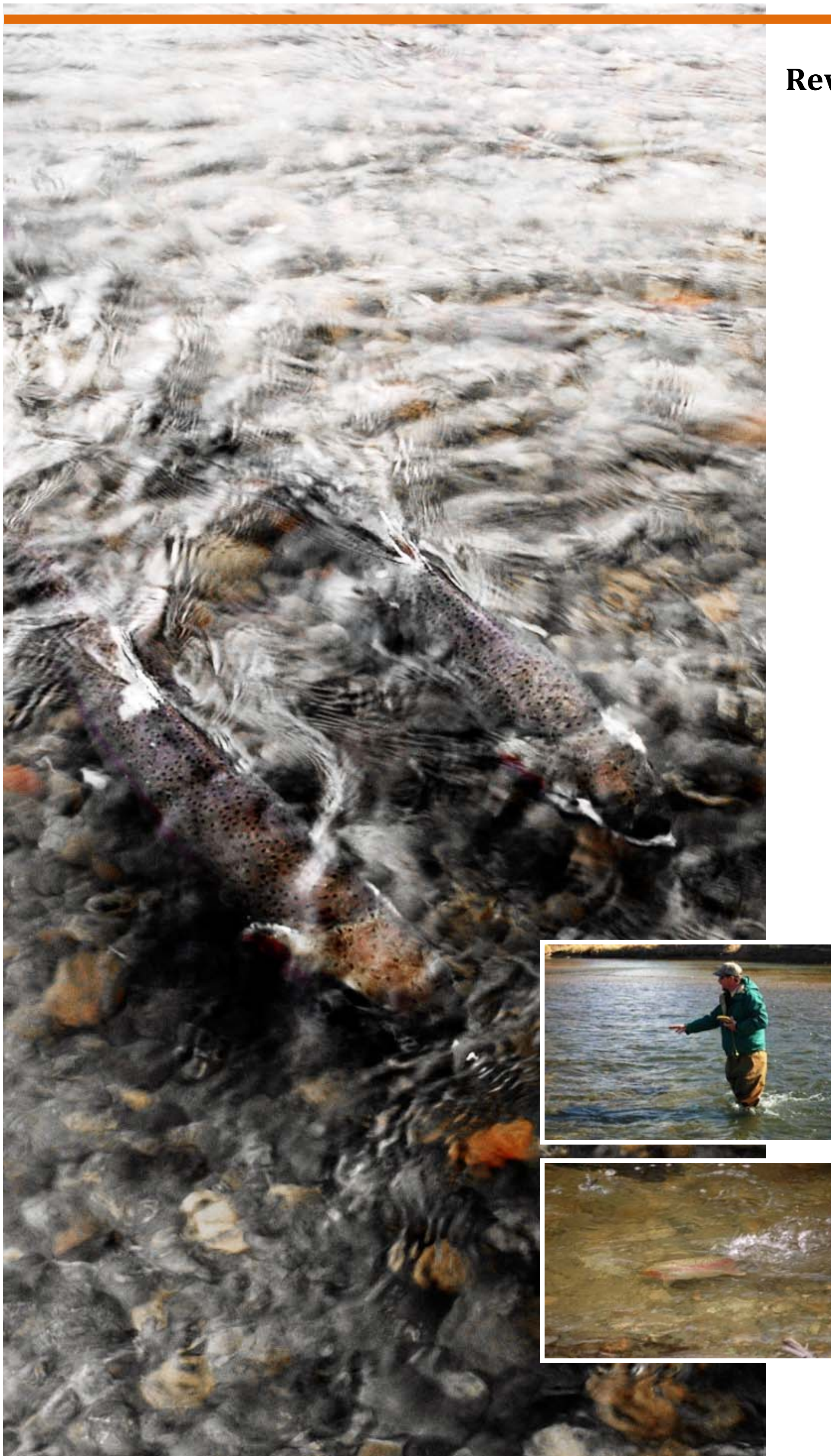
2009 Okanogan Basin Steelhead Redd Surveys



Revision 1

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Abstract

Redd surveys of spawning steelhead were conducted in the Okanogan River Basin in 2009 as part of the Colville Tribes' Okanogan Basin Monitoring and Evaluation Program. A total of 566 steelhead redds were observed along the mainstem Okanogan and 244 redds in the Similkameen River. Tributaries within the basin that were utilized by anadromous steelhead in 2009 included Salmon, Omak, Bonaparte, and Tunk Creeks. Escapement estimates for the entire Okanogan River were between 2,020 and 2,198 summer steelhead and of those, 178 to 241 were considered of natural origin. This wild designation was complicated by continued releases of ad-present hatchery steelhead into the Okanogan River. Escapement into Canada was estimated at 434 summer steelhead with 15.1% having intact adipose fins. Mainstem steelhead redd distributions were highest in the upstream reaches of the Okanogan River and lower section of the Similkameen River, where high quality spawning gravels are common and the majority of hatchery releases are focused. Other high density spawning areas included the island section near Tonasket, and near McAlister Rapids, where braided channels and water velocities form favorable habitat for summer steelhead spawning. Annual collection of steelhead spawning data in future years will provide a more comprehensive depiction of spawning distribution and population trends within the Okanogan River Basin.

Introduction

The Okanogan Basin Monitoring and Evaluation Program (OBMEP), created in 2004, established a basin wide monitoring program for anadromous fish in the Okanogan River Basin. OBMEP fills data gaps particularly associated with endangered summer steelhead through implementing a scientifically rigorous, long-term status and trend monitoring design characterizing habitat, water quality, and biological indicators. OBMEP uses protocols derived from the Upper Columbia Strategy (Hillman 2004) that calls for a complete redd census, if possible, or an annual count of the number of redds within already-established index areas, or in randomly selected reaches using an Environmental Monitoring and Assessment Program (EMAP) design. Following the Upper Columbia Strategy's guidance facilitates coordination and standardization with other monitoring and evaluation efforts in the Upper Columbia ESU (Figure 1). In 2004, OBMEP developed the methodologies for implementing redd surveys beginning in 2005 (Arterburn et al. 2004) and these methods were later revised in 2007 (Arterburn et al. 2007c).

In 2005, a complete census of all mainstem habitats was conducted within the U.S. and identified several large areas that contained no redds due to unsuitable habitat for spawning. Eliminating these areas from future surveys reduced program costs without the loss of any biologically important data. Recommendations from the 2005 census helped define the actual reaches that would be surveyed in 2006-2009.

An extensive literature review of historic spawning information related to the Okanogan River Basin can be found in the 2005 report (Arterburn et al. 2005). In 2009, the fifth year of steelhead redd surveys was conducted by the Colville Tribes in the Okanogan Basin. This document builds upon previous information and the entirety of previous years spawning survey reports can be accessed through our web-site at: http://nrd.colvilletribes.com/obmep/Reports.htm

Methods

Steelhead redd surveys were conducted downstream of identified anadromous fish migration barriers in the mainstem and all accessible tributaries of the Okanogan River and Similkameen River drainages (Arterburn et al. 2007a, Walsh and Long 2006). Survey reaches encompassed all known spawning habitat currently available in the United States portion of the Okanogan River Basin where summer steelhead are listed as endangered within the Upper Columbia ESU (Figure 1). Designated main stem and tributary survey reaches have been defined and can be viewed in Table 1. The area of the Okanogan River downstream from Chiliwist Creek is inundated by the Columbia River (Wells Pool/Lake Pateros) and therefore lacks the appropriate velocity and substrate needed for summer steelhead to spawn. Consequently, this lower reach (~ 15 miles) of the Okanogan River has been excluded from surveys or estimates.

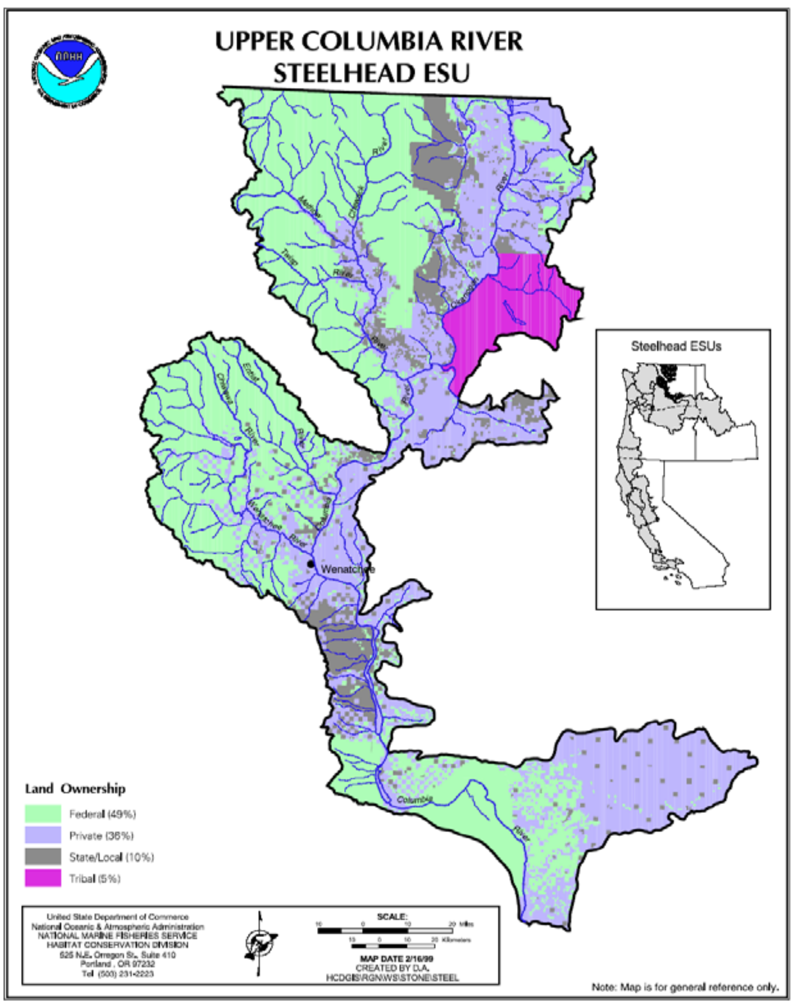

Figure 1. The Upper Columbia River summer steelhead evolutionarily significant unit showing land ownership. *Map courtesy of NMFS-HCD* (http://www.nwr.noaa.gov/reference/frn/1997/62FR43937.pdf).

Each reach was surveyed three times along the mainstem Okanogan River between March 24 and May 4, discharge levels remained below 3,000cfs for the entire period. Tributaries were surveyed one to three times, starting on April 13 and ending May 26, when all tributary reach surveys were completed.

Table 1. Designated redd survey reaches in the United States with location description and length in kilometers used by OBMEP in 2009.

Redd Survey Reaches	Location Description	Reach length(km)
S1/S2	Similkameen/Okanogan Confluence (0) to Enloe Dam (14.6)	14.6
O1	Okanogan River south of Chiliwist Creek (23.7) to Loup Loup Creek (26.7)	3.0
O2	Okanogan River at Salmon Creek (41.4) to the office (52.3)	10.9
O3	Okanogan River at the office (52.3) to Riverside (66.1)	13.8
O4	Okanogan River at Riverside (66.1) to Janis Bridge (84.6)	18.5
O5	Okanogan River at Janis Bridge (84.6) to Tonasket Park (91.4)	6.8
O6	Okanogan River at Horseshoe Lake (112.4) to confluence with Similkameen River (119.5)	7.1
O7	Okanogan River at confluence (119.5) to Zosel Dam (127.0)	7.5
TU1	Tunk Creek at Okanogan River confluence (0) to high water mark (0.2)	0.2
B1	Bonaparte Creek/Okanogan River confluence (0) to Bonaparte Falls (1.6)	1.6
N1	Ninemile Creek from Okanogan River confluence (0) to video weir (1.7)	1.7
TO1	Tonasket Creek/Okanogan River confluence (0) to Tonasket Falls (3.5)	3.5
A1	Antoine Creek/Okanogan River confluence (0) to video weir (1.3)	1.3
L1	Loup Loup Creek/Okanogan River confluence to Loup Loup Creek diversion (2.3)	2.3
WS1	Wild Horse Spring Creek/Okanogan River Confluence to barrier (1.1)	1.1
OM1	Omak Creek/Okanogan River Confluence (0) to Omak Creek trap site (2.0)	2.0
SC1	Salmon Creek confluence with the Okanogan (0) to OID diversion (7.2)	7.2

All steelhead redd surveys were conducted, and redds verified, by at least two Colville Confederated Tribes fisheries staff members trained in the application of the OBMEP redd survey methodology (Arterburn et al. 2007c). Mainstem surveys were conducted from rafts and on foot in a downstream progression. All island sections or other mainstem areas that could not be floated due to limited access and/or obstacles (e.g. wood debris, braided channels, and diversions) were surveyed on foot. Raft surveys were conducted by a minimum of two people using two, 1-man, 10' Skookum ®Steelheader model catarafts (Redman, Oregon). Tributary spawning areas were surveyed on foot, walking upstream.

The Okanogan River was divided into seven segments based on access points. The Similkameen River was surveyed as two reaches and these data were later combined into one reach (S1) to maintain consistency with previous reports. All mainstem reaches were located upstream of Chiliwist Creek confluence (immediately upriver of the influence of Wells' pool). We used data (discharge, air and water temperature, knowledge of fish movements) collected from previous years to determine when to begin surveys on the mainstem for that calendar year.

Redds were marked by surveyor flagging tied to bushes or trees on the stream-bank adjacent to the area where redds were observed. Individual flags were marked with the survey date, direction and distance from the redd/s, consecutive flag number, total number of redds represented by the flag, and surveyor initials. Incomplete redds or test pits were not flagged or counted. The color of the flagging was changed for each survey. Information was collected electronically with the use of a Trimble GeoExplorer XT GPS unit and downloaded into GPS Pathfinder Office® after every survey. The GIS data were reviewed and differentially corrected. Escapement calculations were made for each mainstem reach, sub-watershed, and the entire Okanogan River population.

We employed the method currently used by Washington Department of Fish and Wildlife (WDFW) in the Upper Columbia Basin to extrapolate escapement estimates using the sex ratio of broodstock collected randomly over the run (Andrew Murdoch, WDFW, Pers. Comm.). For example, if the sex ratio of a random sample of the run was 1.5:1.0 males to females, the expansion factor for the run would be 2.5 fish/redd. All escapement calculations using sex ratio multipliers would assume that each female will produce only one redd. This method is used for all supplemented stocks within the Upper Columbia Basin. Sex ratio data was used to provide estimates of total spawner escapement for the population, sub-watershed, or reach.

We refined population estimates by incorporating sex ratio data generated from several adult traps within several sub-watersheds throughout the Okanogan River Basin. Total redd estimates, in combination with spawner escapement where data exists (Omak Creek trap, Bonaparte Creek trap, Inkaneep Creek trap, and Zosel Dam video counts), were summed to estimate total escapement within sub-watersheds, resulting in a highly accurate estimate. The sex ratio was determined by counting and sexing all adult fish collected at Wells Dam, Inkaneep Creek, Omak Creek, and Bonaparte Creek traps. The ratio of males to females was used representatively for the streams where fish were trapped. Values derived from Wells Dam data were applied to mainstem habitats, and the sex ratio from the Omak Creek trap was applied to medium-sized tributaries in the United States. The sex ratio from the Bonaparte Creek trap was applied to similar sized small streams. For fish collected at the trap in Inkaneep Creek, all *O. mykiss* with a clipped adipose fin or greater than 20 inches in total length were considered steelhead as opposed to an adfluvial rainbow trout.

When a trap or video weir did not exist on tributaries, a range of population escapement estimates was created by manipulating the local sub-watershed sex ratios. These range estimates were much more likely than a point estimate to contain the "true" value because range estimates incorporated the variability contained within the raw data.

Results and Discussion

Sex ratios

At Wells Dam, a sample of 1,089 summer steelhead were examined in order to determine a sex ratio for upstream migrants during 2009. A total of 477 male and 612 female steelhead were sexed by Washington Department of Fish and Wildlife personnel (Charlie Snow -personal communications). Wells Dam data resulted in a sex ratio of 0.78 males per female or a sex ratio multiplier of 1.78 steelhead/redd. Forty summer steelhead were collected at the Omak Creek trap (29 males; 11 females) and a ratio of 2.6 males for each female was observed; therefore, we used a sex ratio multiplier of 3.6 steelhead per redd. Twenty-eight summer steelhead (21 males; 7 females) were collected at Bonaparte Creek in 2009, resulting in a sex ratio multiplier of 3.9 steelhead per redd. Field personnel did not document sex at the Inkaneep Creek trap in Canada.

Percent wild

In 2009, WDFW estimated the number of wild summer steelhead that escaped above Wells Dam was 942 or 10.4% of the total escapement. Wells Dam values were based upon fish counts, PIT tags, coded wire tags, scale analysis, harvest, broodstock collection, and stray rates estimated for Wells Hatchery (Charles Frady, WDFW Pers. Comm.). The proportion of wild fish assumed to be bound for the Okanogan River was 192 or 8.5% of the total escapement assumed to be bound for the Okanogan River. This percentage was applied to all mainstem Okanogan reaches to estimate the likely number of wild spawners.

The percent of wild summer steelhead estimated as returning to tributary traps was determined by the presence of an intact adipose fin. The number of natural origin steelhead returning to Omak Creek was estimated at 12.5% (5 out of 40 total fish). Six wild fish were captured in the Bonaparte Creek trap out of 28 total fish; therefore, 21.4% were wild. Only two out of 20 fish at the Inkaneep Trap in Canada had clipped adipose fins, resulting in 90.0% of all steelhead returning to Inkaneep Creek considered wild. At Zosel Dam, 66 out of 437 summer steelhead (15.1%) were documented having intact adipose fins.

Okanogan and Similkameen River Mainstem

Discharge remained below the threshold of 3,000cfs (which has constrained surveys in the past) throughout our surveys in 2009. Visibility was excellent during the majority of mainstem surveys on the Okanogan and Similkameen Rivers. However, the third survey for reach O5 was severely impaired by a lack of visibility in late April because of a sharp increase in discharge (Figure 2).

Detailed escapement calculations, summarized by individual reach, are presented in Table 8.

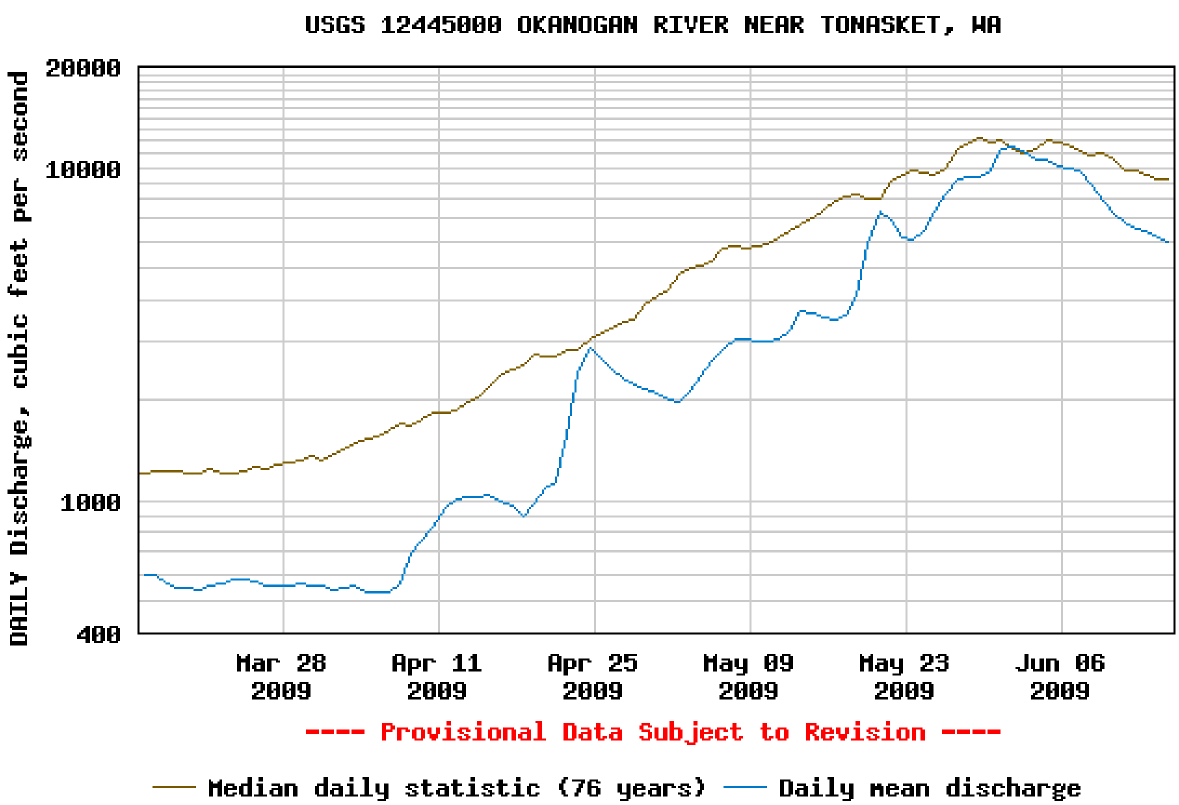

Figure 2. Discharge of Okanogan River as measured at Tonasket, WA for the period from March to June, 2009 compared to the 76-year historic average (graph obtained from the USGS website at www.usgs.gov).

The lower-most reach on the Okanogan River (O1) was surveyed March 24, April 7, and April 29 (Figure 3). A total of seven steelhead redds were documented (1 during the first survey and 6 during the second survey). No new redds were observed during the third survey. Most of the redds found in reach O1 were on the river right side of a mid-stream island, just downstream from the Loup Loup Creek confluence.

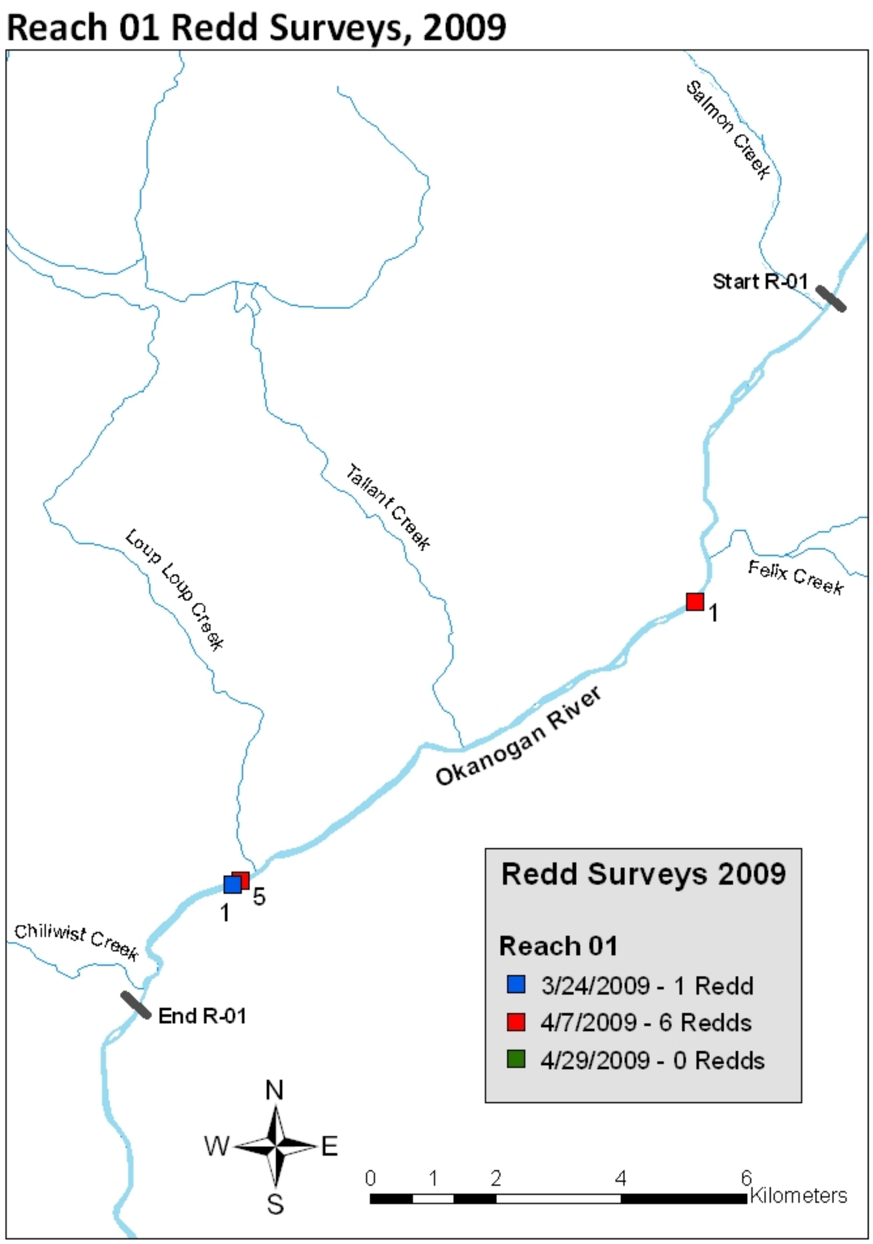

Figure 3. Redd distribution observed in 2009 for Okanogan River reach O1 from the confluence of Salmon Creek downstream to the confluence of Chiliwist Creek.

A total of 16 steelhead redds were identified in the Okanogan River reach O2 in 2009 (Figure 4). The majority of the redds were observed just downstream of the Highway 155 bridge located in Omak, WA and the island complex upriver of Shellrock Point. The first survey was conducted on March 25 and five redds were observed. The second survey occurred April 8 and eight additional redds were observed. On April 21, three redds were observed.

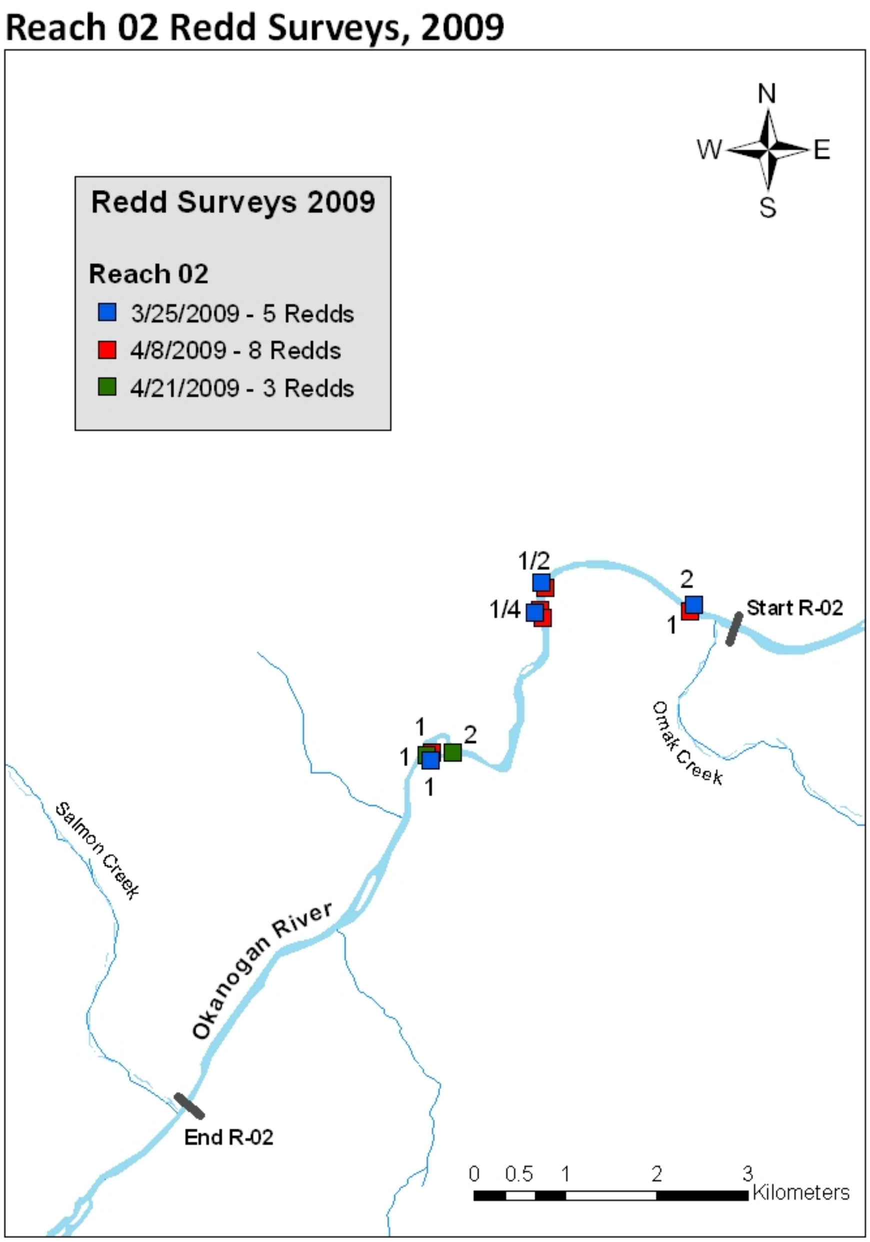

Figure 4. Redd distribution observed in 2009 for Okanogan River reach O2 from the confluence of Omak Creek in Omak downstream to Salmon Creek.

Okanogan River Reach O3 was surveyed on March 26, April 9, and April 22. Only one redd was found during the three rounds of surveys (Figure 5). The one redd observed in reach O3 during 2009 was the fewest recorded during five years of redd surveys.

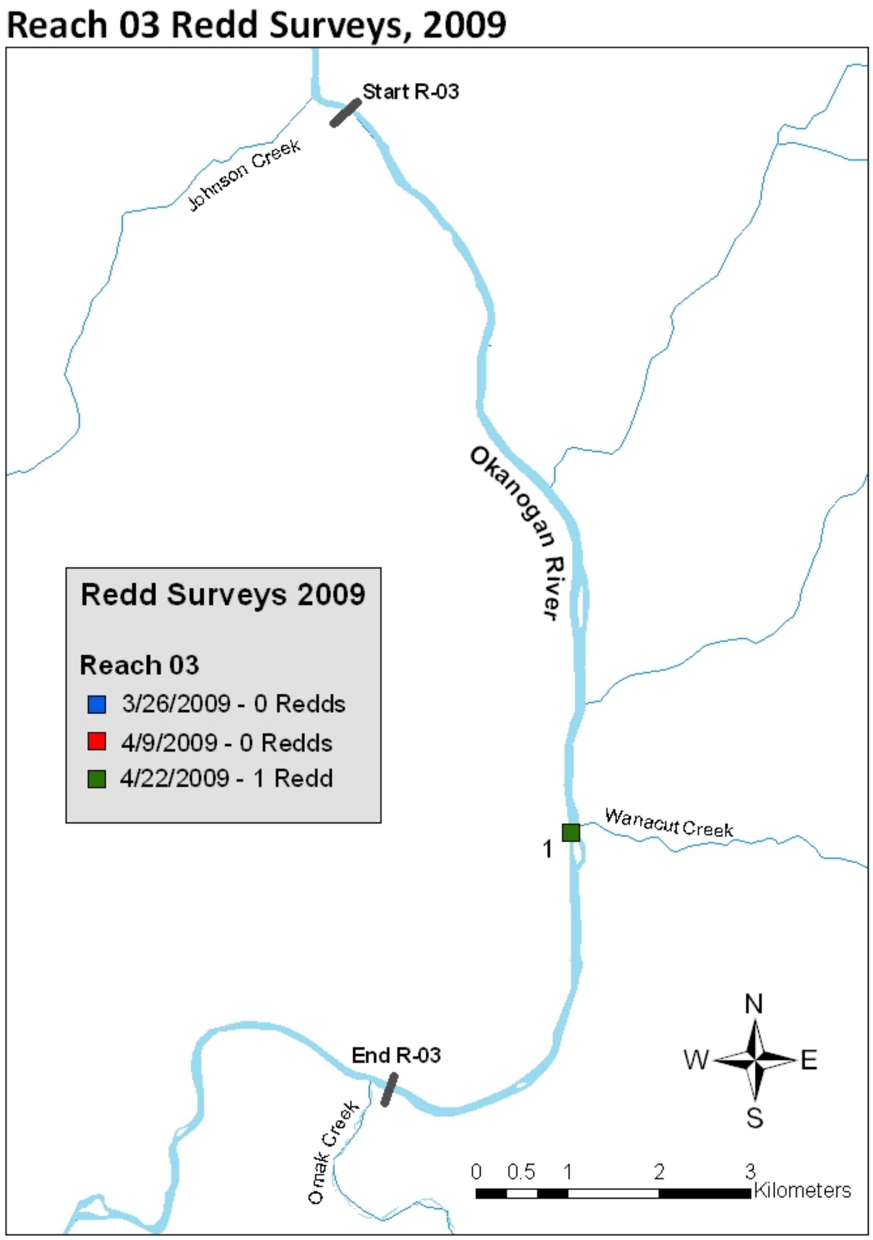

Figure 5. Redd distribution observed in 2009 for Okanogan River reach O3 from the town of Riverside, WA downstream to the confluence with Omak Creek in Omak, WA.

Okanogan River reach O4 was surveyed on March 30, April 14, and April 23 (Figure 6). Ten redds were counted on the first survey, three on the second, and no new redds observed on the final round. The redds were located in two frequently used spawning locations, in the vicinity of Janis Rapids downstream of the confluence with Chewiliken Creek and at the lower end of the braided channel below McAllister Rapids near the confluence with Tunk Creek. The number of redds observed in 2009 was near the lower range of previously observed redds (11-58 redds) within this reach.

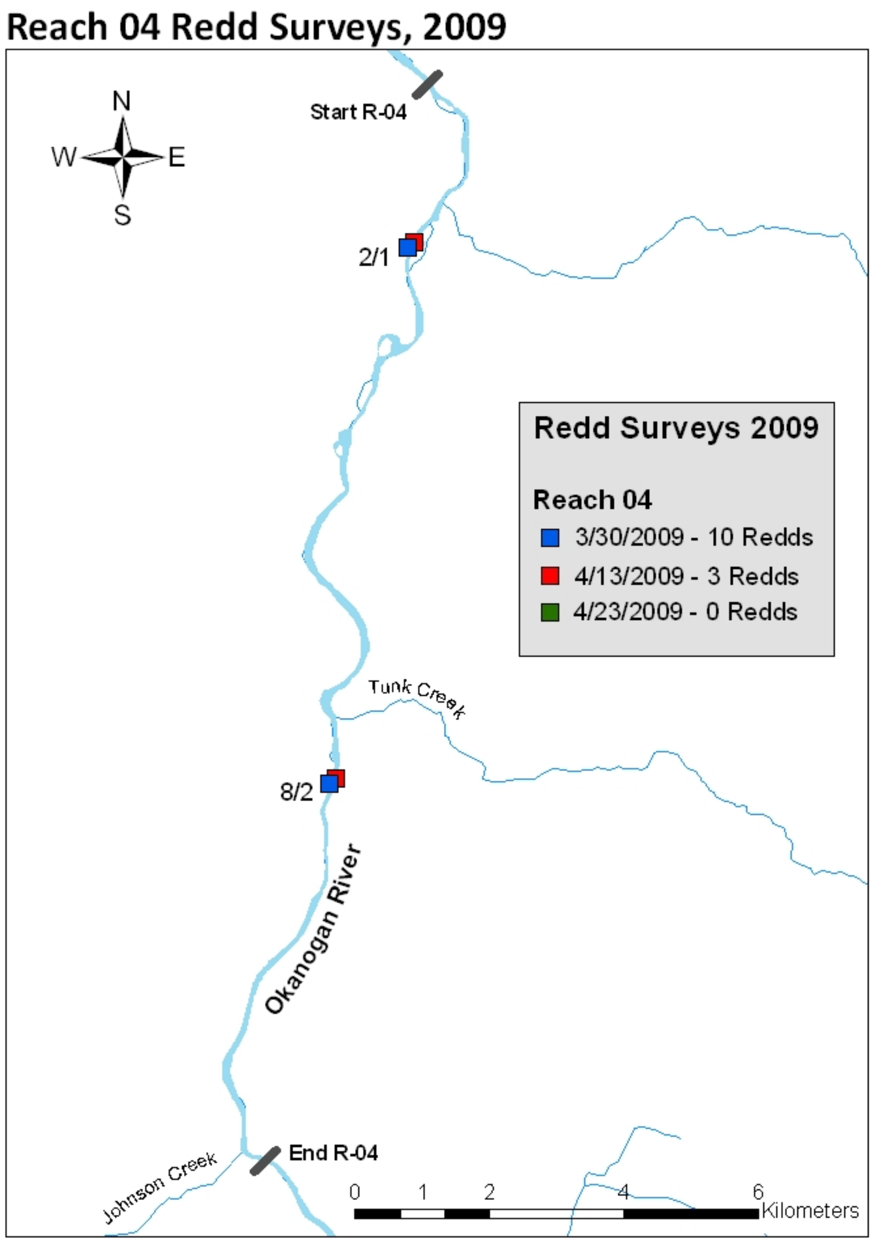

Figure 6. Redd distribution observed in 2009 for Okanogan River reach O4 from Janis Bridge downstream to the town of Riverside, WA.

Okanogan River Reach O5 was surveyed on April 1 and April 14. A total of five redds were identified within this reach on the first survey and none were identified on the second survey (Figure 7). A third survey was conducted on April 27, but no redds were identified, partly due to a sharp increase in runoff and subsequent adverse water clarity. Redds were observed in areas with braided channels downstream of the town of Tonasket, WA. The number of redds observed in 2009 was lower than the previous record low in 2008 (19 redds) and became the lowest recorded within this reach (previous range was 19-63 redds from 2005-2007).

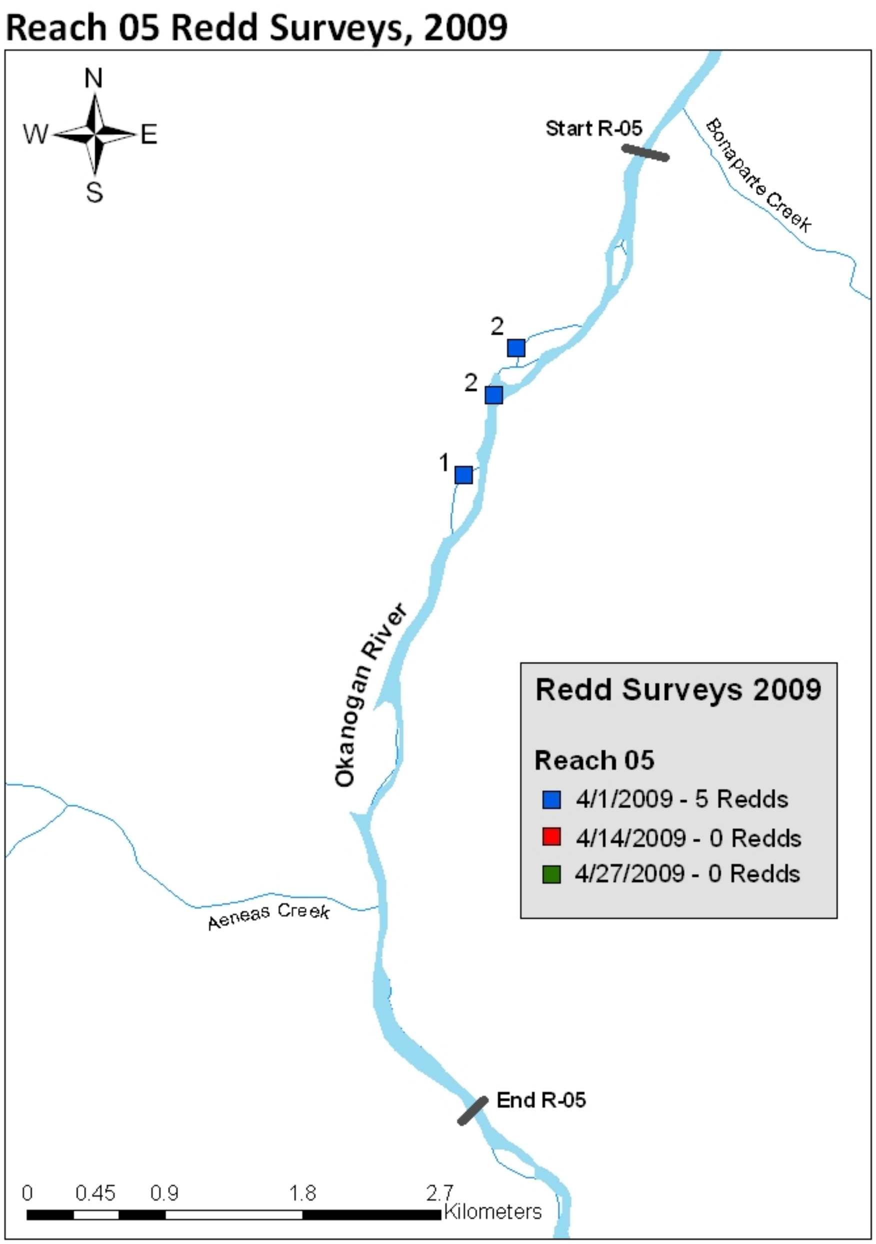

Figure 7. Okanogan River redd distribution observed in 2009 within reach O5 from the Chief Tonasket Park located in the town of Tonasket, WA downstream to the Highway 97 Bridge at Janis, WA.

Surveys were conducted three times during 2009 on Okanogan River Reach O6 (April 2, April 15, and May 1) and no redds were observed during the course of the three surveys. Zero redds were also found in 2008. However, previous annual surveys identified 3-19 redds within this reach. Isolated spawning habitat exists within this reach, but is surrounded by mostly sand substrates. The quality of the spawning habitat may have degraded to the point that it was no longer of a high enough quality to attract adult steelhead spawners.

Okanogan River Reach O7 was surveyed three times in 2009 and a total of 524 summer steelhead redds were identified. On April 6, two redds were identified, 260 redds on April 20, and 262 redds on May 4. A majority of redds were observed downstream of Zosel Dam, but above Driscoll Island in 2009 (Figure 8). The number of redds observed in 2009 exceeded the record number of redds (249) observed in 2008 and became the highest number recorded within this reach (previous range was 141-249 redds from 2005-2008). Spawning habitat within this reach was of high quality and hatchery stocking also occurred near this reach; therefore high redd counts in this reach was not surprising.

Similkameen River reaches S1 and S2 were each surveyed three times in 2009 with a total of 244 summer steelhead redds identified. Most of the steelhead redds were observed downstream of Oroville High School where a braided channel existed (Figure 9). The total number of redds observed in 2009 exceeded the previous record of 132 in 2008 and became the highest number observed in this reach (previous range was 98-132 redds from 2005-2008).

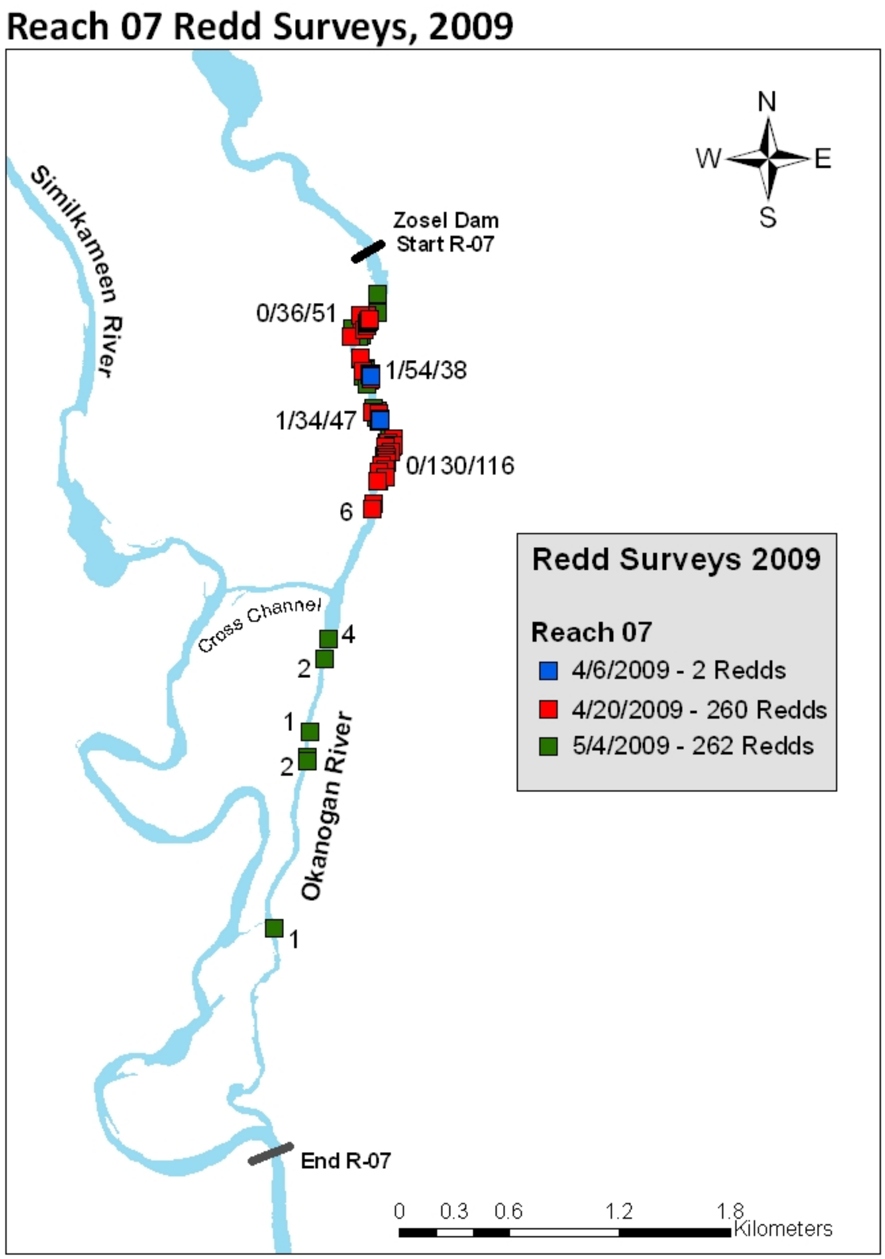

Figure 8. Redd distribution observed in 2009 for Okanogan River reach O7 which extends from Zosel Dam downstream to the confluence with the Similkameen River.

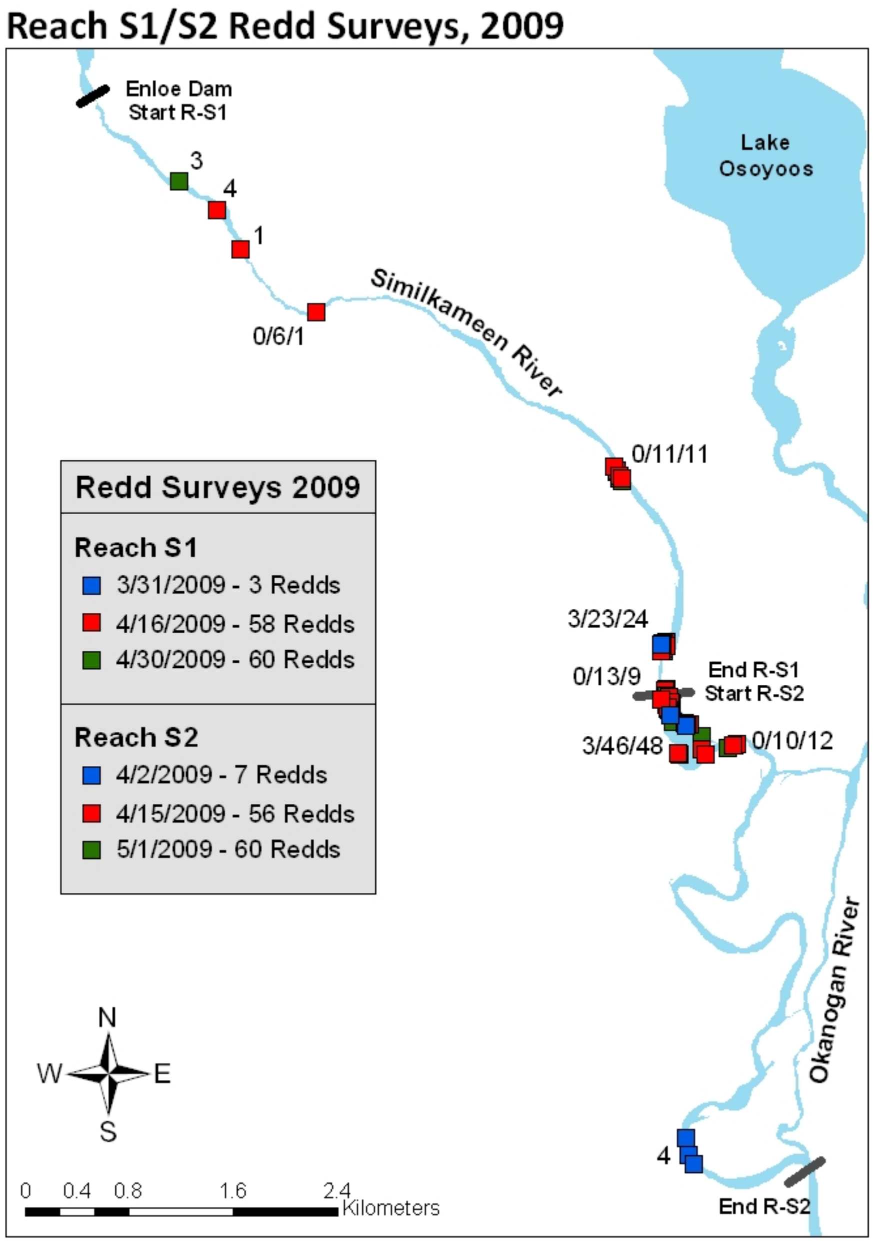

Figure 9. Redd distribution observed in 2009 for Similkameen River reach S1 and Similkameen River Reach S2. Reach S1 extends from the base of Enloe Dam downstream to the water treatment plant in Oroville, WA. Reach S2 extends from the end of Reach S1 to the confluence with the Okanogan River. Any redds observed within the cross-channel are considered a part of S2.

Tributary redd surveys in the Okanogan River Basin

Tributary habitats surveys began as soon as water clarity allowed. Varying snow packs and elevations of different sub-watersheds required unique schedules when surveying redds. Steelhead redd surveys within each tributary were conducted beginning on April 13. The upstream extent of each survey was limited by either a natural fish passage barrier or access to private land, as described in Arterburn et al. (2007a). Precipitation data is listed in Table 2. With little storage in the smaller watersheds and minimal precipitation in April, many adult steelhead had difficulty gaining access into tributaries from the Okanogan River (Figure 10). Below-normal discharge in the Okanogan River mainstem further limited access into the tributaries by failing to inundate impassible deltas at the confluence of some streams (Figure 2).

Table 2. Precipitation totals measured by the National Weather Service at Omak Airport.
http://www.crh.noaa.gov/product.php?site=NWS&issuedby=OMK&product=CLM&format=CI&version=6&glossary=0

Month	Precipitation in 2009 (inches)	Precipitation in 2008 (inches)	Precipitation in 2007 (inches)	Precipitation in 2006 (inches)	Average Precipitation (70 year mean)
March	0.93	0.73	0.08	0.81	1.00
April	0.19	0.19	0.06	0.89	1.11
May	1.23	0.18	0.74	1.35	1.08
Total	2.35	1.10	0.88	3.05	3.19

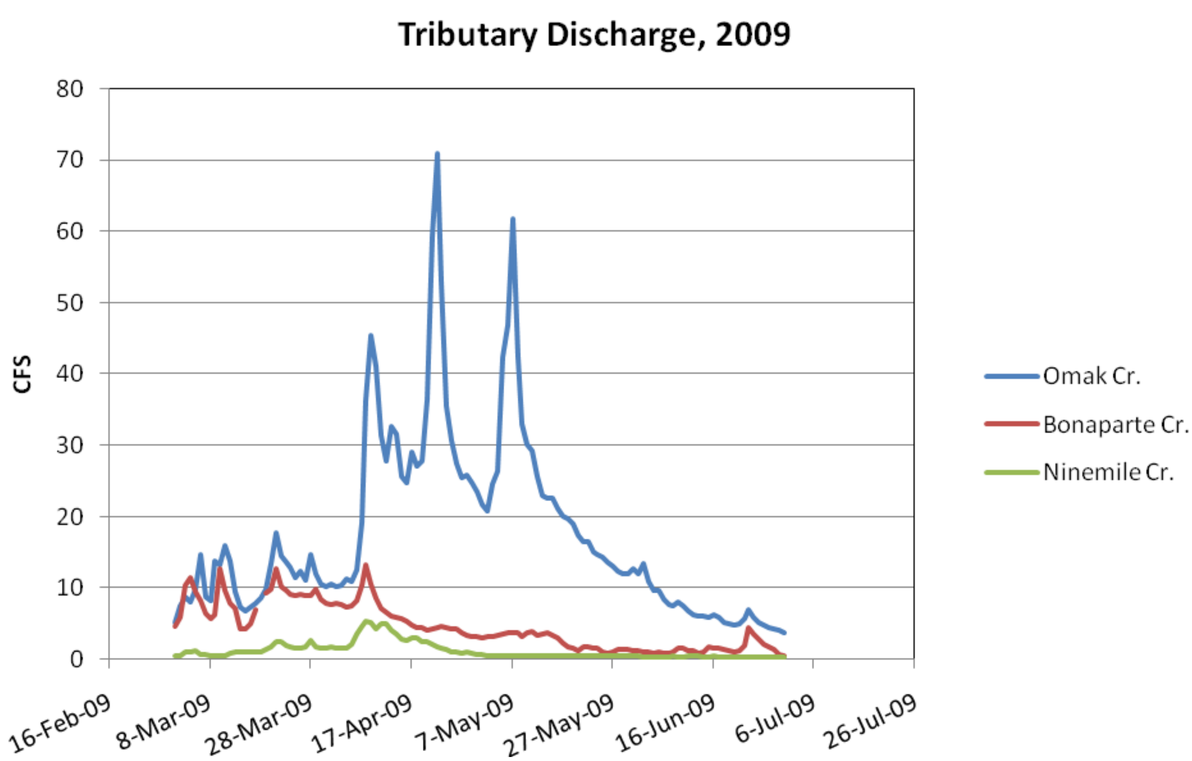

Figure 10. Discharge from March through June of 2009 for three tributary streams known to produce summer steelhead in the Okanogan Basin. https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=49F070

Ninemile Creek

The lower 1.7 km of Ninemile Creek was surveyed on May 26th, and no redds were seen. However, a video weir installed 1.7 km from the confluence with Lake Osoyoos documented three adult steelhead passing through the video chute on April 26, May 1, and May 11. Two of these fish had intact adipose fins.

Tonasket Creek

Steelhead redd surveys were not conducted on Tonasket Creek in 2009 due to lack of sufficient flows to provide connectivity to the mainstem Okanogan River. Past summer steelhead spawner escapement estimates for this creek were 8 in 2006, 17 in 2007, and zero in 2008. During most years, Tonasket Creek flows intermittently during the spring and dries up by mid-summer in the lower most 3 km.

Wild Horse Spring Creek

Wild Horse Spring Creek was inaccessible prior to 2006 due to a large beaver dam located near the confluence with the Okanogan River. However, high flows during the spring of 2006 dislodged this dam. With the barrier removed, summer steelhead began utilizing this habitat. In 2006, three redds were observed by OBMEP crews and verified by WDFW biologists. Again in 2007, steelhead redds were observed within the 1.1 km of available habitat. However, no summer steelhead redds were observed in 2008 due to very low flows during the spawning period. Wild Horse Spring Creek was surveyed April 15, 2009 and no redds were observed. Previous surveys estimated spawner escapement at 5 steelhead in 2006, and 12 in 2007.

Antoine Creek

Antoine Creek flows perennially; however, minimal spring discharge limited access of adult steelhead throughout the 2009 spawning season. When the stream was surveyed on May 6th, no summer steelhead or redds were observed from the confluence with the Okanogan River to the video box and no adult steelhead were documented passing through the video box.

Although escapement was zero in 2008 and 2009, snorkel surveys have identified multiple year-classes of both brook trout and *O. mykiss* indicating that favorable rearing conditions exist (Kistler et al. 2006, Kistler and Arterburn 2007). However, a relatively large delta at the confluence of Antoine Creek makes access difficult for anadromous steelhead and consideration should be given to concentrate flow and improve access during typical flow conditions. To accelerate the reestablishment of summer steelhead in Antoine Creek, approximately 3,000 smolts were released during April of 2008 (Fisher 2008).

Bonaparte Creek

A removable picket weir trap has been in operation since 2006 on Bonaparte Creek and was again installed in 2009. Twenty-eight summer steelhead (21 males; 7 females) were collected at the Bonaparte Creek weir and passed upstream in 2009 (Table 3). An additional three male and four female steelhead were captured and transported to the Cassimer Hatchery as kelts (1 male; 3 female) or for broodstock (2 male; 1 female).

Table 3. Proportions and totals of male, female, and wild summer steelhead passed above the Bonaparte Creek trap in 2009.

Bonaparte Creek Weir Trap, 2009

Description	Total (N)	Wild (N)	Percent Wild (%)
Males	21	5	23.8%
Females	7	1	14.3%
Total	**28**	**6**	**21.4%**

Redd surveys downstream of the Bonaparte Creek weir were conducted on April 13, 23, and 28 and a total of four summer steelhead redds below the trap site were observed (Figure 12). Based upon the sex ratio generated from adult steelhead collected at the trap, an estimated 15 summer steelhead spawned downstream. Of the fish enumerated at the trap, 21.4% had intact adipose fins. From these ratios, an estimated range of 3 natural-origin steelhead spawned downstream of the trap site. The total number of summer steelhead spawners utilizing Bonaparte Creek was estimated to be 43, a minimum of 6 and a maximum of 9 were of natural origin.

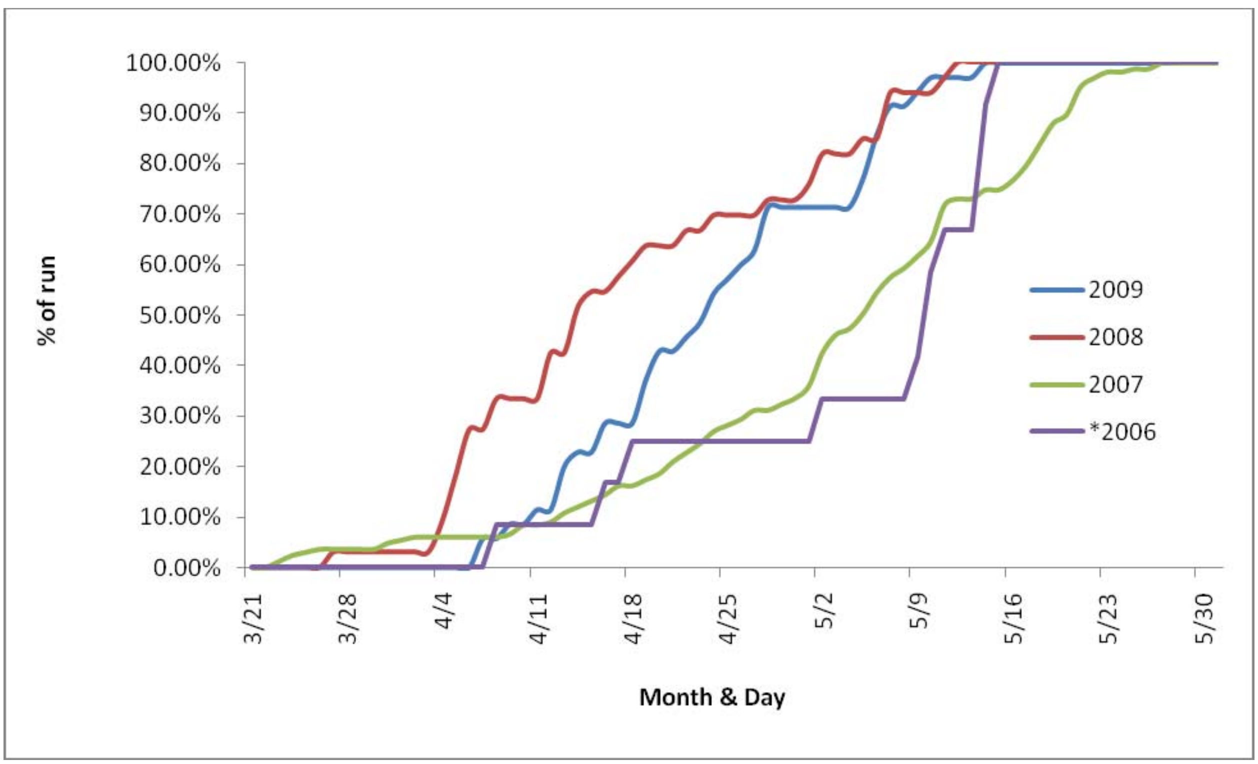

Figure 11. Run timing of summer steelhead at the Bonaparte Creek trap, 2006-2009. *The 2006 trap was only operated for part of the season.

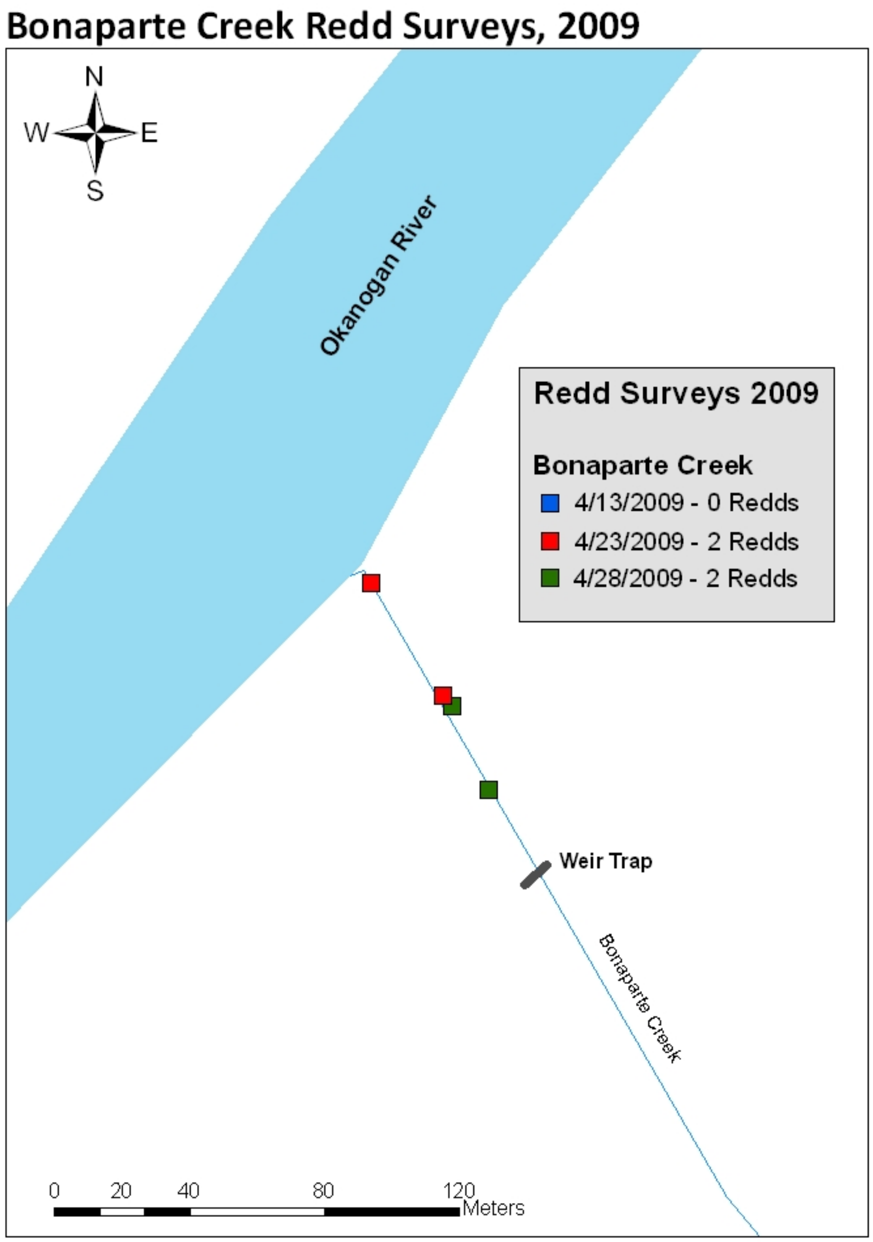

Figure 12. Distribution of redds observed in Bonaparte Creek during 2009 from the confluence with the Okanogan River upstream to the Bonaparte weir trap.

Tunk Creek

On April 13, two redds were identified at the Tunk Creek confluence and one more was identified on April 23. No new redds were observed during the final survey, May 6 (Figure 13). Ten steelhead were estimated to be utilizing the creek in 2009 (using sex ratio multipliers from Bonaparte Creek), two of these were likely of natural origin.

One man-made structure was observed just above the confluence and no redds were found above this structure in 2009, suggesting that it remained an impediment to migrating adults at low discharges. Past steelhead spawner escapements at the confluence were seven in 2005, two in 2006, unknown in 2007, and two in 2008. A section of Tunk Creek approximately ½ mile long was de-watered in 2009, probably due to a nearby well (~ 125 ft. from channel) that waters an agricultural field at a rate of 1,000gpm. Dewatering likely reduces steelhead production in Tunk Creek.

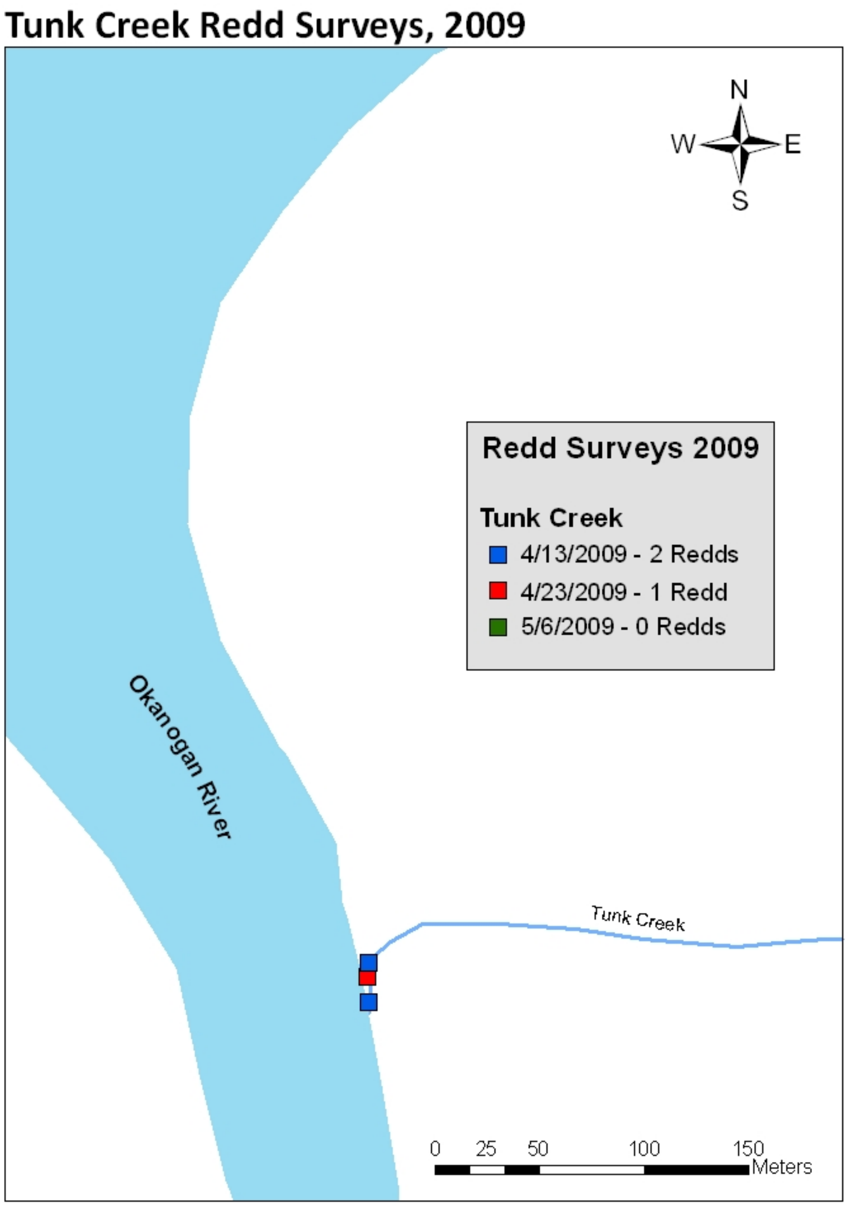

Figure 13. The distribution of redds observed in Tunk Creek during 2009 from the confluence with the Okanogan River upstream to the falls.

Wanacut Creek

Similar to 2008, water from Wanacut Creek in 2009 never reached the Okanogan River. Although Wanacut Creek has a sizeable watershed (roughly 22,000 acres), utilization by summer steelhead is limited to the lower 1 km due to intermittent flows. Access to spawning habitat in Wanacut Creek is only available during years when snow pack is above normal, as it was in 2007. During the spring of 2007, Swimptkin Canyon, Pothole Canyon, and Wanacut Creeks were flowing to the Okanogan River allowing access by summer steelhead. Habitat accessible to anadromous salmonids was documented at river kilometer 2.64 (Arterburn et al. 2007).

Omak Creek

Forty summer steelhead were collected at the Omak Creek trap (29 males; 11 females) and a ratio of 2.6 males for each female was observed (Table 4). Four steelhead were identified as originating from the Cassimer Hatchery (3 males; 1 female). In addition to the 40 fish that passed upstream of the trap, 5 male and 5 female summer steelhead were transported to the Cassimer Hatchery as kelts (3 male; 1 female) or broodstock (2 male; 4 female).

A total of 25 redds were observed downstream of the trap (Figure 14). The Omak Creek weir sex ratio was multiplied by redds observed downstream of the trap, which resulted in an estimate of 90 adults. Therefore, a total of 130 summer steelhead (trap and redd count estimate) returned to Omak Creek in 2009. Of these fish, 16 were estimated to be of natural origin. The 2009 spawning escapement was comparable with data from the last six years (Figure 16), but this obscures the real restoration story in Omak Creek that has taken this stream form near zero spawners in 1997 to where it is today (an 8 year average of 121 spawners per year). Due to the previous investments and the amount of potential habitat available upstream of Mission Falls, investigations to augment passage should continue. As efforts to address passage at Mission Falls continue, so should redd surveys or another means of evaluating passage and enumeration upstream of the falls.

Table 4. Proportions and totals of male, female, and wild summer steelhead passed above the Omak Creek trap in 2009.

Omak Creek Weir Trap, 2009

Description	Total (N)	Wild (N)	Percent Wild (%)
Males	29	5	17.2%
Females	11	0	0.0%
Total	**40**	**5**	**12.5%**

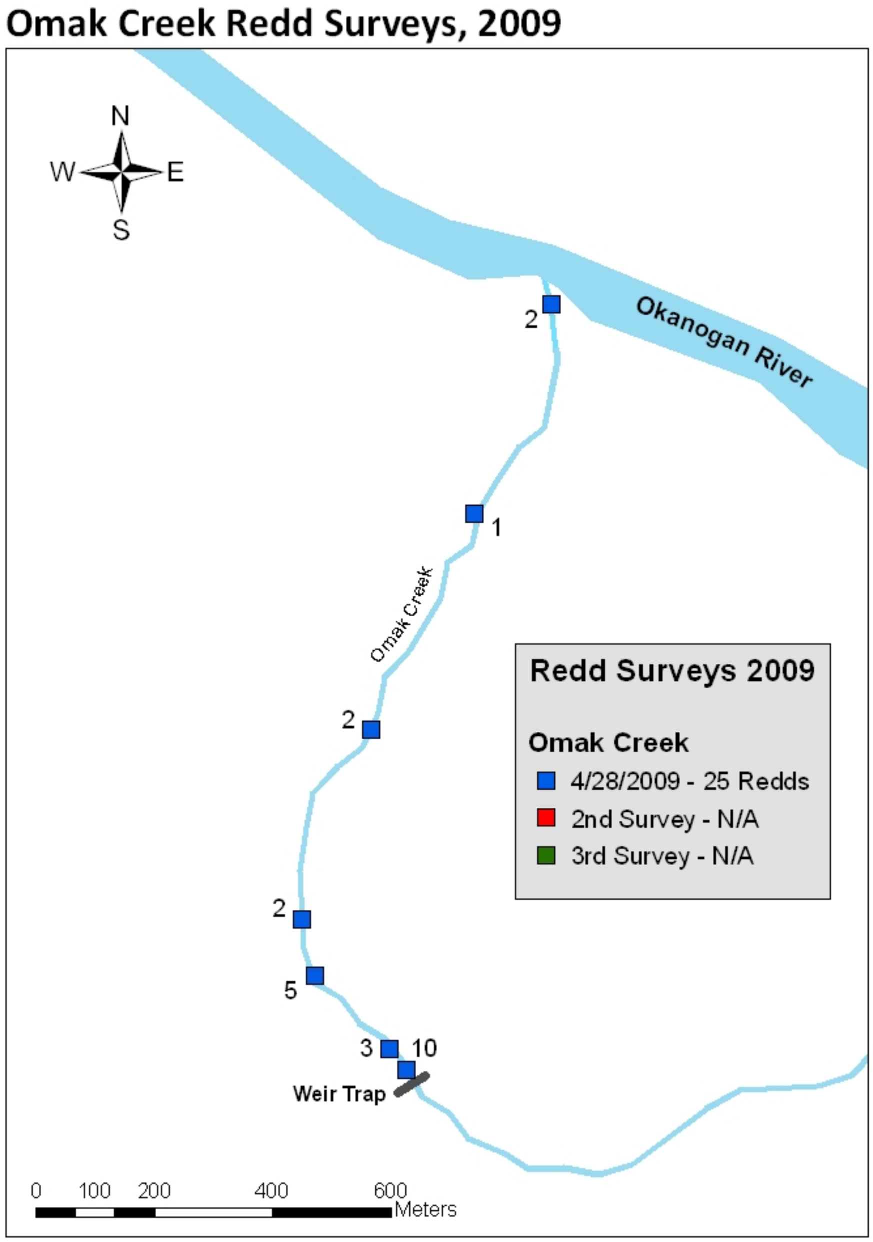

Figure 14. Map of summer steelhead redds observed below the Omak Creek trap during the spring of 2009.

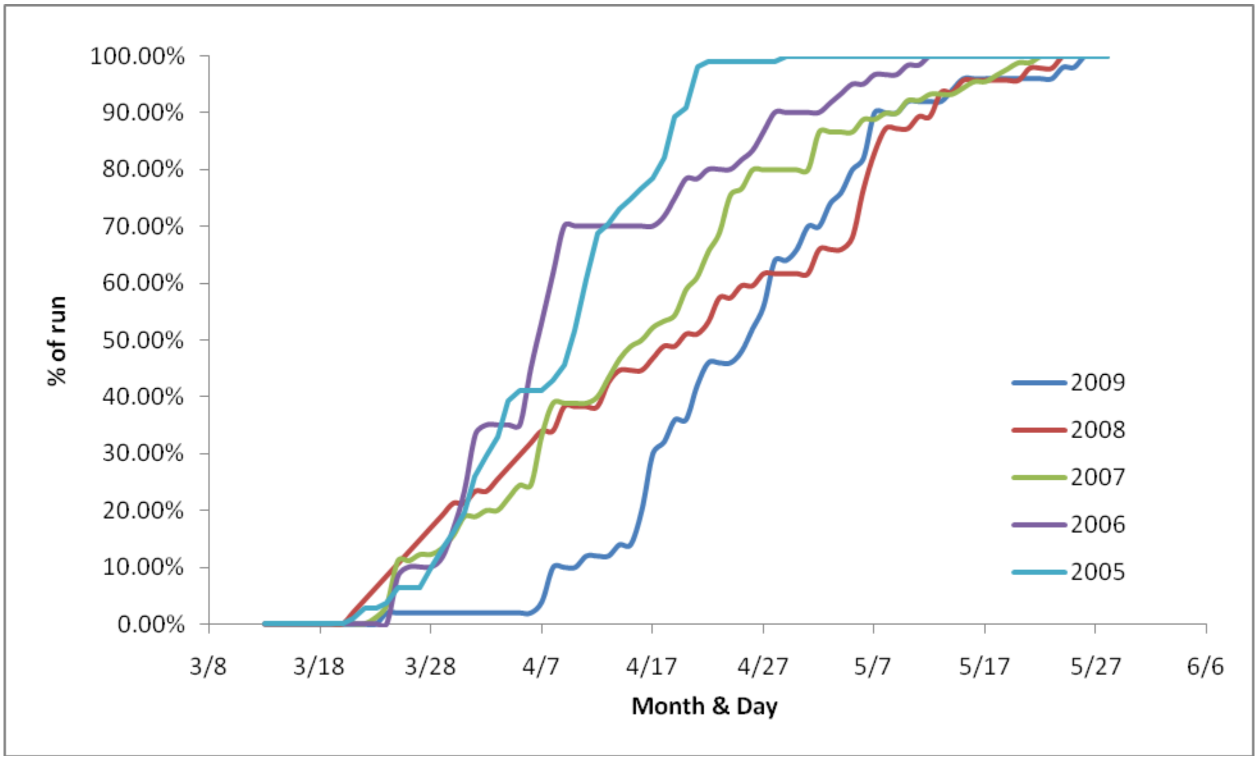

Figure 15. Run timing of summer steelhead at the Omak Creek trap, 2005-2009.

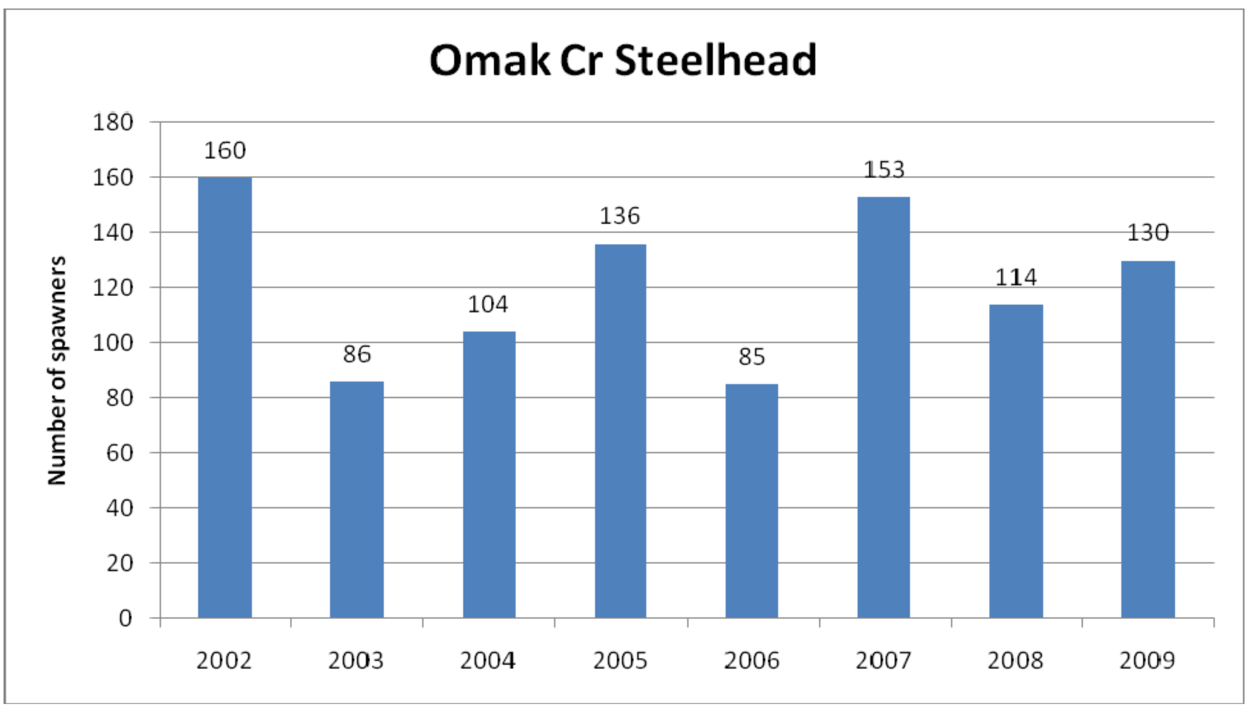

Figure 16. Number of summer steelhead spawners in Omak Creek from 2002 to 2009.

Salmon Creek

Since the early 1900's, Salmon Creek has been entirely diverted for irrigation usage. The resulting dry stream channel extends from the Okanogan Irrigation District (OID) diversion dam (7.2 km) to the confluence with the Okanogan River. Occasionally, uncontrolled spills occur downstream of the OID diversion dam. These spills usually occur after summer steelhead spawn (mid-May to June). However, summer steelhead passage flows were evaluated during a controlled release of 22 cfs from April 1 through April 14, 2003. During this two week period, six redds were constructed within the lower reach of Salmon Creek (Fisher and Arterburn 2003).

As a result of these passage evaluation studies, a long-term water lease was negotiated between the Colville Tribes and the OID that provided sufficient water for smolt releases since 2007. A low flow channel was constructed in the fall of 2008 to improve access for adult steelhead. In 2009, 1,220 ac-ft of water were released over a period of 53 days (April 9 through May 28), and discharge ranged from 7.84 cfs to 21.39 cfs (Figure 17), with a mean of 13.2 cfs (Pers. Comm. Chris Fisher Colville Tribes Fish Biologist). During that time, 12 redds were observed in the lower 7.2 km of Salmon Creek (Figure 18). Using a sex multiplier of 3.7 (average of Omak and Bonaparte Creeks) rendered 45 spawners below the diversion. Ad-present fish made up 20.1% of the fish observed in the video counting chamber and because we were uncertain how many of these were truly of natural origin below the OID diversion, a range of 4-9 naturally produced steelhead was estimated.

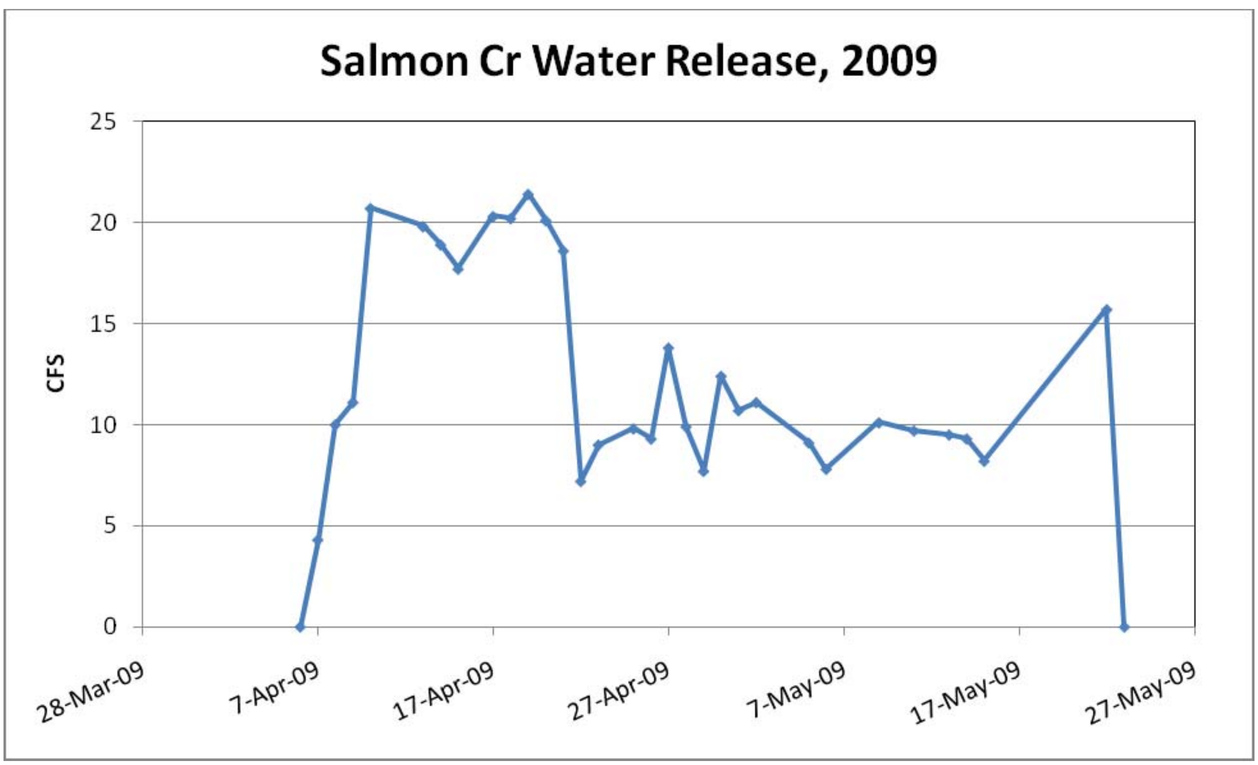

Figure 17. Release of water from Salmon Creek (2009) to allow steelhead passage.

In addition to redd surveys below the OID diversion, a specialized underwater video apparatus was custom-designed to fit into the fish ladder of the OID diversion dam in 2009. A total of 24 adult steelhead passed through the video chamber within a six-day period and 5 had intact adipose fins. The total number of steelhead counted as passing the diversion dam was likely an underestimate because 12 days of video data was overwritten before being reviewed (April 9-May 4 and May 14-20). Three adult steelhead were observed upstream of the diversion dam prior to April 16 and were not recorded passing through the video chamber. Two of these fish were mortalities immediately upstream of the diversion dam and another adult steelhead was observed spawning approximately 0.18 miles upstream of the diversion dam. It was suspected that these fish and possibly more adult steelhead jumped over the diversion dam and avoided swimming through the video chamber when discharge was approximately 20 cfs. Total escapement estimates into Salmon Creek are considered very conservative because of difficulties with data collection during the first year of monitoring adult returns. In order to improve next year's data collection, video equipment will be installed and tested earlier, adding expanded memory in the DVR units thus providing a larger buffer before overwriting of data begins, and installing deflectors to ensure that steelhead do not bypass the video array.

A conservative estimate of 27 summer steelhead spawners were observed above the OID diversion and 45 spawners were estimated below the diversion. Combining these values results in a total spawner count of 72 summer steelhead returning to Salmon Creek in 2009 with a best estimate of 11 being of natural origin.

Table 5. Adult steelhead enumerated at the video weir on Salmon Creek during 2009.

Salmon Creek Video Data

Date	Ad-Clipped	Ad-Present	Total Steelhead
4/16	3	1	4
4/17	0	1	1
4/18	3	2	5
4/19	9	0	9
4/20	3	1	4
4/21	1	0	1
Total*	**19**	**5**	**24**

*Due to overwrite of hard drives, data was not recorded for the time periods of 4/29 thru 5/4 and 5/14 thru 5/20.

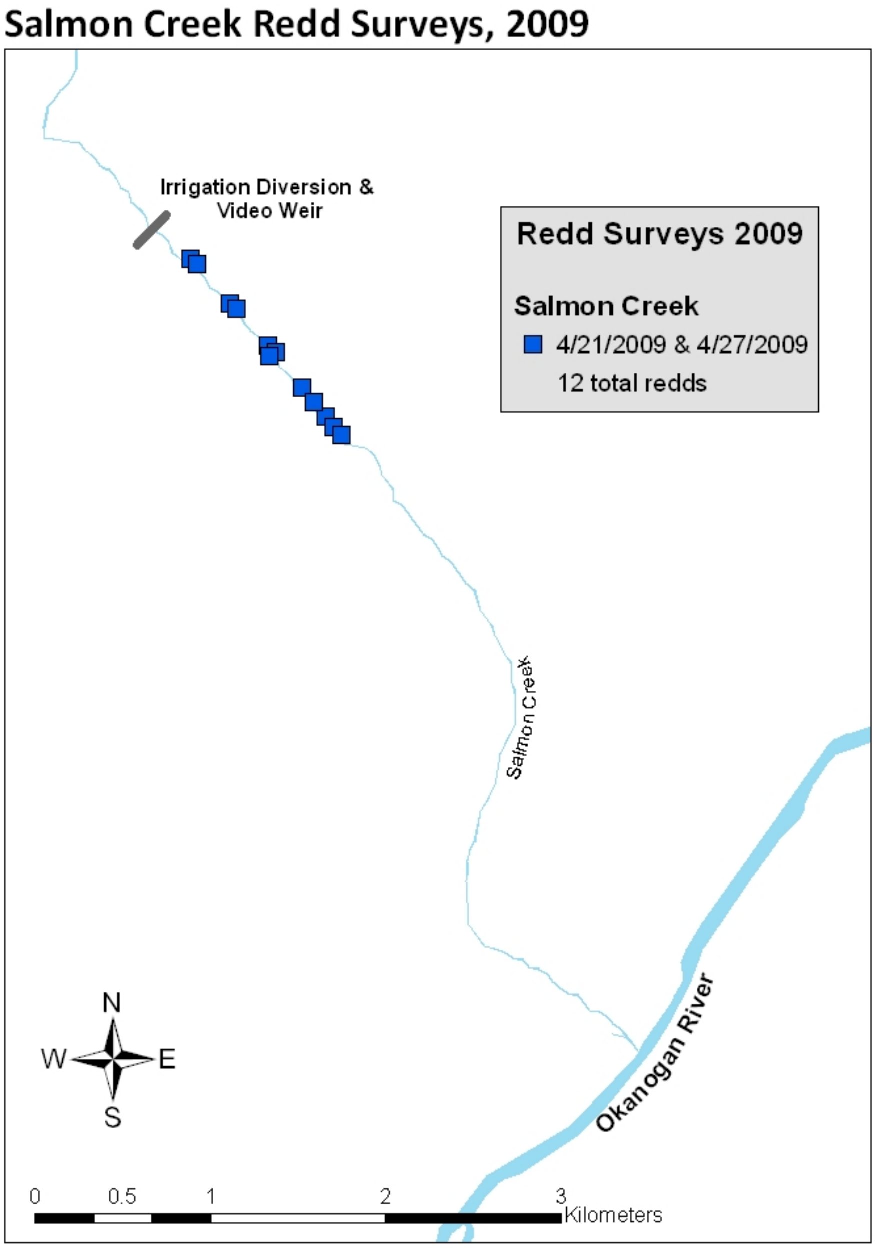

Figure 18. Map of summer steelhead redds observed below the Salmon Creek trap during the spring of 2009.

Loup Loup Creek

Low stream flows in 2009 on Loup Loup Creek were insufficient to provide passage at the lower most impediment (culvert) located at river kilometer 0.1. This was the second year in the last four that no redds were identified in Loup Loup Creek. When sufficient flows are present to allow passage into Loup Loup Creek, summer steelhead attempt to spawn in this creek but production is limited by instream flow as a result of irrigation diversions (Arterburn et al. 2007b). Past surveys have established that an estimated 12 summer steelhead spawned in this creek in 2006 and another 18 in 2007. Use by spawning steelhead would likely increase substantially if perennial flows were reestablished, passage impediments were removed (culverts), in-channel habitats were improved, and steelhead were supplemented using locally-adapted hatchery stocks. Steelhead redd surveys will continue in Loup Loup Creek to provide baseline information, and document the effectiveness of habitat rehabilitation projects, once implemented.

Escapement into Canada

To accurately calculate steelhead escapement into Canada, video counts at Zosel Dam and a removable trap located on Inkaneep Creek were utilized.

To calculate the number of spawners entering Canada, the estimated number of spawners that entered Ninemile (3) and Tonasket (0) Creeks were subtracted from the total number counted at Zosel Dam. These two creeks are located upriver of Zosel Dam but south of the international border. During 2009, 437 summer steelhead were counted passing Zosel Dam. Three were observed entering Ninemile Creek, a United States tributaries above Zosel Dam. Therefore, 434 summer steelhead were observed in close proximity to the 49th parallel during the time steelhead were expected to spawn. However, the distribution of spawners north of the United States boarder with Canada remains unknown even though considerable funds have been expended to try and more accurately define steelhead spawning habitat since 2005.

Sixty-six ad-present summer steelhead were enumerated at Zosel Dam (Table 6). The estimated number entering Ninemile (2) and Tonasket (0) Creeks was subtracted from the total (66), resulting in an estimate of 64 ad-present summer steelhead. Of the total number of summer steelhead destined for Canada, 15% were observed with intact adipose fins. However, there is concern about overestimating the extent of natural origin fish, based on the fact that a proportion of hatchery fish are released unmarked. A more conservative wild estimate was derived from averaging the WDFW Okanogan River wild estimate (8.5%) and Zosel ad-present value (15.1%) to render a value of 11.8%. This would represent an approximate value of 52 naturally produced steelhead from a total of 437 fish.

Table 6. The number of summer steelhead that passed Zosel Dam by month for the 2009 spawner cohort, July 2008 to June 2009.

Zosel Dam Steelhead Passage

Month	Ad-Clipped	Ad-Present	Total
July	0	1	1
August	2	0	2
September	0	1	1
October	0	2	2
November	0	1	1
December	5	1	6
January	0	0	0
February	0	0	0
March	0	1	1
April	345	52	397
May	17	6	23
June	2	1	3
Total	**371**	**66**	**437**

Inkaneep Creek

The Okanagan Nation Alliance operated an adult fish weir on Inkaneep Creek in 2009. The fish fence captured 20 total fish from March 31 to June 5. Of the 20 fish captured, 2 were ad-clipped and of hatchery origin, with the remaining having intact adipose fins (90% ad-present). A mean fork length of 50.8 $\pm$ 8.1 cm was determined.

Due to the fact that the weir trap was not effective in capturing all migrating fish, two redd surveys were conducted on Inkaneep Creek on 5/31/2009 and 6/1/2009 with 86 redds identified. Four additional redds were not included in this count, as they were likely created by smaller resident trout. A disagreement exists on the actual proportion of anadromous steelhead and resident trout that utilize this creek. However, this value cannot be resolved without stable isotope analysis. Without this fundamental piece of data, along with accurate sex ratios, it may be impossible to definitively determine the proportion of resident vs. anadromous *O. mykiss* utilizing the creek. Thus, in the interim, a calculation must be used to estimate escapement into Inkaneep Creek.

In order to determine an estimated range of *O. mykiss* that entered Inkaneep Creek, a sex ratio needed to be determined. Due to the fact that sex was not evaluated at the weir trap in 2009, a surrogate was used; therefore, a conservative estimate of a 1:1 male to female ratio (sex multiplier 2 fish/redd) was used. When the observed 86 redds was multiplied by 2, an estimated 172 *O. mykiss* spawned in Inkaneep Creek. This number likely represented a minimum escapement estimate. In order to obtain a maximum value, the 86 redds were multiplied by the Omak Creek weir sex multiplier of 3.6, a creek of similar size; therefore, a maximum estimate of 310 spawning adult *O. mykiss* was determined.

It is unfortunate that the proportion of anadromy could not have been examined more closely due to problematic trap operations. However, an extrapolation was drawn to predict the number of ad-clipped steelhead spawners in Inkaneep Creek. Using the minimum *O. mykiss* population estimate of 172, multiplied by the ratio of hatchery steelhead handled at the weir in 2009 (0.10), a value of 17 ad-clipped anadromous steelhead likely spawned in Inkaneep Creek. It would be difficult to predict the number of wild steelhead that spawned, as insufficient data exists to perform a meaningful estimate because stable isotope data is lacking.

Remaining Canadian Distribution

Annually, a large number of summer steelhead pass Zosel Dam and enter Canada with an undefined natal stream (Table 7). In 2009, 417 summer steelhead have a distribution that remains undefined. It has been suggested that fall back at Zosel Dam would account for these disparities but no evidence of this has been observed and all downstream passage at Zosel Dam is already removed from any estimates during video data processing. Fallback issues at other facilities has been closely studied, for example, a minimum of 94% of steelhead passing mainstem Columbia River dams survived to known spawning areas, or remained above the dam (English et al. 2001, 2003). More recent PIT tag data indicate that survival from McNary Dam to Wells Dam averaged 97% per project. Using these values may result in a reduction in Zosel Dam counts by between 13 and 28 summer steelhead but would still leave at least 386 summer steelhead unaccounted for in Canada.

Recreational harvest in Osoyoos Lake on both sides of the boarder could account for some of these fish, but it is unknown to what extent. Most of the fish passed Zosel dam in April, which was after the closure of the steelhead fishery (March 15) in the United States, and therefore, it would be illegal to possess these fish in the United States. Harvest estimated for the steelhead fishery in the United States portion of the Okanogan and Similkameen Rivers indicates a mortality of 13.6% for 2009 (WDFW 2009). If the same proportion of the counts at Zosel was removed, this would account for an additional 56 summer steelhead harvested before spawning above Zosel Dam due to recreational fishing. With both potential recreational fishing and fallback accounted for there are still 330 summer steelhead left unaccounted for above Zosel Dam.

The most likely scenario is that, at a minimum, 330 summer steelhead do spawn in Canada. However, past and on-going efforts have failed to determine the quantity and location of spawning with the exception of in Inkaneep Creek. In the future, PIT-tag data collected at VDS-3 and radio-isotope sampling at Inkaneep Creek will greatly help expand our current knowledge about how many steelhead are spawning in certain areas of the Okanogan River in Canada. As these new data become available they will be used to focus our search for the most productive natal streams first before worrying about identifying less productive environments.

Table 7. Summer steelhead spawners with unknown natal stream located above Zosel Dam from 2007-2009

Year	Number of Spawners with unknown distribution in Canada
2009	417
2008	94
2007	24

Bringing it all together

In the United States, summer steelhead are currently listed as “threatened” under the Endangered Species Act in the Upper Columbia River Evolutionary Significant Unit. Detailed percent-wild information for 2009 is provided in this document and every attempt has been made to ensure that these estimates are as accurate as possible. However, these data should be used with caution as if is currently impossible to define natal origin through visual observation alone. Mean values presented in this document represent our best scientific estimate from the best available information, but should not be considered absolute. Thus, high and low estimates are also provided to represent the full range of possible values.

The total escapement estimate for Okanogan River summer steelhead spawners in 2009 was between 2,020 and 2,198 (Table 9). In 2009, WDFW estimated maximum spawner escapement into the Okanogan River Basin at 2,263 summer steelhead (Charles Frady, WDFW, Personal Communications). The WDFW estimates were derived from Wells Dam passage counts modified by subtracting harvest information and divided by river basin through the use of radio telemetry data (English et al. 2001, 2003). However, the radio telemetry data is over a decade old and perhaps these values need to be revalidated.

The abundance of wild fish is a subset of the total escapement estimate and the best available information is used to provide an accurate estimate in the Okanogan River Basin. The WDFW escapement estimate was 192 and OBMEP estimated that between 178 and 241 wild summer steelhead likely spawned within the Okanogan River Basin in 2009 (Table 10). The wide range in our wild fish estimates is directly linked to hatchery programs that do not clip all of their production released in the Upper Columbia. In the future, we plan to install PIT-tag arrays at the downstream extent of most spawning areas or streams throughout the Okanogan River Basin. Once this Okanogan Basin wide PIT-tag array is in place, ad-present adults will be PIT-tagged at mid-Columbia PUD facilities and will carry with them very precise age, sex, and origin data. Recovery of this tag information could be used directly to evaluate the proportion of spawners that are of natural origin and sex ratio with a high degree of certainty, allowing us to incorporate age data into life cycle models, and provide a mechanism for validating our redd surveys with mark-recapture estimates. The mark-recapture methods could help determine spawner distributions throughout Canada but this system is unlikely to be in place, especially in Canada, until 2012 at the earliest.

A summary of the best available counts and estimates for each reach or sub-watershed throughout the Okanogan River Basin is presented in Table 8. Our surveys indicate that mainstem spawning is common throughout the Okanogan River and is most heavily focused in the northern portion of the Okanogan and lower Similkameen rivers. The lack of redds in the mainstem Okanagan River in Canada is surprising because considerable, high-quality habitat exists. Within the United States portion of the basin, most hatchery steelhead are scatter-planted at various locations along the Okanogan and Similkameen rivers, but no hatchery stocking occurs in Canada. It is highly likely that redd distributions in the United States portion of the Okanogan are heavily influenced by the stocking locations used by WDFW. Summer steelhead that spawn in tributary habitats of the Okanogan River are more likely to find suitable environmental conditions and rearing habitats than those spawning in the mainstem. Therefore, if more summer steelhead were stocked into Okanogan Basin tributaries, the chances of these tributaries contributing to recovery efforts could be greatly enhanced.

Table 8. Redd counts and spawner counts for each sub-watershed or counting location along with the estimated number of wild summer steelhead represented by each in 2009. The grand total for the entire Okanogan River population is presented with subtotals for tributary and mainstem habitat types in the United States and Canada.

Distribution of Steelhead Spawners in the Okanogan Basin

Category	Description/location	2009 Spawners	Redd count	# wild
US Mainstem	Spawners into reach O1	12	7	1
US Mainstem	Spawners into reach O2	28	16	2
US Mainstem	Spawners into reach O3	2	1	0
US Mainstem	Spawners into reach O4	23	13	2
US Mainstem	Spawners into reach O5	9	5	1
US Mainstem	Spawners into reach O6	0	0	0
US Mainstem	Spawners into reach O7	933	524	79
US Mainstem	Spawners into reach SI/S2	434	244	37
US Tributary	Spawners into Loup Loup Creek	0	0	0
US Tributary	Spawners above Salmon Creek diversion	27	N/A	5
US Tributary	Spawners below Salmon Creek diversion	45	12	6
US Tributary	Spawners placed above Omak trap	40	N/A	5
US Tributary	Spawners below Omak trap	90	25	11
US Tributary	Spawners into Wanacut Creek	0	0	0
US Tributary	Spawners into Tunk Creek	10	3	2
US Tributary	Spawners placed above Bonaparte trap	28	N/A	6
US Tributary	Spawners below Bonaparte trap	15	4	3
US Tributary	Spawners into Antoine Creek	0	0	0
US Tributary	Spawners into Wild Horse Spring Creek	0	0	0
Zosel Dam Count	Spawners observed passing **Zosel Dam**	437	N/A	52
US Tributary	Spawners into Tonasket Creek	0	0	0
US Tributary	Spawners above Ninemile Video Box	3	0	2
US Tributary	Spawners into lower Ninemile Creek	0	0	0
Canada Tributary	Spawners placed above Inkaneep trap	17	N/A	N/D
Canada Tributary	Spawners below Inkaneep trap	N/D	N/D	N/D
Canada Tributary	Spawners into Vaseux Creek	N/D	N/D	N/D
Canada Mainstem	Spawners into Canadian mainstem	N/D	N/D	N/D
Canada	Unknown or undefined distribution	417	N/D	50
Subtotals	**Adult escapement into US mainstem**	**1,441**	**810**	**122**
Subtotals	**Adult escapement into US tributaries**	**258**	**N/A**	**40**
Subtotals	**Adult escapement into Canada**	**434**	**N/D**	**50**
Grand total		**2,133**		**212**

Table 9. Total escapement of summer steelhead for the Okanogan River since 2005 including combined hatchery and natural-origin summer steelhead estimates. In 2005 and 2006, only low and high estimates were provided so a simple arithmetic mean was computed for both years. The OBMEP estimate for 2007 was based on estimated mainstem data and the 2008 estimate is derived from data presented in Table 6.

Okanogan River summer steelhead spawner population trend data				
Year	**WDFW escapement estimate**	**OBMEP spawner survey estimate**		
		Low	Mean	High
2005	1,322	1,147	1,315	1,482
2006	811	779	855	930
2007	1,258	1,234	1266*	1,280
2008	1,720	1,341	1,386	1,436
2009	2,263	2,020	2,133	2,198

* Contains estimated mainstem reach data rather than empirical data as in other years.

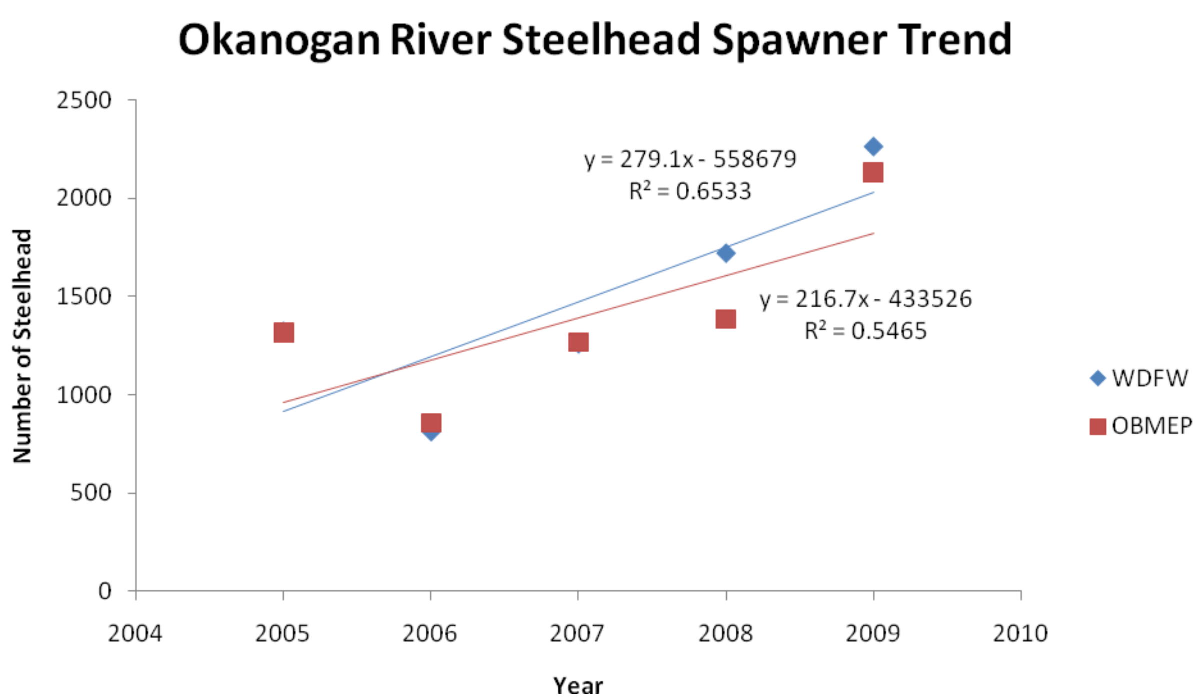

Figure 19. Trends in Okanogan River steelhead spawners, 2005-2009.

Table 10. Natural origin summer steelhead estimates for the Okanogan River since 2005. The estimates in 2005 and 2006 were calculated by multiplying the average wild percent for the Okanogan River. In 2006 and 2007 various sources data were used, such as trap, video, PIT tags, and coded wire tags were used to develop data for Table 6 at the sub-watershed scale. The WDFW estimate is based upon Wells Dam counts and scale analysis. The OBMEP estimate for 2007 is based on estimated mainstem reach data.

Okanogan River wild summer steelhead spawner population trend data				
Year	**WDFW escapement estimate**	**OBMEP spawner survey estimate**		
		Low	Mean	High
2005	N/A	143	164	185
2006	132	127	139	151
2007	116	148	152*	155
2008	233	213	225	266
2009	192	178	212	241

* Contains estimated mainstem reach data rather than empirical data as in other years.

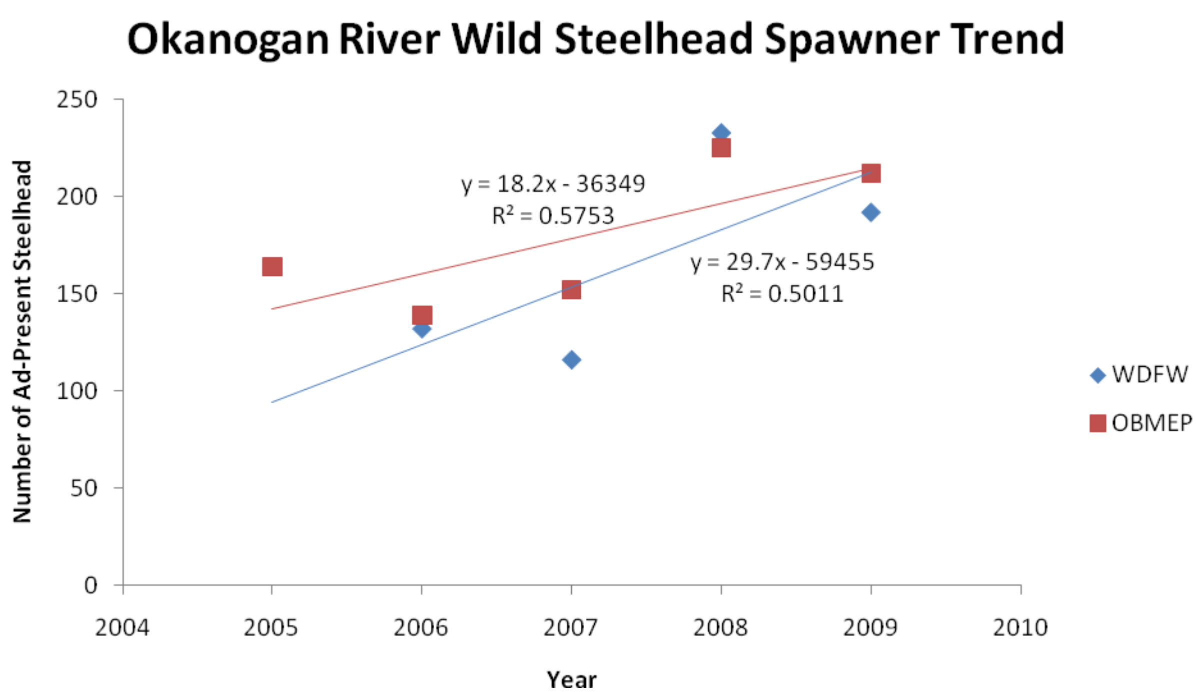

Figure 20. Trends in Okanogan River Ad-Present steelhead spawners, 2005-2009.

Conclusions

Summer steelhead spawner data clearly show that redd surveys throughout the United States portion of the Okanogan River Basin are possible in both tributary and mainstem habitats and the distribution of spawning can be effectively quantified. Baseline information for spawning habitat distribution, spawn timing, and spawner escapement have been determined, but additional annual data are necessary to strengthen the body of information used in trend analysis. Spring spawner data provides a reliable estimate of spawner abundance and less reliable estimates of origin for returning adults. Dependable and reliable estimates such as these are critical for tracking recovery of endangered upper Columbia summer steelhead within the Okanogan River Basin. Using a combination of redd surveys, weir traps, video counting chambers, PIT-tags, and other marks provides results that are more accurate and precise than would be expected from one methodology alone.

Annual variations in redd distribution can be profound for small tributaries within the Okanogan River Basin. Changes in spawner distributions are primarily driven by four factors:
1) The discharge and elevation of the Okanogan River;
2) The discharge of the tributary streams;
3) The timing of runoff that alters the shape of the hydrograph, and most importantly;
4) The stocking location of hatchery smolts.

The first three items are largely part of the natural environmental conditions present in the basin, although they can be altered dramatically by such things as dam releases, irrigation withdrawals, and climate change. These items are inherently difficult for fisheries managers to address. However, the choice of juvenile stocking locations is well within the jurisdiction of fisheries managers to change or modify for the benefit of a given stock. Within the Okanogan River Basin, more effort should be given toward developing locally-adapted summer steelhead broodstocks and stocking into tributary habitats that provide the most suitable environmental and rearing conditions. Years such as 2006, 2008 and 2009 clearly show how low tributary discharge can dramatically alter spawning locations and reduce the number of summer steelhead utilizing tributary streams, especially when coupled with a later than normal runoff of the mainstem Okanogan River. Habitat alterations at the mouths of key spawning tributaries can help, provided sufficient discharge is available for adult steelhead to migrate.

In 2009, mainstem redd distributions were highest in the upstream reaches of the Okanogan River and lower section of the Similkameen River, where high quality spawning gravels are common and hatchery releases are focused. Other high density spawning areas included the island section near Tonasket, and near McAlister Rapids, where braided channels and increased water velocities maintain clean gravels (1 to 3 inch) preferred by summer steelhead (Smith 1973). Most steelhead redds were observed near Chinook spawning areas or redd mounds or near mid-channel islands. Future habitat improvement efforts should focus on providing and sustaining more sites that support a gravel substrate along the mainstem Okanogan River and in close proximity to a cold water refugia to improve egg to fry production for summer steelhead.

Water availability in the Okanogan River Basin was below normal in 2009, and much of the snow runoff in the lower elevations occurred prior to steelhead spawning. Many of the small tributaries were either inaccessible due to the low elevation of the Okanogan River or had insufficient discharge for upstream migration of adult steelhead; therefore, many steelhead selected spawning locations along the mainstem Okanogan and Similkameen Rivers.

Spring spawner data collected over the last four years clearly show that redd surveys are possible and can be enhanced by using underwater video, traps, tags, and marks. However, hatchery activities that do not mark all fish in an easily identifiable way make origin analysis difficult. It is difficult to determine if increasing trends in wild fish are a result of more wild fish production or fewer summer steelhead being marked with an adipose clip. Evaluation of natural production would be enhanced in the future by ensuring that all hatchery summer steelhead are marked by the removal of the adipose fin. Another alternative would be to clip the adipose fin on most and PIT tagging those that are not clipped and expanding the number of PIT tag arrays available for tag interrogation within the Okanogan River Basin. Baseline information for spawning habitat distribution, spawn timing, and spawner escapement have been determined, but additional years of data are necessary to refine this information and will allow for future trend analysis.

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Revision 1

After completion of the 2009 Okanogan Basin Steelhead Redd Surveys Report, a corruption in a GPS file was discovered which subsequently changed the number of redds reported in the preliminary version of this report. In order to ensure accurate reporting of steelhead escapement estimates, a revision was conducted.

Specific changes from the original document include:

Pg. 4 – Updated number of redds for the mainstem Okanogan River and total escapement estimates
Pg. 16 – Reorganized redd distribution for reach 07 for April 20 and May 4, 2009, as well as total redd count for reach 07
Pg. 17 – Updated survey map for reach 07
Pg. 32 – Escapement estimate adjusted to reflect updated numbers
Pg. 33 – OBMEP wild summer steelhead escapement ranges adjusted
Pg. 34 – Table updated to reflect changes in reach 07, subtotal, and grand total numbers
Pg. 35 – Table 9 and Figure 19 updated
Pg. 36 – Table 10 and Figure 20 updated