FISH RESEARCH PROJECT
OREGON

IMPLEMENTATION OF THE ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM (EMAP) PROTOCOL IN THE JOHN DAY SUBBASIN

ANNUAL TECHNICAL REPORT

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Prepared By:

Joshua L. McCormick
Amy M. Bult

Oregon Department of Fish and Wildlife
P.O. Box 9
John Day, OR 97845

and

James R. Ruzycki
Richard W. Carmichael

Oregon Department of Fish and Wildlife
203 Badgley Hall, EOU
One University Blvd.
La Grande, OR 97850

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U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

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Objectives

1. Monitor status and trends in steelhead redd abundance and spawners in the John Day River basin.
2. Estimate the distribution of summer steelhead redds and spawners in the John Day River Basin.
3. Provide background data that can be used for:
   a. Stock assessment.
   b. Comparison data for long-term effectiveness monitoring of habitat projects.
   c. Annual estimates of spawner escapement, age structure, SAR, egg-to-smolt survival, smolt-per-redd ratio, and freshwater habitat use.

Accomplishments and Findings

We sampled 50 random, spatially-balanced sites throughout the John Day River basin during the spring and early summer (2 March - 7 July) of 2010 to determine summer steelhead *Oncorhynchus mykiss* redd abundance. Survey sites encompassed 96.9 km of an estimated 4,323 km of steelhead spawning and rearing habitat within the basin. During these surveys 155 redds and 373 live steelhead were observed. Redds were observed at 22 of the 50 sites. Redd and adult escapement estimates for the basin were 6,914 and 11,027 (95% confidence interval [CI] = 4,628-17,434]) respectively. We observed an additional 27 redds in the South Fork subsample while surveying 24.8 km of the 249 km of habitat available for spawning above the rotary screw trap. We estimate 271 redds were constructed in the South Fork subbasin by 432 ([CI] = 173-692) spawners. Hatchery steelhead composed 8% (21 of 258) of observed live fish where the presence or absence of an adipose fin clip could be determined. We estimate that of the 11,027 steelhead on the spawning grounds in 2010, 882 were of hatchery origin and 10,145 were wild. The 2010 estimate is the highest since the implementation of the EMAP protocol in 2004.

Management Recommendations

1. Using the current data of steelhead spawning distribution and geographic landscape variables, redefine the sampling universe for *O. mykiss* in the John Day River Basin to improve our knowledge of steelhead spawning distribution.

2. Determine the level of change in the escapement estimate that we would consider to be biologically and statistically significant in order to determine short- and long-term population changes.

3. Increase effort in monitoring freshwater life history strategies and survival rates of key salmonid species in the John Day River Basin. Such information will be valuable in assessing critical limiting factors for key species and provide greater guidance for restoration activities.

4. Continue to manage the John Day River basin exclusively for wild steelhead and determine the extent and distribution of hatchery steelhead in the basin through observations of hatchery fish during the spawning season and compiling information from other sources and

projects. Consider using genetic analysis to understand the influence of hatchery stocks and wild strays on John Day River wild summer steelhead stock genetics.

ACKNOWLEDGEMENTS

We would like to acknowledge the assistance and cooperation of the many private landowners throughout the John Day River basin who allowed us access to survey on their property. The cooperation of private landowners and The Confederated Tribes of the Warm Springs Reservation were essential in meeting our project objectives. Additionally, we would like to thank Jeff Neal for providing guidance and advice regarding steelhead spawning ground surveys. The information he provided was extremely helpful for survey planning and landowner contacts. Furthermore, we would like to acknowledge our field crew and the Middle Fork IMW crew members for their assistance. This project was funded by the U. S. Department of Energy, Bonneville Power Administration, Environment, Fish, and Wildlife. Project Number: 199801600. Contract Number: 39054.

INTRODUCTION

The John Day River, located in northeastern Oregon, is unique in that it supports one of the last remaining wild populations of summer steelhead *Oncorhynchus mykiss* in the Columbia River Basin with no hatchery supplementation. However, this population remains depressed relative to historic levels. In 1999, the National Marine Fisheries Service (NMFS) listed the Middle Columbia River summer steelhead Distinct Population Segment (DPS), which includes John Day River summer steelhead, as threatened under the Endangered Species Act (ESA). Although numerous habitat protection and rehabilitation projects have been implemented within the John Day River basin to improve steelhead and other salmonid freshwater production and survival, it has been difficult to estimate the effectiveness of these projects without a systematic program in place to collect information on the status, trends, and distribution of salmonids and habitat conditions within the basin. Prior to the inception of this project, population and environmental monitoring of steelhead in the basin consisted of a combination of index surveys and periodic monitoring of some status and trend indicators. While index spawning data is useful in drawing inference about trends in adult steelhead abundance, it is limited in determining the status of steelhead escapement or distribution at the basin-wide scale because survey sites are not randomly selected, and are likely biased towards streams with higher redd densities. A broader approach to the monitoring and evaluation of status and trends in anadromous and resident salmonid populations and their habitats was needed to provide data to effectively support restoration efforts and guide alternative future management actions in the basin.

The Independent Scientific Review Panel (ISRP), in their guidance on monitoring, strongly recommended that the region move away from index surveys and embrace probabilistic sampling for most population and habitat monitoring. To meet the ISRP recommendation, the structure and methods employed by the Oregon Plan for Salmon and Watersheds Monitoring Program were extended to the John Day basin. This approach incorporates the sampling strategy of the United States Environmental Protection Agency’s (EPA’s) Environmental Monitoring and

Assessment Program (EMAP). The EMAP is a long-term research effort with a statistically based and spatially explicit sampling design. This program applies a rigorous, Tier-2 sampling design to answer key monitoring questions, integrate on-going sampling efforts, and improve agency coordination. EMAP objectives specific to the John Day basin are to determine annual estimates of steelhead spawner escapement, hatchery to wild steelhead stray ratios, and track changes in the status and trends of these estimates over time. In addition, data from on-going projects in the basin, such as smolt monitoring, will be incorporated in future years to develop a more complete picture of status and trends in resources (e.g. life-stage specific survival) not targeted under the EMAP program.

This project provides information as directed by two measures of the Columbia River Basin Fish and Wildlife Program. Measure 4.3C specifies that key indicator naturally spawning populations should be monitored to provide detailed stock status information. In addition, measure 7.1C identifies the need for collection of population status, life history, and other data on wild and naturally spawning populations. This project was developed in direct response to the recommendations and needs of regional modeling efforts, the ISRP, the Fish and Wildlife Program, the Oregon Plan for Salmon and Watersheds, and the Columbia Basin Fish and Wildlife Authority Multi-Year Implementation Plan.

METHODS

Study Area

The John Day River basin is located in north central and northeastern Oregon (Figure 1), and is the fourth largest drainage in the state. The basin is bounded by the Columbia River to the north, the Blue Mountains to the east, the Strawberry and Aldrich Mountains to the south, and the Ochoco Mountains to the west. The John Day River originates in the Strawberry Mountains at an elevation near 1,800 m (5,900 ft) and flows approximately 457 km (284 miles) to its mouth, at an elevation of 90 m (295 ft), at river km 349 (river mile 217) of the Columbia River. It is the second longest free-flowing river in the continental United States, and along with the Yakima River it is one of only two major tributaries to the Columbia River managed for wild salmon and steelhead. There are no hydroelectric dams or hatcheries located on the John Day River, although numerous irrigation diversions dot the drainage. Major tributaries flowing into the mainstem John Day River include the North Fork, Middle Fork, and South Fork John Day rivers. The North Fork is the largest tributary, contributing approximately 60% of the flow to the mainstem. The John Day River basin contains 15,455 km of stream habitat available for fish, but only 4,628 km (30%) are known or assumed to be used for various anadromous salmonid life history stages (spawning, rearing, and migration; Figure 2; Table 1).

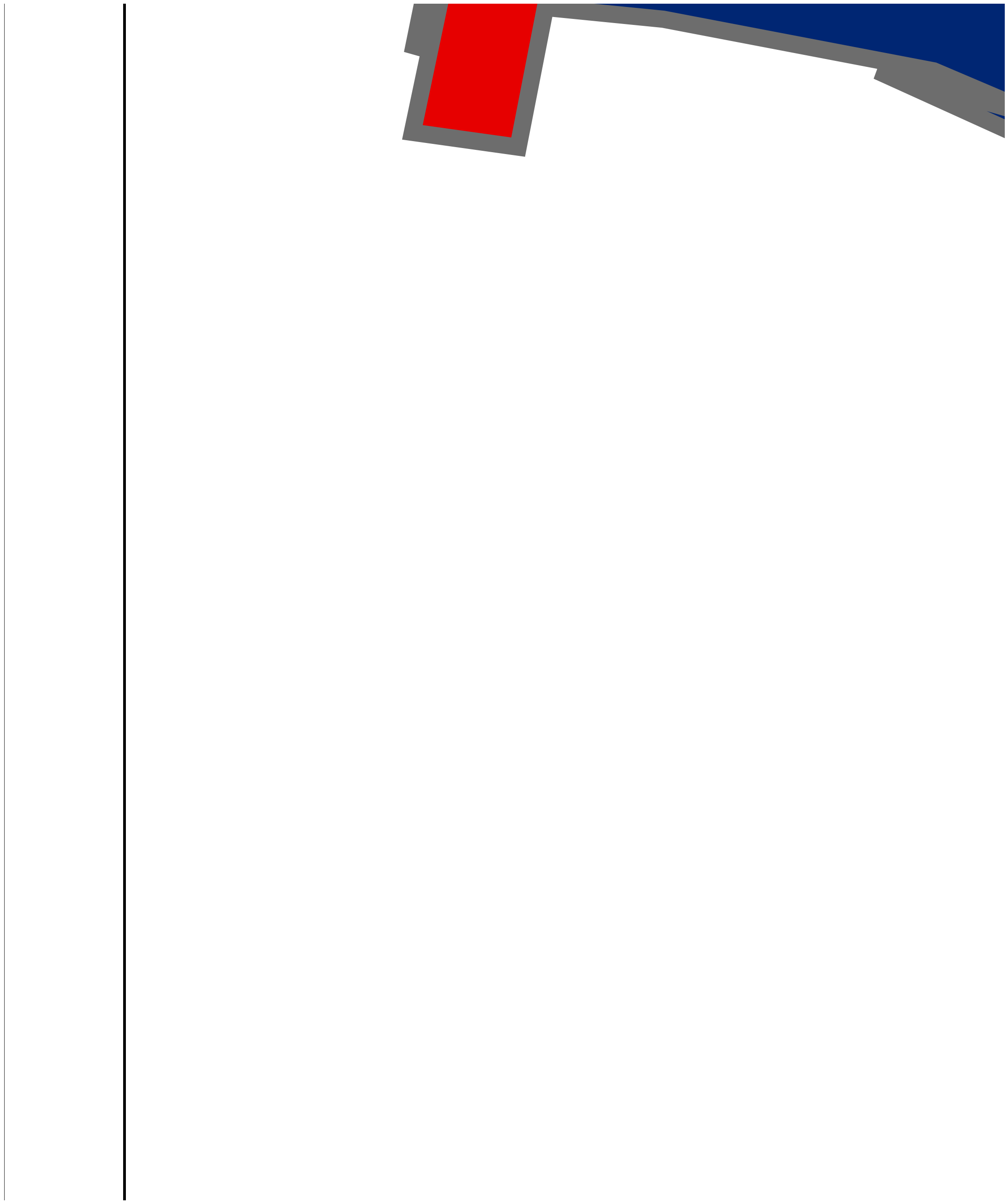

Figure 1. Map of the John Day River basin including the Mainstem John Day River and all three major forks (North Fork, Middle Fork, and South Fork). Dashed grey lines represent subbasin delineations (Lower Mainstem, Upper Mainstem, North Fork, Middle Fork, and South Fork subbasins).

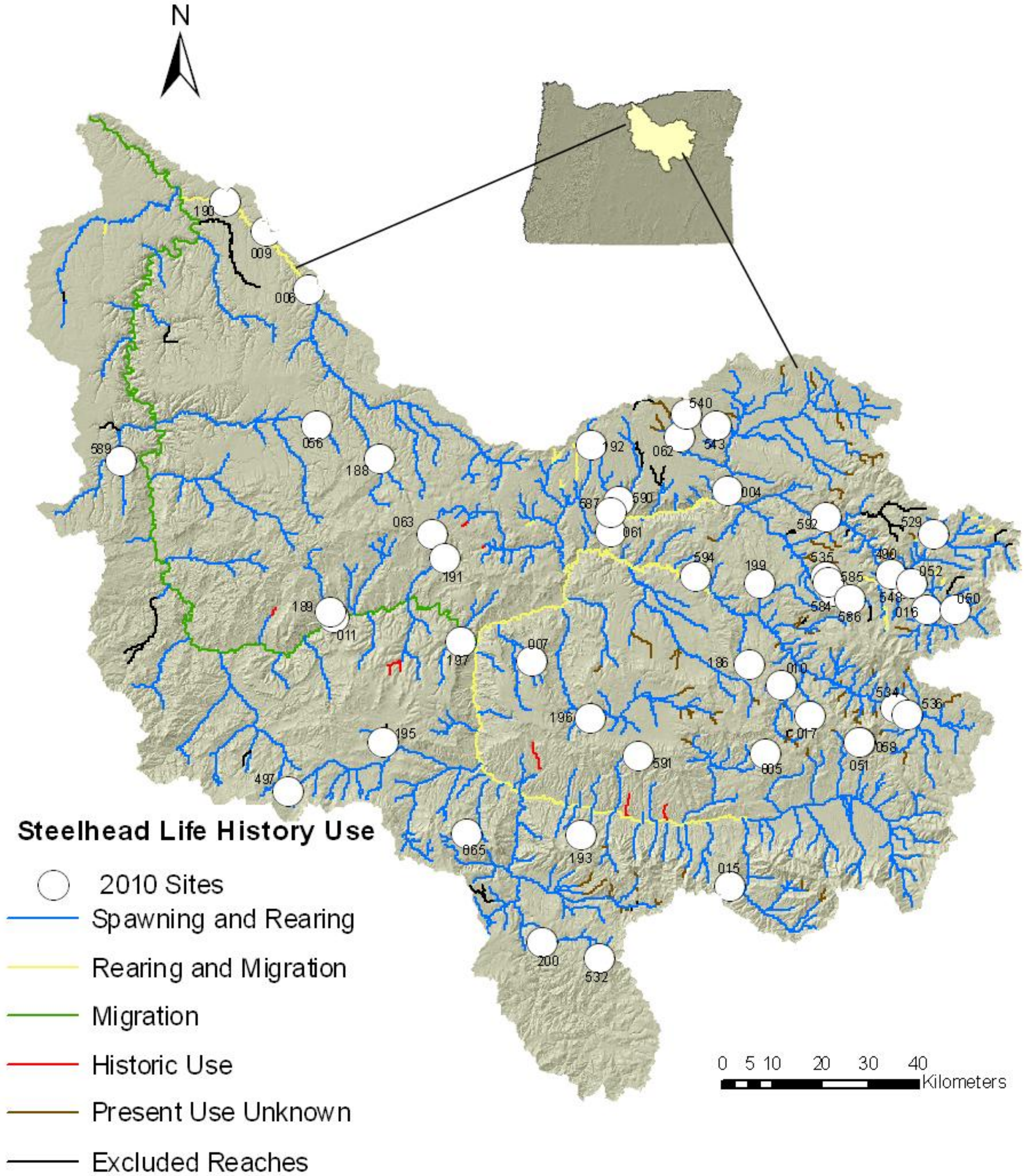

Figure 2. Map of summer steelhead life history use in the John Day River basin and 2010 EMAP sample sites.

Sampling Domain and Site Selection

Sites were selected using the EMAP protocol which uses a spatially balanced random sampling design (Stevens 2002). The sampling universe for EMAP surveys is based on professional knowledge of steelhead life history use in the John Day River basin. This knowledge is derived from ODFW biologists as well as biologists from other natural resource entities, and is currently the best information available concerning the distribution and habitat use of steelhead in the John Day River basin (Figure 2). All reaches upstream of known barriers to anadromous fish passage were eliminated from the sampling universe. Fifty sample sites are targeted each year. In order to balance the needs of status (more random sites) and trend (more repeat sites) monitoring, the following rotating panel design was implemented for the basin:

- 17 sites repeated every year (annual)
- 16 sites repeated once every four years on a staggered basis (four)
- 17 sites new every year (new)

A Geographic Information System (GIS) incorporating a 1:100,000 digital stream network was used to insure an unbiased and spatially balanced selection of sample sites. The GIS site selection process provides geographic coordinates (i.e. latitude and longitude) of each candidate site. From these site coordinates, topographic maps were produced showing the location of each sample point. Landowner contacts were then developed based on county plat maps. With the assistance of ODFW District Biologists, permission was sought from landowners for survey sites. In the field, crews used a handheld Global Positioning System (GPS) to locate the established survey reaches which encompassed the selected EMAP points. Some candidate sites were not sampled due to a lack 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. Every year the EMAP sampling universe is refined based on field observations of previously unknown barriers and other restrictions (e.g. dry streams) that limit fish life history stages (defined as "Excluded Reaches" in Figures 2 and 3; Table 1), or the removal of barriers (e.g. road culverts) that previously limited access to habitat. These stream reaches are removed or added into our sample universe accordingly. The current EMAP sample universe includes 4,322 km of stream (Table 1). The universe does not include sections of stream with use types classified as migration or excluded reaches (Table 1).

Table 1. Length of stream reaches (km) in the John Day River basin classified by life history use type and subbasin.

Use Type	LMJDR	NFJDR	MFJDR	UMJDR	SFJDR	Basin Totals
Spawning and Rearing	1,215	1,185	526	588	237	3,750
Rearing and Migration	94	144	40	57	0	335
Migration	292	1	0	0	0	293
Historic Use	18	2	0	9	0	29
Present Use Unknown	0	97	67	20	23	208
Excluded Reaches	69	73	4	0	12	158
TOTAL	1,688	1,502	637	674	272	4,773

Steelhead Redd Surveys

Steelhead redd surveys based on standard ODFW methods (Susac and Jacobs 1999; Jacobs et al. 2000; Jacobs et al. 2001) were conducted from March to July 2010 (Table 2). Individual sites were surveyed up to six 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. Survey reaches were approximately 2 km in length and encompassed the sample point derived from the EMAP sample draw. Surveyors walked upstream from the downstream end of each reach and counted all redds, live fish, and carcasses observed. New redds were flagged and the location marked with a GPS unit (UTM, NAD 27).

During each visit, surveyors recorded the number of new redds and redds that had been identified and flagged during previous surveys. Redd visibility was estimated for redds that were found during previous surveys. Ideally, each site was to be visited by different surveyors on successive visits, however this was not always logistically possible with the number of personnel available.

Overall redd density (R_D) was estimated by:

$$R_D = \sum_{i=1}^{n} r_i/d_i \qquad (1)$$

where r_i is the number of unique redds observed at site i, d_i is the distance surveyed (km) at site i, and i is the individual sites surveyed. The total number of redds (R_T) occurring throughout the basin was estimated by:

$$R_T = R_D \cdot d_u \qquad (2)$$

where d_u is the total kilometers available to steelhead for spawning and rearing (4,269 km). Steelhead escapement (E_S) was then estimated by:

$$E_S = 1.59 \cdot R_T \qquad (3)$$

Where 1.59 is a fish per redd constant. This constant is developed each year from repeat redd surveys of a tributary (Deer Creek) in the Grande Ronde River basin where a known number of adult steelhead are passed above a counting weir (Flesher et al. 2005; Gee et al. 2008; Lance Clarke and Jim Ruzycki, ODFW, unpublished data). 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 R statistical software (R Development Core Team 2005).

Steelhead carcasses were examined to obtain population and life history information (age, sex, length, and spawner origin). For all carcasses, surveyors collected scale samples from the key scale area (Nicholas and Van Dyke 1982) for age determination, recorded sex, measured MEPS length (middle of eye to posterior scale), and determined spawner origin (hatchery or wild) by inspecting carcasses for the presence (wild) or absence (hatchery) of an adipose fin.
The hatchery

: wild fish ratio 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 estimated by multiplying this proportion of hatchery and wild steelhead by our estimate of steelhead escapement.

Table 2. Stream, site identification number, start and end coordinates, panel type, number of visits, survey distance, and dates for steelhead spawning surveys conducted in the John Day River basin from March to July, 2010. (A); Annual site, (MF); Middle Fork IMW site, (F3); Four 3 site, (SF); South Fork Subsample and EMAP site, (N7); New 7 site.

		Start Coordinates		End Coordinates										
Stream	**Site ID**	**Lattitude**	**Longitude**	**Lattitude**	**Longitude**	**Panel Type**	**Length (km)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Lower John Day														
Cottonwood Creek	65	44.4141	-119.6737	44.3992	-119.6733	Four3	2	6/2						
Fopiano Creek	195	44.5673	-119.8792	44.5736	-119.9007	New7	2	3/22	4/5					
Johnson Creek	197	44.7532	-119.6702	44.7564	-119.6862	New7	2	3/23	4/5	4/19	5/10			
Kahler Creek	191	44.9055	-119.7305	44.9102	-119.7070	New7	2	3/24	4/8	4/22	5/10			
Lone Rock Creek	188	45.1050	-119.9027	45.0919	-119.8904	New7	2	3/17	4/6	5/11				
Long Hollow Creek	589	45.1065	-120.5708	45.0897	-120.5699	Replacement (N7)	2	3/23	4/7					
Lost Valley Creek	56	45.1572	-120.0572	45.1470	-120.0403	Four3	1.8	3/17	4/6	5/13				
Milk Creek	497	44.4775	-120.1326	44.4654	-120.1417	Replacement (A)	1.8	5/18	6/21					
Rock Creek	6	45.4208	-120.0824	45.4090	-120.0742	Annual	1.9	3/4	3/16	3/29	4/12	5/4	5/20	
Rock Creek	9	45.5208	-120.1985	45.5135	-120.1845	Annual	2	3/2	3/16	3/29	4/12	5/4	5/20	
Rock Creek	190	45.5719	-120.3133	45.5691	-120.2926	New7	2	3/2	3/16	3/29	4/12	5/4		
Service Creek	11	44.7969	-120.0025	44.8046	-120.0201	Annual	1.8	3/3	3/15	3/30	4/8	4/27	5/12	
Service Creek	189	44.7969	-120.0025	44.8215	-120.0257	New7	2	3/3	3/18	3/30	4/8	4/27	5/12	
Unnamed stream	63	44.9496	-119.7643	44.9551	-119.7576	Four3	0.9	3/24	4/21					
Middle Fork John Day														
Lick Creek	548	44.8442	-118.5195	44.8501	-118.5075	Replacement (F3)	1.3	5/21						
Middle Fork John Day River	534	44.6215	-118.5790	44.6170	-118.5613	Replacement (A)	1.9	6/14						
Rush Creek	594	44.8677	-119.0730	44.8850	-119.0714	Replacement (N7)	2	3/29	4/12	5/5				
Slide Creek	186	44.7157	-118.9536	44.7027	-118.9385	New7	2.2	4/1	4/13	4/26	5/14	5/24		
Unnamed Stream	199	44.8512	-118.9094	44.8593	-118.9028	New7	1.2	5/5	5/20					
Vinegar Creek	536	44.6013	-118.5351	44.6109	-118.5153	Replacement (F3)	2	4/13	4/30	5/13	5/26			
West Fork Lick Creek	17	44.6235	-118.7876	44.6060	-118.7896	Annual (MF)	2	4/22	5/4	5/18	6/3			
Whiskey Creek	10	44.6624	-118.8355	44.6671	-118.8563	Annual	1.9	4/6	4/28	5/25				
North Fork John Day														
Mallory Creek	587	44.9746	-119.2865	44.9906	-119.2932	Replacement (F3)	2.1	3/24	4/29	5/12	5/28	6/16		
Battle Creek	535	44.8585	-118.7574	44.8636	-118.7357	Replacement (A)	2	5/12	5/27	6/10	6/22			
Bull Run Creek	50	44.8075	-118.4219	44.7967	-118.4025	Four3	2	5/26	6/17					
Camas Creek	4	45.0219	-118.9871	45.0403	-118.9818	Annual	2.4	6/23						
Clear Creek	16	44.7996	-118.4711	44.7826	-118.4688	Annual	2.1	5/26	6/17	6/30				

Table 2. Continued.

		Start Coordinates		End Coordinates										
Stream	**Site ID**	**Lattitude**	**Longitude**	**Lattitude**	**Longitude**	**Panel Type**	**Length (km)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Cottonwood Creek	196	44.6165	-119.3761	44.6108	-119.3574	New7	2	3/30	4/13	5/6				
Deerlick Creek	543	45.1462	-118.9937	45.1458	-119.0163	Replacement (F3)	2	4/15	5/11	5/24				
Desolation Creek	584	44.8446	-118.7338	44.8343	-118.7157	Replacement (A)	2	4/29	5/27	6/23	7/1			
Ditch Creek	192	45.0972	-119.3369	45.1128	-119.3417	New7	2	5/5	5/17	6/7	6/16	6/24		
Fivemile Creek	62	45.1118	-119.1047	45.1253	-119.1073	Four3	2	4/29	5/11	5/24	6/7	6/29		
Gilmore Creek	7	44.7178	-119.5007	44.7067	-119.4926	Annual	1.7	3/23	5/12					
Granite Creek	52	44.8530	-118.5497	44.8472	-118.5293	Four3	2	6/24	7/1					
Granite Creek	490	44.8654	-118.5624	44.8530	-118.5496	Replacement (A)	2.1	7/1						
Little Potamus Creek	590	45.0012	-119.2690	45.0173	-119.2642	Replacement (N7)	2	3/24						
North Fork Desolation Creek	586	44.8196	-118.6888	44.8184	-118.6659	Replacement (F3)	2	5/17	6/23					
North Fork John Day River	61	44.9351	-119.2923	44.9508	-119.2932	Four3	2	3/27	6/28					
North Fork John Day River	592	44.9738	-118.7465	44.9767	-118.7286	Replacement (N7)	2	6/29						
Sponge Creek	585	44.8455	-118.7362	44.8580	-118.7212	Replacement (F3)	2	4/29	5/13	5/27	6/10	6/22		
Sugarbowl Creek	540	45.1525	-119.0910	45.1697	-119.0936	Replacement (F3)	2	4/15	5/11	5/24				
Trout Creek	529	44.9266	-118.4444	44.9387	-118.4554	Replacement (A)	1.9	7/1						
South Fork John Day														
Deer Creek	200	44.1934	-119.4997	44.1964	-119.4797	New7 (SF)	1.9	3/22	3/31	4/14	4/26	5/6	5/18	6/14
South Fork Deer Creek	532	44.1818	-119.3339	44.1657	-119.3383	Replacement (A) (SF)	2	4/26	5/27					
Upper John Day														
Belshaw Creek	591	44.5375	-119.2534	44.5403	-119.2295	Replacement (N7)	2	5/19						
Standard Creek	51	44.5553	-118.6635	44.5648	-118.6476	Four3	2	5/13	6/15					
Standard Creek	58	44.5463	-118.6815	44.5553	-118.6635	Four3	2	4/1	4/27	5/13	6/15			
Tinker Creek	5	44.5371	-118.8998	44.5518	-118.8934	Annual	1.9	4/1	4/20	5/6				
Vance Creek	15	44.2854	-118.9740	44.2930	-118.9976	Annual	2.1	3/31	5/5	5/26				
Widows Creek	193	44.4052	-119.3644	44.3943	-119.3782	New7	2	3/22	4/5	5/5	5/19	6/14		

South Fork John Day River Spawning Subsample

Because of the limited area available for steelhead spawning in the South Fork subbasin, few sites, usually four or less, fall into our sampling frame in any given year. In 2010, we again surveyed 13 additional sites including two sites already in the 2010 sampling frame from the South Fork John Day River subbasin to gather additional spawning data (Figure 3) and to provide an escapement estimate for this subbasin. Subsample sites were determined by selecting the first 13 sites that occurred in the South Fork subbasin from the list of EMAP sample sites. Spawning surveys were conducted as previously outlined in this report and adult steelhead escapement to the South Fork subbasin was estimated using the same equations as noted above except that the distance in the sampling universe (d_u) only encompassed that area within the South Fork subbasin available for steelhead spawning and rearing and upstream of a rotary screw trap operated by Oregon Department of Fish and Wildlife (249 km).

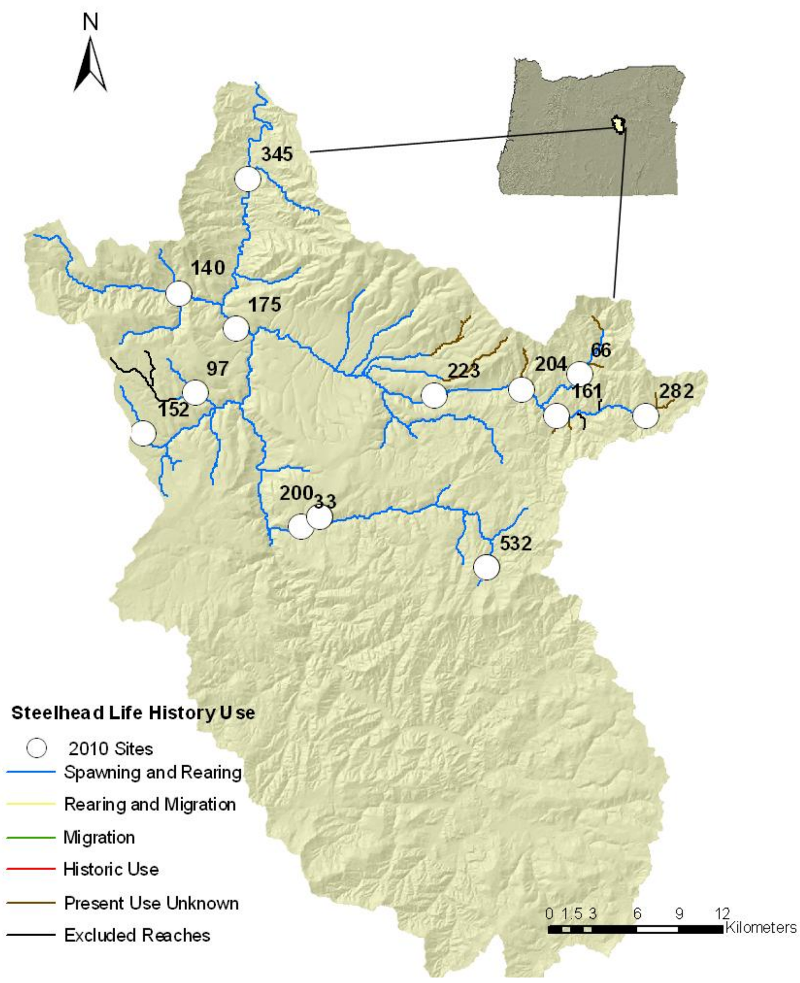

Figure 3. Map of sites selected for sub-sample spawning surveys in the South Fork John Day River subbasin in 2010 and steelhead life history use.

Table 3. Stream, site identification number, start and end coordinates, panel type, number of visits, survey distance, and dates for steelhead spawning surveys conducted in the John Day River basin from March to June, 2010. (A); Annual site.

		Start Coordinates		End Coordinates										
Stream	**Site ID**	**Lattitude**	**Longitude**	**Lattitude**	**Longitude**	**Panel Type**	**Length (km)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Black Canyon Creek	140	44.3374	-119.5847	44.3410	-119.6061	New4	1.9	3/30	4/13	5/5	5/25			
Deer Creek	033	44.1934	-119.4998	44.1968	-119.4797	Four1	2	3/22	3/30	4/14	4/26	5/6	5/18	6/14
Deer Creek	200	44.1934	-119.4997	44.1964	-119.4797	New7	1.9	3/22	3/31	4/14	4/26	5/6	5/18	6/14
Murderers Creek	161	44.2692	-119.2911	44.2605	-119.2753	New5	1.7	4/19	5/3	5/17	6/1	6/14		
Murderers Creek	204	44.2784	-119.3226	44.2772	-119.3047	New8	1.7	3/31	4/14	5/3	5/17	6/1	6/14	
Murderers Creek	223	44.2731	-119.4034	44.2741	-119.3820	New9	2	4/15	5/3	5/17	6/1			
Murderers Creek	282	44.4226	-119.5407	44.4086	-119.5420	New12	2	4/26	5/10	5/25	6/2			
North Fork Wind Creek	097	44.2773	-119.5903	44.2742	-119.6122	New1	1.9	4/26	5/10	5/25				
South Fork Deer Creek	532	44.1818	-119.3339	44.1657	-119.3383	Replacement (A)	2	4/26	5/27					
South Fork John Day River	175	44.3313	-119.5655	44.3174	-119.5554	New6	2	3/25	5/27	6/7				
South Fork John Day River	345	44.4226	-119.5407	44.4086	-119.5420	New16	2	3/25	5/27	7/7				
Tex Creek	066	44.2791	-119.2677	44.2860	-119.2562	Four4	1.7	4/19	5/3	5/17	6/2	6/14		
Wind Creek	152	44.2448	-119.6191	44.2530	-119.6358	New5	2	3/29	4/28					

RESULTS

Steelhead Redds and Escapement

We observed 155 steelhead redds while surveying 96.9 km of an estimated 4,323 km of steelhead spawning and rearing habitat within the John Day River basin in 2010 (Table 4). This resulted in a redd density of 1.6 redds/km. By expansion, an estimated 6,914 observable redds were constructed within the John Day River basin by an estimated 11,027 spawners (Table 5; Figure 4). The Lower Mainstem subbasin had the highest density of redds with 4.19 redds/km followed by the Middle Fork with 2.0 redds/km, the North Fork with 0.35 redds/km, the South Fork with 0.26 redds/km, and the Upper Mainstem with 0.08 redds/km (Table 6). Approximately 56% of sites surveyed in 2010 had no spawning occurring within the survey reaches (Table 4; Figure 5). We observed redds at 64% of sites within the Lower Mainstem, 50% in the Middle Fork, 50% in the South Fork, 35% in the North Fork, and 17% in the Upper Mainstem, (Table 4; Figure 5). We observed redds at 29% of annual sites in 2010 (Table 7). Granite Creek (site 490) and Whiskey Creek (site 10) are the only annual sites where we observed redds during only one year, every other site where redds were observed has contained redds in multiple years (Table 7). We observed redds at 38% of sites in the four-year panel in 2010 (Table 8).

Table 4. Total number of steelhead redds, and unmarked (wild), marked (hatchery), and unknown origin live and dead steelhead observed during spawning surveys in 2010.

				Live				Carcasses			
Stream	**Site ID**	**Redds**	**Redds/km**	**Hatchery**	**Unknown**	**Wild**	**Total Live**	**Hatchery**	**Unknown**	**Wild**	**Total Dead**
LMJDR											
Rock Creek	006	5	2.63	2	0	1	3	0	0	0	0
Rock Creek	009	8	4.00	2	1	4	7	0	0	0	0
Service Creek	011	14	7.78	5	26	37	68	0	1	2	3
Lost Valley Creek	056	0	0.00	0	0	1	1	0	0	0	0
Unnamed stream	063	0	0.00	0	0	0	0	0	0	0	0
Cottonwood Creek	065	0	0.00	0	0	0	0	0	0	0	0
Lone Rock Creek	188	11	5.50	0	0	0	0	0	0	0	0
Service Creek	189	13	6.50	4	6	29	39	0	0	0	0
Rock Creek	190	3	1.50	0	0	1	1	0	0	0	0
Kahler Creek	191	5	2.50	0	0	0	0	0	0	0	0
Fopiano Creek	195	0	0.00	0	0	0	0	0	0	0	0
Johnson Creek	197	50	25.00	4	37	98	139	0	0	5	5
Milk Creek	497	0	0.00	0	0	0	0	0	0	0	0
Long Hollow Creek	589	1	0.50	0	0	0	0	0	0	0	0
LMJDR Total		**110**	**4.19**	**17**	**70**	**171**	**258**	**0**	**1**	**7**	**8**
MFJDR											
Whiskey Creek	010	0	0.00	0	0	0	0	0	0	0	0
West Fork Lick Creek	017	5	2.50	0	0	0	0	0	0	0	0
Slide Creek	186	9	4.09	0	2	0	2	0	0	0	0
Unnamed Stream	199	0	0.00	0	0	0	0	0	0	0	0
Middle Fork John Day River	534	0	0.00	0	0	0	0	0	0	0	0
Vinegar Creek	536	13	6.50	0	5	0	5	0	0	1	1
Lick Creek	548	0	0.00	0	0	0	0	0	0	0	0
Rush Creek	594	2	1.00	0	1	1	2	0	0	0	0
MFJDR Total		**29**	**2.00**	**0**	**8**	**1**	**9**	**0**	**0**	**1**	**1**

Table 4. Continued.

Stream	Site ID	Redds	Redds/km	Live				Carcasses			
				Hatchery	Unknown	Wild	Total Live	Hatchery	Unknown	Wild	Total Dead
NFJDR											
Camas Creek	004	0	0.00	0	0	0	0	0	0	0	0
Gilmore Creek	007	0	0.00	0	0	0	0	0	0	0	0
Clear Creek	016	1	0.48	0	0	0	0	0	0	0	0
Bull Run Creek	050	1	0.50	0	0	0	0	0	0	0	0
Granite Creek	052	0	0.00	0	0	0	0	0	0	0	0
North Fork John Day River	061	0	0.00	0	0	0	0	0	0	0	0
Fivemile Creek	062	1	0.50	0	0	0	0	0	0	0	0
Ditch Creek	192	0	0.00	0	0	0	0	0	0	0	0
Cottonwood Creek	196	1	0.50	0	0	3	3	0	1	0	1
Granite Creek	490	0	0.00	0	0	0	0	0	0	0	0
Trout Creek	529	0	0.00	0	0	0	0	0	0	0	0
Battle Creek	535	0	0.00	0	1	0	1	0	1	0	1
Sugarbowl Creek	540	0	0.00	0	0	0	0	0	0	0	0
Deerlick Creek	543	0	0.00	0	0	0	0	0	0	0	0
Desolation Creek	584	0	0.00	0	0	2	2	0	0	0	0
Sponge Creek	585	1	0.50	0	0	1	1	0	0	0	0
North Fork Desolation Creek	586	0	0.00	0	0	0	0	0	0	0	0
Mallory Creek	587	8	3.81	1	3	6	10	1	0	3	4
Little Potamus Creek	590	1	0.50	0	0	2	2	0	0	0	0
North Fork John Day River	592	0	0.00	0	0	0	0	0	0	0	0
NFJDR Total		**14**	**0.35**	**1**	**4**	**14**	**19**	**1**	**2**	**3**	**6**
SFJDR											
Deer Creek	200	1	0.53	0	4	2	6	0	0	0	0
South Fork Deer Creek	532	0	0.00	0	0	0	0	0	0	0	0
SFJDR Total		**1**	**0.26**	**0**	**4**	**2**	**6**	**0**	**0**	**0**	**0**

Table 4. Continued.

Stream	Site ID	Redds	Redds/km	Live				Carcasses			
				Hatchery	Unknown	Wild	Total Live	Hatchery	Unknown	Wild	Total Dead
UMJDR											
Tinker Creek	005	0	0.00	0	0	0	0	0	0	0	0
Vance Creek	015	0	0.00	0	0	2	2	0	0	0	0
Standard Creek	051	0	0.00	0	0	0	0	0	0	0	0
Standard Creek	058	1	0.50	0	0	0	0	0	0	0	0
Widows Creek	193	0	0.00	0	0	7	7	0	0	1	1
Belshaw Creek	591	0	0.00	0	0	0	0	0	0	0	0
UMJDR Total		**1**	**0.08**	**0**	**0**	**9**	**9**	**0**	**0**	**1**	**1**
Basin Total		**155**	**1.60**	**18**	**86**	**197**	**301**	**1**	**3**	**12**	**16**

Table 5. Distance surveyed, number of unique redds observed, redd density (redds/km), estimated total number of redds, fish per redd estimate from Deer Creek, and spawning escapement estimate with 95% C.I. for the John Day River basin from 2004 to 2010.

Year	km	Redds	Density	Total Redds	Fish/Redd	Escapement	95% Lower	95% Upper
2004	94.7	66	0.7	3,071	1.46	4,484	1,657	7,310
2005	101.2	39	0.39	1,681	2.2	3,698	1,261	6,137
2006	90.5	67	0.74	3,202	1.66	5,315	2,189	8,441
2007	99.6	181	1.82	7,758	1.12	8,689	5,939	11,439
2008	105	56	0.53	2,277	4.07	9,260	4,742	13,775
2009	98.6	44	0.45	1,934	3.81	7,368	3,642	11,099
2010	96.9	155	1.6	6,914	1.59	11,027	4,628	17,434

Table 6. Total redds observed, redd density (redds/km), and live fish observed throughout the John Day River basin (JDR) and by subbasin (LMJDR: Lower Mainstem subbasin; UMJDR: Upper Mainstem subbasin; NFJDR: North Fork subbasin; MFJDR: Middle fork subbasin; SFJDR: South Fork subbasin) from 2004 to 2010.

	JDR			LMJDR			UMJDR			NFJDR			MFJDR			SFJDR		
Year	Redds	Density	Fish	Redds	Density	Fish	Redds	Density	Fish	Redds	Density	Fish	Redds	Density	Fish	Redds	Density	Fish
2004	66	0.70	50	38	1.83	35	0	0.00	0	8	0.21	7	17	1.27	0	3	0.35	1
2005	39	0.39	12	8	0.34	6	20	0.75	6	11	0.38	0	0	0.00	0	0	0.00	0
2006	67	0.74	32	29	1.36	18	13	0.73	2	6	0.18	4	19	1.42	8	0	0.00	0
2007	181	1.82	80	91	3.35	53	32	1.50	6	18	0.63	3	25	1.59	5	15	2.21	13
2008	56	0.53	31	26	1.21	13	3	0.19	1	16	0.37	9	8	0.50	8	3	0.38	0
2009	44	0.45	37	21	0.82	13	10	0.70	11	7	0.20	9	6	0.33	4	0	0.00	0
2010	155	1.60	301	110	4.19	258	1	0.08	9	14	0.35	19	29	2.00	9	1	0.26	6

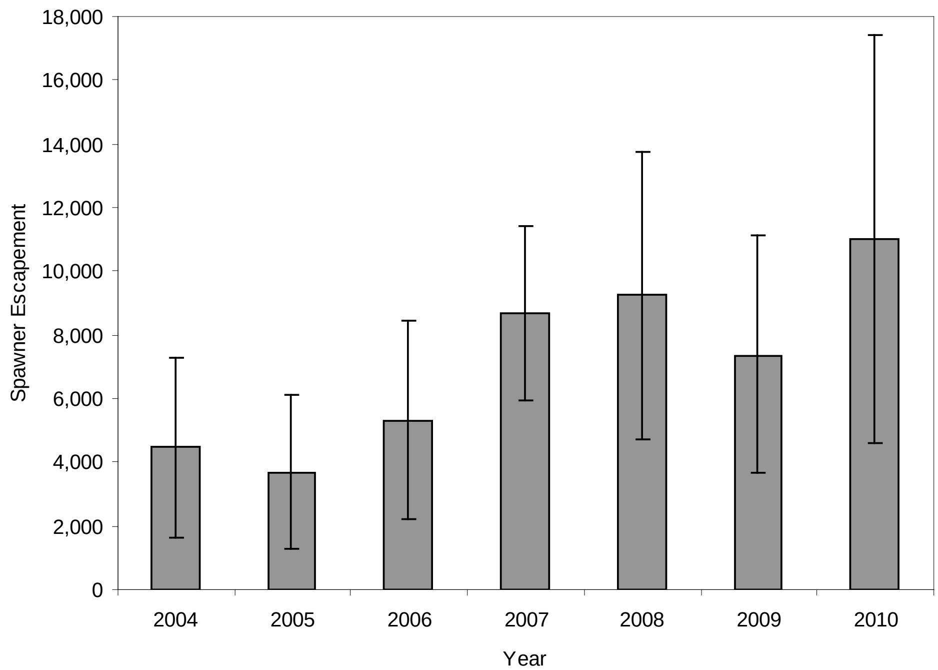

Figure 4. Annual adult steelhead spawner escapement estimates for the John Day River basin from 2004 to 2010. Error bars indicate 95% confidence intervals.

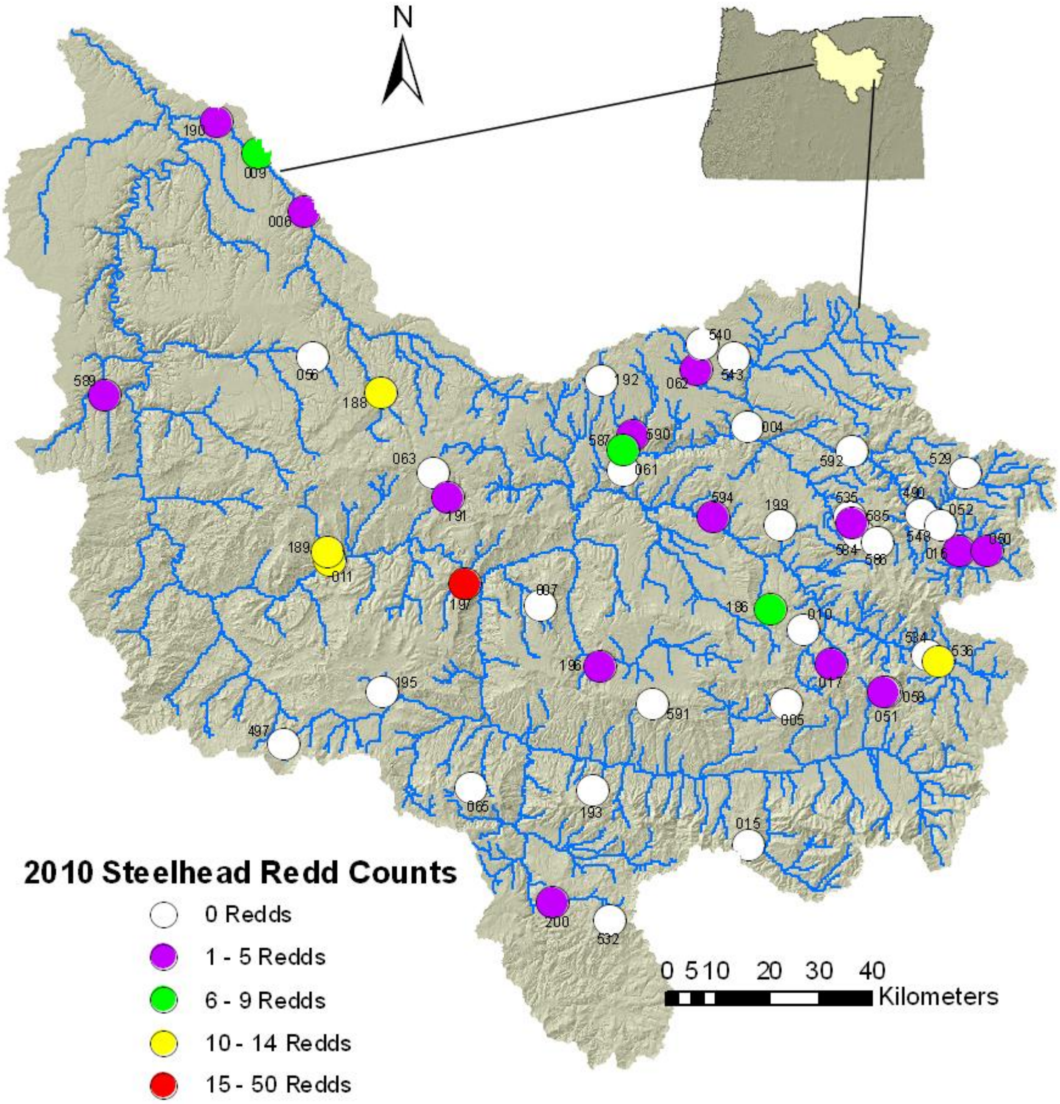

Figure 5. Distribution and number of summer steelhead redds observed in the John Day River basin during spawning surveys conducted in the spring of 2010.

Table 7. Redd observations at annual spawning survey sites in the John Day River basin conducted from February to July, 2004–2010. N/A represents sites that were not surveyed during that year but were added later to replace previous annual sites where access was revoked.

Stream	Site ID	Subbasin	2004	2005	2006	2007	2008	2009	2010
Battle Creek	535	NFJDR	N/A	N/A	0	0	0	0	0
Camas Creek	4	NFJDR	0	0	0	0	0	0	0
Clear Creek	16	NFJDR	3	1	2	2	0	2	1
Gilmore Creek	7	NFJDR	0	0	0	0	0	0	0
Granite Creek	490	NFJDR	0	0	0	1	0	0	0
M.F. John Day	534	MFJDR	N/A	N/A	1	6	0	0	0
Milk Creek	497	LMJDR	0	0	0	0	0	0	0
Rail Creek	13	UMJDR	0	0	0	0	0	N/A	N/A
Rock Creek	6	LMJDR	3	1	6	7	6	2	5
Rock Creek	9	LMJDR	8	2	0	16	4	3	8
Service Creek	11	LMJDR	17	0	14	16	12	8	14
Tinker Creek	5	UMJDR	0	0	0	0	0	0	0
Vance Creek	15	UMJDR	0	0	0	0	0	0	0
WF Lick Creek	17	MFJDR	4	0	2	8	0	4	5
Whisky Creek	10	MFJDR	0	0	0	0	1	0	0
Trout Creek	529	NFJDR	N/A	N/A	0	0	0	0	0
S.F. Deer Creek	532	SFJDR	N/A	N/A	0	0	0	0	0
Rosebush Creek	579	LMJDR	N/A	N/A	N/A	N/A	N/A	0	N/A
Desolation Creek	584	NFJDR	N/A	N/A	N/A	N/A	N/A	N/A	0
TOTAL			**40**	**10**	**37**	**56**	**25**	**19**	**33**

Table 8. Redd observations at four year rotation spawning survey sites in the John Day River basin conducted in the spring of 2006 and 2010. N/A represents sites that were not surveyed during that year but were added later to replace previous annual sites where access was revoked.

Stream	Site ID	Subbasin	2006	2010
Bull Run Creek	50	NFJDR	0	1
Standard Creek	51	UMJDR	0	0
Granite Creek	52	NFJDR	0	0
Lost Valley Creek	56	LMJDR	7	0
Standard Creek	58	UMJDR	0	1
North Fork John Day River	61	NFJDR	1	0
Fivemile Creek	62	NFJDR	2	1
Unnamed Creek	63	LMJDR	0	0
Cottonwood Creek	65	LMJDR	0	0
Vinegar Creek	536	MFJDR	2	13
South Fork Long Creek	538	MFJDR	5	N/A
Rock Creek	539	LMJDR	0	N/A
Sugarbowl Creek	540	NFJDR	0	0
Deerlick Creek	543	NFJDR	0	0
John Day River	547	UMJDR	0	N/A
Lick Creek	548	NFJDR	0	0
Sponge Creek	585	NFJDR	N/A	1
North Fork Desolation Creek	586	NFJDR	N/A	0
Mallory Creek	587	NFJDR	N/A	8
TOTAL			**17**	**25**

South Fork John Day River Spawning Subsample

A total of 27 redds were observed while surveying 24.8 km of steelhead spawning and rearing habitat in the South Fork John Day River subbasin (Table 10; Figure 6). Redd densities at sites in the South Fork subbasin varied from zero to 3.68 redds/km (Table 10). Overall, the average redd density was 1.10 redds/km with an estimated total 271 redds constructed in the South Fork subbasin above the rotary screw trap (Table 9). We estimate that 432 adult steelhead spawners returned to the South Fork subbasin in 2010 (Table 9). We observed 78 live steelhead in the South Fork subsample, 42 of which were of wild origin, 33 were of unknown origin, and three were of hatchery origin (Table 10). A total of three steelhead carcasses were observed, two of wild origin, and one of unknown origin.

Table 9. Distance surveyed, number of unique redds observed, redd density (redds/km), estimated total number of redds, fish per redd estimate from Deer Creek, and spawning escapement estimate with 95% C.I. for the South Fork John Day River basin from 2006 to 2010.

Year	km	Redds (n)	Density	Total Redds	Fish/redd	Escapement	95% Lower	95% Upper
2006	25.9	18	0.69	186	1.66	309	145	472
2007	24.2	58	2.4	675	1.12	756	252	1,260
2008	24.2	29	1.2	301	4.07	1,224	624	1,824
2009	25.9	50	1.93	481	3.81	1,833	795	2,867
2010	24.8	27	1.09	271	1.59	432	173	692

Table 10. Total number of steelhead redds, and unmarked (wild), marked (hatchery), and unknown origin live and dead steelhead observed during South Fork John Day subbasin spawning surveys in 2010.

				Live				Carcasses			
Stream	**Site ID**	**Redds**	**Redds/km**	**Hatchery**	**Unknown**	**Wild**	**Total Live**	**Hatchery**	**Unknown**	**Wild**	**Total Dead**
Deer Creek	033	0	0.00	0	2	0	2	0	0	1	1
Tex Creek	066	0	0.00	0	0	0	0	0	0	0	0
North Fork Wind Creek	097	7	3.68	1	7	8	16	0	1	0	1
Black Canyon Creek	140	7	3.68	2	11	27	40	0	0	1	1
Wind Creek	152	0	0.00	0	0	0	0	0	0	0	0
Murderers Creek	161	0	0.00	0	0	0	0	0	0	0	0
South Fork John Day River	175	2	1.00	0	0	0	0	0	0	0	0
Deer Creek	200	1	0.53	0	4	2	6	0	0	0	0
Murderers Creek	204	5	2.94	0	5	4	9	0	0	0	0
Murderers Creek	223	3	1.50	0	3	1	4	0	0	0	0
Murderers Creek	282	0	0.00	0	0	0	0	0	0	0	0
South Fork John Day River	345	2	1.00	0	1	0	1	0	0	0	0
South Fork Deer Creek	532	0	0.00	0	0	0	0	0	0	0	0
Total		**27**	**1.09**	**3**	**33**	**42**	**78**	**0**	**1**	**2**	**3**

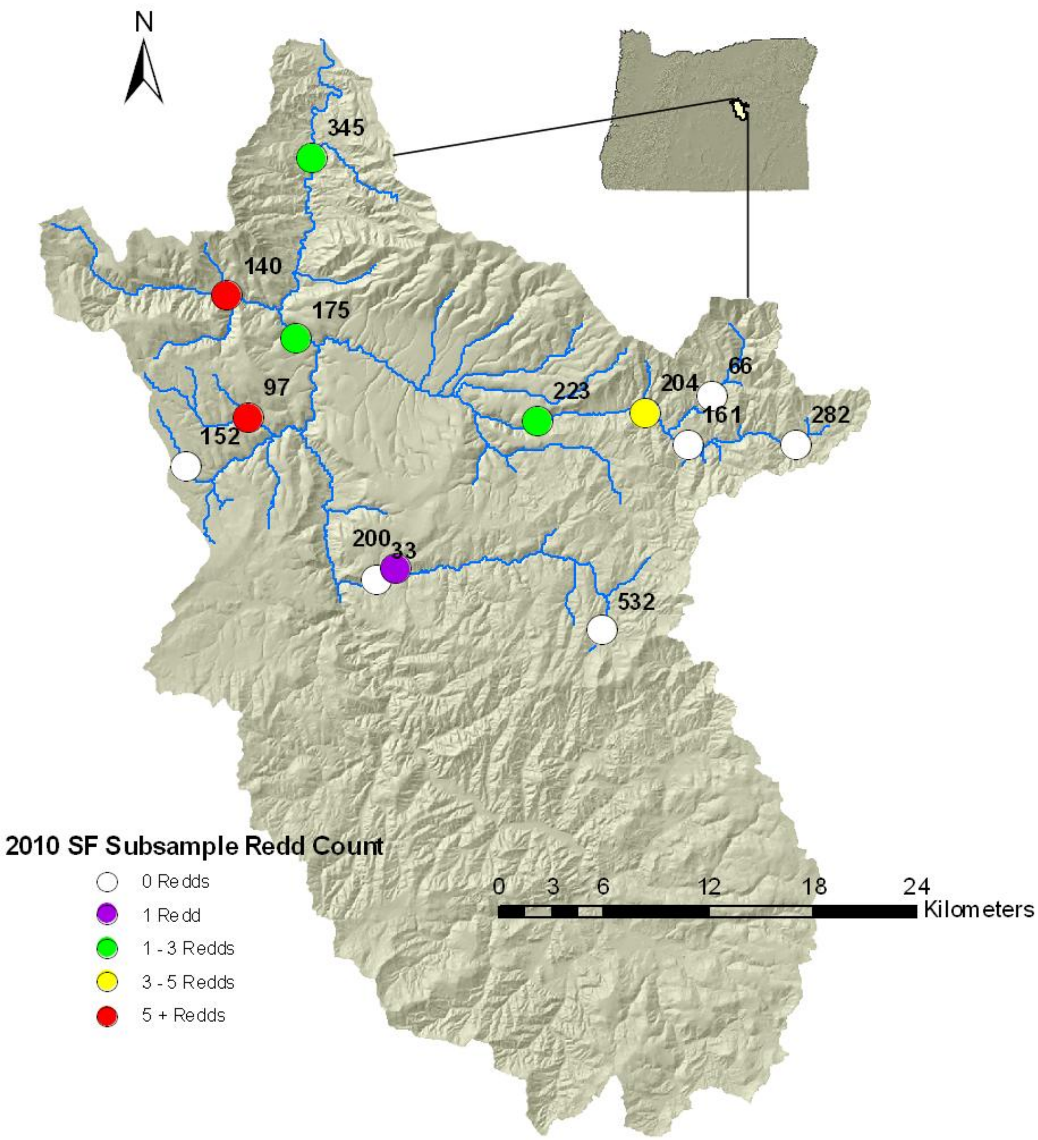

Figure 6. Distribution and number of summer steelhead redds observed in the South Fork John Day River subbasin in 2010.

Hatchery:Wild Observations

Hatchery steelhead composed 8% (21 of 258) of live steelhead observed in the John Day River basin in 2010 where the presence (unmarked, presumed wild) or absence (marked, presumed hatchery) of an adipose fin could be determined, origin was determined for 69% of live fish (Table 11). Using the ratio of live clipped

(Table 11). Wild steelhead were observed at every site where hatchery steelhead were observed (Figure 8). We sampled 16 summer steelhead carcasses in 2010, 8% (1 of 13) were of hatchery origin. Approximately 8% and 4% of fish were of hatchery origin that were observed during ODFW Index spawning surveys and ODFW juvenile salmonid sampling projects respectively (Appendix Table A).

Table 11. Number of live steelhead observed and determined for origin, number and percentage marked and unmarked, and number marked and unmarked steelhead near redds during surveys conducted during 2010. LMJDR: Lower Mainstem subbasin; UMJDR: Upper Mainstem subbasin; NFJDR: North Fork subbasin; MFJDR: Middle Fork subbasin; SFJDR: South Fork subbasin (includes steelhead observed during SF subsample surveys).

SubBasin	# Observed	# Determined	# Marked	% Marked	# Marked Near Redd	# Unmarked	# Unmarked Near Redd
Lower John Day	258	188	17	9.04	8	171	52
Middle Fork John Day	9	1	0	0.00	0	1	1
North Fork John Day	19	15	1	6.67	0	14	3
South Fork John Day	78	45	3	6.67	0	42	10
Upper John Day	9	9	0	0.00	0	9	0
Basin Total	**373**	**258**	**21**	**8.14**	**8**	**237**	**66**

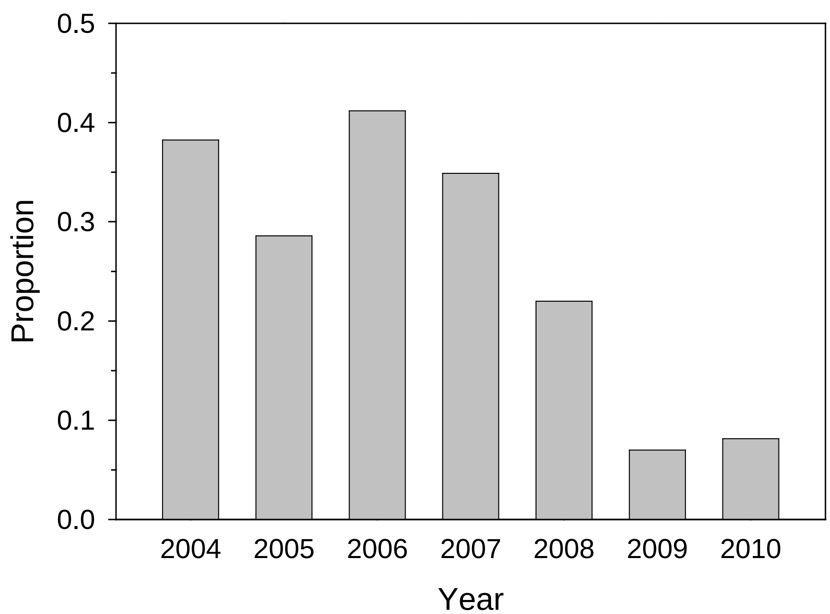

Figure 7. Proportion of steelhead spawners observed during spawning surveys in the John Day River subbasin that were identified as hatchery origin from 2004 to 2010.

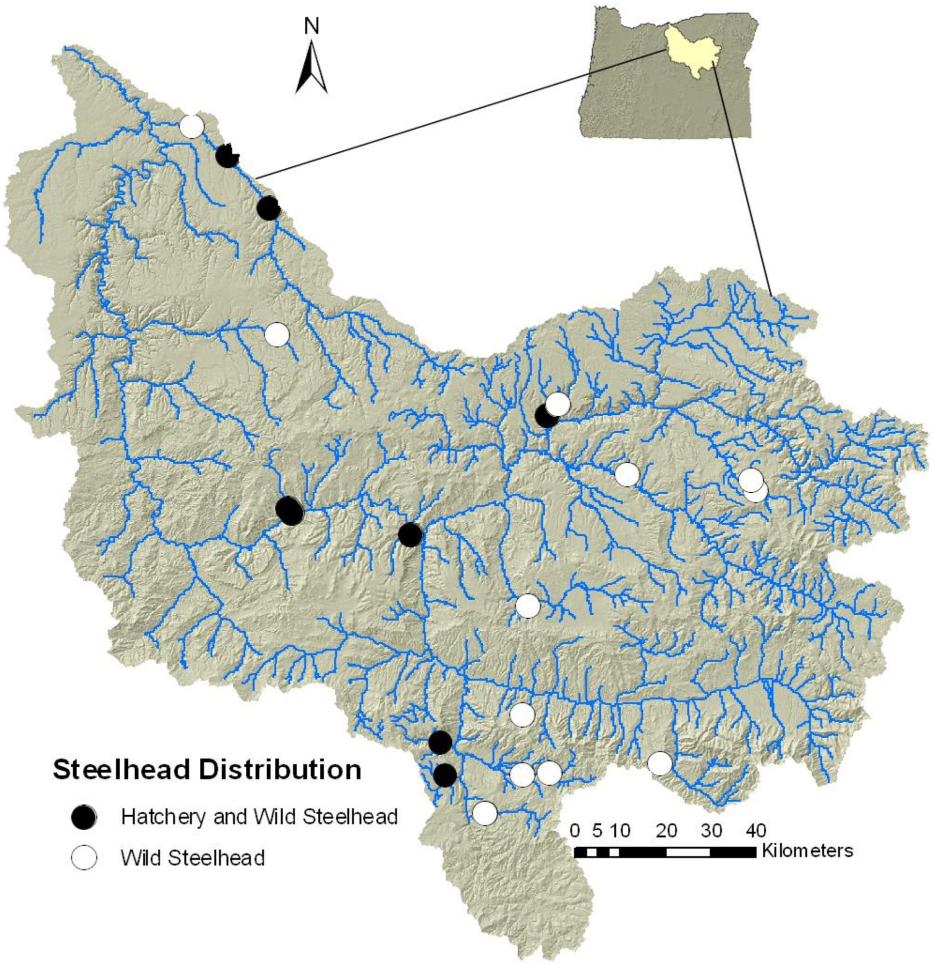

Figure 8. Distribution of hatchery and wild steelhead observations in the John Day River basin during summer steelhead spawning surveys conducted in the spring of 2010 (includes observations in the South Fork Subsample).

Steelhead Spawning Timing

We observed new steelhead redds from 2 March 2010 to 3 June 2010 (Figure 9). Redds were relatively evenly distributed throughout the normal spawning period (mid-March to early June) in 2010 with a majority of redds (47%) observed during the month of April (Figure 9). Fish spawned earliest in the Lower Maintem and latest in the North Fork subbasin, a trend that has been apparent since 2004 (Figure 9). A warm weather period coupled with rain in early June caused discharge to increase throughout the basin and subsequently no new redds were observed after the high flow event (Figure 10). Most sites were not surveyable during this time period due to high and turbid water.

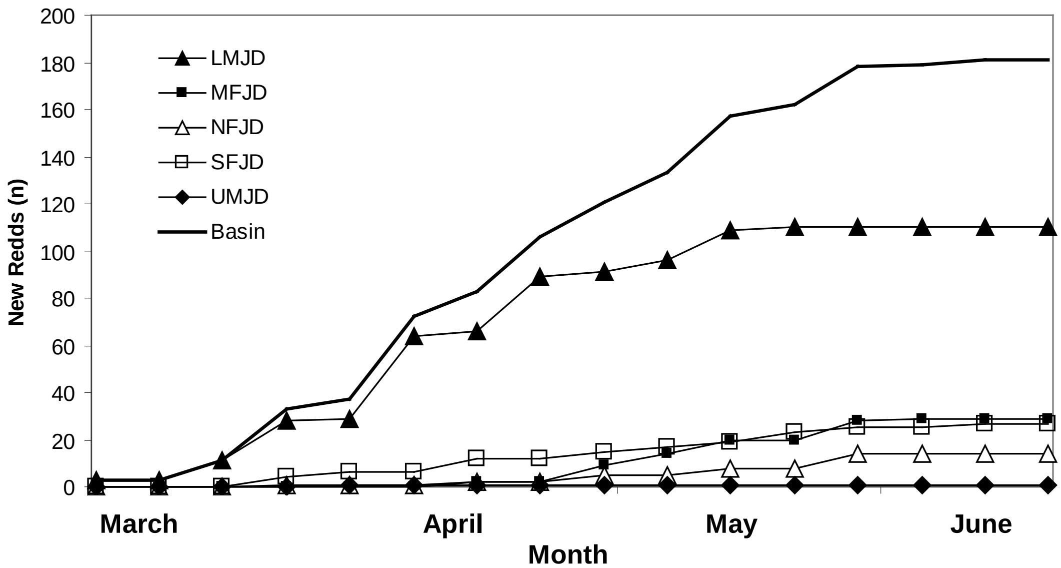

Figure 9. Cumulative number of new steelhead redds observed weekly during EMAP spawning surveys in 2010. LMJDR: Lower Mainstem subbasin; UMJDR: Upper Mainstem subbasin; NFJDR: North Fork subbasin; MFJDR: Middle Fork subbasin; SFJDR: South Fork subbasin (includes steelhead observed during SF subsample surveys).

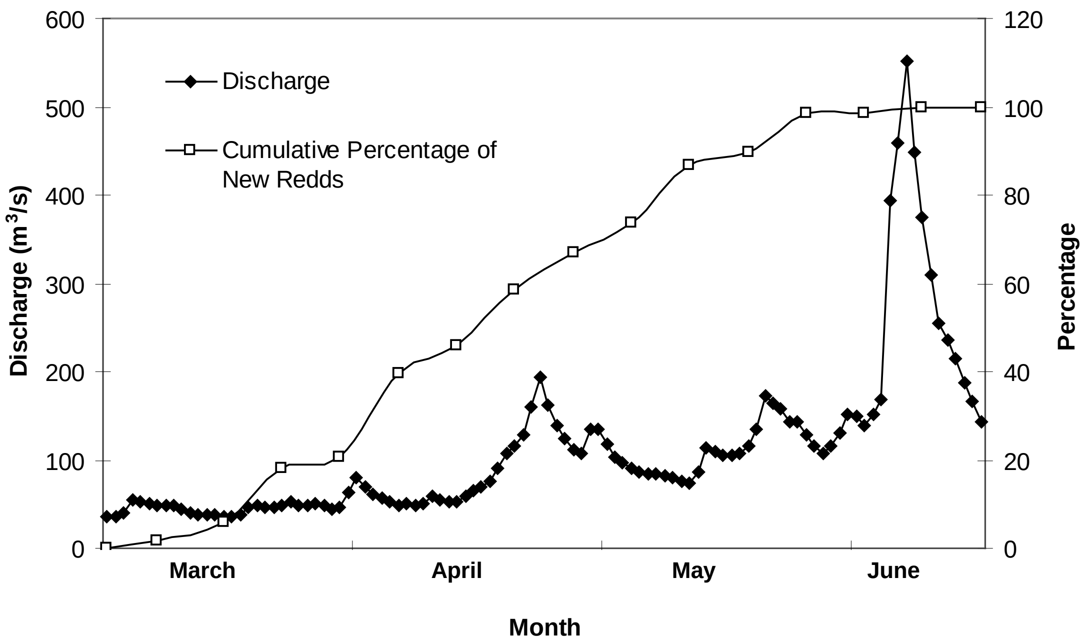

Figure 10. Mean daily discharge (m^3/s) in the John Day River at Service Creek from 1 March 2010 to 14 June 2010 and cumulative percentage of new redds observed.

DISCUSSION

The estimated steelhead spawner escapement in 2010 of 11,027 spawners was the highest return since commencing the EMAP monitoring project in 2004. The count of unclipped steelhead passing over Bonneville Dam from 1 July 2009 to 31 October 2009, was also the highest return since prior to the EMAP project (Kathryn Kostow personal communication). Redd densities observed in 2010 were the second highest recorded since 2004, exceeded only by 2007 which was likely the result of optimal surveying conditions (James et al. 2007). Discharge peaked in March in 2007 before the bulk of spawning activity took place as opposed to June and an initial increase in discharge in April of 2010 (James et al. 2007). Despite the increase in flow during April and June survey conditions were above average for the 2010 survey year when compared to conditions since 2004 (McCormick et al. 2009; McCormick et al. 2008; James et al. 2007; James et al. 2006; Wiley et al. 2005; Wiley et al. 2004) . Index surveys in the John Day River basin conducted by Oregon Department of Fish and Wildlife Biologists in 2010 also resulted in the second highest redd densities recorded since 2004, exceeded only in 2007 (ODFW unpublished data; Appendix Figures A and B). The annual fish per redd constant developed at the Deer Creek weir in the Grande Ronde basin was the second lowest we have used to estimate escapement. The 2007 spawning year provided the lowest fish per redd constant observed since prior to 2004. The annual trend observed between the fish per redd constant at the Deer Creek weir and anecdotal evidence of survey conditions lends credibility to the use of the fish per redd constant as a suitable expansion factor and suggests that Deer Creek survey conditions are similar to conditions in the John Day basin.

We did not observe spawning activity again at a large proportion of sites surveyed in 2010 (56%). In the past six years, greater than 50% of sites surveyed in any given year have been void of any observable spawning activity. Of the 17 sites that we survey annually, we have also observed spawning at less than 50% of sites. Even with record escapement, no redds were observed at annual sites for the first time, and the percentage of sites without redds was within the range observed since 2004. This suggests that with increased escapement levels, steelhead spawning range may not be increasing. While the steelhead spawning distribution in the John Day River basin is likely variable year to year, the fact that over half the sites surveyed in any given year, including annual and four year sites, are not being utilized for steelhead spawning suggests that we do not fully understand current steelhead spawning habitat in the basin.

Since 2004, we provided escapement estimates with coefficients of variation (CV) ranging from 114% to 237% with a mean of 194%. The National Oceanic and Atmospheric Administration (NOAA) Fisheries Service suggests that we should strive for a CV of 15% when describing adult spawner populations that are listed under the ESA in their Guidance for Monitoring Recovery of Salmon and Steelhead report (Crawford and Rumsey 2009). In 2010 we sampled approximately 2% of the available habitat in the basin wide sample and approximately 10% of the available habitat in the South Fork sub sample. Even with the increased sampling intensity, CVs for escapement estimates in the South Fork have ranged from 90% to 122% with a mean of 105%. This suggests that it may require a large amount of additional sampling effort to achieve acceptable variance estimates and effort may be better applied to refining the steelhead sampling universe.

However, increased sampling intensity inherently allows us to evaluate more spawning habitat while conducting spawning surveys thus further refining the sampling universe. Given our high variance levels, we may not be able to sufficiently detect short term changes in steelhead escapement which may effect our evaluation of restoration efforts and management decisions (Maxell 1999).

Jacobs et al. (2009) used a probabilistic sampling design similar to the design we use in order to estimate bull trout population status in the Columbia River Plateau using redd counts. They achieved CVs of 15% to 35% while surveying from 26% to 81% of the target population area (Jacobs et al. 2009). In order to sample 26% of the available habitat in the John Day basin we would need to survey approximately 1,124 km of stream consisting of 562, 2km sites using the methodology described by Jacobs et al. (2009). Dunham et al. (2001) and Mulfeld et al. (2006) suggest that observer variability could provide a large source of error when estimating bull trout escapement through the use redd counts. Holecek and Walters (2007) found that a large number of test digs were misidentified as redds while conducting spawning surveys of an adfluvial rainbow trout population in Idaho. We do not quantify nor report observer variability for steelhead redd counts, which is likely more variable than bull trout redd counts given highly variable viewing conditions and scouring in the spring as opposed to the fall when bull trout spawn. This sampling artifact may be corrected by our fish per redd expansion to escapement estimates; however, the extent of the difference that is accounted for is currently unknown due to the high variance associated with our escapement estimates and the lack of another suitable index in which to compare our escapement estimate. The use of the fish per redd constant provides a better relationship between escapement estimates and counts of wild A-run steelhead over Bonneville dam than does redd densities alone (Appendix Figures C and D). A CV of 15% may be an unreasonable expectation of precision for adult spawner escapement to a basin as large and as variable as the John Day using redd counts as the primary metric.

Lower Mainstem tributaries have accounted for the majority of redds constructed in any given year suggesting that the Lower Mainstem habitat is an important component of steelhead production with the John Day Basin. With the exception of 2005 when water limited adult steelhead access to smaller tributaries, the Lower Mainstem tributaries have accounted for 55% of redd observations in the basin since 2004. There is significant potential for smolt production in the Lower Mainstem habitat. Unfortunately, we are unable to effectively monitor this production due to logistical and monetary constraints.

In 2010 we estimated hatchery composition of adult steelhead at 8%, the second lowest proportion since we began using the EMAP sampling design. Similarly, fewer than average hatchery strays were observed in other ongoing monitoring projects in the basin in 2010 (Appendix Table A). Visual observations during spawning surveys potentially underestimate the hatchery fish component because of a bias towards detecting an adipose fin rather than determining its absence (Susac 2005). Further, not all hatchery fish released in the Columbia River basin have adipose fin clips. In 2010, the lower mainstem had the majority of total fish and hatchery fish observations, a trend that has been apparent since 2004. Using our current protocol it is possible that we overestimate hatchery proportion because the Lower Mainstem fish are apparently easier to observe on the spawning grounds and a higher relative proportion are of hatchery origin. We used peak counts of fish observations to reduce bias that may exist from repeat observations of individual fish, particularly in the Lower Mainstem. We observed a slightly higher proportion of hatchery fish at 10% compared to 8% with our standard protocol. This analysis suggests that wild fish are remaining on the spawning grounds for a longer period of time, allowing us to repeat observations of the same fish, and that we are less likely to observe hatchery fish repeatedly, or that significant bias exists in determining origin based on visual observation as described by Susac (2005).

CONCLUSIONS

Based on the relationship between Bonneville dam counts and index redd counts, it appears as though EMAP redd counts are effective in tracking steelhead abundance, although the high variability associated with escapement estimates suggests room for improvement. To improve our ability to estimate steelhead escapement in the John Day River basin, we need to further refine the current distribution of steelhead spawning habitat. Such refinements will allow us to better determine high priority areas for restoration projects and identify key areas where adequate spawning habitat exists but is not currently being utilized. We currently provide escapement estimates with 95% confidence intervals approximately 50% of the mean. Given similar high variance even with increased sampling intensity within the South Fork sub sample, increasing sample size alone may not be sufficient to reduce sample variance. Refining the current steelhead sampling universe will reduce the number of sample reaches with zero redd counts and thus, reduce the variance of our escapement estimates. The current methods used for assessing hatchery steelhead stray rates into the John Day River basin are not sufficient for measuring the impact of these strays. Additional effort is needed to measure the relative contributions of hatchery and wild fish to natural production, and the relative productivity of streams with hatchery fish compared to tributaries where they are still absent.

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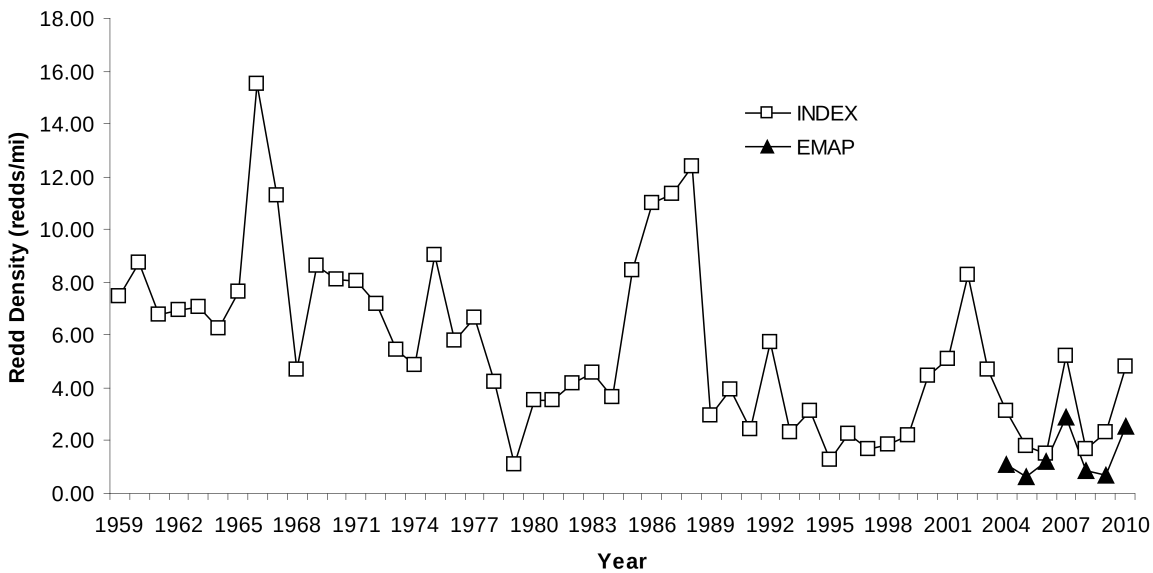
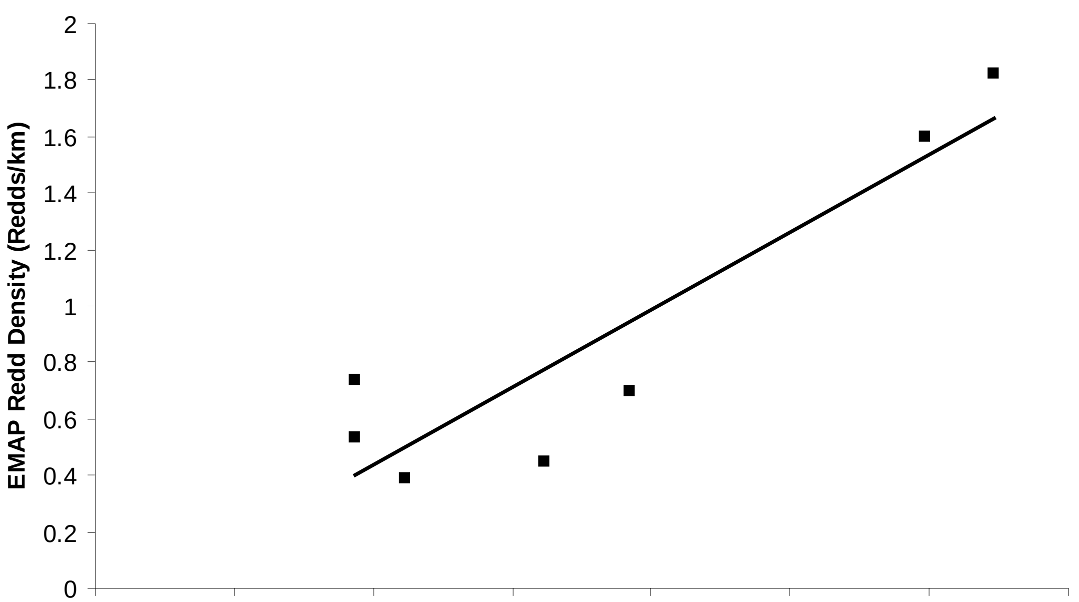
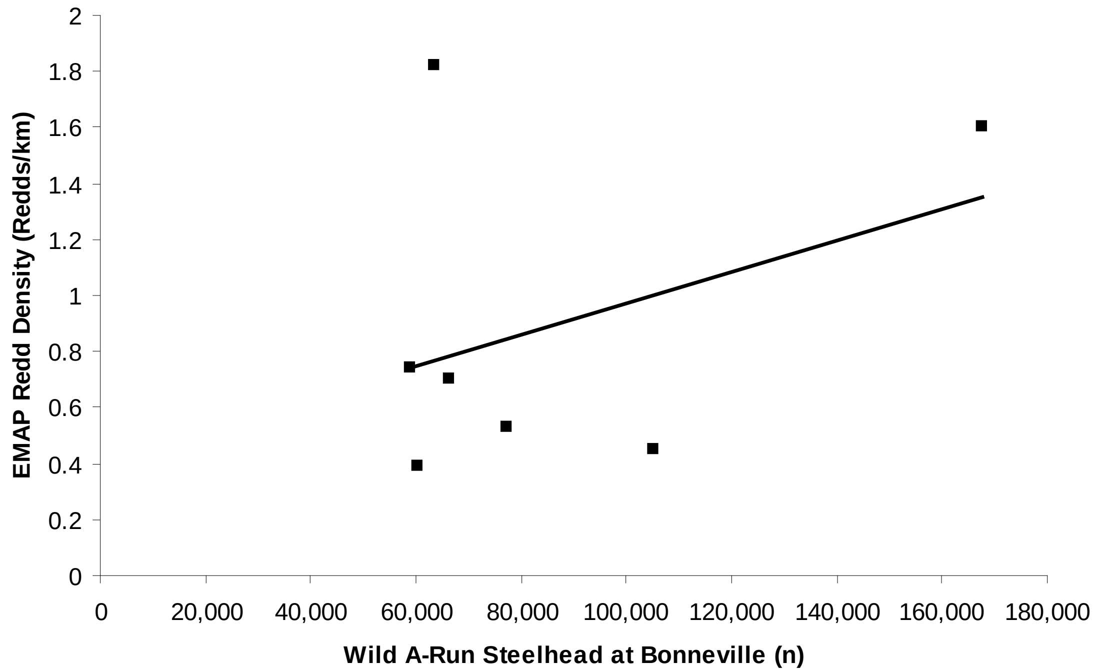
APPENDIX



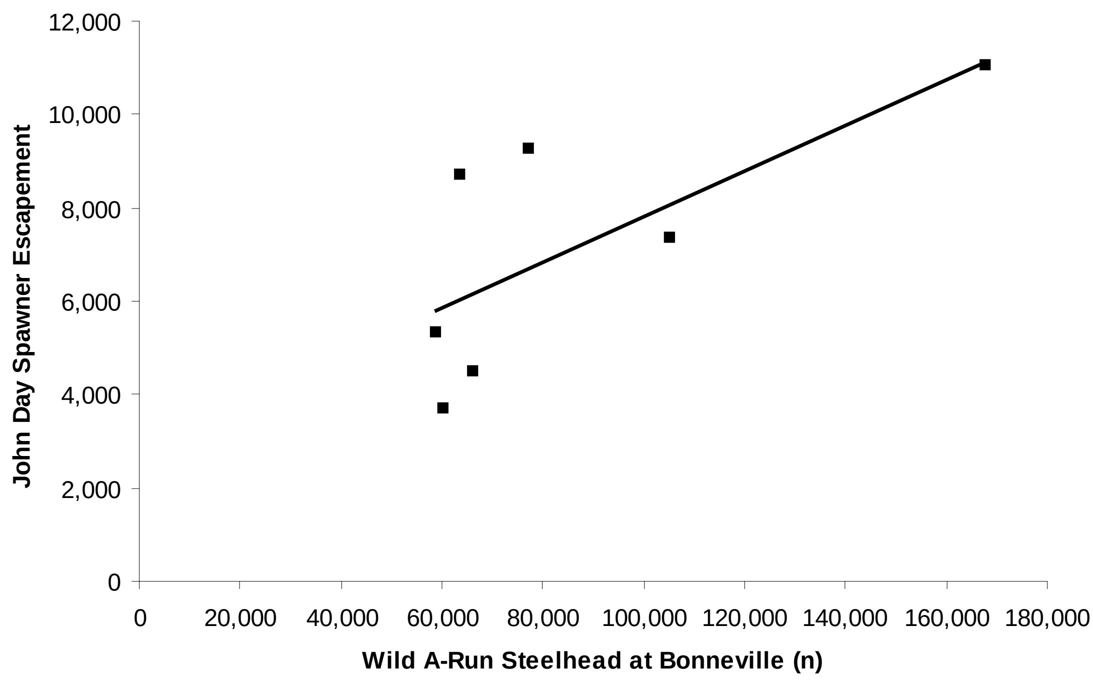
Appendix Figure A. Redd density (redds/mile) observed at EMAP and index survey sites sampled by ODFW personnel in the John Day River basin from 1959 to 2010.



Appendix Figure B. Relationship between Index redd density and EMAP redd density from 2004 to 2010 (R = 0.91).



Appendix Figure C. Relationship between wild A-run steelhead counts at Bonneville Dam and EMAP redd density from 2004 – 2010 (r^2 = .15, p-value = .40).



Appendix Figure D. Relationship between wild A-run steelhead counts at Bonneville Dam and EMAP steelhead spawner escapement estimate from 2004-2010 (r^2 = 0.51, p-value = 0.07).

Appendix Table A. Recovery year, number of wild steelhead, number of hatchery steelhead, and percent hatchery steelhead observed during index steelhead spawning surveys in the John Day River basin (Jeff Neal, unpublished data), seining in the Mainstem John Day River between Kimberly (rkm 298) and Spray (rkm 274), and operation of rotary screw traps in the Middle Fork, South Fork, and Mainstem John Day River. Seining and rotary screw trap data (includes both live fish and carcass observations) were compiled from the John Day Basin Spring Chinook Salmon Escapement and Productivity Monitoring Project (Ruzycki et al. 2002; Carmichael et al. 2002; Wilson et al. 2002; Wilson et al. 2005; Wayne Wilson, unpublished data).

	ODFW Index			**ODFW Juvenile Monitoring Project**		
Year	**Wild (n)**	**Hatchery (n)**	**% Hatchery**	**Wild (n)**	**Hatchery (n)**	**% Hatchery**
2000	--	--	--	11	1	8.3
2001	--	--	--	8	2	20.0
2002	173	16	8.5	20	13	39.4
2003	27	2	6.9	11	2	15.4
2004	12	1	7.7	16	6	27.3
2005	15	1	6.3	8	4	33.3
2006	22	4	15.4	10	5	33.3
2007	41	2	4.6	10	0	0.0
2008	28	2	6.6	19	1	5.0
2009	55	0	0.0	24	5	17.0
2010	57	5	8.0	24	1	4.0
TOTAL	**430**	**33**	**7.0**	**161**	**40**	**19.9**