FISH RESEARCH PROJECT
OREGON

STEELHEAD ESCAPEMENT MONITORING IN THE UPPER GRANDE RONDE RIVER BASIN

ANNUAL TECHNICAL REPORT

CONTRACT PERIOD: August 1, 2009 to July 31, 2010

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Contract Number: AB133F07SE4174

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EXECUTIVE SUMMARY

Objectives

1. Estimate redd density and spawner escapement of summer steelhead for the Upper Grande Ronde River summer steelhead population.
2. Estimate freshwater productivity (smolts/redd or smolts/adult) of summer steelhead above rotary screw trap locations.
3. Estimate spawners/redd above adult weir collection points and correlate independent counts.

Accomplishments and Findings

We sampled 29 random, spatially-balanced sites throughout the Upper Grande Ronde River basin during the spring (2 March–17 June) of 2010 to determine summer steelhead *Oncorhynchus mykiss* redd abundance and adult escapement. Survey sites encompassed 53.9 km of an estimated 934 km of steelhead spawning habitat within the basin. During these surveys, 109 redds and 34 live steelhead were observed resulting in a density of 2.02 redds/km. Redds were observed at 23 of the 29 sites (79%). Redd abundance and adult steelhead escapement estimates for the basin were 1885 and 3009, respectively. Redd counts were greater than the previous years, however our adult escapement estimate was lower than 2009. One hatchery steelhead was observed on West Chicken Creek. High flow events persisted throughout much of May making redd observations difficult. Three random sites were selected for the Catherine Creek watershed, and two sample sites were randomly selected for the Lookingglass Creek watershed, we did not make weir and redd count comparisons for either watershed. Surveys on Deer Creek, where a permanent weir is present, indicated a 1.60 fish/redd ratio during the 2010 spawning season.

Management Recommendations

1. Using the current data of steelhead spawning distribution and geographic landscape variables, refine the sampling universe for *O. mykiss* in the Upper Grande Ronde 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. Continue to manage the Upper Grande Ronde 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.

Acknowledgements

We would like to acknowledge the assistance and cooperation of the many private landowners throughout the Grande Ronde River basin who allowed us access to their property. The cooperation of private landowners was essential in meeting our project objectives. Additionally, we would also like to thank Tim Bailey and Jeff Zakel for providing much needed guidance and advice regarding steelhead spawning ground surveys. The information they provided was helpful for survey planning and landowner contacts. Nadine Craft provided information regarding index spawner surveys and Mike McLean provided data from weir collections. Further, we would like to acknowledge our field crew members Kristen Cathey and Nick Albrecht for their assistance. This project was funded by the U. S. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

INTRODUCTION

The Upper Grande Ronde River basin supports a population of summer steelhead *O. mykiss* that has been defined by segregating it from the other three populations inhabiting the Grande Ronde River basin based on topographic, genetic, observational, and other evidence of interactions. Historically, the Grande Ronde River was one of the more significant anadromous fish producing rivers in the Columbia River Basin. Steelhead in the Grande Ronde River basin compose part of the Snake River DPS for summer steelhead and are listed as threatened by the ESA. Despite recovery efforts, these populations remain depressed relative to historic levels.

This project will evaluate summer steelhead population abundance for the upper Grande Ronde River summer steelhead population by conducting surveys of redds and spawning activity. These surveys will provide the data needed to estimate adult steelhead escapement, improve our understanding of habitat utilization, and contribute to productivity and survival estimates for this population. We monitored steelhead using a probabilistic sampling approach by incorporating a sample-site selection procedure similar to the Environmental Protection Agency (EPA) environmental monitoring and assessment program (EMAP). We used this EMAP or Generalized Random Tessellation Stratified design (GRTS) approach to select sample sites for status and trend monitoring of steelhead redds within the Upper Grande Ronde River watershed. This steelhead monitoring follows the Oregon Plan for Salmon and Watersheds Monitoring Program approach.

METHODS

Study Area

The Grande Ronde River flows generally northeast 212 miles from its origin to join the Snake River at river mile (RM) 169, about 20 miles upstream of Asotin, Washington and 493 miles from the mouth of the Columbia River. The Grande Ronde River begins in the Blue Mountains near the Anthony Lakes recreation area, flows north, then northeast and through the cities of La Grande and Island City (RM 157). Here, in the valley, the river slows and meanders the valley floor before continuing north-northeast. The Upper Grande Ronde watershed drains

approximately 1,650 mi^2, with a perimeter of 264 mi. and contains 917 mi of streams (732 miles of anadromous salmonid habitat). The upper Grande Ronde watershed (Figure 1) includes the Grande Ronde River and its tributaries from the headwaters to the confluence with the Wallowa River. Elevations in the watershed range from 2,312 ft. at the confluence of the Grande Ronde and Wallowa Rivers to over 7,000 ft. in the headwater areas. The upper Grande Ronde summer steelhead population is recognized as encompassing this drainage above the confluence with the Wallowa River. Fish distribution within this watershed was determined by historic and recent surveys of fish and barriers to anadromy, with additional professional judgment. Major tributaries of the river within this area include Lookingglass Creek, Catherine Creek, and Meadow Creek. Catherine Creek originates in the Eagle Cap Wilderness Area of the Wallowa Mountains and flows northwest to join the Grande Ronde at RM 140. Dry Creek, which was an outlier in the genetic analysis, is included in this population. Like other outliers, this may reflect the contribution of resident fish to the sample.

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 Upper Grande Ronde 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 Upper Grande Ronde River basin (Figure 2). All reaches upstream of known barriers to anadromous fish passage were eliminated from the sampling universe. Thirty 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:

- 10 sites repeated every year (annual)
- 10 sites repeated once every 3 years on a staggered basis
- 10 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 site. 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 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. 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”, or the removal of barriers (e.g. road culverts) that limited access to habitat. These stream reaches are removed or added into our sampling universe accordingly.

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 to mid-June 2010 (Table 1). 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. Survey reaches were approximately 2 km in length and encompassed the sample point derived from the EMAP sampling design. Surveyors walked upstream from the downstream end of each reach (except for Five Points and Deer creeks) and counted all redds, live fish, and carcasses observed. New redds were flagged and the location marked with a handheld GPS unit.

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 summing observations of individual survey sites (i) as:

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

where r_i is the number of unique redds observed at site i, d_i is the distance surveyed (km) at site i. 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 (934 km). Steelhead escapement (E_S) was then estimated by:

$$E_S = 1.60 \cdot R_T \qquad (3)$$

where 1.60 is a fish per redd constant. This constant is developed each year from repeat redd surveys of a tributary of the Wallowa River (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). This constant or weighting value represents a single spawning year. A locally weighted neighborhood variance estimator (Stevens 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.

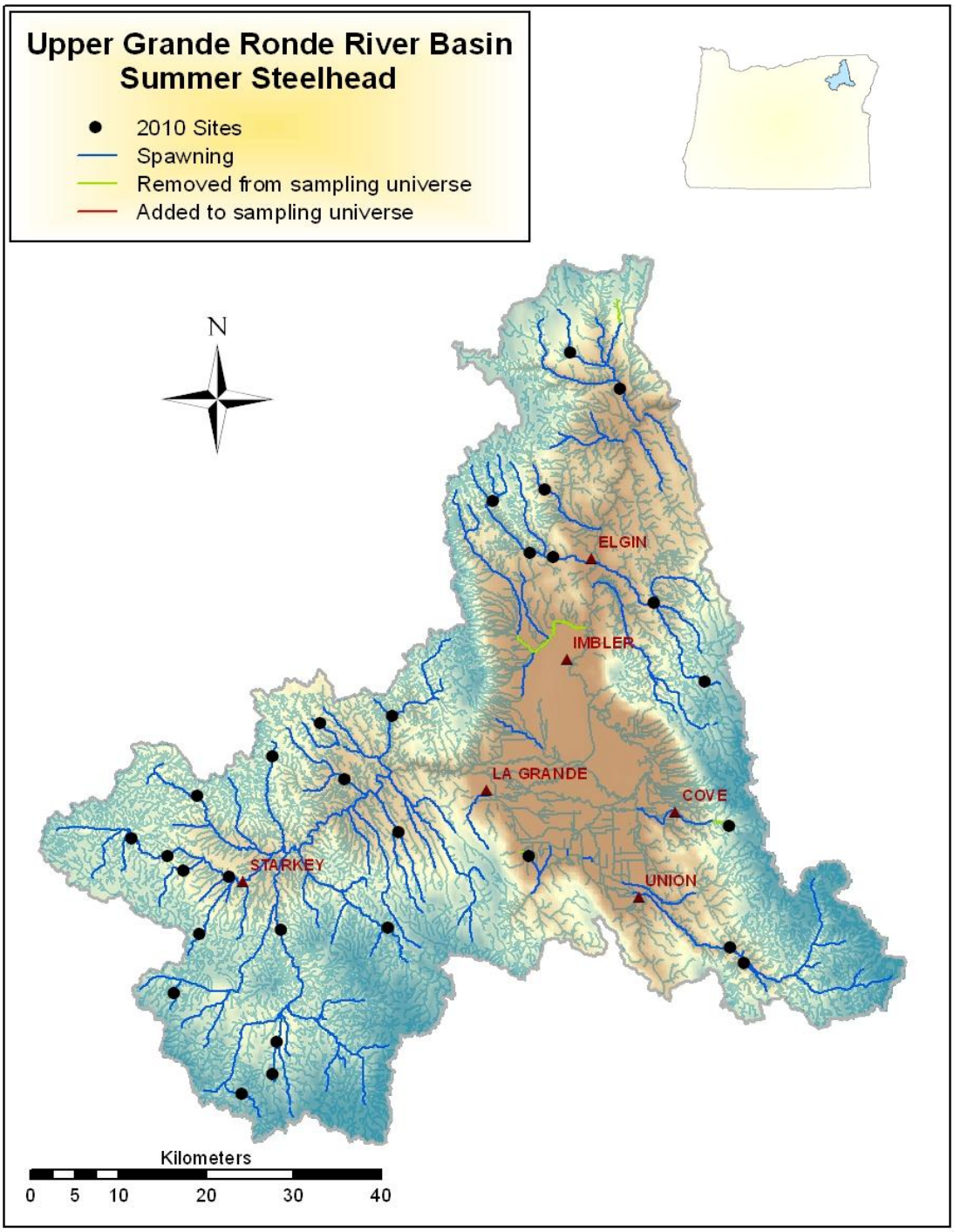

Figure 1. Map of the Upper Grande Ronde River basin showing steelhead use (dark blue stream reaches), sections of stream removed from (green stream reaches) and added to (red stream reaches) the sampling universe, and the 29 sample sites visited during 2010.

Table 1. Stream, site identification number, start and end coordinates (UTM–NAD83), survey distance, and dates for steelhead spawning surveys conducted in the Upper Grande Ronde River basin from 2 March to 17 June, 2010.

		UTM	Start Coordinates		End Coordinates		Distance	Survey						
Stream	**Site ID**	**Zone**	**Easting**	**Northing**	**Easting**	**Northing**	**(km)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Bear Creek	327	11	0381602	5012399	0379851	5011582	2.0	3/23	4/5	4/27	5/11	5/26	6/8	
Beaver Creek	331	11	0404299	5002718	0403084	5004003	2.0	6/10						
Burnt Corral Creek	107	11	0382183	5004526	0380725	5003360	2.0	4/19	5/3	5/18				
California Gulch	322	11	0397455	5027177	0395987	5028170	2.0	3/22	4/6	4/19	5/3	5/17	6/2	
Catherine Creek	332	11	0442066	4999992	0443399	4998669	2.0	3/4	3/16	3/29	4/14			
Chicken Creek	336	11	0389026	4991173	0390255	4989453	2.0	3/30	4/12	4/27	5/10	5/27	6/8	
Clark Creek	318	11	0439384	5031811	0440924	5030775	2.0	5/10	5/27					
Clark Creek	109	11	0435197	5040570	0435955	5038825	2.0	3/10	3/23	4/7	4/20	5/7	5/19	6/14
Dark Canyon Creek	338	11	0390712	5023554	0391139	5025603	2.0	4/19	5/4	5/17	6/3			
East Phillips Creek	105	11	0416396	5052712	0417743	5053809	1.8	4/20	5/4	5/24				
East Sheep Creek	319	11	0383985	4985840	0385696	4985400	2.0	5/12	5/27					
Five Points Creek	106	11	0404307	5028459	0405970	5029285	2.0	4/7	5/19	6/15				
Gordon Creek	333	11	0423956	5053981	0422486	5055111	2.0	3/8	3/24	4/7	4/28	5/11	5/24	6/14
Grande Ronde River	104	11	0390432	5005389	0390852	5003771	2.0	3/23	4/12					
Ladd Creek	328	11	0419616	5011698	0420075	5010762	1.1	4/5	4/28	6/9				
Little Whiskey Creek	314	11	0404424	5015790	0405147	5014232	1.8	3/18	4/5	4/20	5/4	5/18	6/2	
Lookingglass Creek	317	11	0432867	5065033	0432231	5066372	1.6	3/17	4/1	4/13				
McCoy Creek	315	11	0382242	5019873	0380803	5020683	2.0	4/7	4/20	5/3	5/8	6/1		
Meadow Creek	115	11	0374325	5015697	0373596	5016682	1.9	4/19	5/3	5/18	6/1			
Meadow Creek	111	11	0379739	5014229	0378270	5013398	1.9	3/23	4/5	4/27	5/11	5/26	6/8	
Meadow Creek	339	11	0385268	5010692	0383876	5011509	2.0	3/24	4/5	4/19	5/5	5/18	6/2	
Milk Creek	316	11	0443410	4998524	0444557	4997174	2.0	3/3	3/16	3/29	4/15	5/5	5/20	
Mill Creek	324	11	0441019	5014697	0441977	5014392	2.0	4/27						
Mottet Creek	337	11	0428043	5069332	0426727	5070553	2.0	4/1	5/7					
Phillips Creek	329	11	0421536	5047126	0420068	5048030	2.0	3/24	4/6	4/20	5/4	5/19	6/14	
Phillips Creek	113	11	0424074	5046398	0422474	5046704	2.0	3/2	3/25	4/6	4/27	5/10	5/25	6/17
Spring Creek	110	11	0399215	5021324	0397621	5022291	2.0	3/4	3/25	4/5	4/19	5/3	5/12	5/26
Squaw Creek	323	11	0379045	4998623	0378503	4996867	2.0	4/21	4/27	5/13	5/24	6/9		
West Chicken Creek	108	11	0389482	4988843	0389348	4987112	1.8							

RESULTS

Steelhead Redds and Escapement

We observed 109 steelhead redds while surveying 53.9 km of an estimated 934 km of steelhead spawning habitat within the Upper Grande Ronde River basin during 2010 (Table 2). This results in a redd density of 2.02 redds/km. By expansion, an estimated 1,888 observable redds were constructed within the Upper Grande Ronde River basin in 2010 by an estimated 3,020 spawners (95% CIs; 2105, 3913). Redds were observed at 23 of the 29 sites (79%). One hatchery steelhead was observed on spawning ground surveys resulting in a 22:1 ratio of wild to hatchery origin adult steelhead.

Adult steelhead were captured and passed at each of the three weirs operated by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) on the Upper Grande Ronde River basin. Two hundred ninety five adults were passed at the weir on Catherine Creek, 329 were passed at Lookingglass Creek, and 15 were passed at the Upper Grande Ronde River. This total of 639 passed adults was a 69% increase from 2009 (377 adults), and a 151% increase from 2008 (255 adults).

On Deer Creek, where we establish a fish per redd ratio, surveyors observed 84 new redds while conducting surveys on five separate dates from late March through late May. One hundred thirty four adult steelhead were passed above the weir at Big Canyon resulting in a 1.60 fish/redd ratio.

Steelhead Spawning Timing

We observed new steelhead redds from late March through early June, 2010 (Figure 3). The first new redd was observed on Meadow Creek on 23 March while the last new redd was observed on California Gulch on 2 June, 2010. Sixty one of the 109 (56%) new redds were observed in the month of April and 46 of the 109 (42%) new redds were observed in the month of May. Highly variable stream flows during May and June likely influenced both new redd observations and visibility of previously identified redds (Figure 4).

Table 2. Total number of steelhead redds, redds per kilometer, and unmarked (wild), marked (hatchery), and unknown origin live and dead steelhead observed during spawning surveys conducted in the Upper Grande Ronde River basin from 2 March to 17 June, 2010.

				Live Fish				Dead Fish			
Stream	**Site ID**	**Redds**	**Redds/km**	**Unmarked**	**Marked**	**Unknown**	**Total**	**Unmarked**	**Marked**	**Unknown**	**Total**
Bear Creek	327	3	1.50	0	0	0	0	0	0	0	0
Beaver Creek	331	0	0.00	0	0	0	0	0	0	0	0
Burnt Corral Creek	107	0	0.00	0	0	0	0	0	0	0	0
California Gulch	322	6	3.00	0	0	0	0	0	0	0	0
Catherine Creek	332	1	0.50	0	0	1	1	0	0	0	0
Chicken Creek	336	5	2.50	0	0	2	2	0	0	0	0
Clark Creek	109	12	6.00	4	0	1	5	0	0	0	0
Clark Creek	318	1	0.50	0	0	0	0	0	0	0	0
Dark Canyon Creek	338	5	2.50	2	0	0	2	0	0	0	0
East Phillips Creek	105	1	0.56	0	0	0	0	0	0	0	0
East Sheep Creek	319	2	1.00	1	0	0	1	0	0	0	0
Five Points Creek	106	2	1.00	1	0	0	1	0	0	0	0
Gordon Creek	333	13	6.50	5	0	0	5	0	0	0	0
Grande Ronde River	104	1	0.50	0	0	0	0	0	0	0	0
Ladd Creek	328	0	0.00	0	0	0	0	0	0	0	0
Little Whiskey Creek	314	4	2.22	1	0	0	1	0	0	0	0
Lookingglass Creek	317	6	3.75	1	0	2	3	0	0	0	0
McCoy Creek	315	7	3.50	0	0	1	1	0	0	0	0
Meadow Creek	111	3	1.58	0	0	0	0	0	0	0	0
Meadow Creek	115	14	7.37	0	0	2	2	0	0	0	0
Meadow Creek	339	2	1.00	0	0	0	0	0	0	0	0
Milk Creek	316	0	0.00	0	0	1	1	0	0	0	0
Mill Creek	324	0	0.00	0	0	0	0	0	0	0	0
Mottet Creek	337	0	0.00	0	0	0	0	0	0	0	0
Phillips Creek	113	5	2.50	2	0	1	3	0	0	0	0
Phillips Creek	329	3	1.50	2	0	0	2	0	0	0	0
Spring Creek	110	6	3.00	0	0	0	0	0	0	0	0
Squaw Creek	323	1	0.50	0	0	0	0	0	0	0	0
West Chicken Creek	108	6	3.33	3	1	0	4	0	0	0	0
Basin Total		**109**	**2.02**	**22**	**1**	**11**	**34**	**0**	**0**	**0**	**0**

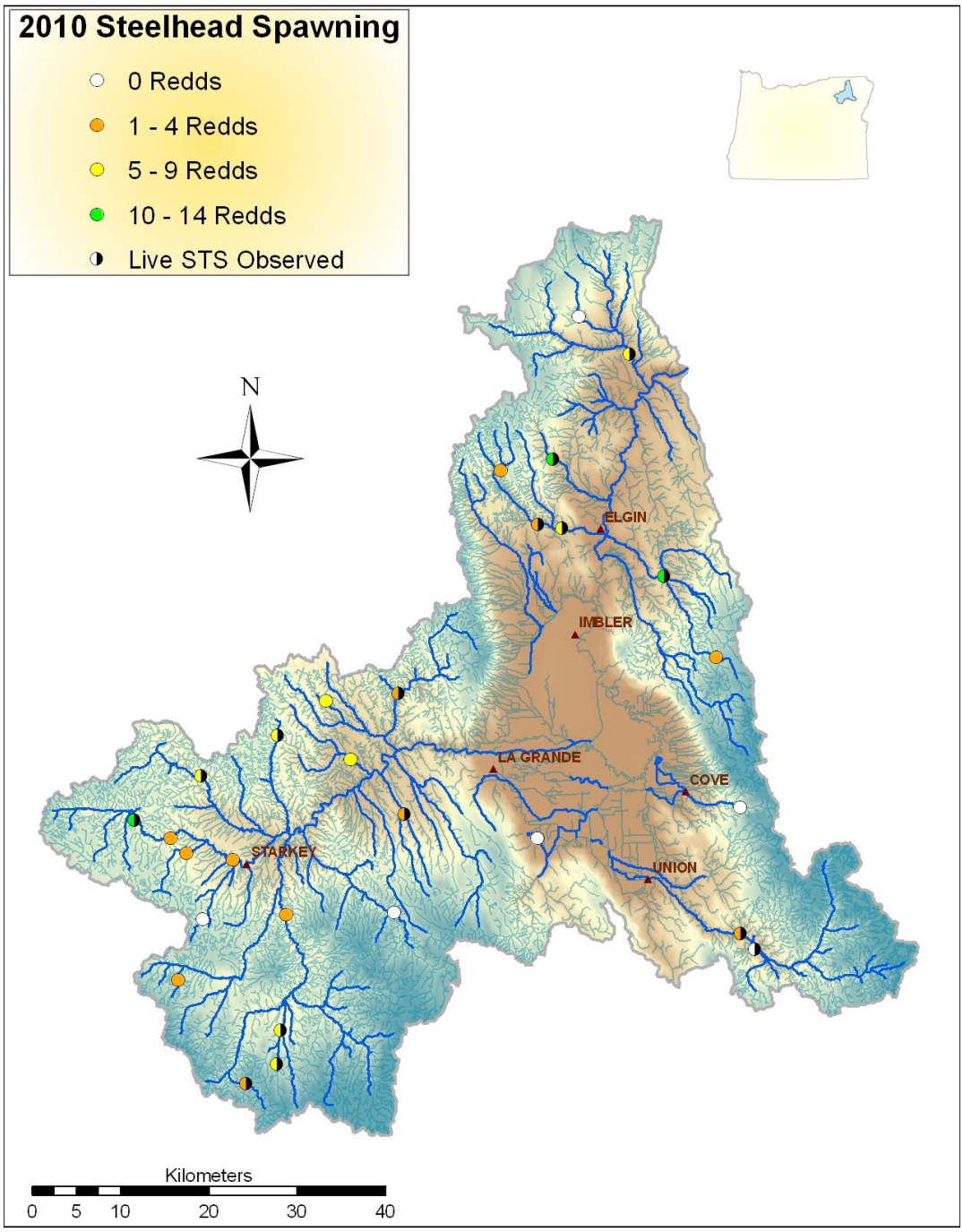

Figure 2. Map of the location and number of redds and steelhead observed in the Upper Grande Ronde River basin during spawning ground surveys conducted during the spring of 2010.

Table 3. Distance surveyed, total number of observed redds, redds/km, total number of estimated redds, and spawning escapement with 95% confidence intervals for steelhead from spawning surveys conducted in the Upper Grande Ronde River basin from March to July, 2008–2010.

Upper Grande Ronde River Basin	Distance Surveyed (km)	Summer Steelhead				95% Confidence Intervals	
		Redds	Redds/Km	Total Redds	Spawner Escapement	Lower	Upper
2010	53.9	109	2.02	1888	3020	2105	3913
2009	58.5	43	0.74	866	3299	2216	4383
2008	69.8	24	0.34	405	1649	491	1916

Table 4. Redd and steelhead observations at annual spawning survey sites in the Upper Grande Ronde River basin conducted from March to July, 2008–2010. N/A represents sites not surveyed that year due to revoked access, unsuitable spawning habitat, or sites added to replace previous annual sites.

Stream	Site ID	Observed redds			Observed steelhead		
		2008	2009	2010	2008	2009	2010
Duncan Canyon Creek	101	0	N/A	N/A	0	N/A	N/A
Willow Creek	102	0	N/A	N/A	0	N/A	N/A
Grande Ronde River	104	0	0	1	1	0	0
East Phillips Creek	105	0	1	1	0	1	0
Five Points Creek	106	0	2	2	0	1	1
Burnt Corral Creek	107	0	1	0	0	0	0
West Chicken Creek	108	0	1	6	0	1	4
Clark Creek	109	2	5	12	3	5	5
Spring Creek	110	4	3	6	3	0	0
Meadow Creek	111	0	3	3	0	2	0
Phillips Creek	113	4	0	5	0	1	3
Meadow Creek	115	--	1	14	--	0	2
Total		**10**	**17**	**50**	**7**	**11**	**15**

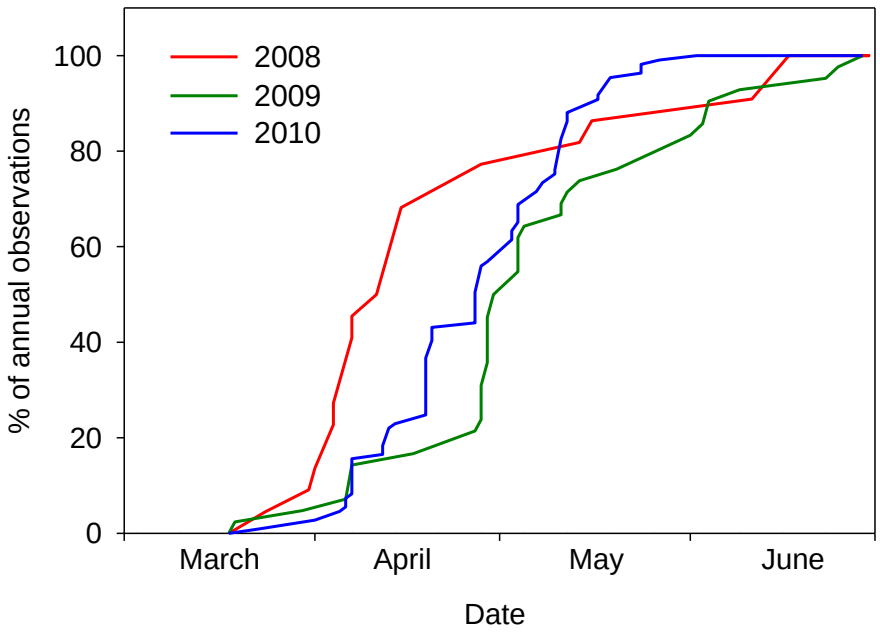

Figure 3. Cumulative percentage of steelhead redds observed annually in the Upper Grande Ronde River basin while conducting EMAP spawning ground surveys during 2008 to 2010.

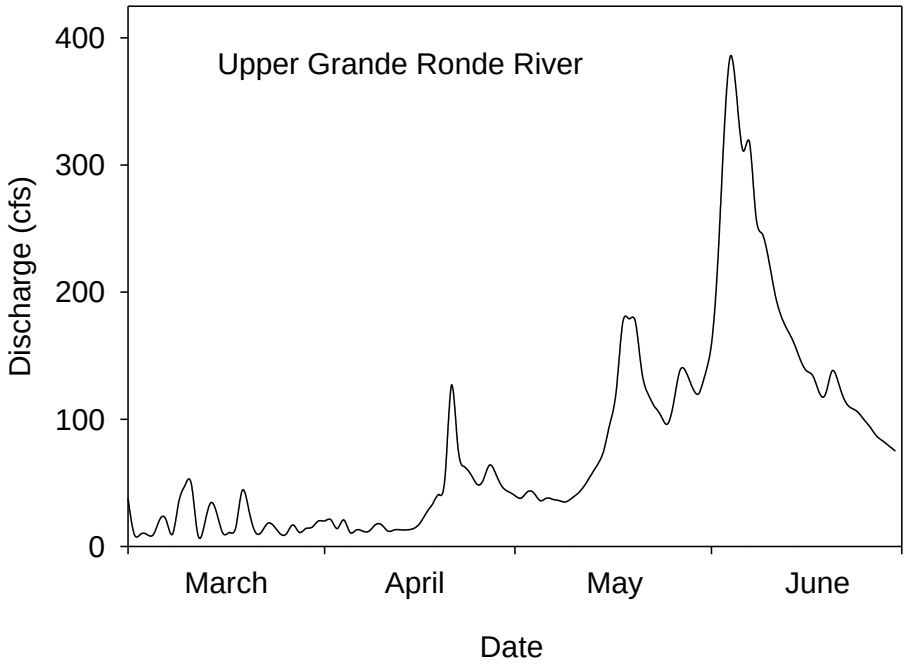

Figure 4. Mean daily discharge (ft^3/s) of the Upper Grande Ronde River (near Clear Creek) from March to July, 2010.

DISCUSSION

Viewing conditions were marginal during late May and early June, but overall they were better than previous years. The steelhead escapement estimate for the Upper Grande Ronde River basin exceeded 3,000 adults. Redd density estimates were greater than 2008 and 2009, approximately two redds for every 1 km. The poor viewing conditions are corrected for by using an annual fish/redd estimate from Deer Creek, a survey with a known adult escapement above a weir. By comparison, redd density for similar surveys conducted in the John Day River basin were 1.60 redds/km or 79% of the density estimate for the Upper Grande Ronde. Snow pack in the Grande Ronde basin was below average for the 2010 water year. However, snow and high flows that washed out road access did prevent us from surveying a drawn reach on the North Fork of Catherine Creek. Cool temperatures early in the spawning season resulted in generally good viewing conditions in March and April, but heavy rain and intermittent warm periods resulted in high flows and relatively turbid water conditions in May and June. Redds were observed at 23 of 30 sites surveyed in 2010. The variable density of redds throughout known steelhead spawning habitat inflates the confidence interval around our mean estimate. Current and future sampling will refine the domain but low redd densities will always affect our variance estimates. Several stream reaches may be eliminated from the spawner distribution based on our observations. Willow Creek, for example, has long reaches of soft bottom substrates and slow currents unsuitable for spawning (Figure 1). Many headwater streams also have inadequate habitat for spawning and only continued site visits will identify these reaches. We will continue to define the extent of these identified stream reaches unsuitable for spawning and locate similar reaches when they are selected in our sample draw.

We were able to identify 23 of the 34 adult steelhead that were observed on surveys. Of these, we observed only one (4%) marked or hatchery origin steelhead. This suggests that 130 hatchery fish entered the Upper Grande Ronde watershed to spawn, however, our small sample size may underestimate the true number. Biologists from CTUIR also currently remove all hatchery marked steelhead at the weirs they operate on Lookingglass and Catherine Creeks and the Upper Grande Ronde River. During 2010, they removed 23 adult hatchery steelhead at the Lookingglass weir and three adult hatchery steelhead at the Catherine Creek weir. No hatchery steelhead were observed at the Upper Grande Ronde River weir although this weir was not operational for much of the spawner migration due to high flows.

After only three years of observation, it is still too early to relate our observations of redds with weir counts. Because the Grande Ronde River weir near Starkey was not operating for most of the spawning season during 2010 and too few surveys reaches were selected above the weirs on Catherine and Lookingglass creeks we cannot identify any significant correlations between redd surveys and weir counts. Drawing relationships between our redd counts and other steelhead metrics will become more feasible in the future when more data becomes available.

REFERENCES

Carmichael, R., G. Claire, J. Seals, S. Onjukka, J. Ruzycki, W. Wilson. 2002. "John Day basin spring Chinook salmon escapement and productivity monitoring; fish research project Oregon", 2000-2001 annual report, project no. 199801600, 63 electronic pages, (BPA Report DOE/BP-00000498-2), http://www.efw.bpa.gov/Publications/A00000498-2.pdf

DART. 2007. Data access in real time. School of Aquatic Fishery Sciences. University of Washington. http://www.cbr.washington.edu/dart/dart.html.

Flesher, M. W., G. R. Vonderohe, G. C. Grant, D. L. Eddy, and R. W. Carmichael. 2005. Lower Snake River Compensation Program: Oregon Summer Steelhead Evaluation Studies. Oregon Dept. of Fish and Wildlife, Salem, Oregon, http://www.fws.gov/lsnakecomplan/Reports/ODFW/Eval/LSRCP%20Oregon%20Steelhead%20Evaluation%20Studies%2001%20and%2002%20annual.pdf

Gee, S.A., M.W. Flesher, D.L. Eddy, L.R. Clarke, J.R. Ruzycki, and R.W. Carmichael. 2008. Lower Snake River Compensation Plan: Oregon Summer Steelhead Evaluation Studies. http://www.fws.gov/lsnakecomplan/Reports/ODFW/Eval/04%20Annual%20STS%20final.pdf

Holecek, D.E. and J.P. Walters. 2007. Spawning characteristics of adfluvial rainbow trout in a north Idaho stream: implications for error in redd counts. North American Journal of Fisheries Management 27:1010-1017.

Jacobs, S., J. Firman, G. Susac, E. Brown, B. Riggers, and K. Tempel. 2000. Status of Oregon coastal stocks of anadromous salmonids. Monitoring program report number OPSW-ODFW-2000-3, Oregon Department of Fish and Wildlife, Portland, Oregon.

Jacobs, S., J. Firman, and G. Susac. 2001. Status of Oregon coastal stocks of anadromous salmonids, 1999-2000. Monitoring program report number OPSW-ODFW-2001-3, Oregon Department of Fish and Wildlife, Portland, Oregon.

Maxell, B.A. 1999. A power analysis on the monitoring of bull trout stocks using redd counts. North American Journal of Fisheries Management 19:860-866.

Moore, K., K. Jones, and J. Dambacher. 2002. Methods for stream habitat surveys. Oregon Department of Fish and Wildlife, Aquatic Inventories Project. Corvallis, Oregon.

Muhlfeld, C.C. 2002. Spawning characteristics of redband trout in a headwater stream in Montana. North American Journal of Fisheries Management 22:1314-1320.

Nicholas, J. W., and L. Van Dyke. 1982. Straying of adult coho salmon to and from private hatchery at Yaquina Bay, Oregon. Oregon Department of Fish and Wildlife, Information report (fish) 82-10, Portland, Oregon.

R Development Core Team. 2005. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Ruzycki, J., W. Wilson, R. Carmichael, B. Jonasson. 2002. John Day basin spring Chinook salmon escapement and productivity monitoring; fish research project Oregon, 1999 -2000 annual report, project no. 199801600, 41 electronic pages, (BPA Report DOE/BP-00000498-1), http://www.efw.bpa.gov/Publications/A00000498-1.pdf

Schmetterlilng, D.A. 2000. Redd characteristics of fluvial westslope cutthroat trout in four tributaries to the Blackfoot River, Montana. North American Journal of Fisheries Management 20:776-783.

Stevens, D. L. 2002. Sampling design and statistical analysis methods for the integrated biolgocial and physical monitoring of Oregon streams. Report No. OPSW-ODFW-2002-07, The Oregon Plan for Salmon and Watersheds, Oregon Department of Fish and Wildlife, Corvallis, OR.

Stevens, D.L. and A.R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Susac, G. L., and S. E. Jacobs. 1999. Evaluation of spawning ground surveys for indexing the abundance of adult winter steelhead in Oregon coastal basins. Oregon Department of Fish and Wildlife. Annual Progress Report F145-R-08. Portland, Oregon.

Susac, G.L. 2005. 2004 Assessment of Nestucca River adult winter steelhead. Oregon Dpartment of Fish and Wildlife. Annual Progress Report F-181-D. Portland, Oregon.

Thurow, R.F., and J.G. King. 1994. Attributes of Yellowstone cutthroat redds in a tributary of the Snake River, Idaho. Transactions of the American Fisheries Society 123:37-50.

Wiley, D.J., M.L. Garriott, J.R. Ruzycki, R.W. Carmichael. 2005. Implementation of the Environmental Monitoring Program (EMAP) protocol in the John Day subbasin of the Columbia Plateau Province: Annual Progress Report. 2004-2005 Technical report, project no. 199801601, 90 electronic pages, (BPA Report DOE/BP-00015113-2), http://www.efw.bpa.gov/Publications/A00015113-2.pdf

Wilson W., T. Seals, J. Ruzycki, R. Carmichael, S. Onjukka, G. O'Connor. 2002. John Day basin spring Chinook salmon escapement and productivity monitoring, 2001-2002 annual report, project no. 199801600, 124 electronic pages, (BPA report DOE/BP- 00005840-1), http://www.efw.bpa.gov/Publications/A00005840-1.pdf

Wilson, W., T. Schultz, T. Goby, J. Ruzycki, R. Carmichael, S. Onjukka, G. O'Connor. 2005. John Day basin Chinook salmon escapement and productivity monitoring, 2002-2003 annual report, project no. 199801600, 165 electronic pages, (BPA Report DOE/BP-00005840-2), http://www.efw.bpa.gov/Publications/A00005840-2.pdf

APPENDIX

Appendix Table 1. Site ID, survey date, stream name, sample panel, number of redds, number of live adult steelhead, and number of carcasses observed for each EMAP survey conducted during the spring of 2010 on the Upper Grande Ronde River basin.

Site ID	Date	Stream	Panel	# New Redds	Live Wild	Live Unknown	Live Hatchery	Dead Total
104	03/23/2009	Grande Ronde River	1	0	0	0	0	0
104	04/03/2009	Grande Ronde River	1	0	0	0	0	0
104	06/25/2009	Grande Ronde River	1	0	0	0	0	0
105	04/29/2009	East Phillips Creek	1	1	0	1	0	0
105	05/13/2009	East Phillips Creek	1	0	0	0	0	0
105	06/02/2009	East Phillips Creek	1	0	0	0	0	0
106	05/12/2009	Five Points Creek	1	0	0	1	0	0
106	05/28/2009	Five Points Creek	1	2	0	0	0	0
106	06/10/2009	Five Points Creek	1	0	0	0	0	0
107	04/21/2009	Burnt Corral Creek	1	0	0	0	0	0
107	05/05/2009	Burnt Corral Creek	1	0	0	0	0	0
107	05/20/2009	Burnt Corral Creek	1	1	0	0	0	0
107	06/02/2009	Burnt Corral Creek	1	0	0	0	0	0
108	04/21/2009	West Chicken Creek	1	0	0	0	0	0
108	05/05/2009	West Chicken Creek	1	1	1	0	0	0
108	05/18/2009	West Chicken Creek	1	0	0	0	0	0
108	06/01/2009	West Chicken Creek	1	0	0	0	0	0
108	06/22/2009	West Chicken Creek	1	0	0	0	0	0
109	03/26/2009	Clark Creek	1	0	0	0	0	0
109	04/07/2009	Clark Creek	1	3	1	2	0	0
109	04/16/2009	Clark Creek	1	0	0	0	0	0
109	04/27/2009	Clark Creek	1	2	1	0	1	0
109	05/11/2009	Clark Creek	1	0	0	0	0	0
109	05/27/2009	Clark Creek	1	0	0	0	0	0
109	06/08/2009	Clark Creek	1	0	0	0	0	0
110	04/07/2009	Spring Creek	1	0	0	0	0	0
110	04/16/2009	Spring Creek	1	0	0	0	0	0
110	04/28/2009	Spring Creek	1	1	0	0	0	0
110	05/11/2009	Spring Creek	1	0	0	0	0	0
110	05/26/2009	Spring Creek	1	0	0	0	0	0
110	06/08/2009	Spring Creek	1	0	0	0	0	0
111	03/24/2009	Meadow Creek	1	0	0	0	0	0
111	04/06/2009	Meadow Creek	1	1	0	0	0	0
111	04/28/2009	Meadow Creek	1	1	0	2	0	0
111	05/12/2009	Meadow Creek	1	0	0	0	0	0
111	05/26/2009	Meadow Creek	1	0	0	0	0	0
111	06/09/2009	Meadow Creek	1	1	0	0	0	0

113	03/18/2009	Phillips Creek	1	0	0	1	0	0
113	03/30/2009	Phillips Creek	1	0	0	0	0	0
113	06/02/2009	Phillips Creek	1	0	0	0	0	0
113	06/16/2009	Phillips Creek	1	0	0	0	0	0
115	05/15/2009	Meadow Creek	1	0	0	0	0	0
115	05/26/2009	Meadow Creek	1	0	0	0	0	0
115	06/08/2009	Meadow Creek	1	0	0	0	0	0
115	06/23/2009	Meadow Creek	1	1	0	0	0	0
216	03/19/2009	Catherine Creek	2	1	0	0	0	0
216	03/30/2009	Catherine Creek	2	1	0	0	0	0
216	06/25/2009	Catherine Creek	2	1	0	0	0	0
217	04/17/2009	Little Lookingglass Creek	2	1	0	0	0	0
217	05/04/2009	Little Lookingglass Creek	2	3	1	3	0	0
217	06/03/2009	Little Lookingglass Creek	2	1	0	0	0	0
217	06/16/2009	Little Lookingglass Creek	2	0	0	0	0	0
218	04/06/2009	Middle Fork Clark Creek	2	0	0	0	0	0
218	05/14/2009	Middle Fork Clark Creek	2	1	3	0	0	0
218	06/08/2009	Middle Fork Clark Creek	2	0	0	0	0	0
219	04/22/2009	East Sheep Creek	2	0	0	0	0	0
219	05/18/2009	East Sheep Creek	2	0	0	0	0	0
219	06/01/2009	East Sheep Creek	2	1	0	0	0	0
219	06/23/2009	East Sheep Creek	2	0	0	0	0	0
220	05/19/2009	Dry Beaver Creek	2	0	0	0	0	0
220	06/01/2009	Dry Beaver Creek	2	0	0	0	0	0
222	05/04/2009	Pelican Creek	2	0	0	0	0	0
222	05/20/2009	Pelican Creek	2	0	0	0	0	0
222	06/01/2009	Pelican Creek	2	0	1	0	0	0
222	06/30/2009	Pelican Creek	2	1	0	0	0	0
224	04/02/2009	South Fork Limber Jim Creek	2	0	0	0	0	0
224	04/13/2009	South Fork Limber Jim Creek	2	0	0	0	0	0
224	04/29/2009	South Fork Limber Jim Creek	2	0	0	0	0	0
225	04/27/2009	Clark Creek	2	0	0	0	0	0
225	05/13/2009	Clark Creek	2	0	0	0	0	0
225	06/03/2009	Clark Creek	2	0	0	0	0	0
225	06/18/2009	Clark Creek	2	0	0	0	0	0
227	03/24/2009	Battle Creek	2	0	0	0	0	0
227	04/08/2009	Battle Creek	2	0	0	0	0	0
227	04/21/2009	Battle Creek	2	0	0	0	0	0
227	05/05/2009	Battle Creek	2	0	0	0	0	0
227	05/20/2009	Battle Creek	2	0	0	0	0	0
228	05/11/2009	Coyote Creek	2	0	0	0	0	0
229	04/07/2009	Dry Creek	2	0	0	0	0	0

229	04/29/2009	Dry Creek	2	2	0	0	0	0
229	05/19/2009	Dry Creek	2	0	0	0	0	0
229	06/03/2009	Dry Creek	2	0	0	0	0	0
229	06/18/2009	Dry Creek	2	0	0	0	0	0
230	04/29/2009	Whiskey Creek	2	3	1	0	1	0
230	05/11/2009	Whiskey Creek	2	1	1	1	0	0
230	05/29/2009	Whiskey Creek	2	0	0	0	0	0
230	06/09/2009	Whiskey Creek	2	0	0	0	0	0
231	06/04/2009	Beaver Creek	2	2	0	0	0	0
231	06/30/2009	Beaver Creek	2	0	0	0	0	0
232	04/01/2009	Catherine Creek	2	0	0	0	0	0
232	06/25/2009	Catherine Creek	2	0	0	0	0	0
236	04/08/2009	Chicken Creek	2	0	0	0	0	0
236	04/20/2009	Chicken Creek	2	0	0	0	0	0
236	04/30/2009	Chicken Creek	2	2	0	0	0	0
236	05/13/2009	Chicken Creek	2	0	0	0	0	0
236	06/01/2009	Chicken Creek	2	0	0	0	0	0
236	06/22/2009	Chicken Creek	2	0	0	0	0	0
237	04/20/2009	Duncan Canyon Creek	2	0	0	0	0	0
237	05/04/2009	Duncan Canyon Creek	2	2	0	0	0	0
237	05/19/2009	Duncan Canyon Creek	2	0	0	0	0	0
238	04/28/2009	Spring Creek	2	1	2	0	0	0
238	05/12/2009	Spring Creek	2	1	0	0	0	0
238	05/26/2009	Spring Creek	2	0	0	0	0	0
238	06/08/2009	Spring Creek	2	0	0	0	0	0
239	04/06/2009	Burnt Corral Creek	2	0	0	0	0	0
239	04/28/2009	Burnt Corral Creek	2	1	0	0	0	0
239	05/12/2009	Burnt Corral Creek	2	0	1	0	0	0
239	05/26/2009	Burnt Corral Creek	2	0	0	0	0	0
239	06/09/2009	Burnt Corral Creek	2	1	0	0	0	0
240	05/21/2009	Camp Creek	2	0	0	0	0	0
240	06/09/2009	Camp Creek	2	0	0	0	0	0
240	07/01/2009	Camp Creek	2	0	0	0	0	0
241	04/27/2009	Clark Creek	2	0	0	0	0	0
241	05/11/2009	Clark Creek	2	1	0	0	0	0
241	05/27/2009	Clark Creek	2	0	0	0	0	0
241	06/08/2009	Clark Creek	2	0	0	0	0	0