elevations in the basin are substantially lower than the UGRR basin, and range from 273 m at its confluence with the lower Grande Ronde

River to around 1,673 m in the headwater areas. Physiography within the drainage is a mixture of hills and valleys at the upstream end, and canyonlands in the downstream portion (Figure 1). Land use is primarily cattle grazing in the upper reaches, especially upstream of the origin of Joseph Creek. Some grazing occurs in the lower reaches and tributaries; however, most of lower Joseph Creek flows through federal (US Forest Service) and Nez Perce Tribal property. No significant municipalities exist in the Joseph Creek basin.

Deer Creek flows north from its origin in the Wallowa Mountains until reaching the Wallowa River at rkm 18. It is a narrow, elongated drainage, covering 79 km² with elevations ranging from 2,259 m to 787 m. Approximately 18.7 km of stream are considered anadromous fish spawning habitat, and all 18.7 km are surveyed annually. A concrete fish acclimation facility (Big Canyon), with a permanent weir, is located approximately 0.25 km from the mouth of Deer Creek. All wild-origin adult steelhead captured at Big Canyon were marked with an opercle punch and passed above the weir during their spawning migrations. The known number of adult steelhead allowed into the spawning areas enables us to determine the adult fish:red ratio for extrapolation to the larger UGRR and Joseph Creek populations (Flesher et al. 2005; Gee et al. 2008; James Ruzycki, ODFW, unpublished data). Land use is almost entirely timberlands upstream of the permanent weir.

METHODS

Sampling domain and site selection

Steelhead were monitored using a probabilistic sampling approach that incorporates a sample-site selection procedure created for the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). The Generalized Random Tessellation Stratified (GRTS) design achieves a spatially balanced distribution of sites selected at random from the available spawning habitat to extrapolate an estimate of redd, and therefore, spawner abundance (Jacobs et al. 2009). This method follows the Oregon Plan for Salmon and Basins Monitoring Program approach (Stevens 2002).

This GRTS design was first implemented in the UGRR in 2008 and 2012 for Joseph Creek. Sample sites were limited to the current steelhead spawning distribution, which was defined by redd and fish counts from previous spawning ground surveys and barriers identified during habitat surveys for summer steelhead. This information is annually updated to include newly identified barriers as well as new reaches of spawning habitat. All reaches upstream of known barriers to anadromous fish passage were eliminated from the potential sampling area. Thirty sample sites were targeted in the UGRR for this year. Twenty-five sample sites were targeted in the Joseph Creek basin for this year.

Beginning in 2012, a new survey design implementing sites selected from the Columbia Habitat and Monitoring Program (CHaMP) was integrated into the legacy design that includes the following components for the UGRR:

- 10 sites repeated every year (annual)
- 10 sites repeated once every 3 years on a staggered basis
- 5 sites from UGRR CHaMP frame to be repeated once every 3 years.
- 5 sites new every year (once-only)

Under the new survey design, stream segments were stratified into three classifications (source, transport, and depositional) and sites were evenly distributed among those three strata (logistics allowing). Stream segments were classified using Geographical Information System (GIS) by several attributes including valley width, stream gradient and bankfull width (Tim Beechie, unpublished data). In stratifying the sampling universe, we attempted to identify and isolate areas of habitat differentially utilized for spawning, thereby increasing the precision of future adult escapement estimates.

There were no sites in the Joseph Creek basin integrated from CHaMP because the program is not implemented in that basin. Additionally, GRTS-selected sites were not stratified by stream classification. The initial GRTS draw (2012) was stratified similarly to UGRR, but resulted in significant site clustering in depositional stream reaches. We removed the stratification to promote wider distribution of sites within the basin. Therefore, sites were selected as follows:

- 10 sites repeated every year (annual)
- 15 sites repeated once every 3 years on a staggered basis

Incorporating a 1:100,000 digital stream network, GIS was used to insure an unbiased and spatially balanced selection of sample sites. The GIS site selection process generated geographic coordinates (i.e. latitude and longitude) for each candidate site (Table 1). A two-kilometer reach was established encompassing each candidate site. Topographic maps were produced showing the downstream and upstream ends of each survey reach along with the included GRTS sample point. In the field, crews used a handheld Global Positioning System (GPS) to locate the established survey reaches. Some candidate sites were not sampled due to denial of permission from private landowners or because sites were located upstream of previously unknown fish passage barriers. In such events, replacement sites were drawn from a pre-selected list of over-sample sites.

Steelhead redd surveys

Steelhead redd surveys were based on standard ODFW methods (Susac and Jacobs 1999; Jacobs et al. 2000; Jacobs et al. 2001) and were conducted from March through June, 2015. Individual sites were surveyed up to seven times to quantify the number of redds constructed at each site, with approximately two week intervals between successive surveys to account for the temporal variation in spawning activity. Generally, surveyors walked upstream from the bottom of each sample reach and counted all redds, live fish, and dead fish observed. In some cases the larger streams were surveyed in a downstream direction for safety.

New redds were flagged and locations were marked with a handheld GPS unit. During each visit, surveyors recorded the number of new redds as well as previously identified flagged redds. Redd visibility was rated 0 for newly discovered redds and ranged from 1 (clearly visible) to 5 (no longer visible) for previously observed redds. To reduce bias of surveyor observations, surveyors were rotated through sites and partners if logistics allowed.

Steelhead carcasses were examined to obtain population and life history information by recording fork length (mm), MEPS (middle of the eye to posterior scale) length (mm), sex, egg retention (females), and origin determined by presence (wild) or absence (hatchery) of an adipose fin. For all carcasses, surveyors also collected scale samples from the key scale area (Nicholas and Van Dyke 1982) for age determination. Additional details of the survey protocol

can be downloaded from the PNAMP, Monitoring Methods website (<https://www.monitoringmethods.org/Protocol/Details/757>).

Spawning timing

Weir Counts

Five weirs located on the UGRR, Joseph, and Deer creeks (Figure 1) were used to evaluate timing of steelhead entering the basins prior to spawning. The UGRR weirs, operated by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), are located on the mainstem Grande Ronde River (rkm 291), Catherine Creek (rkm 32), and Lookingglass Creek (rkm 3; Figure 1). The weir on Deer Creek, operated by ODFW, is located 0.25 rkm upstream of its confluence with the Wallowa River. Wild adult steelhead trapped at the Deer Creek weir were marked with an opercle punch and released upstream of the weir to spawn naturally. All wild and hatchery-origin adult steelhead were passed above the UGRR weirs to spawn naturally.

The Nez Perce Tribe (NPT) operates the weir on Joseph Creek just upstream of its confluence with the Grande Ronde River. All adult steelhead (wild- and hatchery-origin) were captured and passed above the weir unmarked to spawn naturally (John Robbins, NPT, unpublished data).

Discharge and temperature

We attempted to relate redd observations to discharge for the UGRR, Joseph and Deer creeks. We used discharge measurements taken by Oregon Water Resources Department (OWRD) on the mainstem Grande Ronde River (station ID 13318960) by Perry (rkm 263). Unfortunately the Joseph Creek gauge (station ID 35G060, Washington Department of Ecology) lost funding in late 2012, and is no longer operational.

Estimating escapement

A locally weighted neighborhood variance estimator (Stevens and Olsen 2004), which incorporates the pair-wise dependency of all points and the spatially constrained nature of the design, was used to estimate a 95% confidence interval of the escapement estimate using SP Survey for R statistical software (R Development Core Team 2005). The statistical test was ran both with a single weighting value for the total spawning distribution and broken into a matrix of three strata by classification (source, transport, depositional) with weighting values depending on distance and number of surveys for each category (3).

Total escapement of adult steelhead (E_s) was determined by summing the product of the weight value (W), number of redds observed/km surveyed at each site (i), and fish:red ratio determined from Deer Creek Surveys as:

$$E_s = \sum_{i=1}^n W_s \left(\frac{\text{Redds}}{\text{km}} \right)_i \left(\frac{\text{Fish}}{\text{Redd}} \right) \quad (2)$$

Weight equals the distance of available spawning habitat in km (determined from GIS layer) divided by the number of sites surveyed as:

$$W = \left(\frac{\text{km avail.}}{\text{no.sites}} \right) \quad (3)$$

The proportion of hatchery to wild-origin steelhead was calculated by dividing the total number of fin marked fish by all fish that could be observed for marks (live fish only). The number of hatchery fish straying to the basin was then estimated by multiplying this proportion of hatchery and wild-origin steelhead by our estimate of steelhead escapement.

Table 1. Steelhead spawning ground survey characteristics, location and stream classification for sites in the UGRR basin, 2016.

Site ID	Stream	Panel	Stream Classification	Survey Distance (km)	Upstream Latitude	Upstream Longitude	Downstream Latitude	Downstream Longitude
CBW05583-013882	Peet Creek	Panel 3	Source	2.10	45.26007	-118.614613	45.27758	-118.616047
CBW05583-252730	Meadow Creek	Panel 3	Depositional	1.98	45.24506	-118.423222	45.25662	-118.406089
dsgn4-000094	Fly Creek	Panel 3	Transport	2.01	45.12082	-118.454013	45.13670	-118.447670
dsgn4-000161	South Fork Catherine Creek	Panel 3	Source	1.97	45.10680	-117.560751	45.10510	-117.582950
dsgn4-000213	Meadow Creek	Panel 3	Depositional	1.97	45.25668	-118.405956	45.26586	-118.390169
ORW03446-010424	Dark Canyon Creek	Panel 3	Transport	2.17	45.37531	-118.390198	45.35762	-118.396042
ORW03446-018904	Spring Creek	Annual	Transport	2.39	45.34725	-118.307330	45.33805	-118.286129
ORW03446-025816	Ladd Creek	Panel 3	Transport	1.07	45.24570	-118.018638	45.25399	-118.024474
ORW03446-036920	Indian Creek	Random	Source	2.03	45.40778	-117.799460	45.42154	-117.806760
ORW03446-051964	Catherine Creek	Panel 3	Depositional	2.17	45.14295	-117.723370	45.15211	-117.744435
ORW03446-059352	Clark Creek	Annual	Depositional	1.84	45.50022	-117.819943	45.51500	-117.828889
ORW03446-079752	Grande Ronde River	Annual	Depositional	1.99	45.17927	-118.389368	45.19335	-118.395185
ORW03446-084462	Lookingglass Creek	Panel 3	Depositional	1.56	45.74738	-117.871155	45.73620	-117.863077
ORW03446-092632	Spring Creek #3	Random	Source	2.07	45.35952	-118.323000	45.34736	-118.307429
ORW03446-095416	Meadow Creek	Random	Transport	1.97	45.27111	-118.590680	45.28292	-118.598773
ORW03446-095704	Beaver Creek	Panel 3	Transport	2.00	45.17138	-118.217880	45.18258	-118.233143
ORW03446-101102	Phillips Creek	Annual	Depositional	2.30	45.56971	-117.993709	45.56694	-117.973246
ORW03446-101560	Meadow Creek	Annual	Transport	1.97	45.29236	-118.612176	45.28316	-118.602238
ORW03446-102024	East Sheep Creek	Panel 3	Source	1.95	45.01283	-118.450759	45.01652	-118.472414
ORW03446-118408	West Chicken Creek	Annual	Source	1.95	45.02682	-118.403583	45.04449	-118.403882
ORW03446-120904	Burnt Corral Creek	Annual	Source	2.13	45.17401	-118.516512	45.18431	-118.499661
ORW03446-125832	Meadow Creek	Annual	Depositional	2.17	45.26362	-118.551468	45.27139	-118.533272
ORW03446-130904	Little Whiskey Creek	Panel 3	Source	1.78	45.27513	-118.209089	45.28907	-118.219059
ORW03446-131128	Clark Creek	Panel 3	Source	1.94	45.42778	-117.754936	45.43719	-117.774760
ORW03446-139144	Meadow Creek	Panel 3	Depositional	1.96	45.24724	-118.479667	45.24037	-118.462321
ORW03446-147928	Five Points Creek	Annual	Depositional	2.36	45.41072	-118.201787	45.40341	-118.222762
ORW03446-150408	Meadow Creek	Random	Depositional	2.25	45.26082	-118.498800	45.24885	-118.482690
ORW03446-157422	Phillips Creek	Panel 3	Transport	1.98	45.58136	-118.024369	45.57275	-118.006014
ORW03446-177134	East Phillips Creek	Annual	Source	2.20	45.63454	-118.055699	45.62304	-118.072221

Table 2. Steelhead spawning ground survey characteristics, location and stream classification for sites in the Joseph Creek basin, 2016.

Site ID	Stream	Panel	Stream Classification	Survey Distance (km)	Upstream Latitude	Upstream Longitude	Downstream Latitude	Downstream Longitude
CBW05583-002175	Crow Creek	Annual	Transport	2.07	45.69023	-117.150370	45.70545	-117.15186
CBW05583-007682	Joseph Creek	Panel 2	Depositional	1.93	45.75829	-117.17381	45.76882	-117.17566
CBW05583-022018	Cottonwood Creek	Panel 2	Source	1.95	45.84475	-116.97982	45.85937	-116.96811
CBW05583-051026	Unnamed trib to Alder	Annual	Source	1.69	45.69084	-117.011250	45.70425	-117.02264
CBW05583-061375	Swamp Creek	Panel 2	Transport	2.00	45.76823	-117.233080	45.78399	-117.22899
CBW05583-062978	Chesnimnus Creek	Panel 2	Transport	1.75	45.72751	-116.949718	45.73944	-116.96217
CBW05583-103938	Unnamed Tributary	Panel 2	Source	1.91	45.84640	-117.029376	45.83164	-117.01898
CBW05583-112130	Devils Run Creek	Annual	Source	2.02	45.78225	-116.969200	45.78081	-116.98547
CBW05583-120658	Crow Creek	Panel 2	Transport	2.06	45.62649	-117.13800	45.64198	-117.14323
CBW05583-141826	Basin Creek	Annual	Source	2.12	45.91900	117.059000	45.93269	-117.05829
CBW05583-155138	Joseph Creek	Panel 2	Depositional	2.07	45.73329	-117.159764	45.74244	-117.16532
CBW05583-157522	Chesnimnus Creek	Panel 2	Depositional	2.28	45.70261	-117.101747	45.69801	-117.11955
CBW05583-167426	Chesnimnus Creek	Annual	Depositional	2.44	45.75440	-116.998440	45.75067	-117.01907
CBW05583-169810	Chesnimnus Creek	Annual	Transport	2.08	45.71144	-116.911870	45.65759	-116.92303
CBW05583-187906	Peavine Creek	Panel 2	Source	2.17	45.75514	-117.083208	45.73627	-117.08356
CBW05583-227263	Davis Creek	Panel 2	Transport	2.15	45.68828	-117.260646	45.70665	-117.25699
CBW05583-231250	Salmon Creek	Panel 2	Transport	2.02	45.68697	-117.053312	45.70391	-117.04851
CBW05583-265730	TNT Gulch	RP 2	Source	2.09	45.75381	-116.918992	45.77061	-116.92672
CBW05583-301570	Cottonwood Creek	Annual	Source	1.88	45.93356	-117.052350	45.94326	-117.05991
CBW05583-310786	Chesnimnus Creek	Panel 2	Depositional	1.90	45.70934	-117.091207	45.70310	-117.10101
CBW05583-389247	Chesnimnus Creek	Annual	Depositional	1.94	45.69840	-117.121006	45.70513	-117.13607
CBW05583-408066	Summit Creek	Panel 2	Source	1.83	45.79374	-116.946766	45.77793	-116.94913
CBW05583-493394	Salmon Creek	Annual	Transport	1.92	45.70401	-117.049560	45.71857	-117.05021
CBW05583-510466	Broady Creek	Panel 2	Source	2.15	45.90052	-117.091864	45.91843	-117.09353
CBW05583-515586	Chesnimnus Creek	Annual	Depositional	2.40	45.73674	117.033240	45.73187	-117.05089
CBW05583-527618	Horse Creek	Panel 2	Source	1.92	45.97595	-116.986910	45.98423	-117.00566

RESULTS

Sampling domain and site selection

We surveyed 29 sites in the UGRR (Figure 2) encompassing 58.2 km of an estimated 892 km (6.5 %) available steelhead spawning habitat (Table 1). One site was not surveyed due to persistent high discharge and water clarity. This site was not included in our calculations. Stream classification for the 29 surveyed sites was distributed evenly (10 sites in source classification, 8 in transport, and 11 in depositional). Four sites were located above the Grande Ronde River weir, two above the Catherine Creek weir, and one above the Lookingglass Creek weir.

Twenty-six sites were surveyed in Joseph Creek and tributaries (Figure 3), encompassing 52.7 km of an estimated 384 km (13.7 %) available spawning habitat (Table 2), all of which were above the weir. Stream classification for the 26 sites was random with 11 sites surveyed in source classification, eight in transport, and seven in depositional.

We conducted four surveys on Deer Creek encompassing 18.7 km of utilized spawning habitat from the weir to the USFS road 8270 bridge. In previous years, additional surveys were conducted upstream of these 18.7 km, and no redds or adult steelhead were observed.

Steelhead redd surveys

We conducted 117 surveys in the UGRR basin in 2016, with a mean interval of 14.5 days between surveys. A total of 128 steelhead redds were observed at 22 of the 29 sites (Table 3). Redds were evenly distributed among stream classifications: 38 (30%) were found in source areas, 44 (34%) in transport, and 46 (36%) in depositional reaches. A total of three, live adult steelhead were observed in the UGRR (Table 5). Of these fish two were of wild origin and one was of unknown origin. No carcasses were found in the UGR.

A total of 109 surveys were completed in the Joseph Creek basin, with a mean interval of 13.9 days between surveys. We found 177 steelhead redds at 19 of the 26 sites (Table 4). More redds were found in the source stream classification (n=82, 46%) than depositional or transport reaches (n=34, 19%) and (n=61, 34%) and respectively). Eighteen live adult steelhead were observed at seven sites (Table 6), and one wild origin female carcass was observed (Table 7). No adipose-clipped hatchery fish were observed during our Joseph Creek surveys.

On 18.7 km of Deer Creek, 63 redds, nine live steelhead, and zero carcasses were observed during survey visits. However, we encountered 31 steelhead carcasses at the weir and 22 kelts that were passed downstream of the weir. Of these 53 adult steelhead all were marked with a left operculum punch (LOP) received in the Big Canyon fish trap.

Spawning timing

Based on our redd observations, onset of spawn timing was similar between the UGRR and Joseph Creek basins, but a little later for Deer Creek. We observed the first redds on 17 March in the UGRR, March 08 Joseph Creek basins (Figure 4) and 31 March in Deer Creek (Figure 5). The last redds were observed on 08 June in the UGRR, 01 June in Joseph Creek and 23 May in Deer Creek. By 20 April 48% of the total redds in the UGRR basin were observed. By 20 April 59% of the total redds in the Joseph Creek basin were observed. By 27 April, 89% of the total redds were observed on Deer Creek. Onset of redd building was similar among basins as well as peak redd observations (Figure 4). Although onset of redd building was similar among basins, peak redd observations occurred slightly later in Joseph Creek than UGRR (Figure 4), which is similar to the pattern observed in 2012 and 2013 (Dobos et al. 2012, Fitzgerald et al. 2013). Most redds in the UGRR basin were first observed during

the descending hydrographs of early May to late June (Figure 4). Surveys on Deer Creek coincided with low discharge periods (Figure 5).

Weir Counts

The Catherine Creek, Lookingglass Creek, and the Grande Ronde River weirs were operable 1 March. During the spring of 2016, 253 wild and three hatchery adult steelhead were passed at the Lookingglass Creek weir, 198 wild adult steelhead at the Catherine Creek weir, and 25 wild adult steelhead at the Grande Ronde River weir (Table 8). The first adult steelhead were passed on 2 March at the Lookingglass Creek, 3 March at Catherine Creek, and 7 March on Grande Ronde River. The last steelhead were passed on 01 June at the Grande Ronde River and 03 June at Lookingglass Creek and 27 May in Catherine Creek (Mike McLean, CTUIR, unpublished data). The Catherine Creek, Lookingglass, and the Grande Ronde River weirs were closed 05 August, 16 September, and 03 June, respectively.

Adult steelhead were captured at the weir operated by Nez Perce Tribe (NPT) near the mouth of Joseph Creek and all fish (wild- and hatchery-origin) were passed above the weir to spawn naturally (Table 8, Clark Watry, NPT, unpublished data 2016).

At the Deer Creek weir, 82 adult wild-origin steelhead were passed upstream to spawn naturally (Table 8).

Estimating escapement

A fish:red ratio of 1.30 (82/63) was generated using the number of fish passed above the weir at Deer Creek and the number of redds observed there in 2016.

Using this ratio and a single weight value for all stream classifications (30.8), 2,572 adult steelhead (95% C.I.: 1,548–3,596) escaped into the UGRR basin and naturally spawned (Table 9; Figure 6). No adipose-clipped hatchery fish were observed during surveys on the UGRR. Using this same method with a weight value of 14.8, 1,663 adult steelhead (95% C.I.: 924–2,402) escaped into the Joseph Creek basin (Table 9; Figure 6).

Using the weight values for each strata, source (41.18), transport (30.33), and depositional (19.7), we estimated that 2,558 (95% CI, 1,284–5,513) adult steelhead for the UGRR population (Table 10). For Joseph Creek estimates changed by only one fish: using the weight values for each strata, source (14.45), transport (14.38), and depositional (15.86), we estimated that 1,651 (95% CI, 914–2,389) adult steelhead returned to spawn (Table 11).

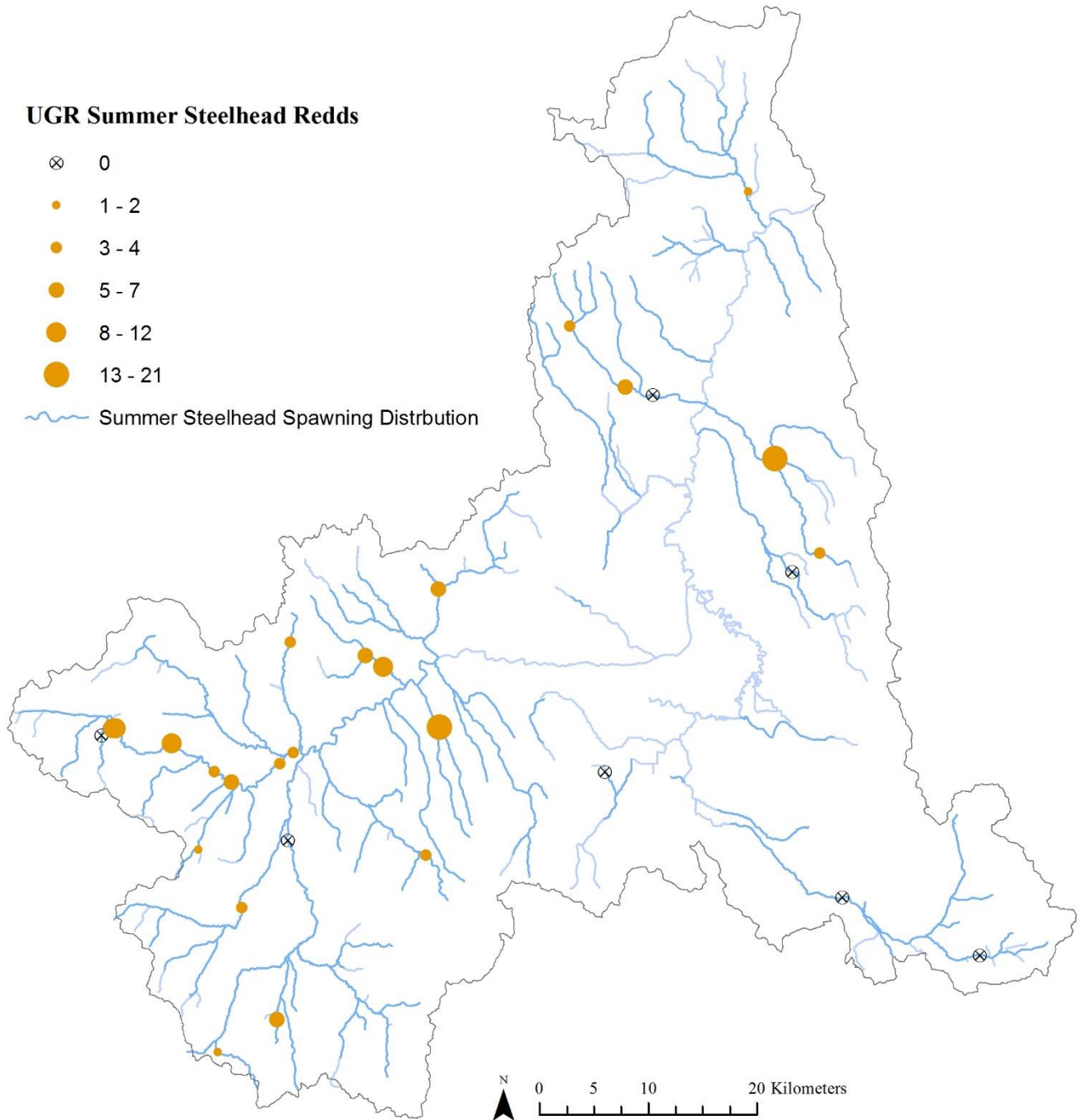


Figure 2. Map of the Upper Grande Ronde River basin displaying count of redds observed at each site in 2016.

Joseph Summer Steelhead Redds

- ⊗ 0
 - 1 - 3
 - 4 - 5
 - 6 - 13
 - 14 - 21
 - 22 - 31
- Steelhead Spawning Distribution

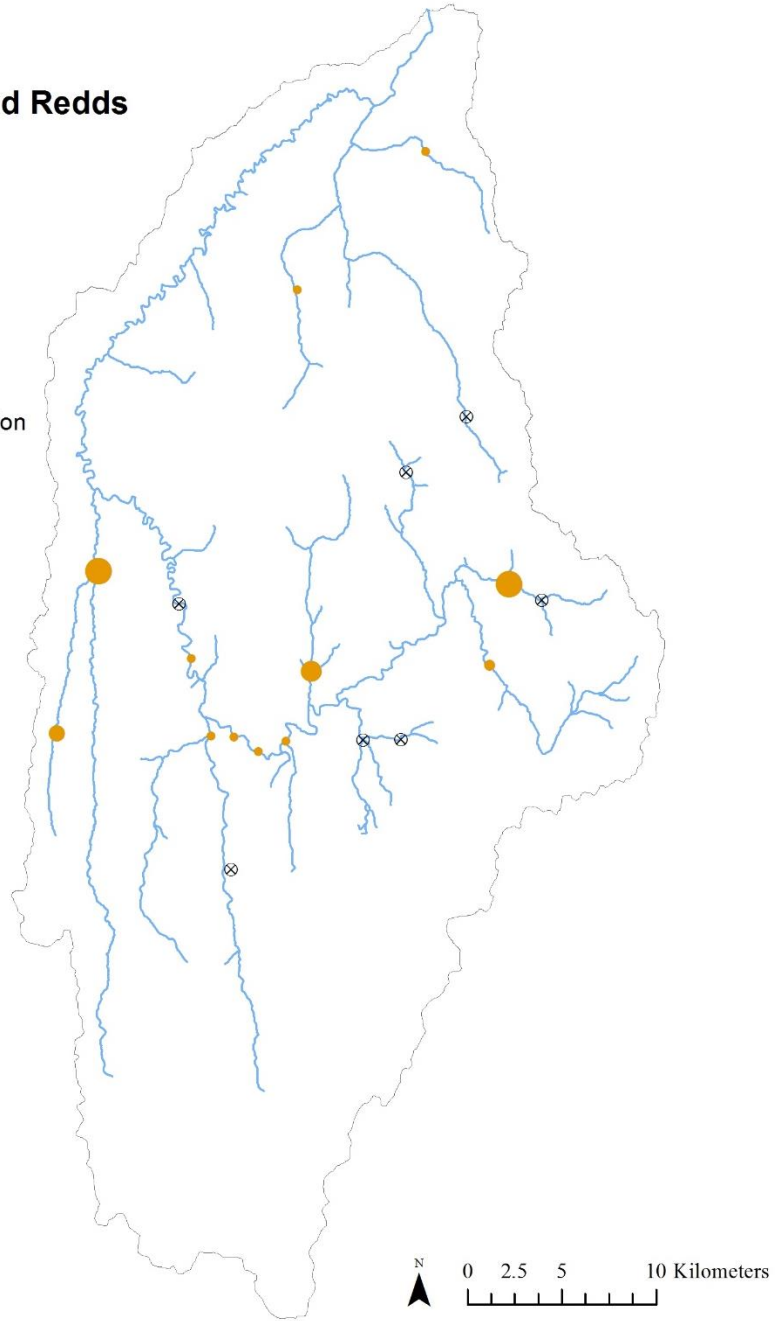


Figure 3. Map of the Joseph Creek basin showing count of redds observed at each site in 2016.

Table 3. Completion dates and general results for redd surveys in the Upper Grande Ronde River basin 2016.

Short Site ID	Stream	Mean No. days between surveys	Redd Count	1st Survey	2nd Survey	3rd Survey	4th Survey	5th Survey	6th Survey	7th Survey
CBW05583-013882	Peet Creek	12.7	0	4/14/2016	5/5/2016					
CBW05583-252730	Meadow Creek	12.7	3	3/31/2016	4/18/2016	5/4/2016	5/18/2016	5/26/2016		
dsgn4-000094	Fly Creek	14.3	3	5/5/2016	5/19/2016	5/31/2016				
dsgn4-000161	South Fork Catherine Creek	15.0	0	5/12/2016	5/24/2016					
dsgn4-000213	Meadow Creek	13.5	2	3/31/2016	4/18/2016	5/4/2016	5/18/2016	5/26/2016		
ORW03446-010424	Dark Canyon Creek	14.5	3	4/11/2016	4/25/2016	5/9/2016	5/24/2016			
ORW03446-018904	Spring Creek	13.3	9	3/14/2016	3/28/2016	4/11/2016	4/25/2016	5/9/2016	5/24/2016	
ORW03446-025816	Ladd Creek	14.0	0	3/28/2016	4/13/2016	4/28/2016	5/10/2016	5/23/2016		
ORW03446-036920	Indian Creek	16.0	0	5/25/2016	6/6/2016					
ORW03446-051964	Catherine Creek	0.0	0	5/24/2016						
ORW03446-059352	Clark Creek	14.2	16	3/21/2016	4/5/2016	4/21/2016	4/28/2016	5/12/2016	5/24/2016	6/8/2016
ORW03446-079752	Grande Ronde River	14.0	0	5/3/2016	5/18/2016	6/1/2016				
ORW03446-084462	Lookingglass Creek	14.3	1	5/24/2016	6/7/2016					
ORW03446-092632	Spring Creek	13.2	5	3/14/2016	3/28/2016	4/22/2016	4/25/2016	5/9/2016	5/24/2016	
ORW03446-095416	Meadow Creek	13.5	9	4/4/2016	4/20/2016	5/2/2016	5/16/2016	5/31/2016		
ORW03446-095704	Beaver Creek	15.6	2	5/12/2016	5/24/2016					
ORW03446-101102	Phillips Creek	14.2	0	3/21/2016	4/11/2016	4/28/2016	5/10/2016	5/24/2016		
ORW03446-101560	Meadow Creek	16.2	12	4/4/2016	4/20/2016	5/2/2016	5/16/2016	5/31/2016		
ORW03446-102024	East Sheep Creek	17.8	1	4/18/2016	5/4/2016	5/19/2016	6/2/2016			
ORW03446-118408	West Chicken Creek	14.5	5	4/8/2016	5/5/2016	5/19/2016	6/1/2016			
ORW03446-120904	Burnt Corral Creek	14.5	1	4/8/2016	4/18/2016	5/4/2016	5/19/2016			
ORW03446-125832	Meadow Creek	14.0	8	4/4/2016	4/20/2016	5/2/2016	5/16/2016	5/31/2016		
ORW03446-130904	Little Whiskey Creek	14.0	21	3/17/2016	4/6/2016	4/19/2016	5/19/2016			
ORW03446-131128	Clark Creek	14.2	2	4/26/2016	5/9/2016	5/25/2016	6/6/2016			
ORW03446-139144	Meadow Creek	15.4	5	4/7/2016	4/19/2016	5/3/2016	5/17/2016	6/1/2016		
ORW03446-147928	Five Points Creek	18.7	7	4/19/2016	5/4/2016	5/13/2016	6/1/2016			
ORW03446-150408	Meadow Creek	17.8	4	4/7/2016	4/19/2016	5/3/2016	5/17/2016	6/1/2016		
ORW03446-157422	Phillips Creek	13.7	6	3/30/2016	4/11/2016	4/28/2016	5/10/2016	5/24/2016		
ORW03446-177134	East Phillips Creek	15.5	3	4/28/2016	5/12/2016	5/26/2016				

Table 4. Completion dates and general results for surveys in the Joseph Creek basin, 2016.

Site ID	Stream	No. surveys completed	Mean No. days between surveys	Redd Count	1st Survey	2nd Survey	3rd Survey	4th Survey	5th Survey	6th Survey
CBW05583-002175	Crow Creek	5	13.8	1	3/9/2016	3/22/2016	4/6/2016	4/19/2016	5/3/2016	
CBW05583-007682	Joseph Creek	3	12.0	0	4/11/2016	4/21/2016	5/5/2016			
CBW05583-022018	Cottonwood Creek	1	N/A	0	5/31/2016					
CBW05583-051026	Unnamed trib to Alder	5	13.5	0	3/16/2016	3/28/2016	4/12/2016	4/25/2016	5/9/2016	
CBW05583-061375	Swamp Creek	2	17.0	31	4/28/2016	5/15/2016				
CBW05583-062978	Chesnimnus Creek	6	13.4	5	3/10/2016	3/23/2016	4/5/2016	4/19/2016	5/2/2016	5/16/16
CBW05583-103938	Unaned trib	1	N/A	0	5/2/2016					
CBW05583-112130	Devils Run Creek	5	17.3	21	3/24/2016	4/7/2016	4/20/2016	5/4/2016	6/1/2016	
CBW05583-120658	Crow Creek	5	13.8	0	3/9/2016	3/22/2016	4/6/2016	4/19/2016	5/3/2016	
CBW05583-141826	Basin Creek	5	13.8	1	3/8/2016	3/21/2016	4/4/2016	4/18/2016	5/2/2016	
CBW05583-155138	Joseph Creek	3	12.0	2	4/11/2016	4/21/2016	5/5/2016			
CBW05583-157522	Chesnimnus Creek	3	12.0	2	4/11/2016	4/21/2016	5/5/2016			
CBW05583-167426	Chesnimnus Creek	6	14.0	20	3/17/2016	3/29/2016	4/7/2016	4/20/2016	5/4/2016	5/26/16
CBW05583-169810	Chesnimnus Creek	6	13.4	10	3/10/2016	3/23/2016	4/6/2016	4/19/2016	5/3/2016	5/16/16
CBW05583-187906	Peavine Creek	6	12.3	18	3/14/2016	3/23/2016	4/7/2016	4/20/2016	5/4/2016	5/24/16
CBW05583-227263	Davis Creek	5	13.5	13	3/31/2016	4/14/2016	4/25/2016	5/11/2016	5/24/2016	
CBW05583-231250	Salmon Creek	5	13.5	0	3/16/2016	3/28/2016	4/12/2016	4/25/2016	5/9/2016	
CBW05583-265730	TNT Gulch	3	13.5	0	4/6/2016	4/20/2016	5/3/2016			
CBW05583-301570	Cottonwood Creek	6	14.0	13	3/8/2016	3/21/2016	4/4/2016	4/18/2016	5/2/2016	5/17/16
CBW05583-310786	Chesnimnus Creek	4	14.0	2	3/29/2016	4/11/2016	4/26/2016	5/10/2016		
CBW05583-389247	Chesnimnus Creek	4	14.7	3	4/11/2016	4/21/2016	5/5/2016	5/25/2016		
CBW05583-408066	Summit Creek	4	16.0	25	4/14/2016	4/26/2016	5/11/2016	6/1/2016		
CBW05583-493394	Salmon Creek	5	13.5	1	3/16/2016	3/28/2016	4/12/2016	4/26/2016	5/9/2016	
CBW05583-510466	Broady Creek	1	N/A	3	4/1/2016					
CBW05583-515586	Chesnimnus Creek	5	14.3	5	3/29/2016	4/11/2016	4/26/2016	5/10/2016	5/25/2016	
CBW05583-527618	Horse Creek	5	14.3	1	3/7/2016	3/21/2016	4/4/2016	4/18/2016	5/3/2016	

Table 5. Locations, dates, and characteristics of live steelhead observations in the UGRR and Deer Creek basins, 2016.

Site ID	Stream	Observation Date	Fin Clip	On/Off Redd
ORW03446-095704	Beaver Creek	5/12/2016	No	Off
ORW03446-101560	Meadow Creek	4/20/2016	No	Off
ORW03446-118408	West Chicken Creek	4/8/2016	Unk	On
Deer3-0	Deer Creek	4/13/2016	Unk	Off
Deer3-0	Deer Creek	4/13/2016	No	Off
Deer3-0	Deer Creek	4/27/2016	Unk	Off
Deer3-0	Deer Creek	5/11/2016	Unk	On
Deer3-0	Deer Creek	5/11/2016	Unk	Off
Deer3-0	Deer Creek	5/23/2016	No	Off
Deer6-3	Deer Creek	4/27/2016	Unk	On
Deer6-3	Deer Creek	4/27/2016	No	On
Deer6-3	Deer Creek	4/27/2016	No	Off

Table 6. Locations, dates, and characteristics of live steelhead observations in the Joseph Creek basin, 2016.

Site ID	Stream	Observation Date	Fin Clip	On/Off Redd
CBW05583-062978	Chesninnus Creek	4/5/2016	Unk	Off
CBW05583-112130	Devils Run Creek	4/20/2016	Unk	Off
CBW05583-167426	Chesninnus Creek	4/7/2016	Unk	Off
CBW05583-167426	Chesninnus Creek	4/20/2016	Unk	On
CBW05583-167426	Chesninnus Creek	4/20/2016	Unk	Off
CBW05583-169810	Chesninnus Creek	4/6/2016	Unk	On
CBW05583-187906	Peavine Creek	3/14/2016	No	On
CBW05583-187906	Peavine Creek	3/23/2016	Unk	On
CBW05583-187906	Peavine Creek	3/23/2016	Unk	Off
CBW05583-187906	Peavine Creek	4/7/2016	No	Unknown
CBW05583-187906	Peavine Creek	4/7/2016	Unk	Unknown
CBW05583-187906	Peavine Creek	4/7/2016	Unk	Unknown
CBW05583-187906	Peavine Creek	4/7/2016	Unk	Unknown
CBW05583-227263	Davis Creek	3/31/2016	Unk	Off
CBW05583-408066	Summit Creek	4/14/2016	No	Off
CBW05583-408066	Summit Creek	4/14/2016	No	Off
CBW05583-408066	Summit Creek	4/14/2016	Unk	On
CBW05583-408066	Summit Creek	4/14/2016	Unk	Off

Table 7. Locations, dates, and characteristics of dead steelhead observations in Joseph Creek basin, 2016.

Site ID	Population	Stream Name	Date Observed	Fish Sex	Fork Length (mm)	Origin
CBW05583-167426	Joseph	Chesninnus Creek	4/20/2016	Female	680	Wild

Table 8. Origin of fish passed above Joseph Creek, UGRR, Catherine Creek, Lookingglass Creek and Deer Creek weirs in 2016.

	Natural Origin	Hatchery Origin	Proportion Hatchery (%)	Total Fish
Joseph Creek*	1,437	62	4.1%	1,499
UGRR**	25	0	0	25
Catherine Creek**	198	0	0	198
Lookingglass Creek**	254	3	1.2%	257
Deer Creek***	82	0	0	82

*Clark Watry, Nez Perce Tribe, Department of Fisheries Resources Management, unpublished data, personal communication

**Michael McLean, Confederated Tribes of the Umatilla Indian Reservation, Department of Natural Resources, Fisheries Program, unpublished data, personal communication

***Michael Flesher, Oregon Department of Fish & Wildlife, La Grande Fish Research, unpublished data, personal communication

Table 9. Annual results of steelhead spawning ground surveys, 2008–2016. Available spawning habitat was refined yearly based on previous surveys.

Year	No. of sites	Spawning habitat (km)	Weight value	Redds observed	Distance surveyed (km)	Fish:red ratio	Total spawner escapement	95% CI	CI as % of escapement
UGRR basin									
2008	29	1,301	44.9	24	64.2	4.07	2,096	±1,142	54.50%
2009	30	1,178	39.3	42	59.9	3.81	3,148	±1,047	33.20%
2010	29	934	32.2	109	56.4	1.6	2,876	±897	31.20%
2011	28	929	33.2	44	59.5	4.75	3,275	±1,028	31.40%
2012	30	897	29.9	70	60.7	3.14	3,261	±1,077	33.00%
2013	29	892	30.8	52	56.1	1.91	1,553	±757	48.70%
2014	29	892	30.8	65	61.3	2.67	2,512	±974	38.77%
2015	29	892	30.8	246	61.6	1.37	4,837	±1,891	39.09%
2016	29	892	30.8	128	58.2	1.30	2,572	±1,024	39.81%
Joseph Creek basin									
2012	30	384	12.8	67	58.4	3.14	1,357	±380	28.00%
2013	26	384	14.8	153	51.5	1.91	2,197 _a	±934	42.50%
2014	25	384	15.4	130	51.8	2.67	2,522 _b	±778	30.85%
2015	24	384	16	286	48.3	1.37	2,967 _c	±991	33.40%
2016	26	384	14.8	177	52.7	1.30	1,663 _d	±739	44.44%

a. With 2.2% hatchery proportion the total natural spawners is 2,149 (95% CI ±913).

b. With 1.1% hatchery proportion the total natural spawners is 2,494 (95% CI ±769).

c. With 1.8% hatchery proportion the total natural spawners is 2,914 (95% CI ±938).

d. With 4.1% hatchery proportion the total natural spawners is 1,595 (95% CI ±709).

Table 10. Survey characteristics and results, grouped by stream classification type for the UGRR basin, 2016.

Stream Classification	No. of sites	Spawning habitat (km)	Weight value	Distance surveyed (km)	Total redds observed	Redds per km	Spawner escapement	Lower 95% CI	Upper 95% CI
Source	10	453	41.18	20.12	38	1.9	1,186	16	2,356
Transport	8	243	30.33	15.56	44	2.8	841	481	1,201
Depositional	11	197	19.70	22.55	46	2.0	530	178	884
Total	29	892	91.21	58.23	128	4.1	2,558	1,284	5,513

Table 11. Survey characteristics and results, grouped by stream classification type for the Joseph Creek basin, 2016.

Stream Classification	No. of sites	Spawning habitat (km)	Weight value	Distance surveyed (km)	Total redds observed	Redds per km	Spawner escapement	Lower 95% CI	Upper 95% CI
Source	11	159	14.45	21.73	82	3.7	783	219	1,346
Transport	8	115	14.38	16.05	61	3.8	565	147	983
Depositional	7	111	15.86	14.96	34	2.3	304	78	529
Total	26	384	44.69	52.74	177	9.8	1,651	914	2,389

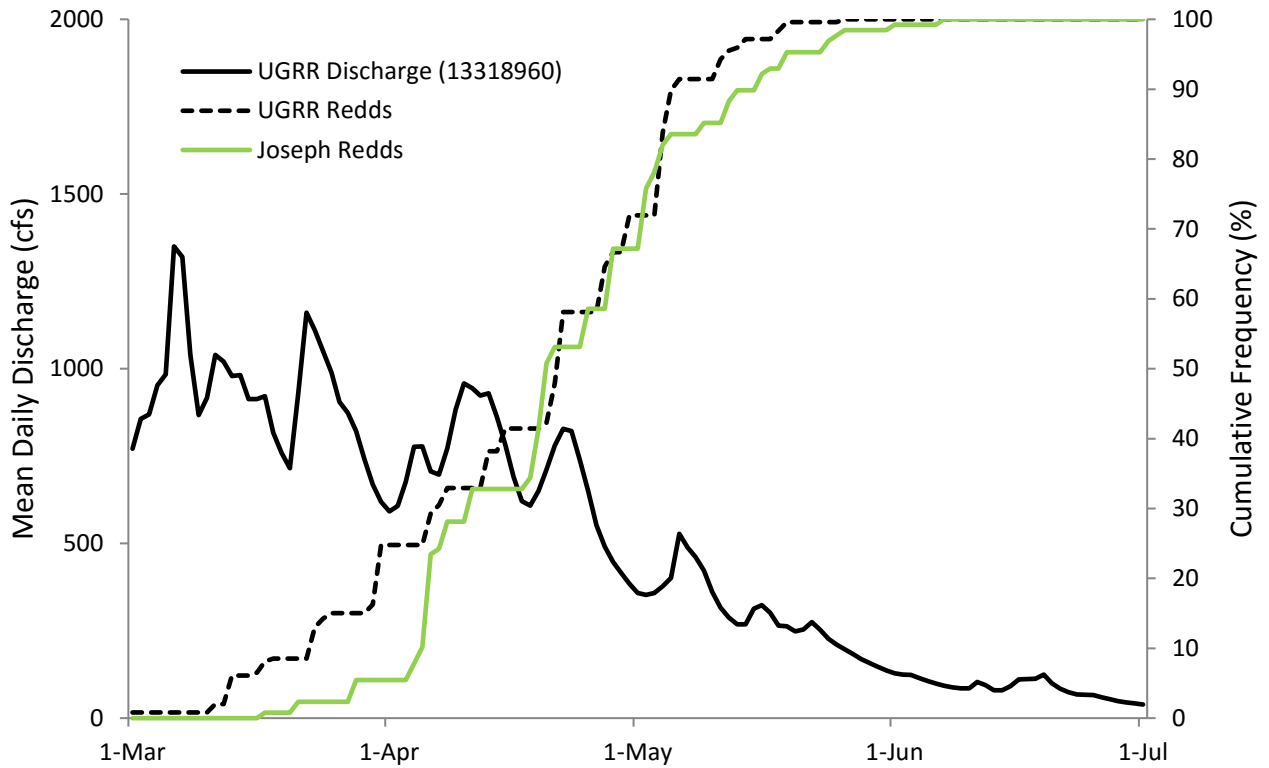


Figure 4. Cumulative frequency of observed redds and mean daily discharge during the spawning period for the UGRR basin (OWRD station #13318960) in 2016.

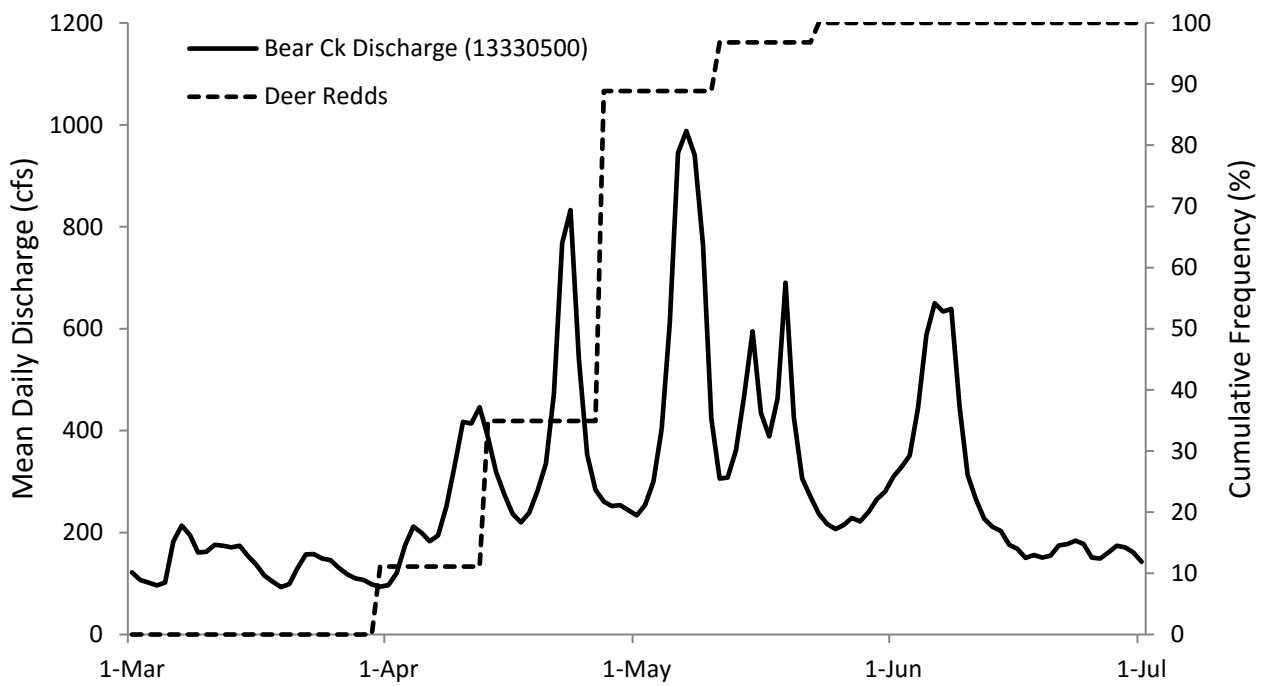


Figure 5. Cumulative frequency of observed redds during the spawning period for Deer Creek and discharge from neighboring Bear Creek (OWRD station #13330500) in 2016.

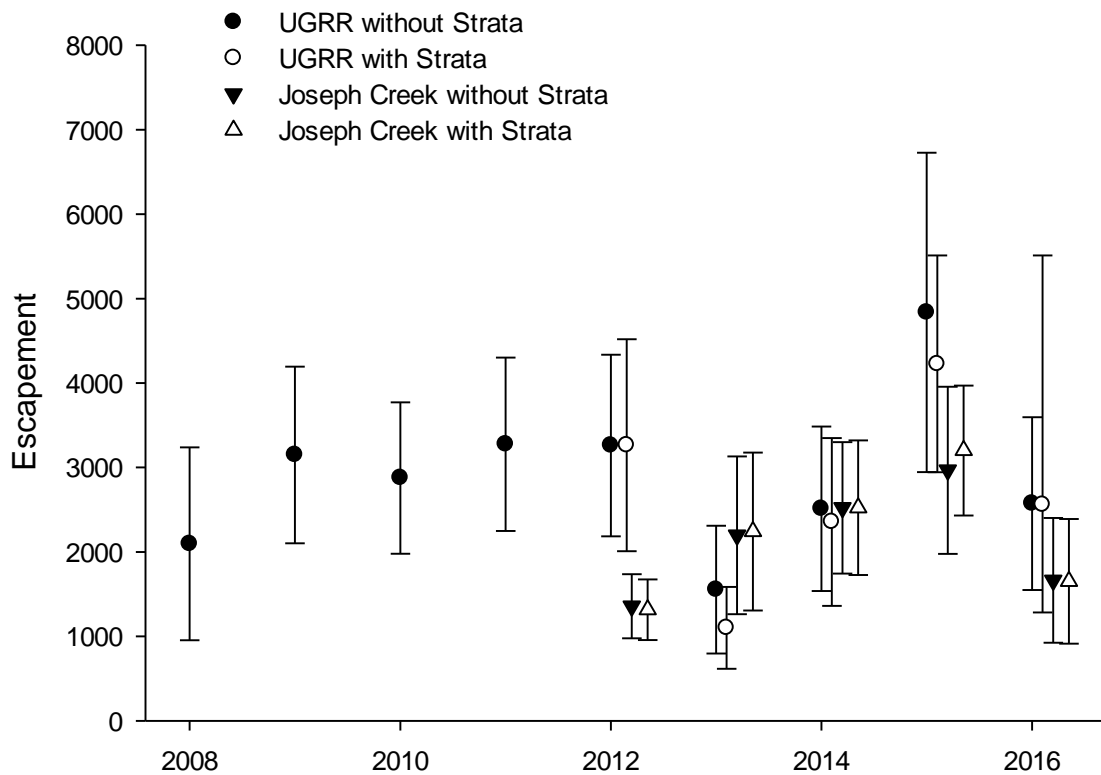


Figure 6. Escapement estimates with 95% confidence intervals for steelhead in the Upper Grande Ronde River basin using a single weight value, 2008–2016 and using strata weights for the three classifications of stream type for UGRR and Joseph Creek, 2012–2016.

DISCUSSION

Steelhead redd surveys

Water clarity during surveys was moderate in both the UGRR and Joseph Creek basins throughout most of the season. Water clarity and our ability to observe redds generally improved as the season progressed. Restriction of snow to higher elevations, low precipitation, and moderate to low flows in March resulted in early access to most sites and good visibility. Flows were generally higher, and persisted longer in Lookingglass, Deer, and Catherine creeks, and other tributaries flowing from the Wallowa Mountains due to their high elevation headwaters. Our protocol indicates that surveys should be conducted at two week intervals and we achieved this in the UGRR and Joseph Creek basins.

The efficiency of our surveys on larger tributaries (i.e. Lookingglass and Catherine creeks) was poor. Even when we were able to survey the stream, we were often unable to cross or even walk in the channel for significant stretches. This may explain why only one redd was observed in Lookingglass Creek and zero redds in Catherine Creek, despite hundreds of steelhead being captured at their respective fish weirs (Table 8). One site on Catherine Creek near the town of Union was too high throughout the entire spawning season that we were unable to successfully.

The fish:red ratio from Deer Creek correlated strongly with the total water volume from UGRR (Figure 7). This suggests that the use of fish:red is an appropriate method to compensate for our ability to successfully observe redds throughout the basin based on water conditions.

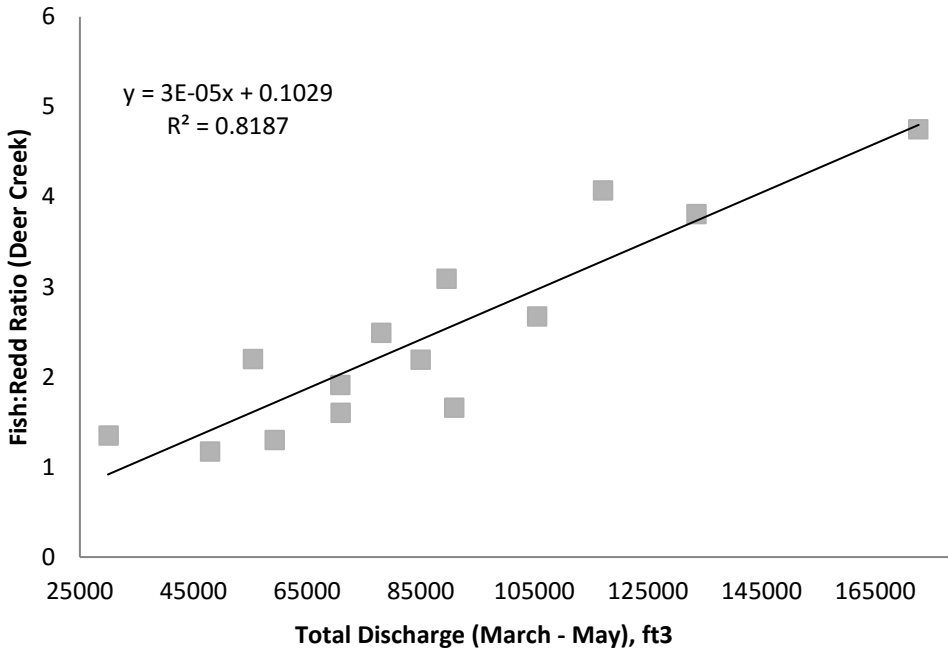


Figure 7. Relationship between total discharge in UGRR (Perry Station) and the fish:red ratio derived from Deer Creek surveys, 2002 – 2003 and 2005 – 2016.

Spawning timing

Most redds were first observed during descending limbs of the hydrograph. However, any relationship of spawning to stream flow may be obscured by artifacts of our sampling technique. Our ability to observe redds is strongly influenced by water clarity, which is generally better on the descending limb of hydrographs than on rising limbs. Even though our observations of redds were during these descending periods, they do not indicate exactly when the redd was made. Deer creek surveys illustrate this point. We were only able to survey during the low water periods between peaks in the hydrograph (Figure 5). However, redds were likely built during the high water periods between surveys. Our surveys cannot determine or estimate when redds were built (unless we observe fish actively spawning) limiting our ability to infer a relationship between flow and spawning activities.

Timing of initial redd observations was similar across both basins and in Deer Creek. However, the progression of redd building appeared to be slower in Joseph Creek. This seems counterintuitive, as Joseph Creek is lower in elevation, and generally warmer than UGRR or Deer Creek. We observed a two week lag (early April) between redd building in UGRR and Joseph Creek (Figure 4). This lag period was also observed 2012 -2014 (Dobos et al. 2012, Fitzgerald et. al 2013, Banks et al. 2014), the first three years of Joseph Creek surveys. We were unable to determine if this is a real discrepancy in spawn timing, or an inability to effectively survey Joseph Creek tributaries during March and early April. Surveyors recorded water clarity (scale 1-3) at each survey event, and water clarity did improve substantially in Joseph Creek by early April. However, if water clarity/redd visibility was limiting our counts, one would expect a rapid increase in redd counts once water clarity

improved. This was not the case, as redd observations climbed steadily after mid-April, but not faster than UGRR or Deer Creek.

Estimating escapement

Population-scale escapement estimates had relatively poor precision for both Joseph Creek and UGRR (95% CI ~40% of the estimate). This is similar to last year's precision estimate of ~39% of estimate. Confidence intervals have consistently been 31–55% of the UGRR escapement estimate since 2008 (Table 9). This is despite our refinement of known steelhead spawning distribution, which has been reduced in length by 31% since 2008. It appears that the variable distribution of redds throughout the spawning distribution inflates the confidence intervals. In particular, observations of zero redds substantially increase the confidence interval, and certain streams are not likely to produce redds regardless of the number of adults returning. In 2016, we observed zero redds at 24% of our UGRR basin sites, and 27% of those in Joseph Creek. With continued observations of zero redds at some survey sites, it seems unlikely that precision will improve unless some other method of identifying appropriate spawning habitat can be found.

This is our sixth year of attempting to correlate redd locations with stream classifications. Redd observations were highest in source reaches for both UGRR and Joseph Creek. There seems to be only minor utility in attempting to relate stream classification generated from landscape level variables to redd locations. Steelhead are likely not choosing appropriate spawning sites at the landscape scale. With the overlap of CHaMP sites and steelhead spawning ground surveys, we are exploring other potential relationships between redd building and small-scale habitat characteristics.

We will continue to define the extent of these identified stream reaches deemed unsuitable for spawning and locate similar reaches when they are selected in our sample draw. As the spawning distribution is refined, precision in our escapement estimates should increase. We will also continue to monitor trends of both methods and relate redd locations to immediate habitat to gain better understanding of how spawning habitat is utilized.

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