Colville Tribes, Fish & Wildlife Department

2012 Okanogan Basin Steelhead Escapement and Spawning Distribution

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Executive Summary

Summer steelhead (*Oncorhynchus mykiss*) spawning distribution and abundance estimates were determined throughout the Okanogan Subbasin in 2012 using redd surveys, adult weir traps, PIT tag detections, and underwater video enumeration. We estimated that 2,799 summer steelhead spawned in the Okanogan River Subbasin, 324 of those were likely of natural origin. Escapement estimates continued to show that adult wild steelhead abundance was below recovery targets. Due to an unusually high water year with prolonged high flows and turbid water that limited visibility, many mainstem redd surveys missed the peak and the later portion of spawning. Therefore, we used previous years' data, including the proportion of the run spawning in each mainstem reach, to synthesize an estimated escapement for mainstem reaches. Steelhead spawning estimates for tributaries to the Okanogan River were more straightforward, primarily due to multiple data collection methods, including PIT tag detections, underwater video observation, and successful on-the-ground redd surveys. From 2010 through 2012, fisheries regulations required the harvest of all steelhead with clipped adipose fins, which may have contributed to higher percentages of ad-present spawners than had been documented in previous years. Across all years' surveys, the highest density of steelhead redds have been documented in the lower extent of the Similkameen River and in the downstream vicinity of Zosel Dam on the Okanogan River. Annual collection of steelhead spawning data continues to provide a comprehensive depiction of spawning distribution and minimum escapement within the Okanogan River Subbasin. We also provide a synthesis of the past eight years of steelhead spawning data in the Okanogan Basin, including trend analysis.

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Introduction

Summer steelhead (*Oncorhynchus mykiss*) are listed as threatened in the Upper Columbia Evolutionarily Significant Unit (ESU) under the Endangered Species Act (ESA). To recover this ESU requires that all four populations (Wenatchee, Methow, Entitat, and Okanogan) meet minimum adult abundance thresholds, have positive population growth rates, and each population must be widely distributed within respective basins (UCSRB 2007). Within the Okanogan River Subbasin, the Okanogan Basin Monitoring and Evaluation Program (OBMEP) monitors adult abundance attributes. Since 2004, OBMEP developed protocols derived from the Upper Columbia Strategy (Hillman 2004) that called for a complete census of all spawning. Preliminary methodologies for implementing redd surveys were developed in 2005 (Arterburn et al. 2004) and these methods were later revised in 2007 (Arterburn et al. 2007c).

In addition to redd surveys, adult weir traps, PIT tag arrays, and underwater video counting were combined to improve escapement estimates, reduce project costs, and coordinate with other on-going data collection efforts. Weir traps have been operated on Omak Creek since 2001 and Bonaparte Creek since 2006. These weir traps provided supplemental biological data, such as length, weight, sex, mark/tags, origin, and age that are also used to evaluate adult steelhead returns. Underwater video enumeration has allowed adult steelhead to be counted at fixed locations, such as Zosel Dam since 2006, and Ninemile, Antoine, and Salmon Creek since 2008. In cooperation with the Washington Department of Fish and Wildlife (WDFW), we expanded the use of PIT tag arrays, which are primarily used to monitor adult summer steelhead use of small tributaries to the Okanogan River.

This document builds upon knowledge and information gained from preceding years' surveys. An extensive literature review of historic spawning information related to the Okanogan River Subbasin can be found in Arterburn et al. (2005). Previous years' data and reports can be accessed at: www.cctobmep.com. A census of all mainstem habitats was conducted within the U.S. in 2005 and identified several large areas that contained no redds due to unsuitable spawning habitat. Eliminating these areas from future surveys reduced program costs, and it is assumed there was minimal loss of relevant data. Recommendations from the 2005 surveys helped define the actual reaches that would be surveyed from 2006 through 2012.

Methods

The Okanogan River flows from the northern headwaters near Vernon, BC to the confluence with the Columbia River near Brewster, WA (Figure 1). We conducted counts of all summer steelhead spawning downstream of anadromous fish migration barriers in the mainstem and all accessible tributaries of the Okanogan and Similkameen River drainages within the United States (Arterburn et al. 2007a, Walsh and Long 2006). Adult weir traps, PIT tag arrays, and underwater video enumeration were used at locations where habitat was extensive or difficult for surveys to be performed on foot. Redd surveys were used to cover all remaining spawning habitat.

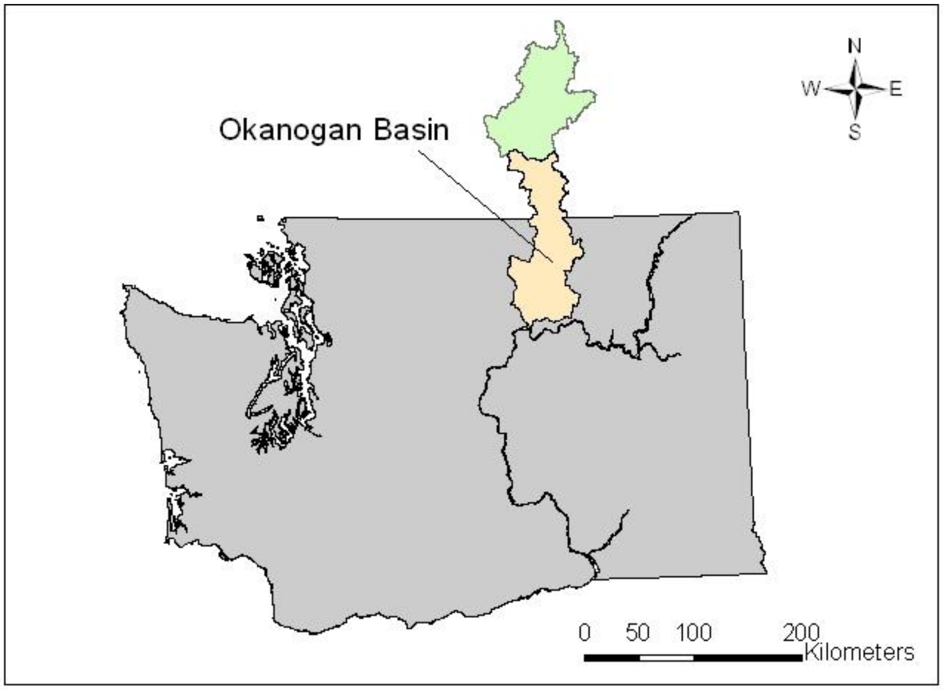

Figure 1. The extent of historic and current habitat in the Okanogan River Basin accessible to anadromous fish.

For weir traps, protocols were developed for the collection of locally adapted broodstock (Dasher 2011). The semi-permanent Omak Creek weir trap was located approximately 1.6 kilometers upstream of the confluence with the Okanogan River. At the trap, fish species were identified, weighed (g) and measured (mm) , sexed, observed for marks, scanned for tags and biosamples were taken as needed for DNA analysis and aging. After handling, fish were placed upstream of the weir, taken for broodstock, or relocated downstream. The Bonaparte Creek temporary picket weir trap was installed seasonally since 2006; however, it was not operated in 2012.

Underwater video data were collected following procedures as described in Nash (2007). Video counting was conducted at Zosel Dam, where continuous data (24 hours per day, 7 days per week) have been collected since 2006. Seasonal video systems were installed in Ninemile and Antoine Creeks, near their confluence with the Okanogan River. A seasonal video monitoring station was also installed in Salmon Creek, at the Okanogan Irrigation District's diversion at river kilometer (RKM) 7.2. Above this point, most of the land is privately owned and access for a complete redd survey has been unattainable.

Summer steelhead were enumerated in all remaining spawning habitats following the OBMEP redd survey protocol (Arterburn et al. 2007c). The area of the Okanogan River downstream from Chiliwist Creek is inundated by the Columbia River (Wells Pool/Lake Pateros). Consequently, this lower reach (~23 km) of the Okanogan River was excluded from surveys because it lacks appropriate velocity and substrate needed for summer steelhead to spawn. Designated mainstem and tributary survey reaches are listed in Table 1. The Okanogan River was divided into seven survey reaches based on access points. The Similkameen River was surveyed as two reaches. We used discharge data, air and water temperature, and local knowledge of fish movements collected from previous years to determine when to begin surveys on the mainstem. 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 10' Skookum ®Steelheader model catarafts (Redman, Oregon). Small tributaries were surveyed on foot, walking in an upstream direction.

Geographic positions of redds were collected with a Trimble GeoExplorer XT GPS unit and downloaded into GPS Pathfinder® after each survey. The GIS data were reviewed and differentially corrected. To avoid recounting, redds were marked by flagging tied to bushes or trees adjacent to the area where they 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.

Aerial redd surveys on the mainstem were conducted for the first time in 2012 to assess their accuracy and feasibility of augmenting or replacing ground surveys. The mainstem Okanogan is a broad, shallow river with low gradient and very good water clarity prior to spring runoff. Aerial redd surveys can be an effective way to enumerate redds, and it is an efficient way to cover long distances that would take much longer to cover on the ground by raft or on foot. Aerial surveys of the mainstem took place on March 23 and April 5, prior to the spring freshet. During surveys, a fixed wing aircraft with two observers flew the entire extent of the mainstem river at low altitudes to document spawning. Two reaches were not included in aerial redd counts: the reach directly below Zosel dam, due to the impractical nature of counting high density of redds, and the Similkameen canyon section.

Table 1. Designated Okanogan River redd survey reaches used by OBMEP in 2012.

Redd Survey Reach	Location and Description	Reach Length (km)
Similkameen - S1/S2	Similkameen/Okanogan Confluence (0) to Enloe Dam (14.6)	14.6
Okanogan - O1	Okanogan River south Loup Loup Creek (26.7) to Salmon Creek (41.4)	14.7
Okanogan - O2	Okanogan River at Salmon Creek (41.4) to the office (52.3)	10.9
Okanogan - O3	Okanogan River at the office (52.3) to Riverside (66.1)	13.8
Okanogan - O4	Okanogan River at Riverside (66.1) to Janis Bridge (84.6)	18.5
Okanogan - O5	Okanogan River at Janis Bridge (84.6) to Tonasket Park (91.4)	6.8
Okanogan - O6	Okanogan River at Horseshoe Lake (112.4) to confluence with Similkameen River (119.5)	7.1
Okanogan - O7	Okanogan River at confluence (119.5) to Zosel Dam (127.0)	7.5
Tunk Creek	Tunk Creek at Okanogan River confluence (0) to high water mark (0.2)	0.2
Bonaparte Creek	Bonaparte Creek/Okanogan River confluence (0) to Bonaparte Falls (1.6)	1.6
Ninemile Creek	Ninemile Creek from Okanogan River confluence (0) to video weir (0.7)	0.7
Tonasket Creek	Tonasket Creek/Okanogan River confluence (0) to Tonasket Falls (3.5)	3.5
Antoine Creek	Antoine Creek/Okanogan River confluence (0) to video weir (1.3)	1.3
Loup Loup Creek	Loup Loup Creek/Okanogan River confluence to Loup Loup Creek diversion (2.3)	2.3
Wild Horse Sp Creek	Wild Horse Spring Creek/Okanogan River Confluence to barrier (1.1)	1.1
Omak Creek	Omak Creek/Okanogan River Confluence (0) to Omak Creek trap site (2.0)	2.0
Salmon Creek	Salmon Creek confluence with the Okanogan (0) to OID diversion (7.2)	7.2

We employed the method currently used by Washington Department of Fish and Wildlife (WDFW) in the Upper Columbia basin to extrapolate escapement estimates from redd counts using the sex ratio of broodstock collected randomly over the run at Wells Dam (Andrew Murdoch, WDFW, pers. comm.). For example, if the sex ratio of a random sample of the run was 1.5:1.0 male to female, the expansion factor for the run would be 2.5 fish per redd (FPR). All escapement calculations using sex ratio multipliers assume that each female will produce only one redd. This method is used for all supplemented stocks within the Upper Columbia River Basin.

Sex ratio data were used to provide an estimate of total spawner escapement for the population, tributary, and mainstem reaches. Sex ratio was determined by counting and sexing a sample of adult steelhead at Wells Dam, as well as all fish collected at the Omak weir trap. 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 all mainstem survey reaches and the sex ratio from the Omak Creek trap was applied to tributaries to the Okanogan River. Total redd estimates, in combination with counts at video sites, were summed to estimate total escapement within sub-watersheds.

Permanent and temporary PIT tag arrays were operated on many of the tributaries to the Okanogan in 2012. Population estimates derived from PIT tag detections were calculated following Murdoch et al. 2011. A random representative sample of steelhead were captured at Priest Rapids Dam, two days per week over the course of the run, from July through November. A proportion of fish, approximately 13.1%, were tagged and released above Priest Rapids Dam. The mark rate was used to expand the number of detections into escapement estimates for tributaries with PIT tag arrays. For example, if three hatchery and two wild steelhead were detected at a given creek, the escapement estimate would be 23 hatchery and 15 wild steelhead, calculated from the mark rates at Priest Rapids. Based on the relatively few numbers of detections at most locations, particularly for small tributaries, escapement estimates derived from PIT tag detections may be highly variable and should be considered a general estimate. In addition to fish tagged at Priest Rapids, steelhead may have also received PIT tags at other locations (as out-migrating juveniles, adults returning to Bonneville Dam, Wells Dam, among others); however, sampling at those locations were not consistent across the run. Therefore, any extrapolation from detections to an escapement estimate was derived only from the Priest Rapids release group. Detections from fish tagged at other locations may be mentioned anecdotally in this report.

The estimates for main stem survey reaches were derived from the total run escapement estimates generated by WDFW at Well's Dam and past habitat utilization patterns documented from redd surveys. Due to high spring runoff that lasted longer than usual, it was not possible to conduct redd surveys on the mainstem for the last part of the run. Therefore, estimates for individual main stem reaches were derived by multiplying the average proportion of the total run each reach contained in previous years (2005-2011) by the total run estimate generated by WDFW (Table 4).

Table 2 has been provided below to outline habitat capacity, delisting, and recovery goals for steelhead in the Okanogan Basin, based on our current knowledge of the system. Table 3 is a modified version of Table 2, which was adjusted to remove currently inaccessible habitat or streams that may not be currently contributing to recovery of steelhead.

Table 2. Capacity, delisting, and recovery goals for steelhead in the Okanogan basin. Five-hundred wild steelhead are required for NOAA's delisting.

Diagnostic Units / Spawning Areas	Length (m)	Bank full area (m²)	Weighted Intrinsic Potential Area (m²)	Proportion of IP in each DU within the U.S.	Proportional contribution to minimum recovery threshold (IP% * 500)	CCT spawner recovery goals	Spawner capacity from IP
Salmon Creek	26,090	311,434	247,580	23.5%	117	200	495
Similkameen River	14,206	724,470	171,281	16.2%	81	100	343
Omak Creek (Lower)	9,002	112,008	106,198	10.1%	50	100	212
Antoine Creek	18,997	154,099	105,534	10.0%	50	100	211
Johnson Creek	16,160	112,304	45,498	4.3%	22	100	91
Ninemile Creek	8,402	59,235	39,496	3.7%	19	50	79
Loup Loup Creek	3,401	27,686	23,229	2.2%	11	50	46
Okanogan River	125,595	8,170,205	19,550	1.9%	9	40	39
Bonaparte Creek	1,600	19,359	19,359	1.8%	9	30	39
Omak Creek (Upper)	34,812	267,960	234,738	22.2%	111	300	469
Tonasket Creek	3,401	27,545	18,226	1.7%	9	10	36
Tunk Creek	1,200	9,963	6,643	0.6%	3	10	13
Wild Horse Spring Creek	1,200	8,280	5,520	0.5%	3	10	11
Siwash Creek	2,801	20,724	4,946	0.5%	2	10	10
Aeneas Creek	1,000	6,902	4,601	0.4%	2	10	9
Wanacut Creek	1,801	9,722	2,320	0.2%	1	5	5
Chiliwist Creek	600	4,140	998	0.1%	0	0	2
Total	270,268	10,046,036	1,055,717	100%	500	1,125	2,111

Table 3. Capacity, delisting, and recovery goals for steelhead in the Okanogan basin, *modified* to remove currently inaccessible habitat and ephemeral streams, which likely are not currently adding to recovery. Values for delisting criteria were reapportioned to the remaining systems.

Diagnostic Units / Spawning Areas	Length (m)	Bank full area (m²)	Weighted Intrinsic Potential Area (m²)	Proportion of IP in each DU within the U.S.	Proportional contribution to minimum recovery threshold (IP% * 500)	CCT spawner recovery goals	Spawner capacity from IP
Salmon Creek	26,090	311,434	247,580	31.8%	159	200	495
Similkameen River	14,206	724,470	171,281	22.0%	110	100	343
Omak Creek (Lower)	9,002	112,008	106,198	13.7%	68	100	212
Antoine Creek	18,997	154,099	105,534	13.6%	68	100	211
Johnson Creek	16,160	112,304	45,498	5.9%	29	100	91
Ninemile Creek	8,402	59,235	39,496	5.1%	25	50	79
Loup Loup Creek	3,401	27,686	23,229	3.0%	15	50	46
Okanogan River	125,595	8,170,205	19,550	2.5%	13	40	39
Bonaparte Creek	1,600	19,359	19,359	2.5%	12	30	39
Total	223,453	9,690,800	777,725	100%	500	770	1,555

Results and Discussion

Sex Ratio

A sample of 669 summer steelhead, including 309 males (275 hatchery, 34 wild) and 360 females (300 hatchery, 60 wild), were sexed at Wells Dam in 2011 by Washington Department of Fish and Wildlife personnel (Charles Frady, WDFW, pers. comm.). Adjusted proportionally for the run, the WDFW calculated a sex ratio of 0.87 males per female or 1.87 FPR. This value was used to expand redd counts on the mainstem Okanogan River into escapement estimates.

In 2012, 158 summer steelhead were captured and handled at the Omak Creek trap. A ratio of 2.93 males for each female (117 males; 40 females) was observed, yielding 3.93 FPR. The Bonaparte Creek trap was not operated in 2012, and therefore, a sex ratio was not determined for this location.

Percent-Wild

The WDFW estimated that the proportion of wild fish bound for the Okanogan River was 261 out of a total of 2,784 steelhead, or 9.4% (Charles Frady, WDFW, pers. comm). This value was based on ad-present steelhead counts, PIT tags, coded wire tags, scale analysis, harvest, broodstock collection, and stray rates estimated at Wells Dam. The wild percentage was applied to all mainstem Okanogan River expanded redd counts in order to estimate the number of wild spawners at those locations.

The percent of wild summer steelhead that returned to the Omak Creek weir trap was determined by the presence of an intact adipose fin, PIT tag information, and/or coded wire tag. The percent of natural origin steelhead handled at the Omak Creek weir was 13.3% (21 out of 158 total fish). Video weirs were used on three tributaries and the mainstem Okanogan near the Washington-British Columbia border. In previous years, a percent-wild value was calculated from observations of passing steelhead at each of these locations. Due to above average discharge and high turbidity, the video systems were only able to record observations of steelhead, but it was not always possible to determine sex or origin due to the quality of image. Therefore, it was concluded that data were unreliable to determine an accurate percent wild estimates at those locations.

Okanogan and Similkameen River Mainstem

Redd surveys were largely unsuccessful at documenting the spawning activity of steelhead in mainstem reaches in 2012. Due to an earlier than usual onset of high runoff in the Okanogan and Similkameen Rivers (Figure 2), only two early surveys could be completed on most mainstem reaches. Flows dramatically increased from a mean daily average of 2,450 cfs to 12,500 cfs in a matter of days. Flows remained high through the end of July, when spawning had long since concluded and steelhead redds were indistinguishable. Although an unknown number of redds were missed in each reach, any redds documented during ground or aerial surveys are included in Appendix A. Assuming that the ratio of spawning remained analogous to previous year's surveys, spawner escapement estimates for 2012 were calculated by combining data from past OBMEP redd survey distributions and Wells Dam count estimates generated by WDFW. The proportion of spawning that occurred in each reach (2005-2011) was multiplied by the WDFW escapement estimate for the Okanogan Basin in 2012. The estimated numbers of spawners for mainstem reaches are provided in Table 4.

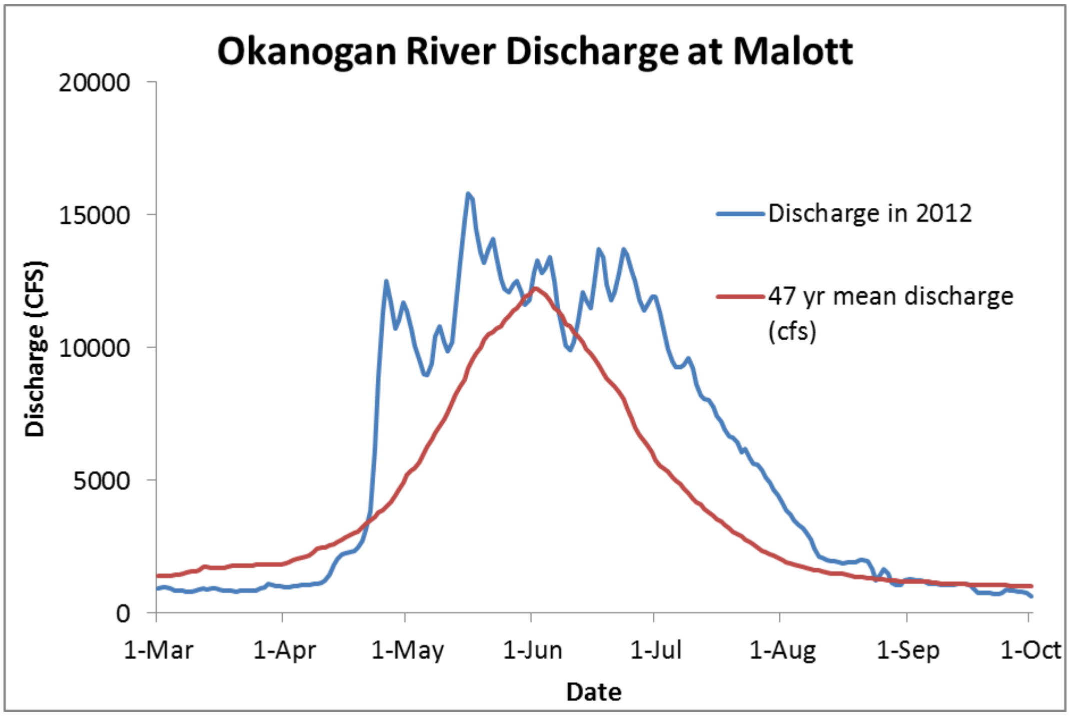

Figure 2. Discharge at USGS gauge 12447200 at Malott, WA on the mainstem Okanogan River. Warm temperatures causing rapid snow melt in the mountains coincided with large precipitation events that caused the rapid spike in flow in late April.

Table 4. Okanogan and Similkameen River adult steelhead spawner estimates for 2012, showing past year's average returns to each diagnostic unit and the representative proportion to the total average return. The total number of spawners in those habitats were derived by multiplying the historic average proportion in each reach by the WDFW estimate of 2,784 adult steelhead for 2012.

Mainstem survey reaches	Avg # spawners, 2005-2011	Proportion by reach	Estimated spawners, 2012
OK River 1 (Chiliwist Cr to Salmon Cr)	16	0.009	26
OK River 2 (Salmon Cr to Omak Cr)	58	0.033	93
OK River 3 (Omak Cr to Riverside)	12	0.007	19
OK River 4 (Riverside to Janis Bridge)	49	0.028	78
OK River 5 (Janis Bridge to Siwash Cr)	78	0.045	125
OK River 6 (Horseshoe lake to Confluence)	20	0.012	33
OK River 7 (Confluence to Zosel Dam)	501	0.289	805
Sim River 1 (Confluence to Oroville)	169	0.098	272
Sim River 2 (Oroville Plant to Enloe Dam)	128	0.074	205
Total	**1,031**	**0.595**	**1,656**

Mainstem River Trend Analysis

Trend graphs through the period 2005-2012 have been appended to this report in Appendix B. Figure 3 represents the cumulative total of all mainstem river spawning habitats since OBMEP began collecting steelhead spawning data. Trends across all mainstem river diagnostic unit reaches located in the United States portion of the Okanogan River 33% had an upward trend, 11% had a downward trend, and 56% had no trend or remained stable between 2005 and 2012.

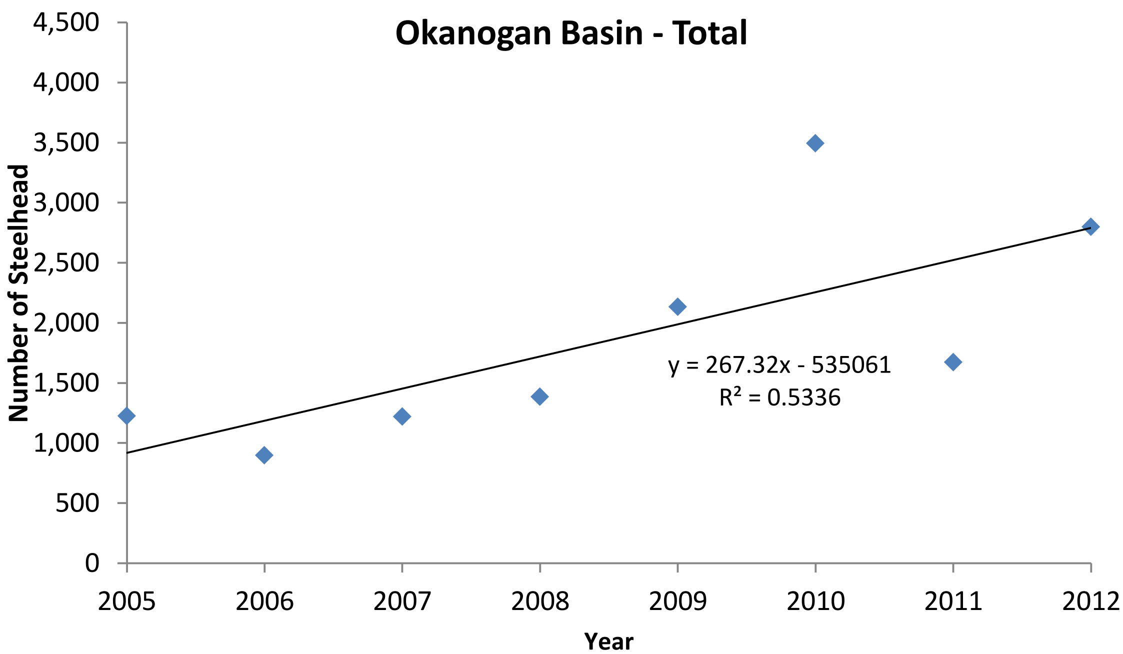

Figure 3. The trend for total summer steelhead returns to all mainstem river spawning habitats located with the Okanogan River Basin between 2005 and 2012.

Tributary Redd Surveys in the Okanogan River Subbasin

Tributary redd surveys were considered more successful at documenting locations of spawning steelhead when compared to the mainstem in 2012. Survey efforts on tributaries were occasionally limited by localized high water events from snow melt and precipitation. Some tributaries were successfully surveyed across the entire spawning period, while others were not surveyed at times when visibility remained poor. Steelhead redd surveys within tributary habitats were conducted from March 31 through July 5. 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). Above-normal precipitation (Table 3) and discharge (Figure 4) in 2012 allowed adult steelhead to access many of the small tributaries which are frequently inaccessible due to low flows or dry creek beds. However, increased flows frequently resulted in reduced water clarity, which at times, limited the effectiveness of redd surveys on many small tributaries.

Table 5. Precipitation totals measured by the National Weather Service at the Omak airport for March, April, and May. http://www.nws.noaa.gov/climate/index.php

Month	Avg Precip (1981-2010)	2012	2011	2010	2009	2008	2007	2006
March	0.89	1.87	2.72	0.52	0.93	0.73	0.08	0.81
April	0.91	1.16	0.23	1.21	0.19	0.19	0.06	0.89
May	1.18	0.53	2.96	3.05	1.23	0.18	0.74	1.35
Total	2.98	3.56	5.91	4.78	2.35	1.10	0.88	3.05

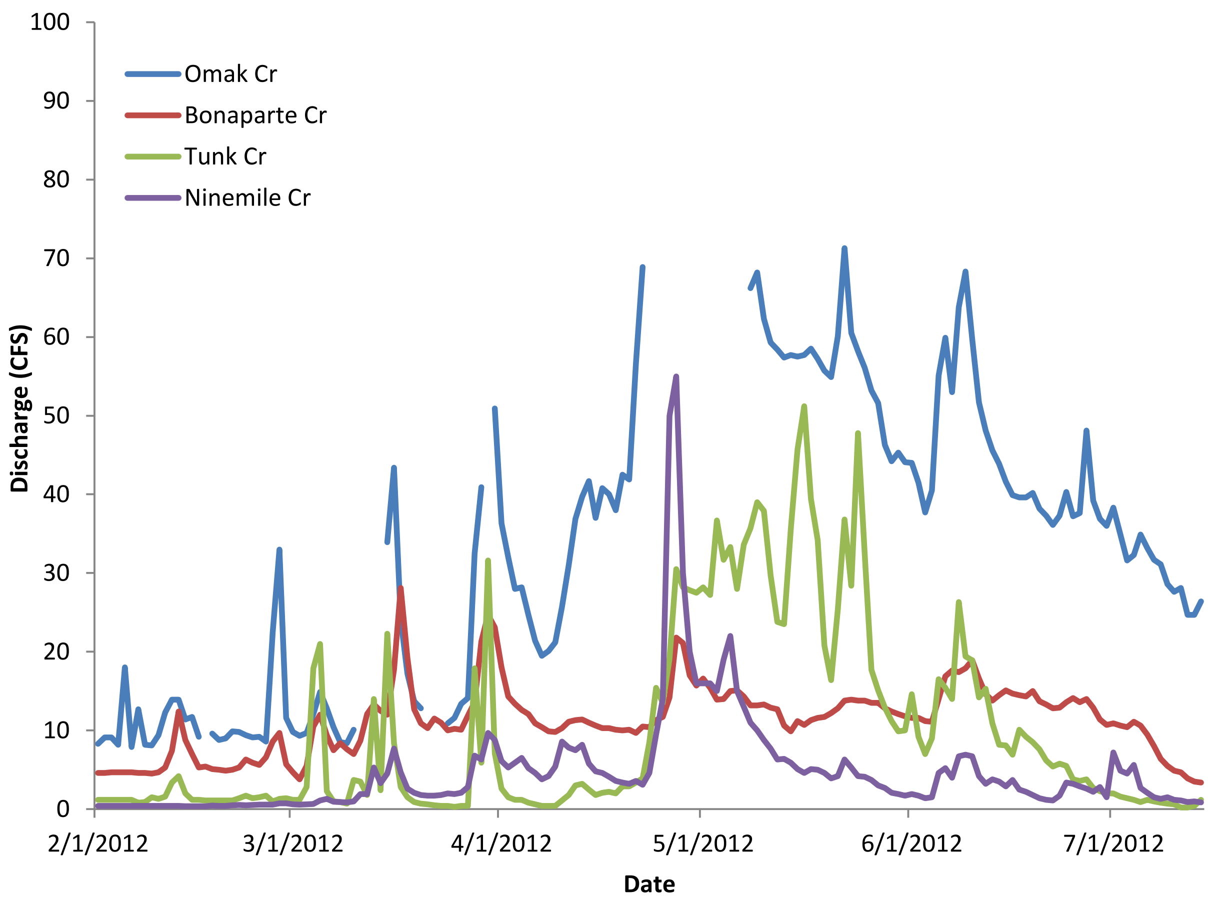

Figure 4. Discharge from February through July of 2012 for four tributary streams known to produce summer steelhead in the Okanogan Basin. Data were obtained from the USGS and WA Department of Ecology.

Loup Loup Creek

A history of low stream flows at the mouth of Loup Loup Creek has restricted anadromous adult steelhead access in previous years, primarily due to an impediment (culvert) located at river kilometer (RKM) 0.2. However, adequate flows have allowed steelhead access into Loup Loup Creek and passage above the culvert in 2010 and 2011. Steelhead entering the creek in 2012 faced no impediment due to the culvert being replaced with a bottomless arch structure in the fall of 2011. Redd surveys were attempted at intervals no greater than every 2 weeks. A total of 15 redds were observed during the period from May 5th to May 29th (Figure 6). The redds were expanded to 8 wild and 51 hatchery steelhead, based on 3.93 FPR and 13.3% wild rate captured at the Omak weir trap. The 8-year average percent wild for Loup Loup Creek is 6%, which remains below the basin tributary average of 21.4%.

PIT tag data were also used to develop a local escapement estimate, independent of redd surveys. Two wild and nine hatchery PIT tagged steelhead were detected at the seasonal PIT tag array located at the mouth of Loup Loup Creek. Based on the adult summer steelhead tagging program at Priest Rapids Dam, a random sample of all steelhead were pit tagged representing 13.1% of the upper Columbia ESU population. By PIT-tag expansion, we estimated 61 hatchery and 8 wild steelhead returned to Loup Loup Creek in 2012. Because redd estimates are frequently biased low, the PIT tag estimate is likely more representative of the true number of steelhead returning to Loup Loup Creek in 2012. The wild estimates using both methods were identical. A total return of 69 summer steelhead is well above the 8-year average of 30 for this stream (Figure 5). Trend analysis for Loup Loup Creek can be found in Appendix B.

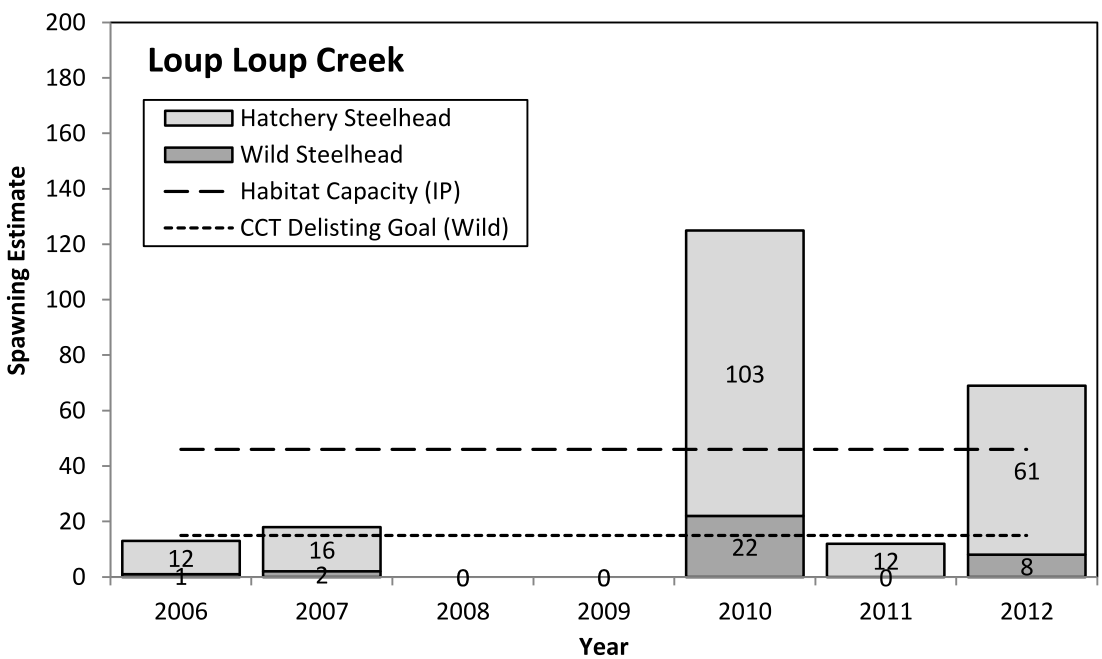

Figure 5. Spawning estimates for Loup Loup Creek from 2006-2012.

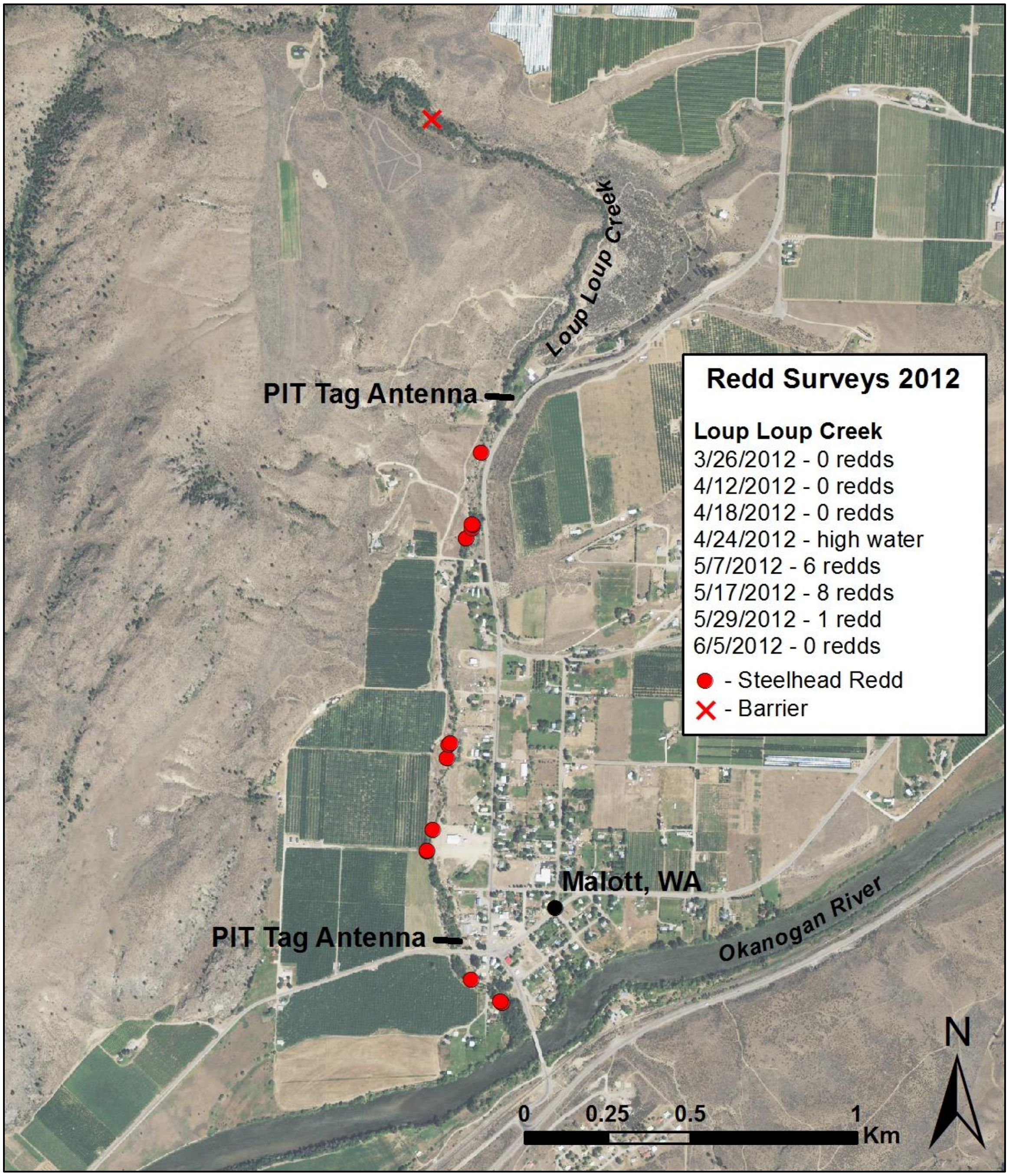

Figure 6. Map of summer steelhead redds observed in Loup Loup Creek, from the confluence with the Okanogan River to the irrigation diversion (upper PIT tag antenna), during the spring of 2012.

Salmon Creek

Since the early 1900's, the majority of water from Salmon Creek had been diverted for irrigation usage. The resulting dry stream channel extended from the Okanogan Irrigation District (OID) diversion dam (7.2 km) to the confluence with the Okanogan River. Occasionally, uncontrolled spills occurred downstream of the OID diversion dam in high water years. These spills typically occurred in mid-May to June, which is after summer steelhead have already moved into tributaries to spawn. In order to provide sufficient water during the migration window of spring-spawning steelhead, the Colville Tribes purchased water from the OID and allowed it to flow down the channel to the Okanogan River. After several years of successful evaluations of steelhead passage, the Tribes negotiated a long term water lease agreement with the OID. Since 2006, the long term water lease has provided small window of water for returning adults and out-migrating juvenile salmonids.

In 2012, water was again provided for a migration window, primarily for summer steelhead (Chris Fisher, Colville Tribes, pers. comm.). The potential for adult steelhead to access Salmon Creek from the mainstem Okanogan began in late March. Additionally, above average precipitation in 2012 significantly increased the amount of runoff that came down Salmon Creek in late April through June (Figure 7).

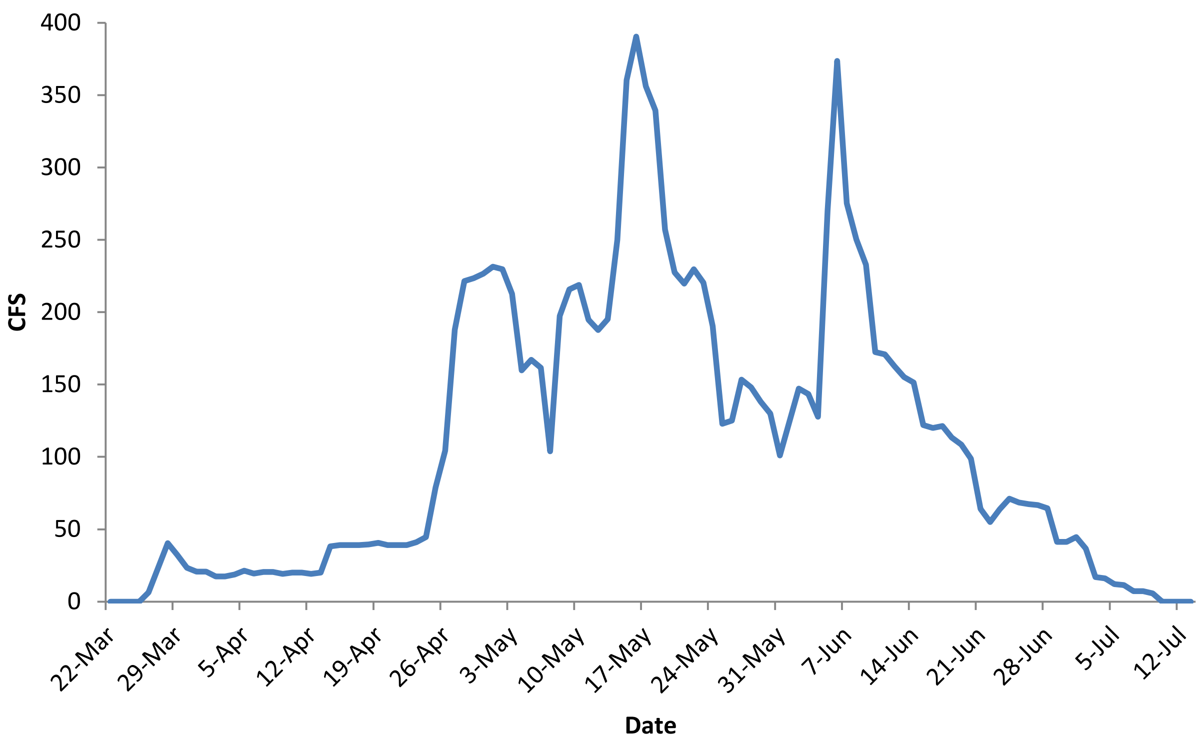

Figure 7. Salmon Creek discharge in 2012.

A specialized motion detection underwater video apparatus was installed into the fish ladder of the OID diversion dam in 2012. The first steelhead was seen on April 1 and the final fish was counted the first week of June. Due to the sustained high discharge rates occurring in 2012, water spilled over a concrete wall adjacent to the fish-ways at the diversion site. When this occurred, it was possible for steelhead to pass upstream of the diversion without passing through the video array by jumping over the wall, especially during nighttime hours. A total of 68 hatchery and 17 adipose present adult steelhead (20.0% wild) were observed passing upstream through the video system (Table 6, Figure 8). An additional nine fish passed upstream and the origin could not be determined because the adipose fin was obscured. Two of the nine unknown origin fish were estimated to have been wild, based on the 20.0% observed wild rate.

Salmon Creek was surveyed for redds on April 11 and April 24. A total of 17 steelhead redds were documented in the lower 7.2 km of Salmon Creek (Figure 10). Surveys could not be conducted after this date due to sustained high discharge rates until July. At that date, any previously constructed redds were unidentifiable. Using a FPR value of 3.93 (from Omak Creek) rendered 67 spawners expanded from redd counts below the diversion. The 20.0% ad-present rate (observed in the video weir) was applied to downstream redd counts, which rendered 32 ad-present steelhead spawning between the confluence with the Okanogan River and the diversion site. The combined estimate of 161 spawners from redd surveys and video observations should be considered a minimum escapement estimate, due to high water and incomplete surveys in 2012.

Two wild, 30 hatchery, and one unknown origin steelhead were detected at the PIT tag array on Salmon Creek above the city of Okanogan. The calculated escapement estimate from tags from Priest Rapids Dam release group (25) was 191 total steelhead (Table 8). The percentage wild using PIT-tag detection would be 10%. However, the observed video estimate was 20%, so an average of 15% was used to calculate an estimated 29 wild steelhead. No redds were found downstream of the PIT-tag array.

Table 6. Steelhead observed passing the Salmon Creek video weir.

Direction	Adipose Present	Adipose Clipped	Unknown Origin	Total
Upstream	17	68	9	94
Downstream	12	25	9	46

Table 7. Spring Chinook observed passing the Salmon Creek video weir.

Direction	Adipose Present	Adipose Clipped	Unknown Origin	Total
Upstream	3	0	1	4
Downstream	1	0	0	1

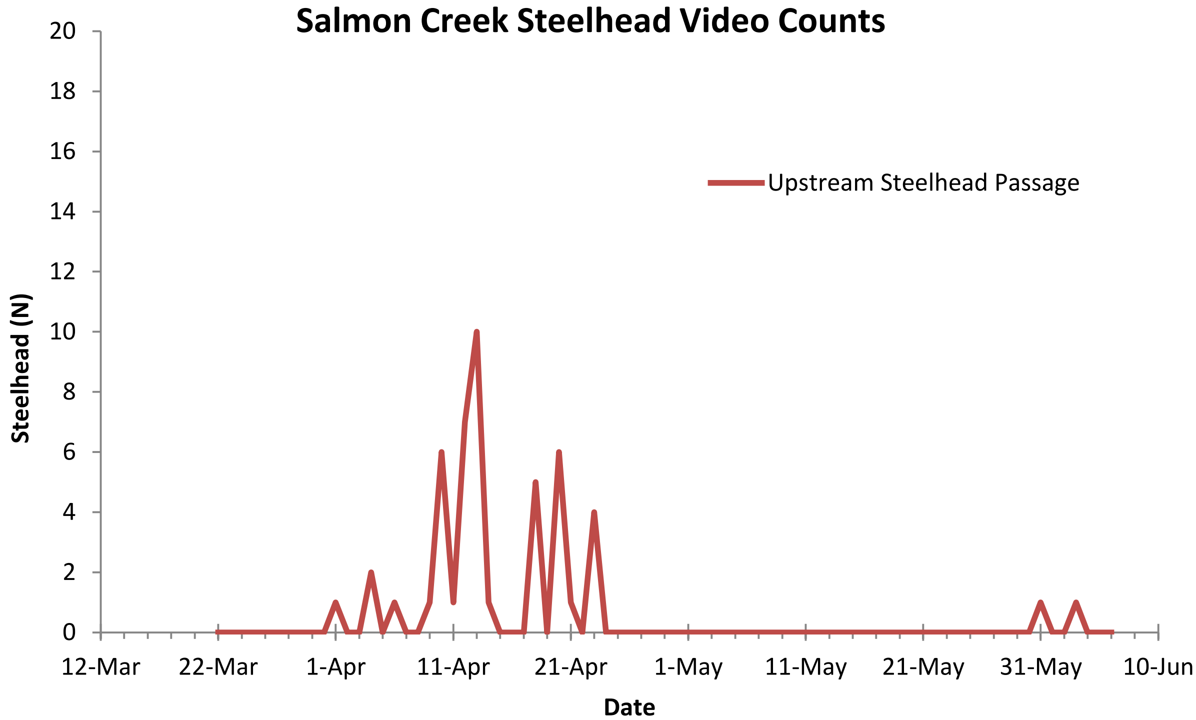

Figure 8. Steelhead observed passing the Salmon Creek video weir during the spring of 2012.

Table 8. Two methods for calculating escapement estimates in Salmon Creek. (A) Video counts at the OID diversion and redd surveys conducted below the diversion and (B) expansion based on PIT tag detections.

A. Redd surveys and video count, Salmon Creek

	Documented # of Redds	Estimated Total # Spawners	Estimated # Wild
Below Diversion (Redd surveys)	17	67	13
Above Diversion (Video monitoring)	Surveys not conducted	94	19
Total	n/a	161	32

B. PIT Tag detection estimation, Salmon Creek

	Documented # of Redds	Estimated Total # Spawners	Estimated # Wild
Total	n/a	191	29

Figure 9. Images of male (top) and female (bottom) steelhead observed passing the Salmon Creek underwater video system in April, 2012.

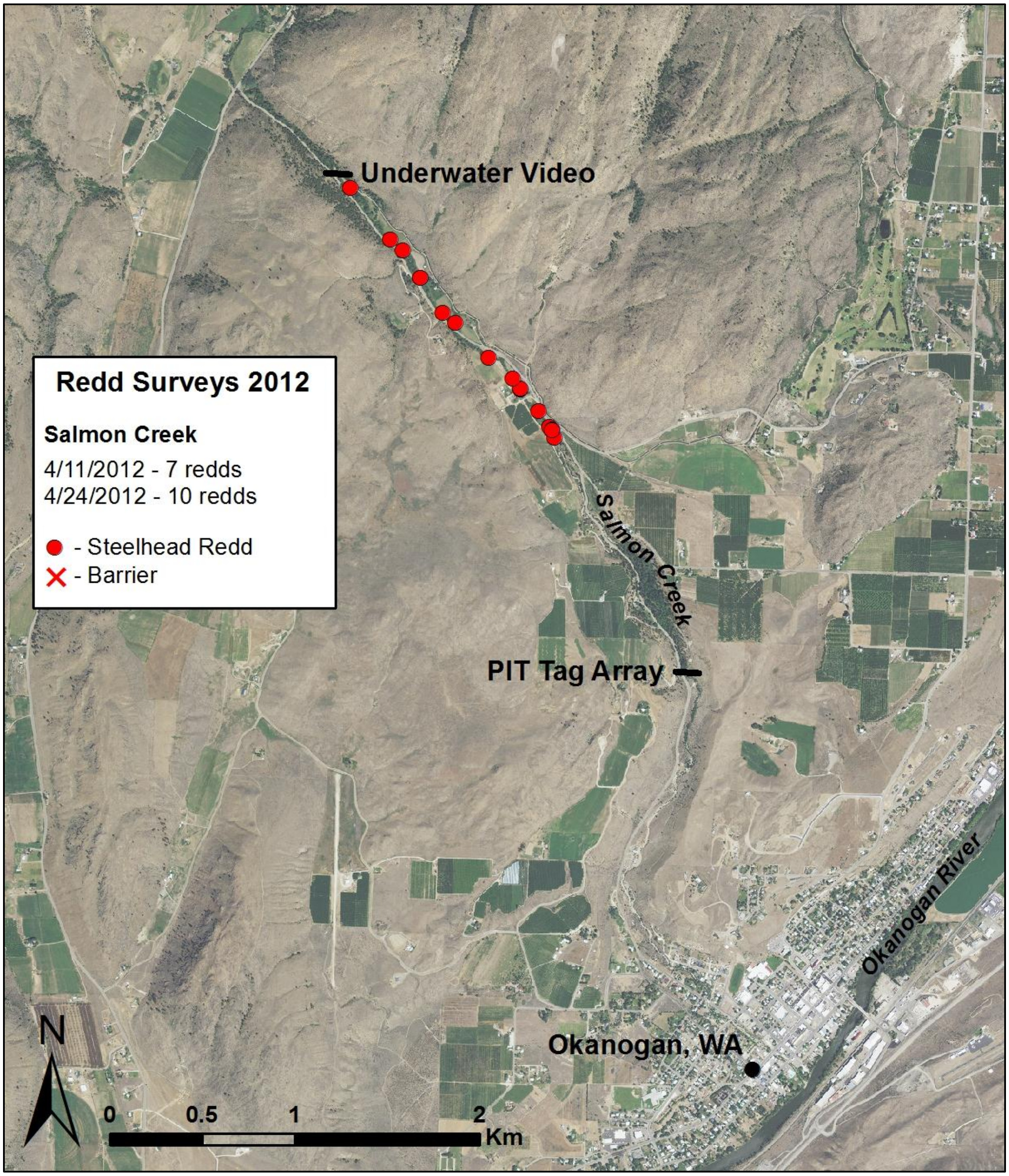

Figure 10. Map of summer steelhead redds observed below the Salmon Creek diversion during the spring of 2012.

Using the multiple analysis approach found in Table 2, the Colville Tribes have established the number of adult steelhead spawners that can be sustained within the available habitat (unpublished data). The goal for salmon Creek is set at 200 summer steelhead. Through 2012, the vast majority of return adults were of hatchery origin, due to the habitat being largely disconnected to the Okanogan River for over 80 years. Now that steelhead have had an opportunity to seed the habitat, the number of wild returning adults should increase in future years.

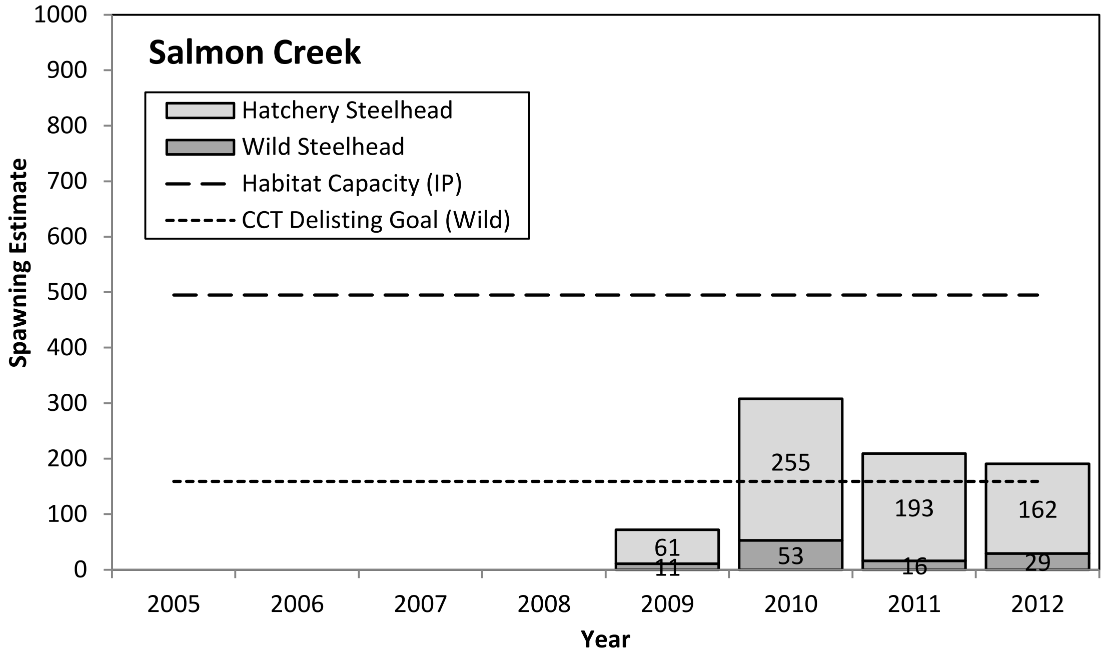

Figure 11. Spawning estimates for Salmon Creek from 2009-2012.

Omak Creek

A total of 158 unique steelhead were captured at the Omak Creek weir in 2012 (Table 9). A 13.3% wild rate was calculated from the 21 wild and 137 hatchery steelhead handled and released upstream of the trap. Forty female and 117 male steelhead were sexed, rendering a sex ratio of 2.93 M:F (3.93 FPR) for Omak Creek. The weir was compromised due to high flows from April 21 through May 6 and an unknown number of steelhead may have passed during that timeframe. Complete run timing at the Omak Creek weir was not determined due to unknown capture rates at the weir. Steelhead run timing in Omak Creek from 2005-2011 is presented in Figure 14 for reference.

Redd surveys identified 9 redds below the Omak Creek weir trap (Figure 15). Two surveys were conducted prior to high flows, at which point, surveys were unfeasible until July. Those redds were expanded to 30 hatchery and five wild steelhead from FPR and percent wild values derived at the weir. Based on combined redd surveys and weir counts, the escapement estimate was 193 adult steelhead for in Omak Creek in 2012.

A permanent PIT tag array was located on Omak Creek, just upstream from the confluence with the Okanogan River, but below the adult weir trap. A total of 41 steelhead from the Priest Rapids Dam release group were detected, resulting in an estimate of 313 summer steelhead returning to Omak Creek (Table 9). Using the percent of wild detected at the weir indicates that 42 of the total steelhead return were likely of natural origin. No steelhead redds were observed below the PIT tag array.

Table 9. Two methods for calculating escapement estimates in Omak Creek. (A) Weir counts and redd surveys below the weir and (B) expansion based on PIT tag detections.

A. Redd survey and adult weir count, Omak Creek

	Documented # of Redds	Estimated Total # Spawners	Estimated # Wild
Below Weir (Redd surveys)	9	35	5
Above Weir	Surveys not conducted	158	21
Total	n/a	193	26

B. PIT Tag detection estimation, Omak Creek

	Documented # of Redds	Estimated Total # Spawners	Estimated # Wild
Total	n/a	313	42

The trends for wild steelhead in Omak Creek increased by 15 fish per year (see Omak Creek, Appendix B). This was the fastest rate of any habitat in the Okanogan River basin. The habitat below the falls is nearly fully seeded, primarily with hatchery spawners (Figure 12), and the number of hatchery fish released is currently being reduced to avoid negative impacts on wild production. Projects have been implemented to place PIT tags into naturally produced steelhead to further understand the juvenile production component of Omak Creek.

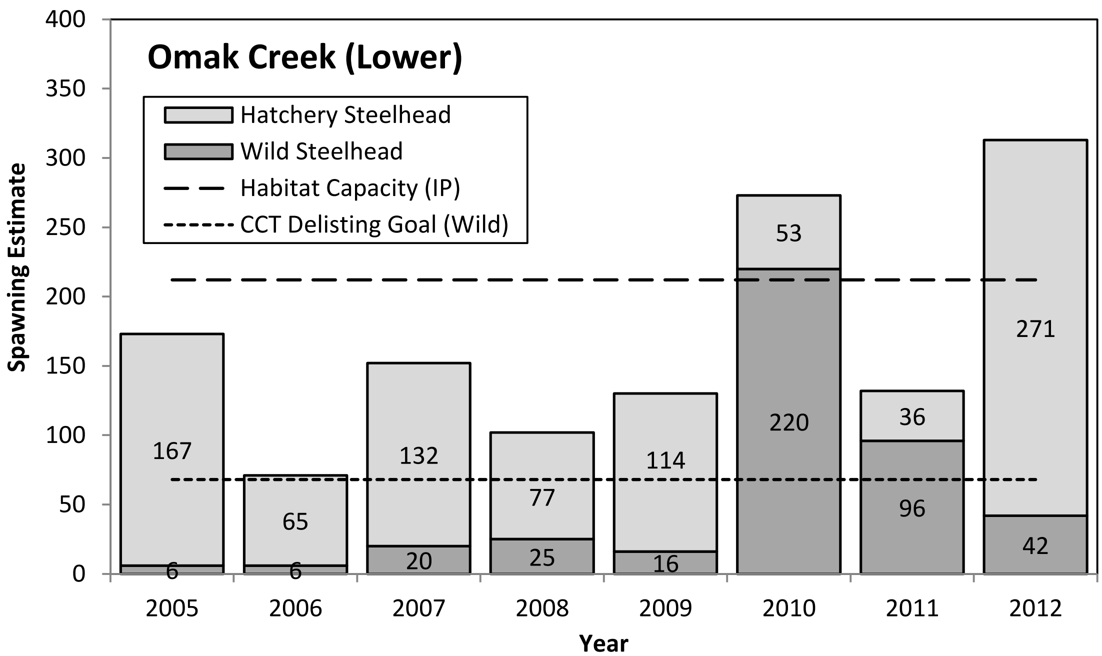

Figure 12. Spawning estimates for Omak Creek from 2005-2012.

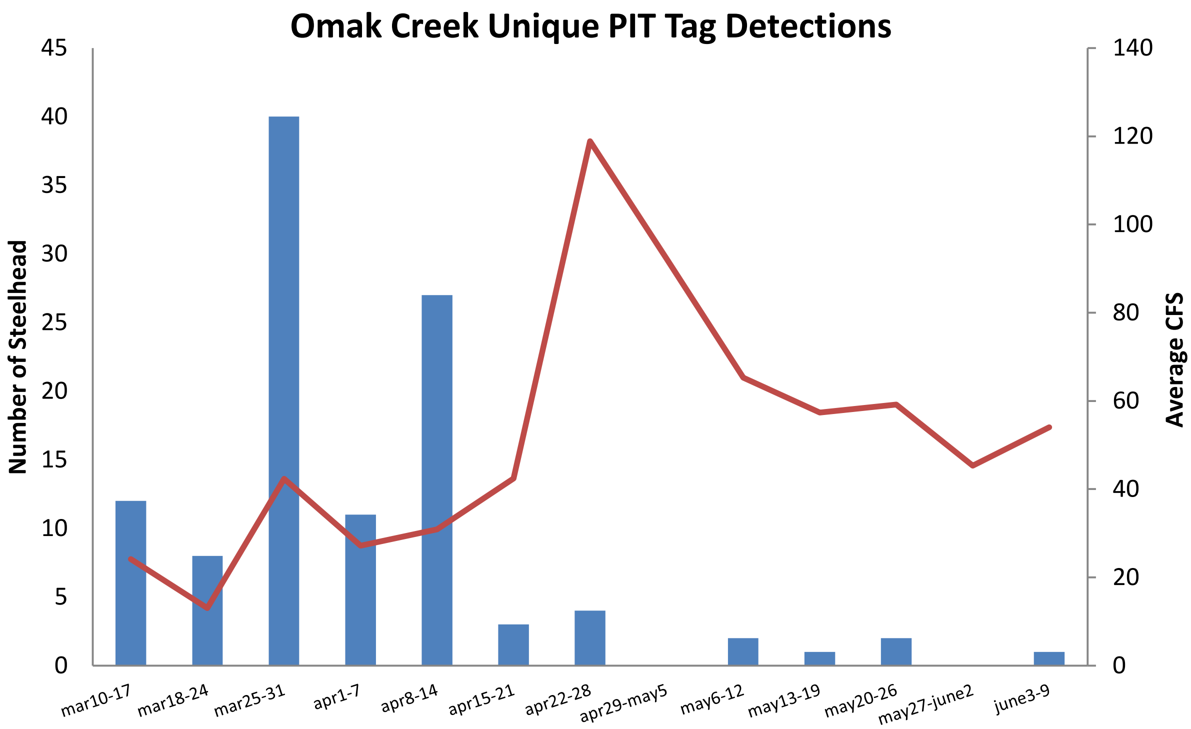

Figure 13. Detections of PIT tagged steelhead in the spring of 2012, near the mouth of Omak Creek (site OMK). Data are presented by first observation per week.

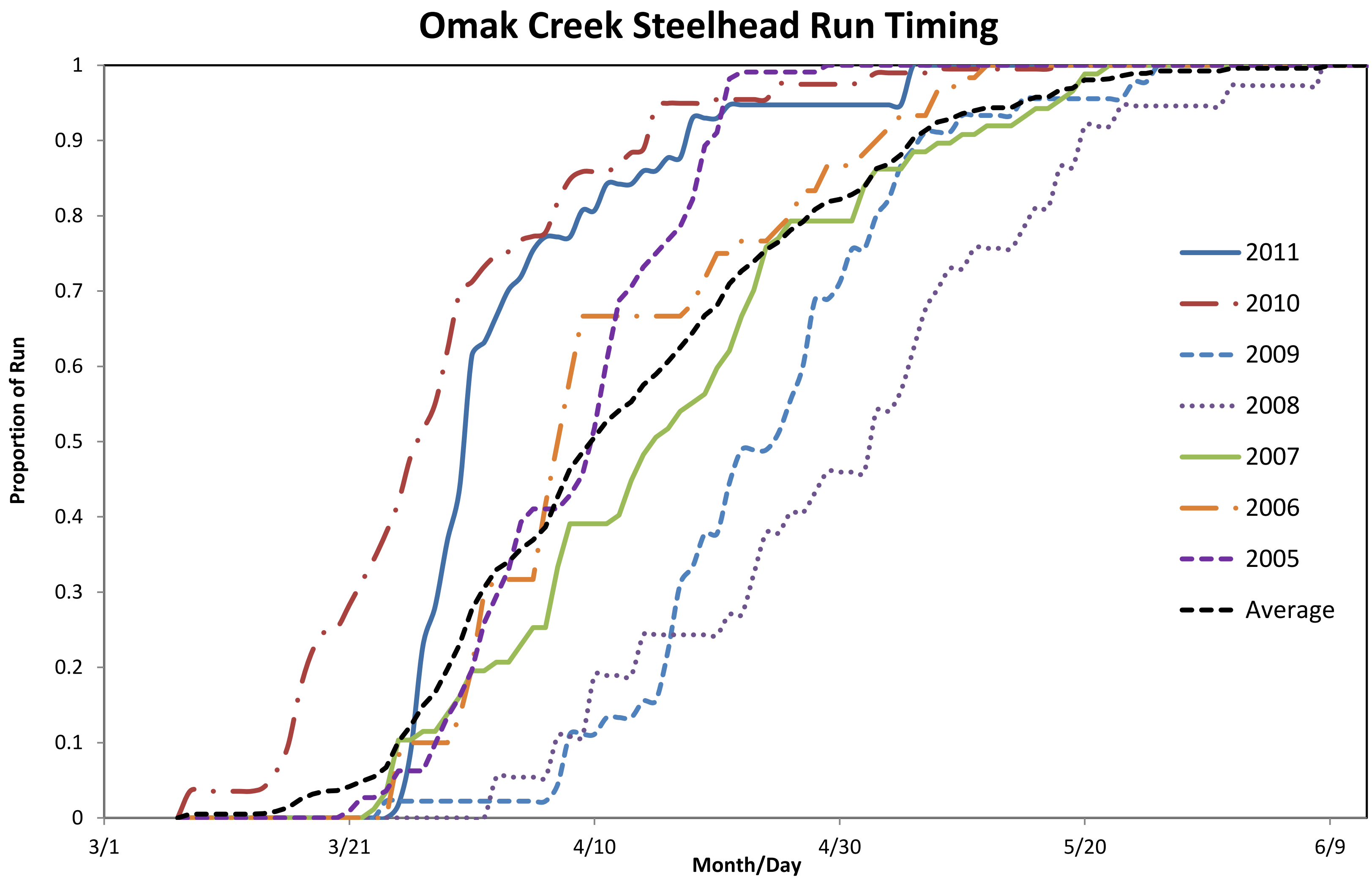

Figure 14. Run timing of summer steelhead captured at the Omak Creek weir trap, 2005-2011. Data from 2012 was omitted due to high water and low capture rates of adult steelhead, which skewed actual timing.

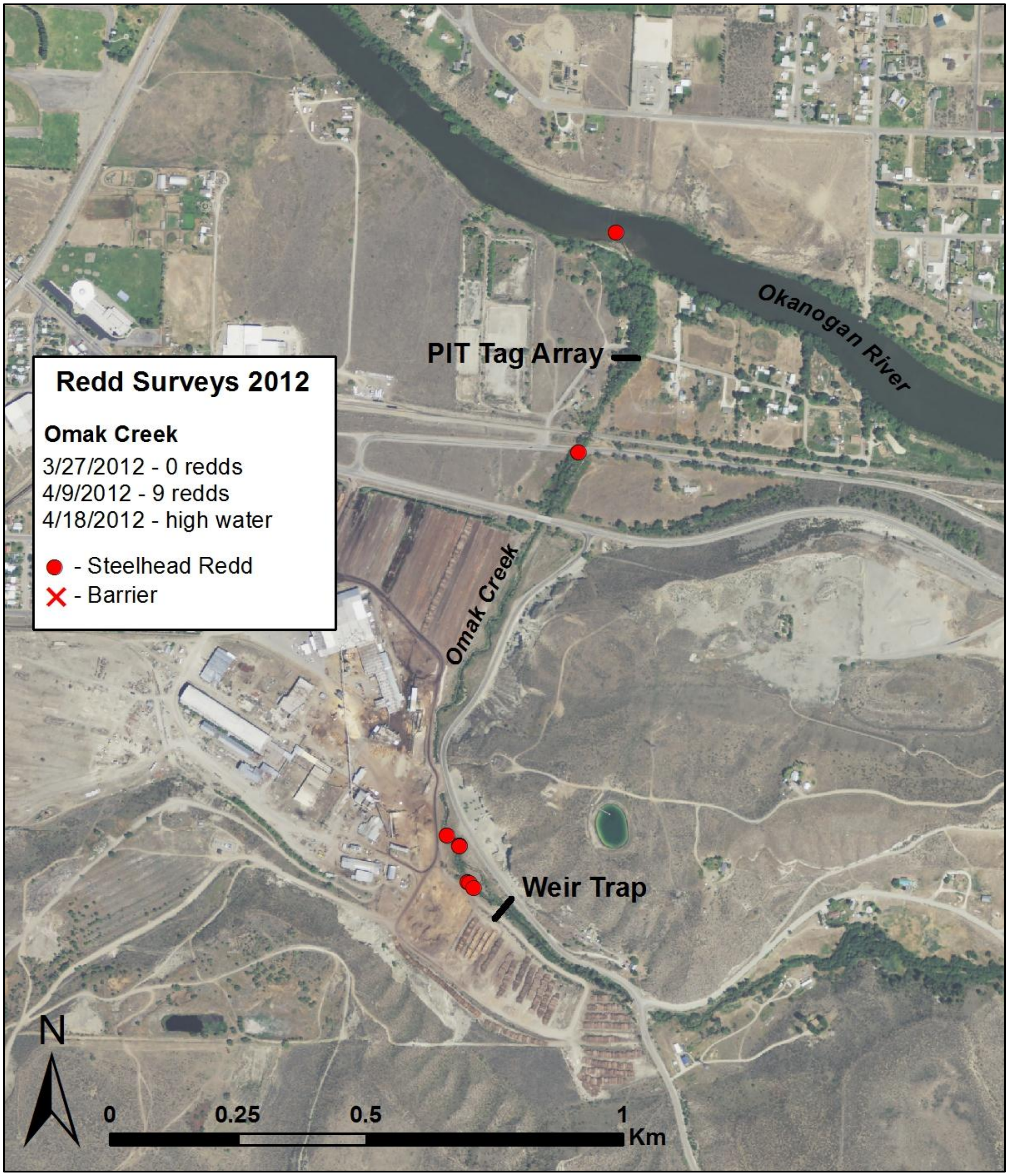

Figure 15. Map of summer steelhead redds observed below the Omak Creek trap during the spring of 2012.

Wanacut Creek

Sufficient flows existed to allow water from Wanacut Creek to reach the Okanogan River in 2012. A total of two redds were documented on May 17 (Figure 16). Due to the fact that Wanacut has been an ephemeral stream in recent years, the most conservative FPR (1.87) and percent wild (9.4%) values were used to expand redd counts. One wild and three hatchery steelhead were expanded from the two observed redds.

One wild and two hatchery steelhead were detected on the seasonal PIT tag array, which was located just upstream of the confluence with the Okanogan. However, only one wild and one hatchery fish were detected from the Priest Rapids adult tag file. The estimated adult spawner return was 8 hatchery and 8 wild fish, which was greater than the estimates from redd surveys. There is question of the accuracy of PIT tag expansion estimates in small streams when small numbers fish were detected. In 2012, the true number of spawners was likely was between 4 and 16, with our best estimate being a total of 12 steelhead (8 hatchery and 4 wild), due to the ephemeral nature of this small system. Redd surveys have been conducted since 2007 in Wanacut Creek; including data from 2012, the average annual number of steelhead spawning in Wanacut creek was two steelhead.

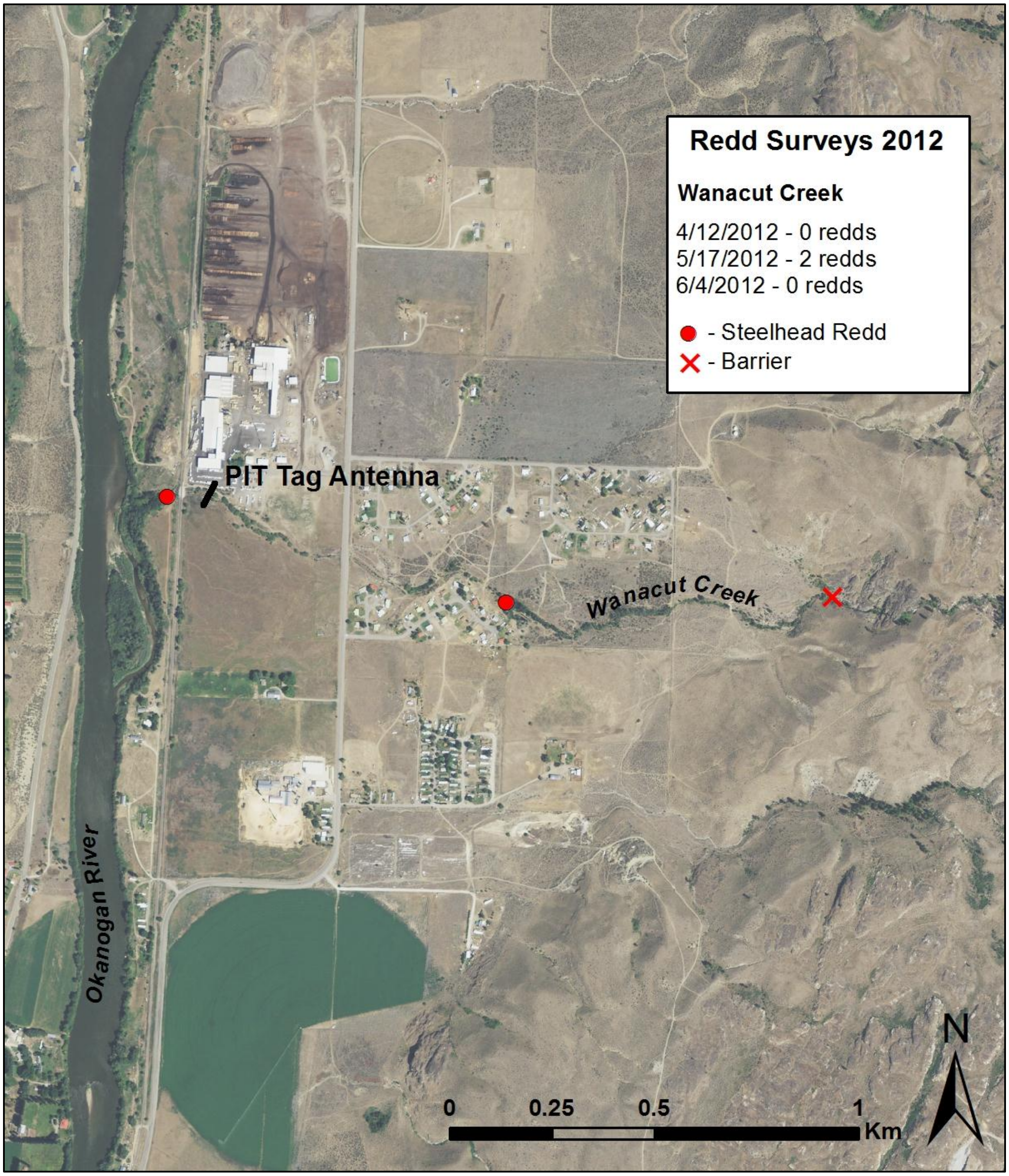

Figure 16. Map of summer steelhead redds observed in Wanacut Creek during the spring of 2012.

Johnson Creek

Steelhead spawning surveys were conducted for the first time in Johnson Creek in 2012. Although the creek does not visually appear to contain appropriate spawning substrate, 14 redds were documented on April 30th, many with steelhead currently on them (Figure 17). Much of the substrate in the creek is comprised of compact clay, sand, embedded cobble, and a few locations containing small pea gravel. On subsequent visits, no new redds were noted and previous redds which were made in fine substrate were indistinguishable. The 14 observed redds were expanded by 1.87 FPR and a 9.4% wild rate to estimate a total number of spawners as 24 hatchery and two wild steelhead.

A seasonal PIT tag antenna was operated near the mouth of the creek. A total of seven PIT tagged steelhead, five of hatchery origin and two of unknown origin, were detected at this location. However, only one hatchery steelhead was detected from the Priest Rapids adult PIT-tag release group. Using the PIT tag expansion would have resulted in an estimate of only eight hatchery steelhead. Given that on multiple visits to Johnson Creek redd survey crews observed between 10 and 20 adult steelhead, we believe that the redd survey estimates more accurately reflect the true number of spawning steelhead in Johnson Creek this year.

A number of potential barriers to adult migration were noted to be present on the creek and most were associated with culverts in the town of Riverside, WA. The spatial location of these features are included in Figure 17. In order for steelhead to pass above the town, they must navigate through five culverts. In 2012, steelhead were seen above the first four, but not above the highway culvert. Just after the highway culvert, there is a large man-made rock weir structure, which may also present a passage obstacle. It is currently unknown what other barriers might exist higher in the watershed. It is unknown what egg to fry survival in this stream might be, although Johnson Creek is a spring fed creek, with summer water temperatures lower than most other systems in the basin. If steelhead could successfully spawn in Johnson Creek, rearing habitat appears to be adequate.

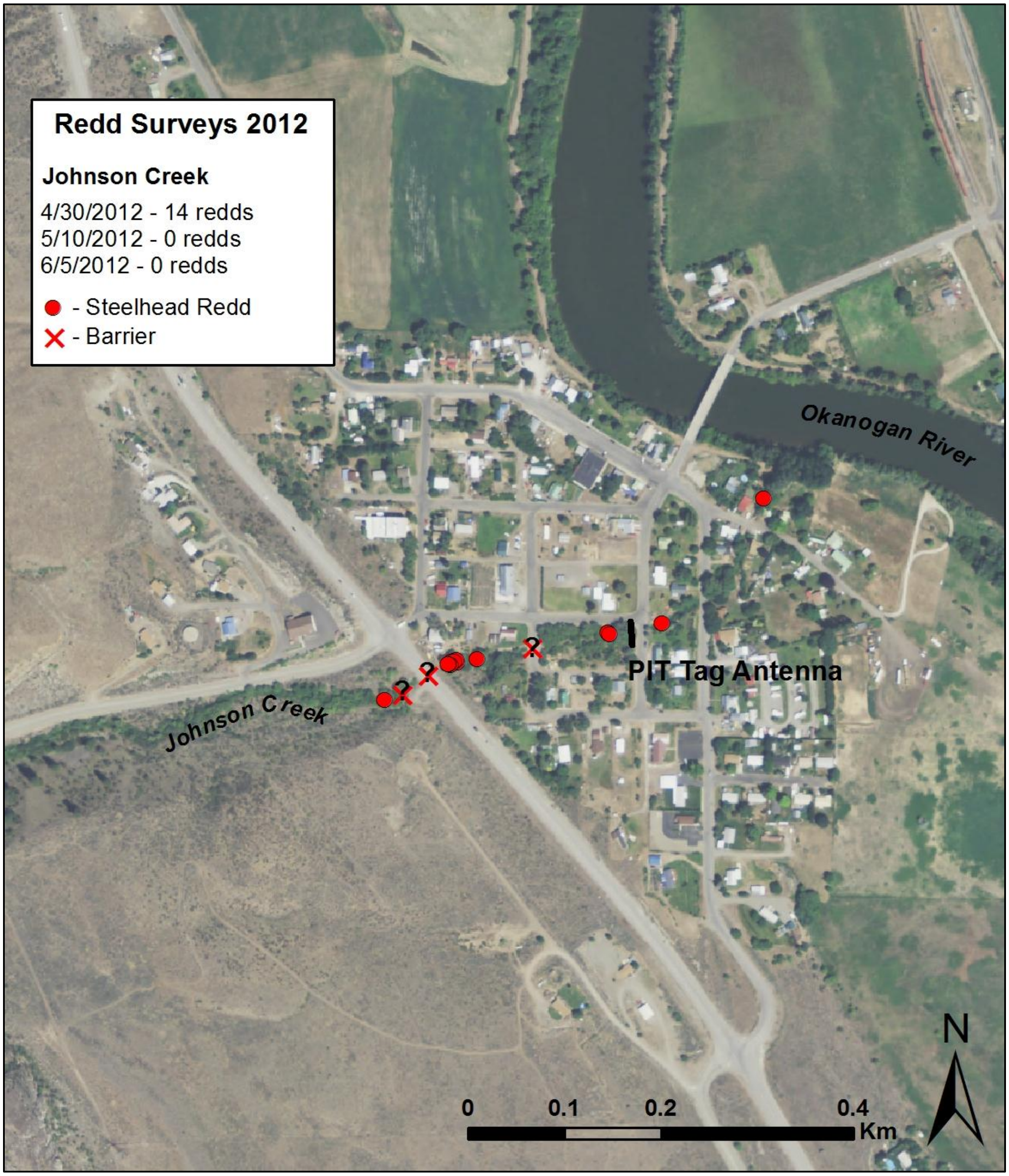

Figure 17. Map of summer steelhead redds observed in Johnson Creek during the spring of 2012.

Tunk Creek

Redd surveys were attempted every two weeks on Tunk Creek, from March 26 to June 21; however, water clarity was only conducive on 4 visits. On May 30, six redds were identified along with another 23 redds on June 21 (Figure 18). Using a value of 3.93 FPR derived from the Omak Creek weir trap, provided a total estimate of 114 steelhead that spawned in Tunk Creek. Using the percent wild derived from Omak Creek (13.3%) the number of natural origin would be 15 steelhead.

A seasonal PIT tag array was installed near the mouth of Tunk Creek in the spring of 2012. A total of 11 steelhead of hatchery origin were detected at this location. Based on the Priest Rapids release group, the calculated spawning escapement would be 84 hatchery origin steelhead and zero of natural origin. Both estimation methods indicate that numerous steelhead spawned in Tunk Creek (84-114). However, the number of natural origin ranges from 0-15 steelhead, depending upon the method used. Redd surveys are known to be biased low and typically the PIT-tag estimate method results are higher. In 2012, redd surveys were delayed until after most of the spawning occurred making it more difficult to get an accurate redd count. Therefore our best total estimate would be 84 steelhead. However, an estimate of zero natural origin steelhead is difficult to hypothesize given the 8 year average for natural origin steelhead in Tunk Creek has been over 17%. Therefore, our best estimate of natural origin steelhead was the median value within the range of possible values (8 steelhead).

During the first few years of data collection, only the lower reach of Tunk Creek was surveyed due to access related restrictions. From 2010 through 2012, the creek was surveyed entirely from the confluence with the Okanogan River up to the anadromous barrier. Therefore, the trend data was reset to 2010 in order to reflect a more accurate view of actual changes in the Tunk Creek watershed (Appendix B). Caution should be taken when identifying trends with only three years of data.

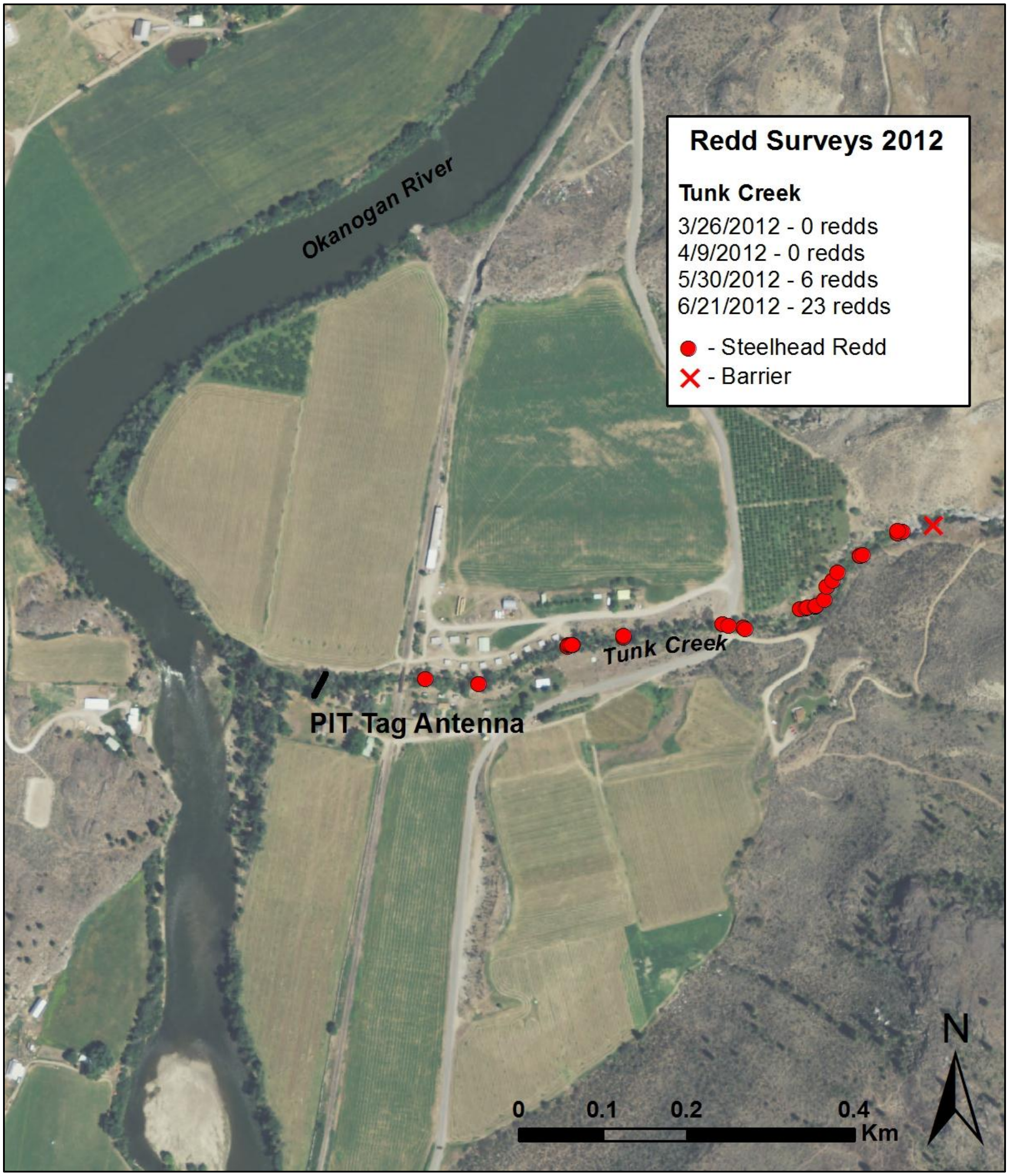

Figure 18. The distribution of redds observed in Tunk Creek during 2012, from the confluence with the Okanogan River upstream to Tunk Falls (anadromous barrier).

Bonaparte Creek

Redd surveys were conducted on April 9 and April 23, which documented 16 steelhead redds (Figure 20). High flows and turbid water prevented surveys after that date. A value of 3.93 FPR derived from the Omak Creek weir trap provided a total estimate of 63 steelhead that spawned in Bonaparte Creek in 2012. Using the percent wild derived from Omak Creek (13.3%), the number of natural origin would be 8 steelhead.

A temporary PIT tag antenna was installed near the mouth of Bonaparte Creek in 2012. The antenna operated throughout the runoff season and documented a total of five wild, 20 hatchery, and two unknown origin steelhead at this location. Based on the Priest Rapids release group, the calculated spawning escapement would be 168 steelhead, of which, 38 would be of natural origin. Due to the fact that redd surveys could only be conducted over a part of the spawning period, the PIT tag estimate was used as our best estimate for 2012.

Escapement estimates for Bonaparte Creek indicate that steelhead commonly exceeded the proportional delisting goal for this system (refer to Table 3). Protecting the existing habitat and flows should be the highest priority in the Bonaparte Creek watershed.

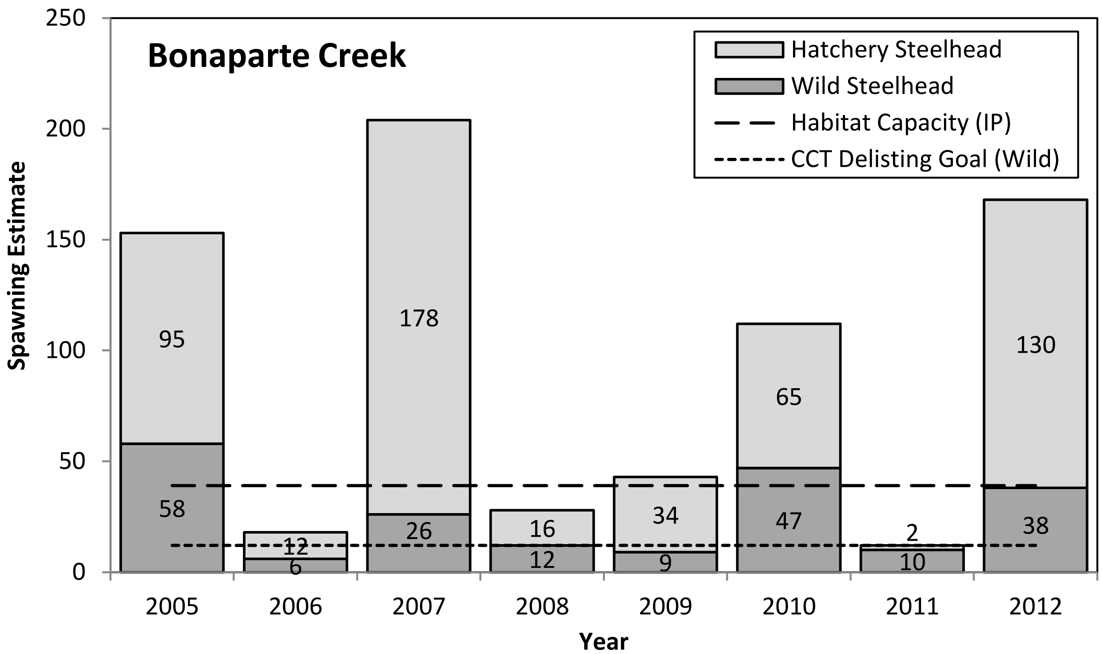

Figure 19. Spawning estimates for Bonaparte Creek from 2005-2012.

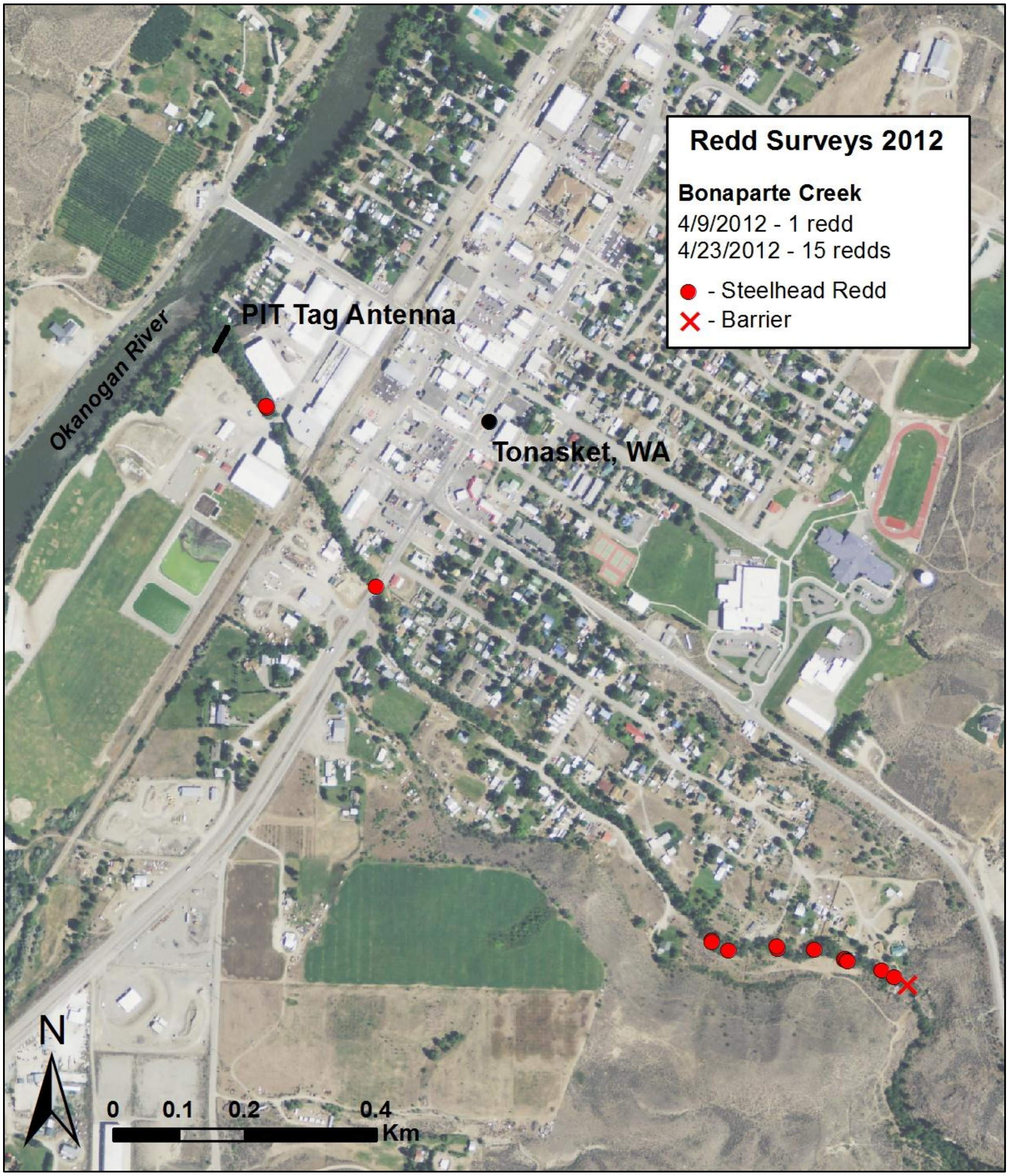

Figure 20. Distribution of redds observed in Bonaparte Creek during 2012, from the confluence with the Okanogan River upstream to the falls (anadromous barrier).

Antoine Creek

A relatively large alluvial fan at the confluence of Antoine Creek and the Okanogan River has made access difficult for returning adult steelhead, except under elevated flows. Discharges in 2012 were sufficient to allow access into the creek. Redd surveys were conducted, but documented no redds between the confluence and the underwater video system (Figure 23). Twenty-nine steelhead (six ad-present, 12 hatchery, and 11 unknown origin) were documented passing upstream through the video box in the spring of 2012 (Table 10, Figure 21). The observed 33.3% wild rate was applied to the unknown origin steelhead for an estimated total of 10 ad-present and 19 hatchery steelhead above the video weir.

A permanent four antenna PIT tag array was installed at the same location as the video box. A total of five hatchery and one unknown origin steelhead were documented in Antoine Creek. Based on the Priest Rapids release group, the calculated spawning escapement would be 31 steelhead, of which eight would be of natural origin (if the one unknown was assumed to be wild). The two methods were closely aligned, validating both approaches.

The trends indicate that very few (average of 5 per year) adult summer steelhead have used Antoine Creek for spawning since 2005 (see Antoine Creek, Appendix B). Habitat improvements have been underway over the last few years. In 2012, the upstream extent of anadromous fish was approximately 1 km upstream of the highway. In 2013, this habitat may expand to approximately 20 km due to passage improvements. The large expanse of newly available habitat could be more rapidly colonized by stocking hatchery steelhead into Antoine Creek for the next several years, until the habitats are fully seeded by returning steelhead from these hatchery stocking efforts.

Table 10. Two methods for calculating escapement estimates in Omak Creek. (A) Weir counts and redd surveys below the weir and (B) expansion based on PIT tag detections.

A. Redd surveys and video counts, Antoine Creek

Direction	Adipose Present	Adipose Clipped	Unknown Origin	Total
Upstream	6	12	11	29
Downstream	3	7	21	31

B. PIT Tag detection estimation, Antoine Creek

	Documented # of Redds	Estimated Total # Spawners	Estimated # Wild
Total	n/a	31	8

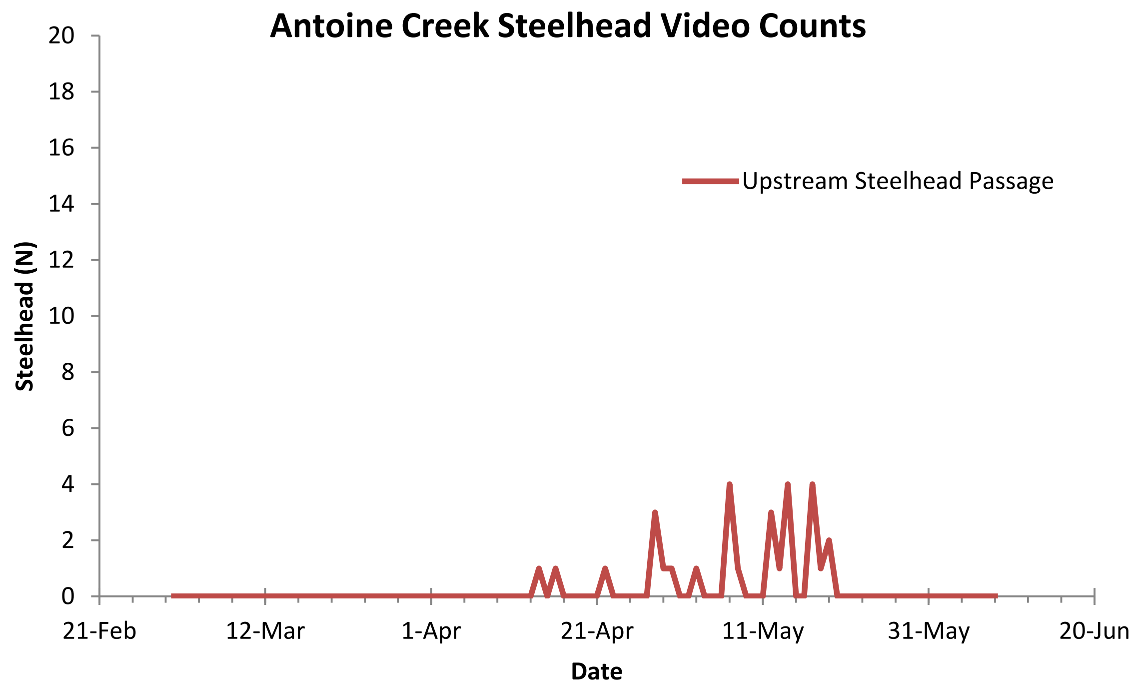

Figure 21. Steelhead observed passing the Antoine Creek video weir during the spring of 2012.

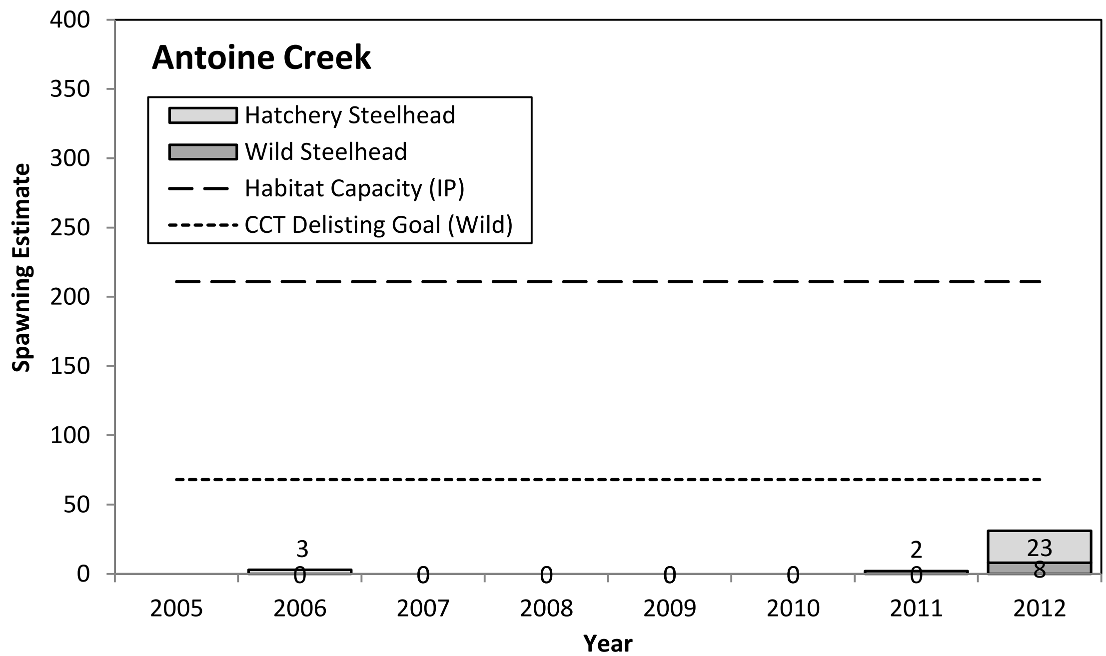

Figure 22. Spawning estimates for Antoine Creek from 2006-2012.

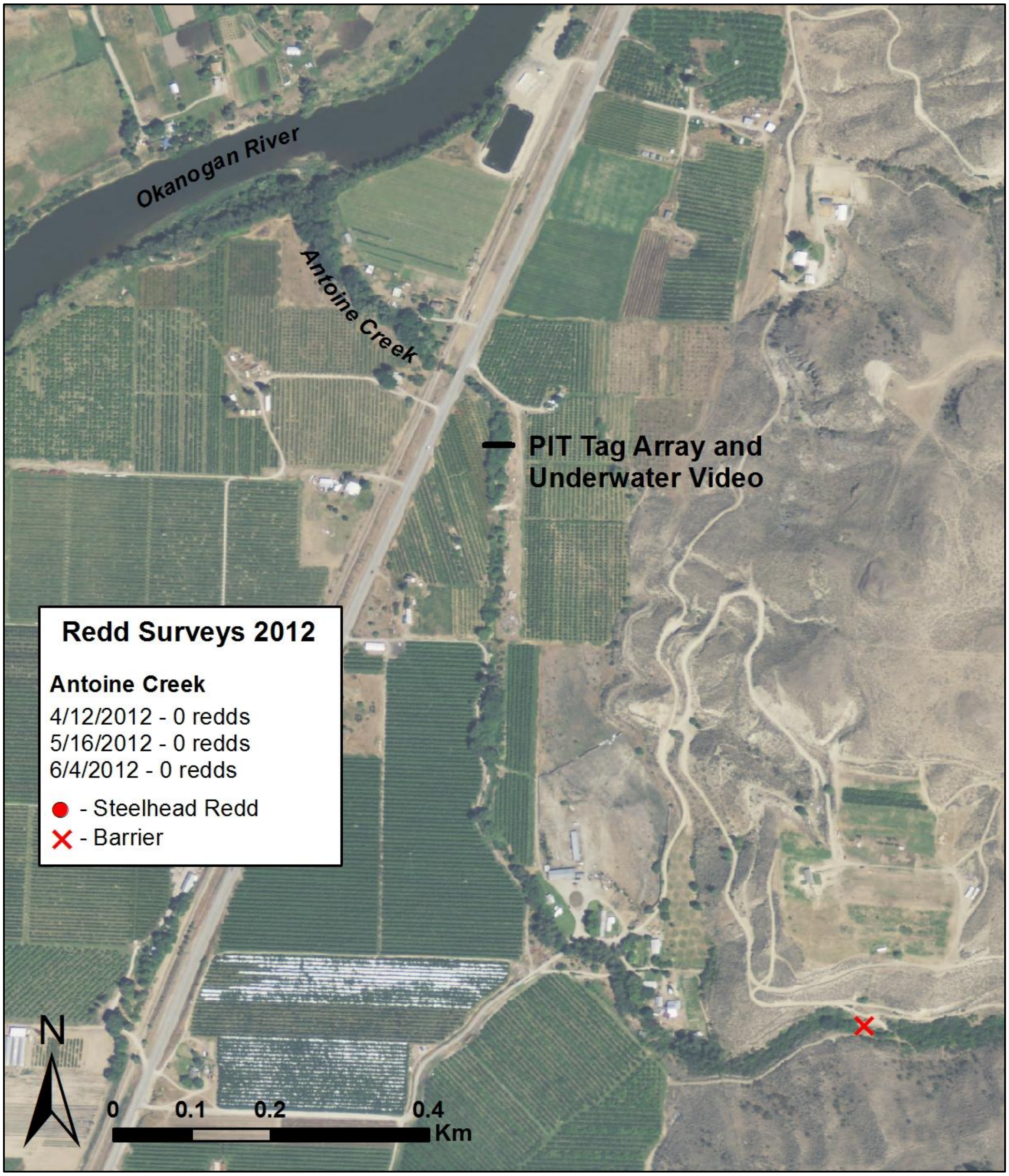

Figure 23. Redd distribution observed in 2012 for Antoine Creek from the confluence with the Okanogan River upstream to the video array.

Wild Horse Spring Creek

Wild Horse Spring Creek was surveyed four times during the spring of 2012. A total of 11 redds were documented (Figure 24). Twenty-one steelhead, two of those considered of natural-origin, were estimated to have spawned in this creek in 2012 based on 1.87 FPR and a 9.4% wild rate. The most conservative FPR and percent wild values (derived from Wells Dam) were used for redd expansion estimates in Wild Horse Spring Creek because it flows intermittently during the spring, was nearly completely dry by late spring, and the overwhelming majority of fish observed in the creek were of hatchery origin.

PIT tag antennas were installed at three locations on Wild Horse Spring Creek; one near the mouth and one on each of the two forks approximately 1.2 km upstream (shown on Figure 24). A total of three hatchery steelhead were counted at the lower antenna and all three were also detected at the north fork antenna. No detections occurred on the South Fork antenna. Based on the Priest Rapids release group, the calculated spawning escapement would be 8 hatchery origin steelhead and zero of natural origin. Given that on multiple visits to Wild Horse Spring Creek redd survey crews observed many adult steelhead actively spawning, it is likely that the redd survey estimate more accurately reflected the true number of spawning steelhead.

The between year variability in adult returns to Wild Horse Spring Creek have are the largest of all streams in the Okanogan River (see Wild Horse Spring Creek, Appendix B). In recent years, the number of spawners has far exceeded the amount of habitat found within this watershed even though the stream often goes dry in the summer.

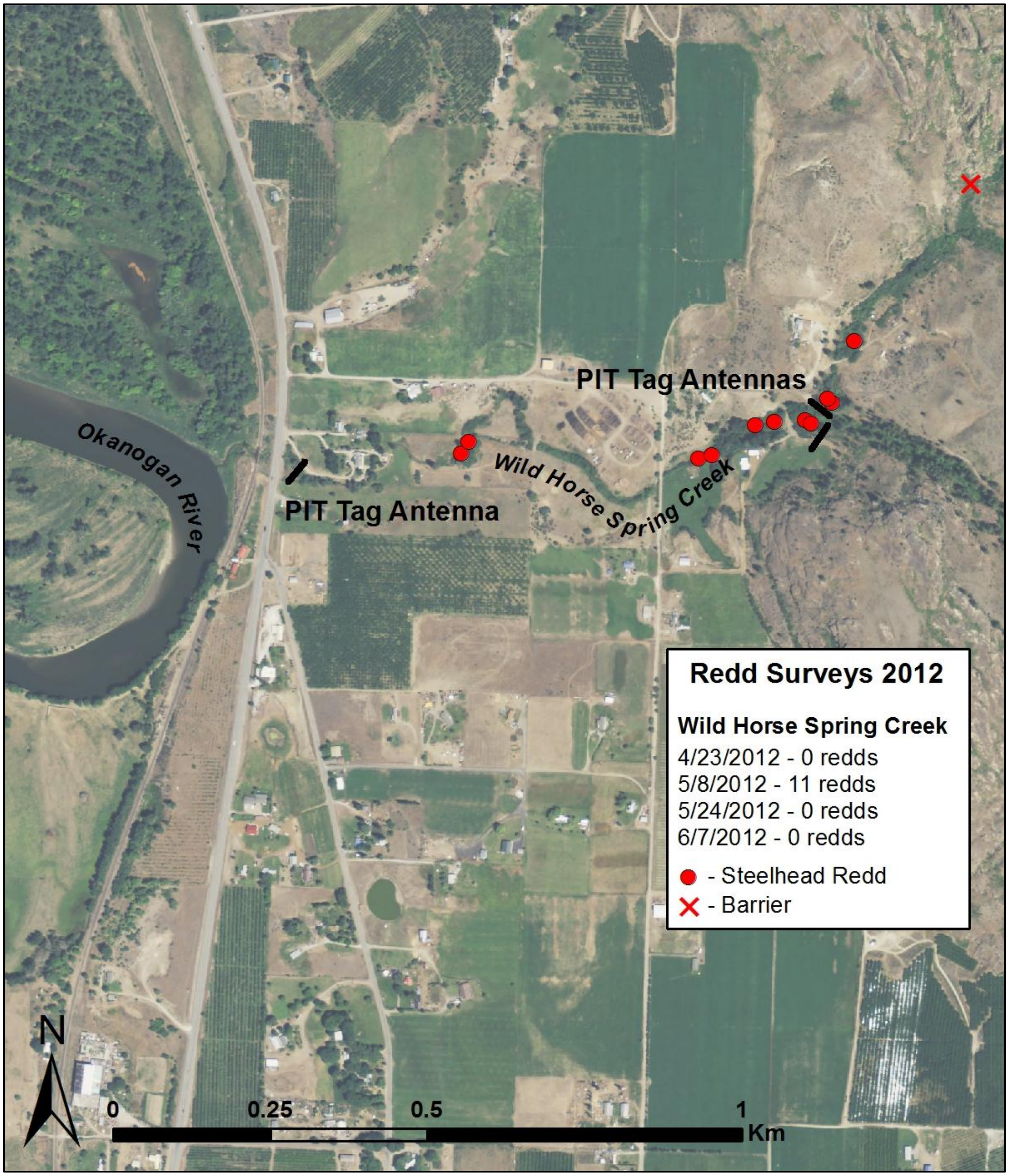

Figure 24. Redd distribution observed in 2012 for Wild Horse Spring Creek from the confluence with the Okanogan River upstream to the falls (anadromous barrier).

Tonasket Creek

During most years, Tonasket Creek flows intermittently during the spring and completely dries up by mid-summer in the lower-most 3 km. However, above average flows existed in 2012 which allowed for steelhead passage. Steelhead redd surveys were conducted in 2012 and a total of 19 redds were identified (Figure 25). Using a value of 3.93 FPR derived from the Omak Creek weir trap, provided a total estimate of 75 steelhead that spawned in Tonasket Creek. Using the percent wild derived from Omak Creek (13.3%) the number of natural origin would be 10 steelhead.

A PIT tag array located near the mouth of Tonasket Creek documented 12 hatchery steelhead. Based on the Priest Rapids release group, the calculated spawning escapement would be 76 hatchery origin steelhead and zero of natural origin. Both methods derive a nearly identical total number of adult spawners. However, an estimate of zero natural origin steelhead is difficult to hypothesize given the 8 year average for natural origin steelhead in Tonasket Creek has been nearly 8%. Therefore, our best estimate is the median value within the range of possible values (0-10 steelhead), which would be 5. This number represents a percent wild of 6.7%, and is more closely aligned with the average value for this stream. The best estimates for Tonasket Creek are 75 total steelhead and 5 of natural origin. The trend for Tonasket Creek has been increasing at a rate of approximately 11 steelhead per year, since 2005.

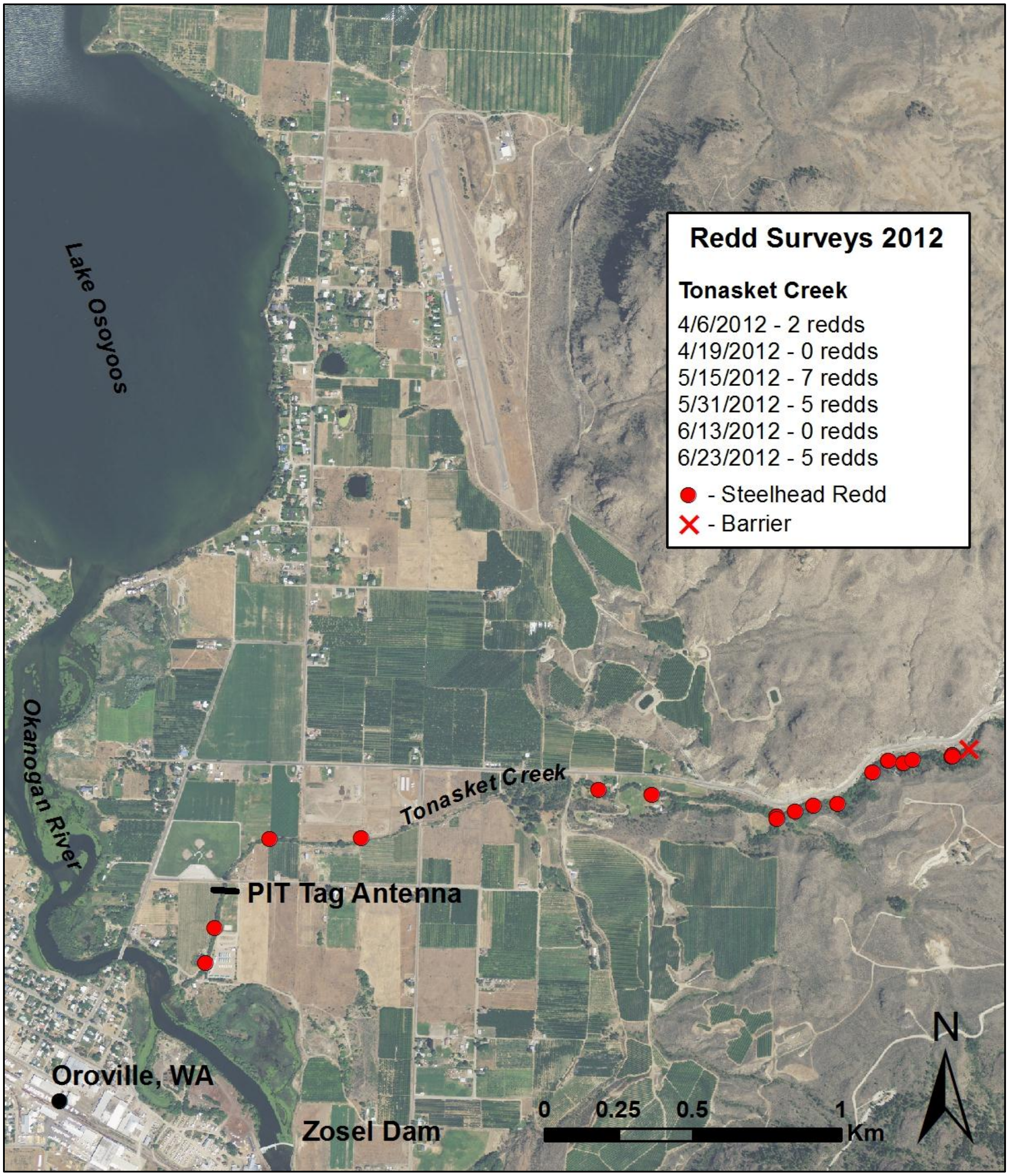

Figure 25. Redd distribution observed in 2012 for Tonasket Creek, from the confluence with the Okanogan River upstream to the anadromous barrier.

Ninemile Creek

Eleven steelhead (five ad-present, four hatchery, and two unknown origin) were documented passing upstream through the Ninemile Creek underwater video system in the spring of 2012 (Table 11, Figure 27). Video observations included that 55.5% had adipose fins for an estimated total of 6 ad-present and 5 adipose fin clipped steelhead. Over the last several years, the number of steelhead counted using video has been far below that estimated from redd survey or PIT tag data.

Redd surveys were conducted within the lower 0.7 km of Ninemile Creek on April 14, April 19, April 23, May 16, and May 31. The reach from the video weir to the falls was surveyed only twice, once on May 19 and June 6, due to access restrictions in that reach. Only one redd was documented below the video weir; the remaining 20 were in the upper reach (Figure 28). Using a value of 3.93 FPR, derived from the Omak Creek weir trap, provided a total estimate of 4 steelhead below and 79 steelhead above the video weir. Using the percent wild derived from Omak Creek (13.3%), the number of natural origin steelhead was calculated to be none below the video weir and 11 steelhead above. During the redd surveys between the video array and the falls, it was noted that spawning *O. mykiss* observed lengths were highly variable, with several being smaller than typical steelhead. It is possible that these fish may have been either resident rainbow trout or adfluvial trout from Osoyoos Lake.

A permanent four-antenna PIT tag array was in place throughout 2012 at the same location as the underwater video system. Two hatchery and two wild steelhead were recorded passing this location. Based on the tag rate of the Priest Rapids release group, two hatchery and one wild detection were expanded to 15 and 8 steelhead, respectively (Table 12). For the third year in a row, three adult enumeration methods were employed on Nine Mile Creek with all the estimates generating different results. Based on the data from each of the last three years, local biologists agreed that they had the most confidence in the PIT tag estimation methodology at this location. Also, the PIT tag estimate represents the mode of the three values in 2012 and reaffirms our confidence in this method on Ninemile Creek for 2012. The true value is likely within the range from 11-83 summer steelhead; our best point estimate would be 23 total of which 8 were likely of natural origin. In future years, only PIT tag estimates will be generated for this stream with an upstream array being used to determine extent. Considerable habitat restoration has occurred in this stream over the last several years and the Colville Tribes may use this stream to examine colonization rates without direct hatchery stocking in the creek, which has been conducted in several other stream in the basin.

Table 11. Steelhead observed passing the Ninemile Creek video weir.

Direction	Adipose Present	Adipose Clipped	Unknown Origin	Total
Upstream	5	4	2	11
Downstream	6	3	0	9

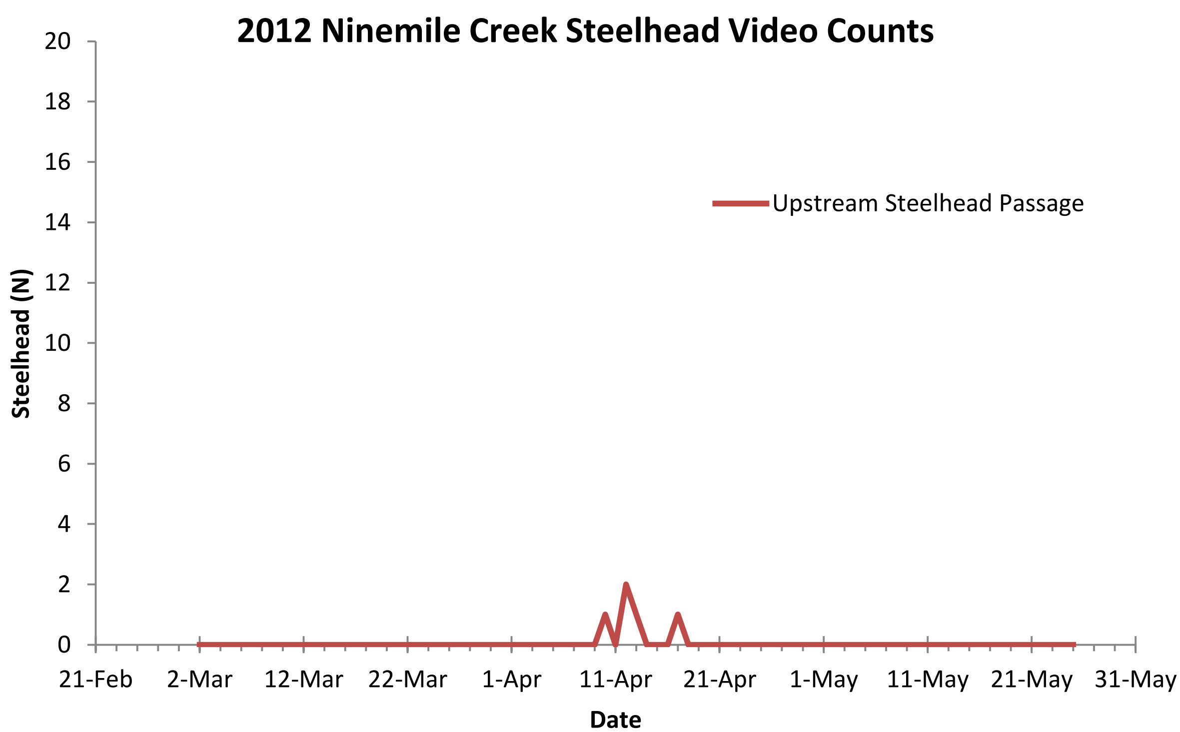

Figure 26. Steelhead observed passing the Ninemile Creek video weir during the spring of 2012.

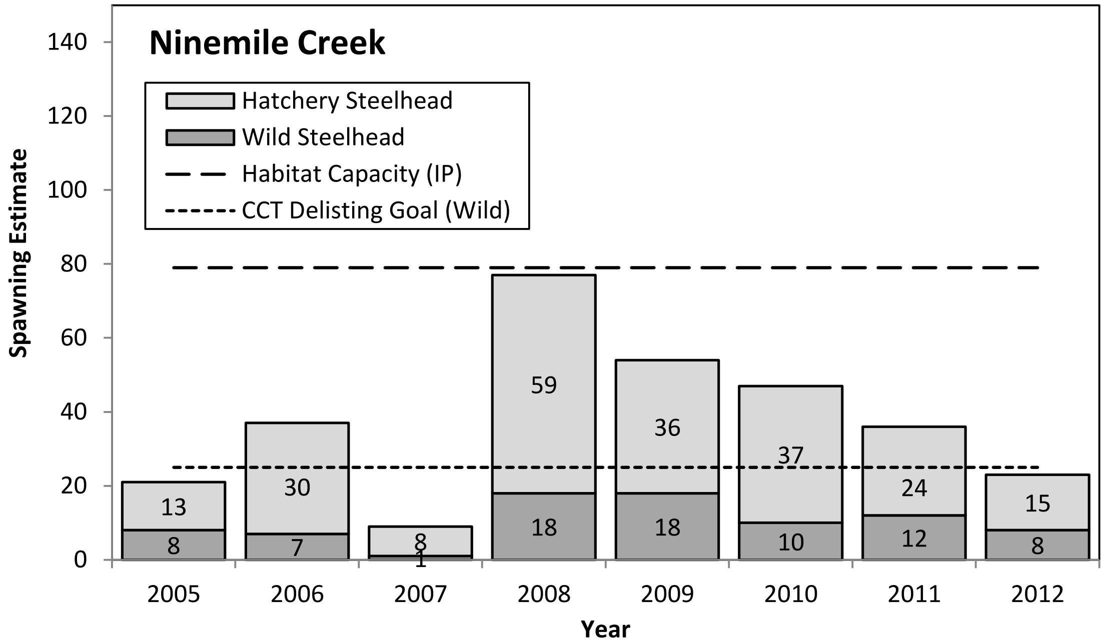

Figure 27. Spawning estimates for Ninemile Creek from 2005-2012.

Table 12. Two methods for calculating escapement estimates for Ninemile Creek. (A) Video count and redd survey conducted below the video station and (B) expansion based on PIT tag detections.

A. Redd survey and video count, Ninemile Creek

	Documented # of Redds	Estimated Total # Spawners	Estimated # Wild
Below Video Weir (Redd surveys)	1	4	0
Above Video Weir	20	79	11
Total	21	83	11

B. PIT Tag detection estimation, Ninemile Creek

	Documented # of Redds	Estimated Total # Spawners	Estimated # Wild
Total	n/a	23	8

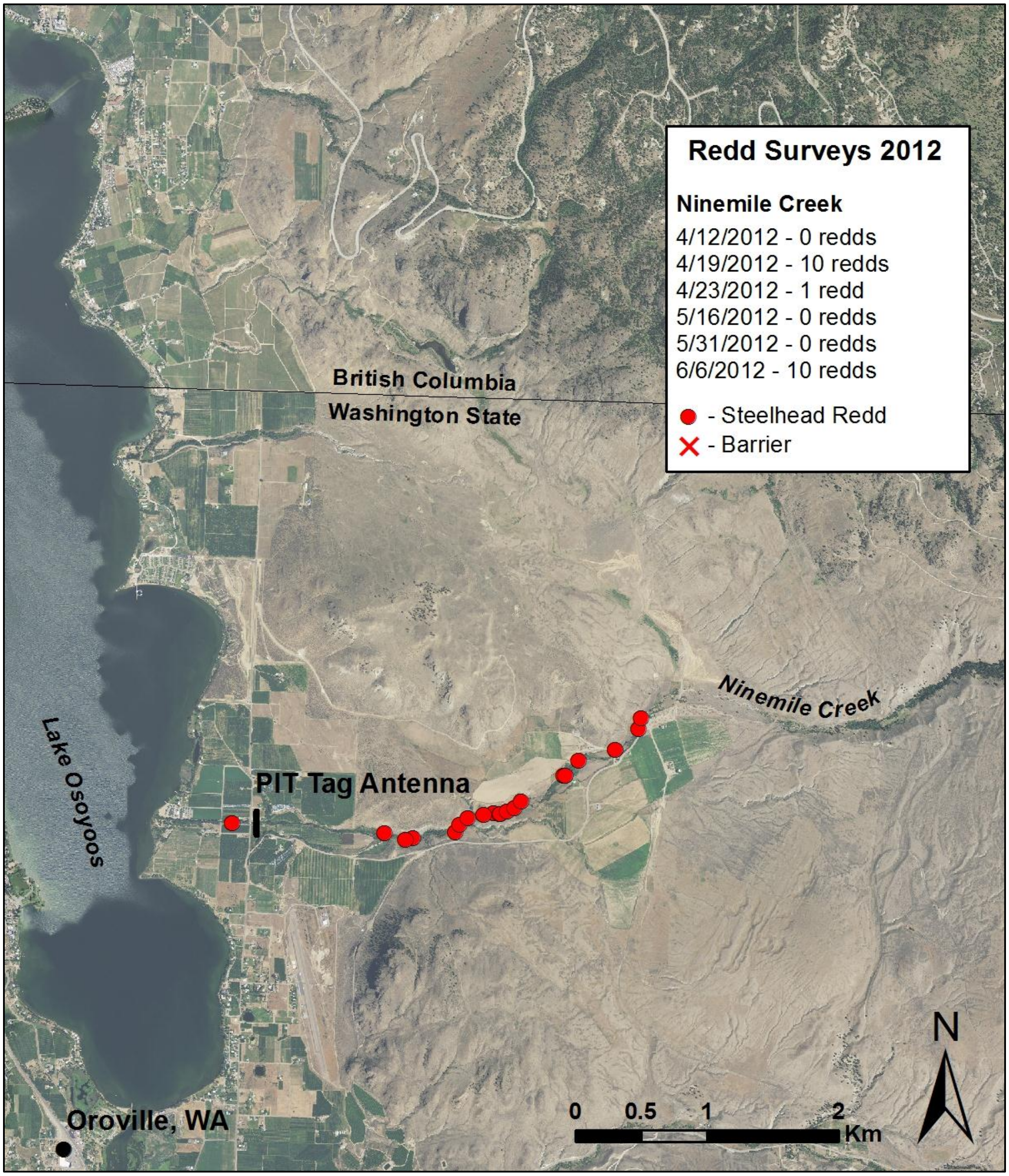

Figure 28. Redd distribution observed in 2012 for Ninemile Creek, from the confluence with Lake Osoyoos upstream to the anadromous barrier.

Escapement into British Columbia

From July 2011 through June 2012, 203 summer steelhead were counted on underwater video passing through the Zosel Dam fish passage structures (Table 13, Figure 29). In order to determine the number of steelhead unaccounted for above Lake Osoyoos, the estimated number of spawners that entered Ninemile (23 steelhead) and Tonasket (75 steelhead) Creeks were subtracted from the total number counted at Zosel Dam. These two creeks are located upriver (north) of Zosel Dam, but south of the international border. Therefore, 105 summer steelhead may have passed into habitats beyond Lake Osoyoos. Currently, the fallback rate is unknown at this facility.

A total of 55 ad-present summer steelhead were observed at the Zosel Dam video station. The estimated number entering Ninemile (8 ad-present steelhead) and Tonasket (5 ad-present steelhead) Creeks were subtracted from the total, resulting in an estimate of 42 ad-present summer steelhead. Of the total number of summer steelhead unaccounted for in Lake Osoyoos, 40% were likely ad-present.

Table 13. The number of adult summer steelhead that passed Zosel Dam by month for the 2012 spawner cohort, July 2011 to June 2012.

Steelhead Video Counts, Zosel Dam

Month	Adipose Clipped	Adipose Present	Total
July, 2011	0	0	0
August	0	0	0
September	1	4	5
October	1	6	7
November	0	1	1
December	0	0	0
January, 2012	0	0	0
February	0	0	0
March	3	8	11
April	143	36	179
May	unknown	unknown	unknown
June	unknown	unknown	unknown
Total	**148**	**55**	**203**

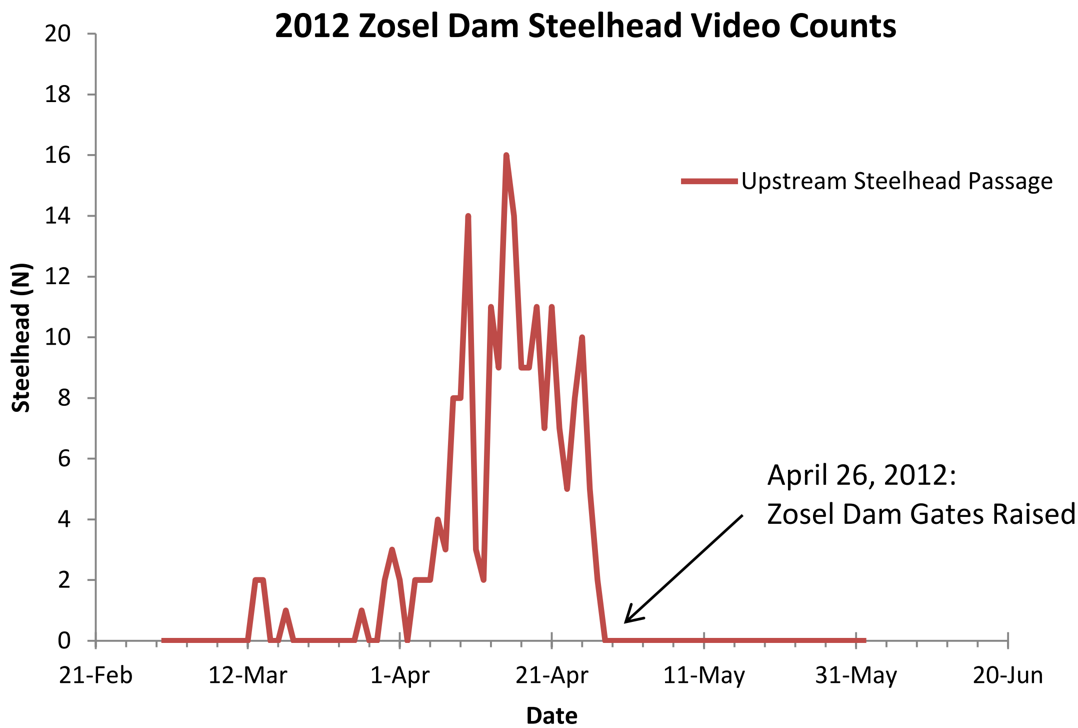

Figure 29. Steelhead observed passing Zosel Dam during the spring of 2012. After April 26th, adult steelhead could pass under the spill gates and stopped passing through the fish ladder, where the video system is located.

PIT Tag Detections at VDS-3

A total of five PIT tagged adult steelhead were detected at the PIT tag array located at VDS-3 on the mainstem Okanogan River, just north of Osoyoos Lake. Only four of these were from the Priest Rapids release group. Based on those detections, an estimated 31 steelhead passed above this point (16 hatchery origin and 15 wild origin). Using only PIT tag detections at Zosel Dam, 228 total steelhead passed north of the Dam. Seventy-five entered Tonasket Creek, 23 on Ninemile Creek, and 31 exiting Osoyoos Lake left 99 hatchery origin steelhead undetected elsewhere, with the most likely final location being either Inkaneep Creek or Zosel Dam fallbacks. In 2012, 28 steelhead of wild origin were estimated to have passed Zosel dam. Fifteen were accounted for above Osoyoos Lake, 8 on Ninemile Creek, and 5 on Tonasket Creek. All of the wild steelhead were apportioned using this approach. PIT tag detections and video enumeration at Zosel Dam indicated very similar numbers of steelhead being unaccounted for.

The only location in Canada where trend data for summer steelhead can be determined is at the PIT tag array located at VDS-3, north of Lake Osoyoos. Due to the fact that this site has only been in operation for 3 years, little certainty regarding long term trends can be implied.

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 2012 are provided in this document and every attempt has been made to ensure that these estimates are as accurate as our methods currently allow. However, these data should be used with caution, as it is difficult to define natal origin through visual observation alone (i.e. intact adipose fin). Values presented in this document represent our best scientific estimate from available information, but the variability surrounding point estimates are unknown. A summary of the best available counts and estimates for each reach or sub-watershed throughout the Okanogan River Basin are presented in Table 14. Multiple years of these data have been compiled for each redd survey reach and attached to this document as Appendix B.

The total escapement estimate for Okanogan River summer steelhead spawners in 2012, based on redd surveys, weir traps, PIT tags, and video data, was 2,799 (Table 15). For 2012, the WDFW estimated maximum spawner escapement into the Okanogan River Basin at 2,784 summer steelhead (Charles Frady, WDFW, pers. comm.). The WDFW estimate was derived from Wells Dam passage counts, modified by harvest information, and divided into individual subbasins (Methow and Okanogan) through the use of radio telemetry data (English et al. 2001, 2003). For the 2012 spawning estimates, our methods relied on the WDFW total value to calculate the mainstem spawning component, so it was not surprising that the two estimates were comparable. The WDFW escapement estimate for wild steelhead in the Okanogan Basin was 261. OBMEP estimated that 324 ad-present steelhead spawned within the Okanogan River Basin in 2012 (Table 16). Inconsistent percentages of ad-present steelhead that utilized individual tributaries may have complicated percent-wild calculations from redd counts where we had no means of determining local counts.

Trend data indicate since 2005, the number of spawning summer steelhead in the Okanogan River has been growing at a rate of 267 per year, with an 8-year average of 1,894 steelhead (Figure 31). The abundance of natural origin steelhead is increasing at a rate of 44 per year with an 8-year average of 281 steelhead (Figure 32). This value is well below the basin-wide NOAA abundance recovery target of 1,000 wild steelhead. These data should be used with caution, as surveys have only been conducted during an 8-year period, from 2005-2012, and a relatively large return in 2010 likely skewed trend data in an upward direction.

Many assumptions have been made when developing local escapement estimates. These data should be used with caution, as on-the-ground surveys have only been conducted over short periods in the Okanogan basin, from 2005-2012. Occasionally, modeled escapement data were used when discharge rates were not conducive for visual surveys. Other methods, such as PIT tag estimates and redd expansion estimates, rely heavily on calculated escapement values. Additionally, relatively low returns in 2005 and 2006, when coupled with a very large return in 2010, likely skewed the 8-year trend data in an upward direction. We encourage readers to examine trend graphs with prudent consideration, as parsing out observations of steelhead into small discrete systems has been an intricate task.

Large variations in estimates exist in many reaches from year to year, but oftentimes, these accurately reflect real-world situations, rather than survey bias or calculation error. Small creeks may have extremely low flows for two years, blocking access with no spawning occurring, and then experience a large run of fish the following year when sufficient flows exist (ex. Loup Loup Creek: 0, 0, 125). This irregular nature of small scale population data frequently results in data being scattered loosely around a linear trend line. Numerous methods have been described in the literature for analyzing complex fisheries data. When more years of data become available, additional detailed data analysis methods may be employed. We have made every effort to ensure that the reported values are as accurate as possible, including using multiple data collection methods for validation, comprehensive on-the-ground surveys, and best scientific judgment, based on extensive local experience with the basin.

Table 14. Estimated number of total and wild spawning steelhead for each sub-watershed or counting location in 2012. The grand total for the Okanogan River population is presented with subtotals for tributary and mainstem habitat types in Washington and British Columbia.

Distribution of Steelhead Spawning in the Okanogan Basin, 2012

Category	Description/location	Estimated Total # Spawners	Estimated Total # Wild
WA Mainstem	Reach O1	26	2
WA Mainstem	Reach O2	93	9
WA Mainstem	Reach O3	19	2
WA Mainstem	Reach O4	78	7
WA Mainstem	Reach O5	125	12
WA Mainstem	Reach O6	33	3
WA Mainstem	Reach O7	805	75
WA Mainstem	Reach S1	272	26
WA Mainstem	Reach S2	205	19
WA Tributary	Loup Loup Creek	69	8
WA Tributary	Salmon Creek	191	23
WA Tributary	Omak Creek	313	42
WA Tributary	Wanacut Creek	12	4
WA Tributary	Johnson Creek	26	2
WA Tributary	Tunk Creek	84	8
WA Tributary	Bonaparte Creek	168	38
WA Tributary	Antoine Creek	31	8
WA Tributary	Wild Horse Spring Creek	21	2
Zosel Dam	**Observed Passing Zosel Dam**	228	28
WA Tributary	Tonasket Creek	75	5
WA Tributary	Ninemile Creek	23	8
Subtotals	**Adult escapement into WA mainstem**	**1,656**	**155**
Subtotals	**Adult escapement into WA tributaries**	**1,014**	**154**
Subtotals	**Adult escapement into BC**	**130**	**15**
Grand total		**2,799**	**324**

Table 15. Total escapement of summer steelhead for the Okanogan River, since 2005, including combined hatchery and natural-origin summer steelhead estimates.

Okanogan River summer steelhead spawner population trend data				
Year	**WDFW escapement estimate** [b]	**OBMEP spawner survey estimate**		
		Low	Estimate	High
2005	2,233	1,147	1,315[c]	1,482
2006	1,602	779	855[c]	930
2007	1,921	1,234	1,266[d]	1,280
2008	1,755	1,341	1,386	1,436
2009	2,211	2,020	2,133	2,198
2010	3,920	3,236	3,496	3,596
2011	2,497	1,479	1,674	1,687
2012	2,784		2,799[c]	

[b] WDFW revised previous escapement estimates from previous years in 2010.
[c] Estimated mainstem reach data rather than empirical data, as in other years.
[d] Only a low and high value was reported, so a simple arithmetic mean was computed.

Table 16. Natural origin summer steelhead estimates for the Okanogan River, since 2005.

Okanogan River wild summer steelhead spawner population trend data				
Year	**WDFW escapement estimate** [e]	**OBMEP spawner survey estimate**		
		Low	Estimate	High
2005	153	143	164[f]	185
2006	130	127	139[f]	151
2007	110	148	152[g]	155
2008	227	213	225	266
2009	202	178	212	241
2010	352	630	728	853
2011	338	307	329	339
2012	261		324[h]	

[e] WDFW revised escapement estimates from previous years in 2010.
[f] The Okanogan mainstem percent wild was applied across all reaches.
[g] Only a low and high value was reported, so a simple arithmetic mean was computed.
[h] Estimated mainstem reach data rather than empirical data, as in other years.

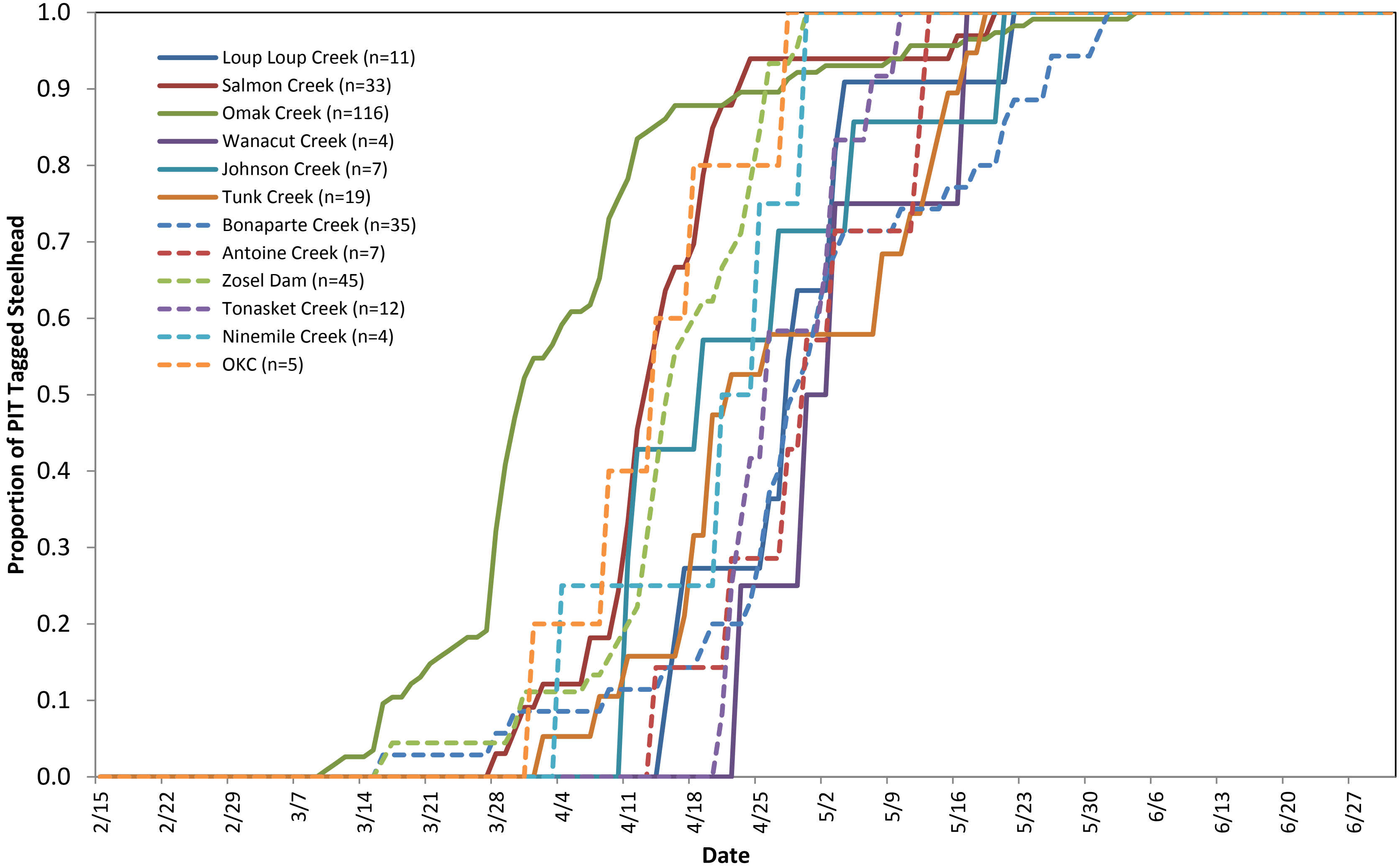

Figure 30. Run timing of PIT tagged summer steelhead in tributaries to the Okanogan River, 2012.

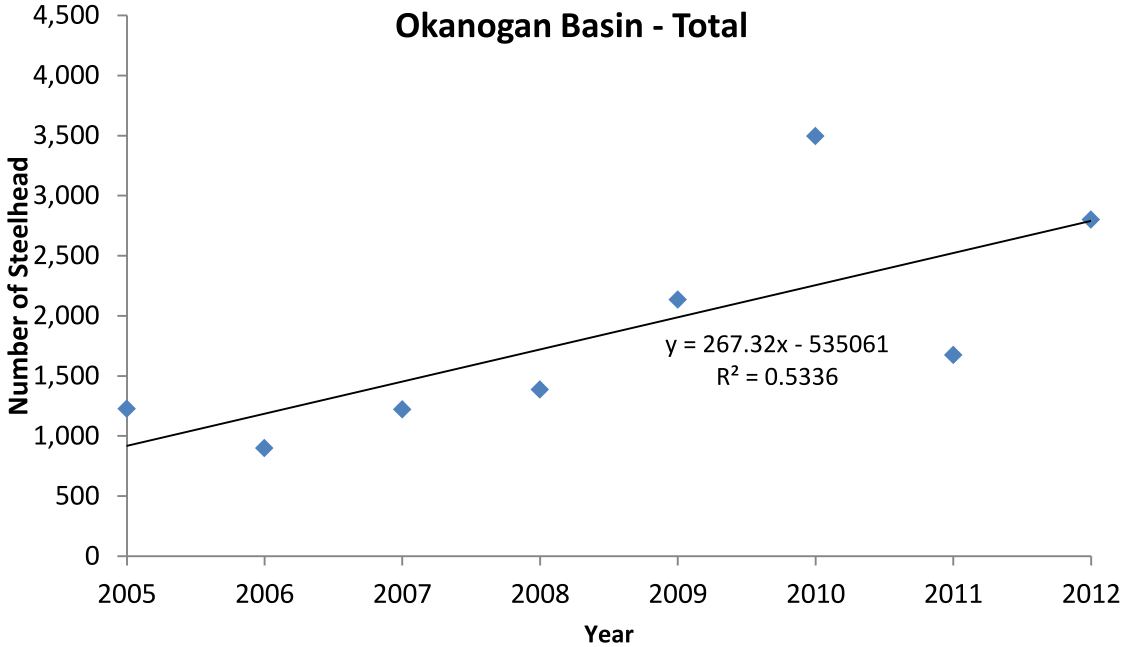

Figure 31. The trend in the total number of summer steelhead spawning in the Okanogan River population, since 2005.

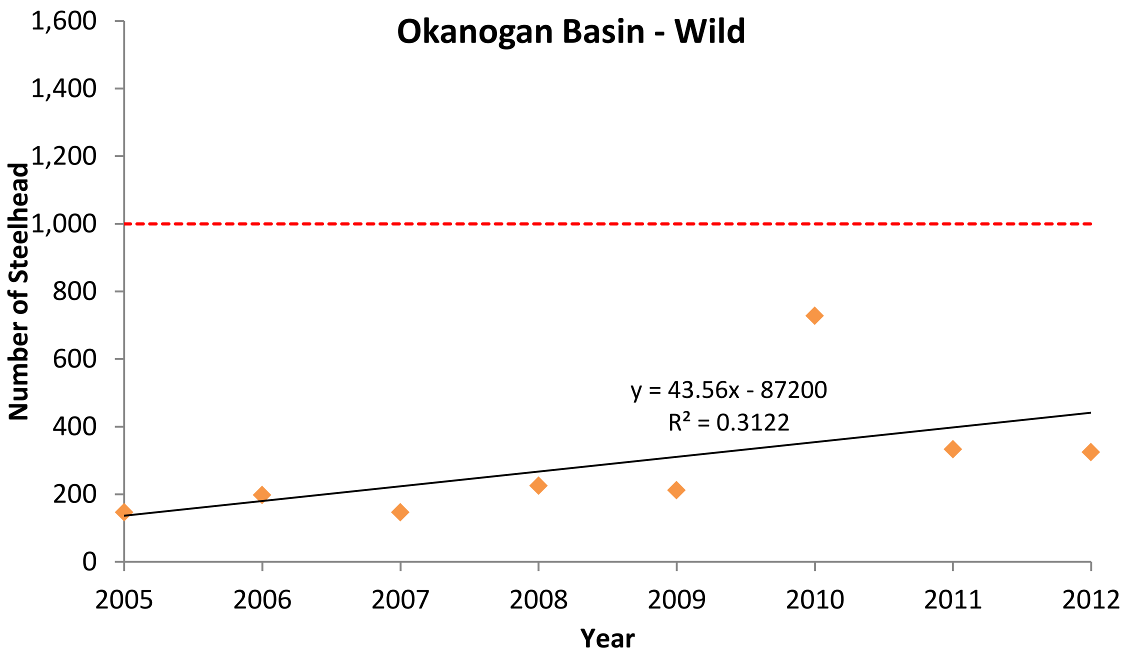

Figure 32. The trend in the total number of natural origin summer steelhead spawning in the Okanogan basin, since 2005. Redline indicates recovery goal for both United States and Canadian side of the boarder.

Conclusions

Results from steelhead adult enumeration efforts in the Okanogan Basin indicate that the number of spawning steelhead in the Okanogan River continued to increase since the program began collecting data in 2005. Spawning occurs throughout the mainstem Okanogan River, although narrowly focused to distinct areas that contained suitable spawning substrates and water velocities. Steelhead spawning has been documented to be most heavily concentrated below Zosel Dam on the Okanogan River and in braided island sections of the lower Similkameen River. It is likely that distribution of spawning is largely influenced by stocking location because juvenile hatchery steelhead were scatter-planted in Omak Creek, Salmon Creek, and the Similkameen River acclimation site. Steelhead redds have been commonly observed near these stocking locations, as well as near Chinook redd mounds and mid-channel islands.

Annual variations of environmental factors can profoundly impact redd distributions in small tributaries to Okanogan River. Changes in spawner distribution within tributaries appear to be driven by the following four factors:

1) Discharge and elevation of the Okanogan River
2) Discharge of the tributary streams
3) Timing of runoff that alters the shape of the hydrograph
4) Stocking location of hatchery smolts

The first three factors are largely based upon natural environmental conditions, which can be altered dramatically by such things as water releases from dams, irrigation withdrawals, and climate change. Years such as 2006, 2008, and 2009 clearly show how low tributary discharge can dramatically alter spawning location and reduce the available tributary habitat for steelhead to utilize. Habitat alterations at the mouths of key spawning tributaries can improve access, provided that sufficient discharge is available. In 2010, 2011, and 2012 water availability in the Okanogan River Basin was above normal and subsequently, a larger proportion of steelhead spawned in tributaries than was documented in previous years. Approximately 37% and 39% of steelhead were estimated to have spawned in tributaries to the Okanogan in 2010 and 2011, respectively. Because mainstem values were calculated and not directly counted for 2012, no certain conclusions can be drawn for that survey year, although it was likely similar. Summer steelhead that spawn in tributary habitats of the Okanogan River Basin are more likely to find suitable environmental conditions and rearing habitats than those spawning in mainstem habitats.

Spring spawner data can provide a reasonable depiction of steelhead spawning distribution and an estimate of minimum spawner abundance; however, determining the origin of returning adults is less objective. Although the abundance of ad-present spawners appears to be increasing in the Okanogan Subbasin, the current numbers remain well below recovery goals, as outlined by the Upper Columbia recovery plan (UCSRB 2007) (Figure 33). Accurate and reliable determination of origin is critical for tracking recovery of Upper Columbia summer steelhead within the Okanogan River Basin. However, hatchery activities that do not mark all fish in an easily identifiable way complicate origin determinations. In 2010 through 2012, new angling regulations required the retention of all steelhead caught with a clipped adipose fin. The benefits of these regulations may be reduced when not all hatchery fish are properly marked. Evaluation of natural production would be improved in the future by ensuring that all hatchery summer steelhead are marked by the removal of the adipose fin.

PIT tag arrays will again be installed in 2013 at the downstream extent of most tributaries throughout the Okanogan River system. Returning adults will continue to be implanted with PIT tags at mid-Columbia PUD facilities. Once the basin-wide PIT tag arrays are in place, interrogations of PIT tagged adult steelhead will allow further examination of age, sex, and origin within each sub-watershed. The increasing frequency of PIT tag detections also help to validate redd survey observations, provide an escapement estimate when redd surveys could not be conducted, and further improve our ability to describe habitats used by summer steelhead in the Okanogan Subbasin.

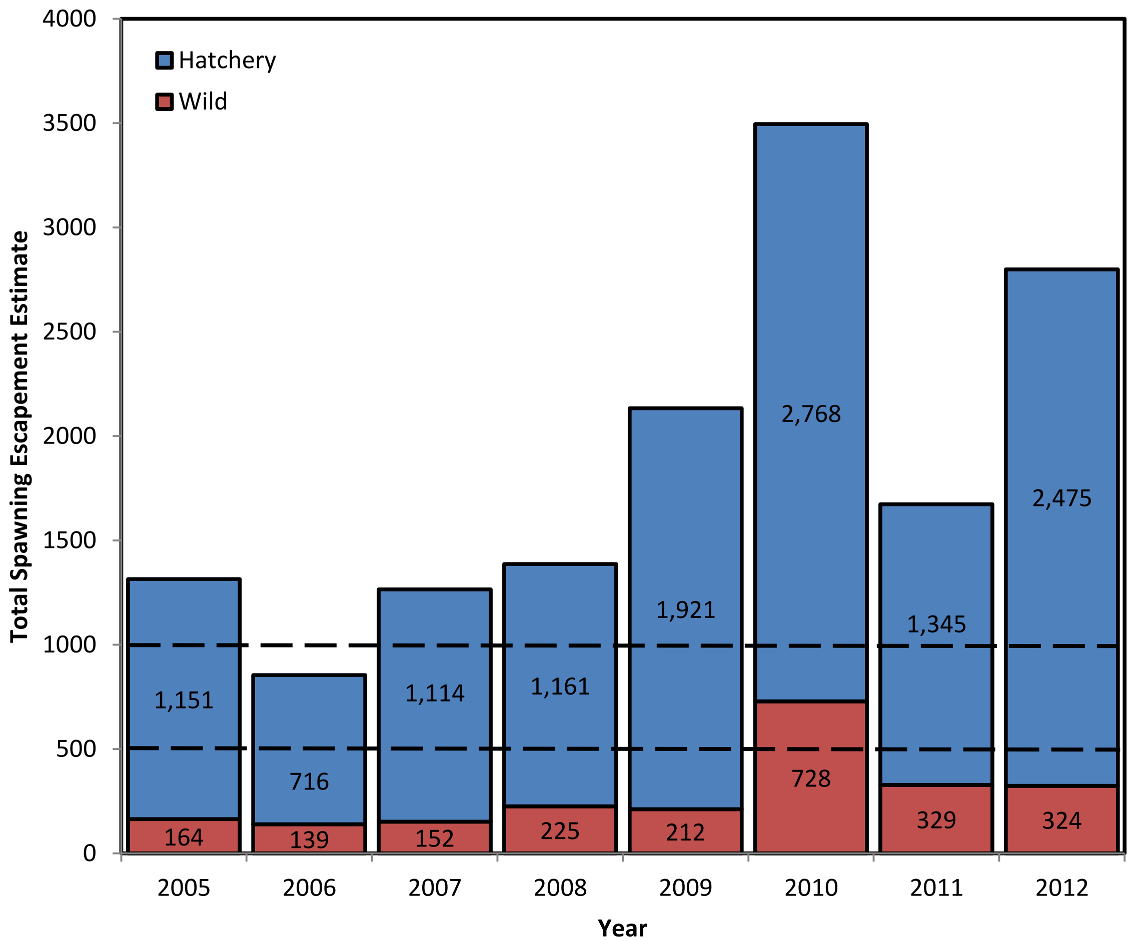

Figure 33. Escapement estimates determined by OBMEP compared with steelhead recovery goals, as outlined in the Upper Columbia Spring Chinook and Steelhead Recovery Plan (UCSRB 2007). The Interior Columbia Basin Technical Recovery Team (ICBTRT) determined that 500 naturally produced steelhead adults would meet the minimum abundance recovery criteria within the U.S. portion of the Okanogan Subbasin. If the Canadian portion of the subbasin was included, minimum abundance recovery criteria would be 1,000 naturally produced adults (UCSRB 2007).

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Appendix A. 2012 Okanogan Basin Mainstem Redd Survey Maps.

*The following maps only contain documented redds with GPS locations. Total redd calculations for each reach are outlined in the above document.

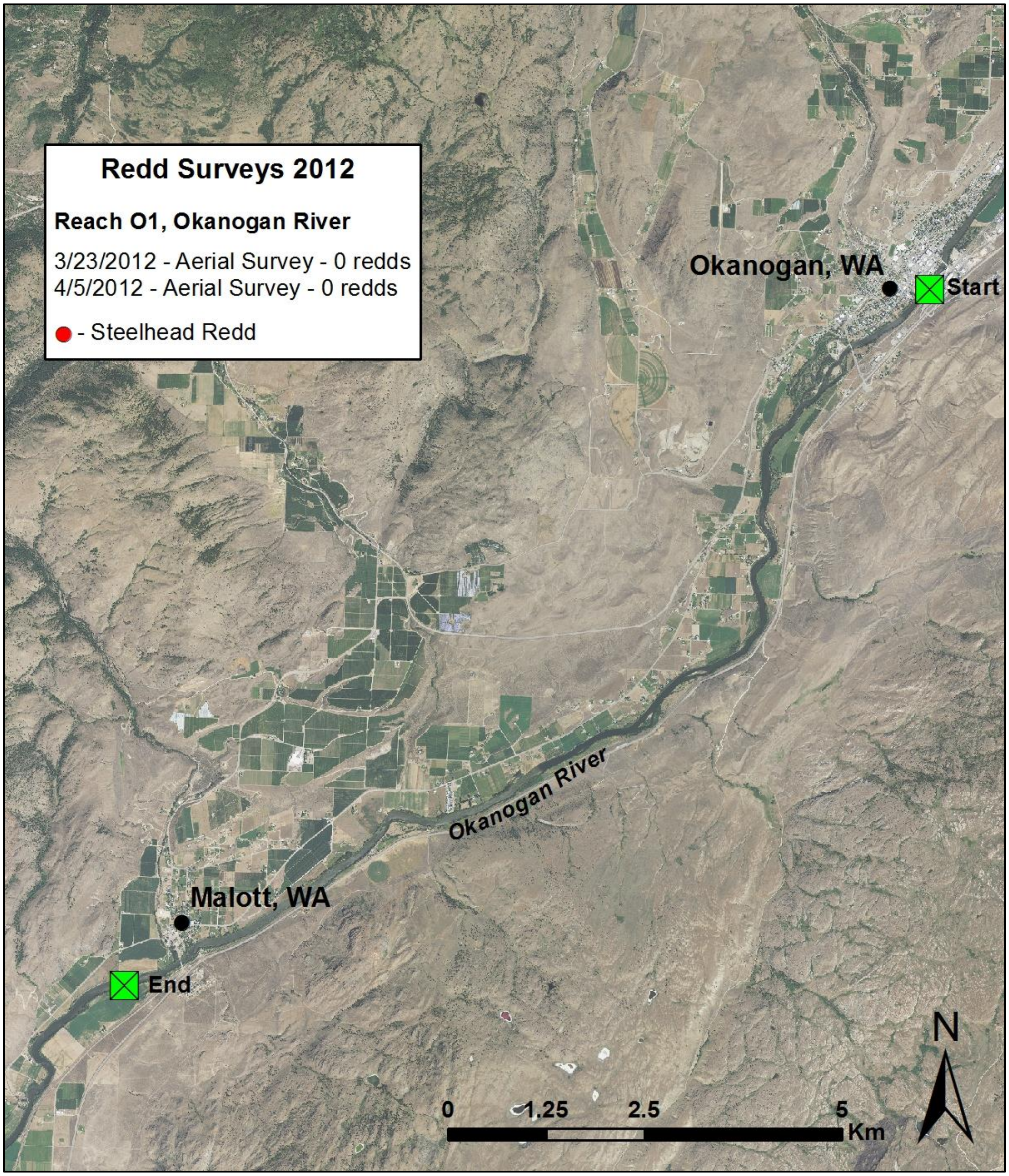

Figure 34. Okanogan River reach O1, from the confluence of Salmon Creek downstream to south of Loup Loup Creek.

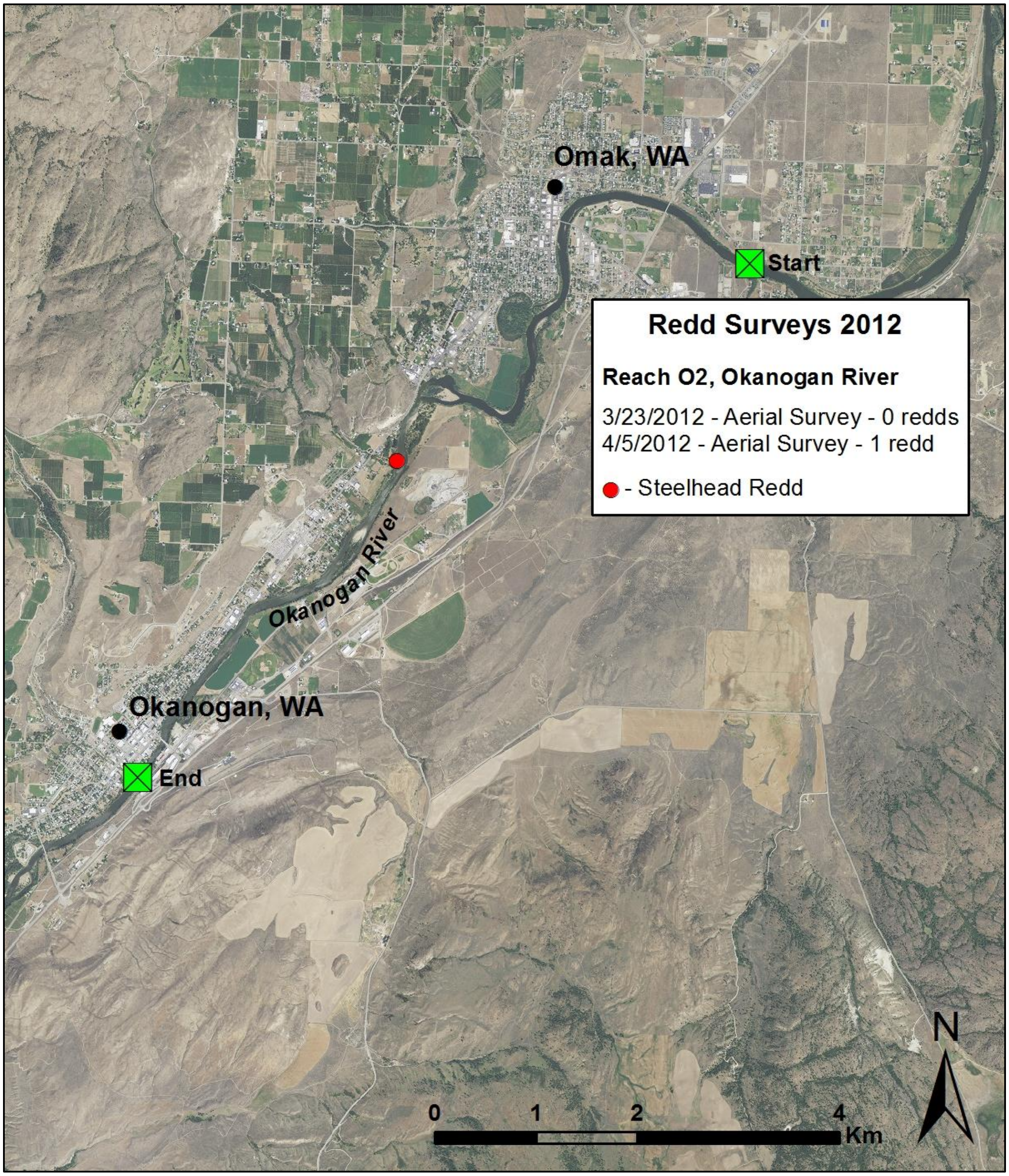

Figure 35. Okanogan River reach O2, from the confluence of Omak Creek in Omak, WA downstream to the confluence of Salmon Creek in Okanogan, WA.

Figure 36. The single redd observed during aerial redd surveys in Okanogan reach O2, before water clarity obscured observation. Located just south of Shellrock Point, near Omak, WA.

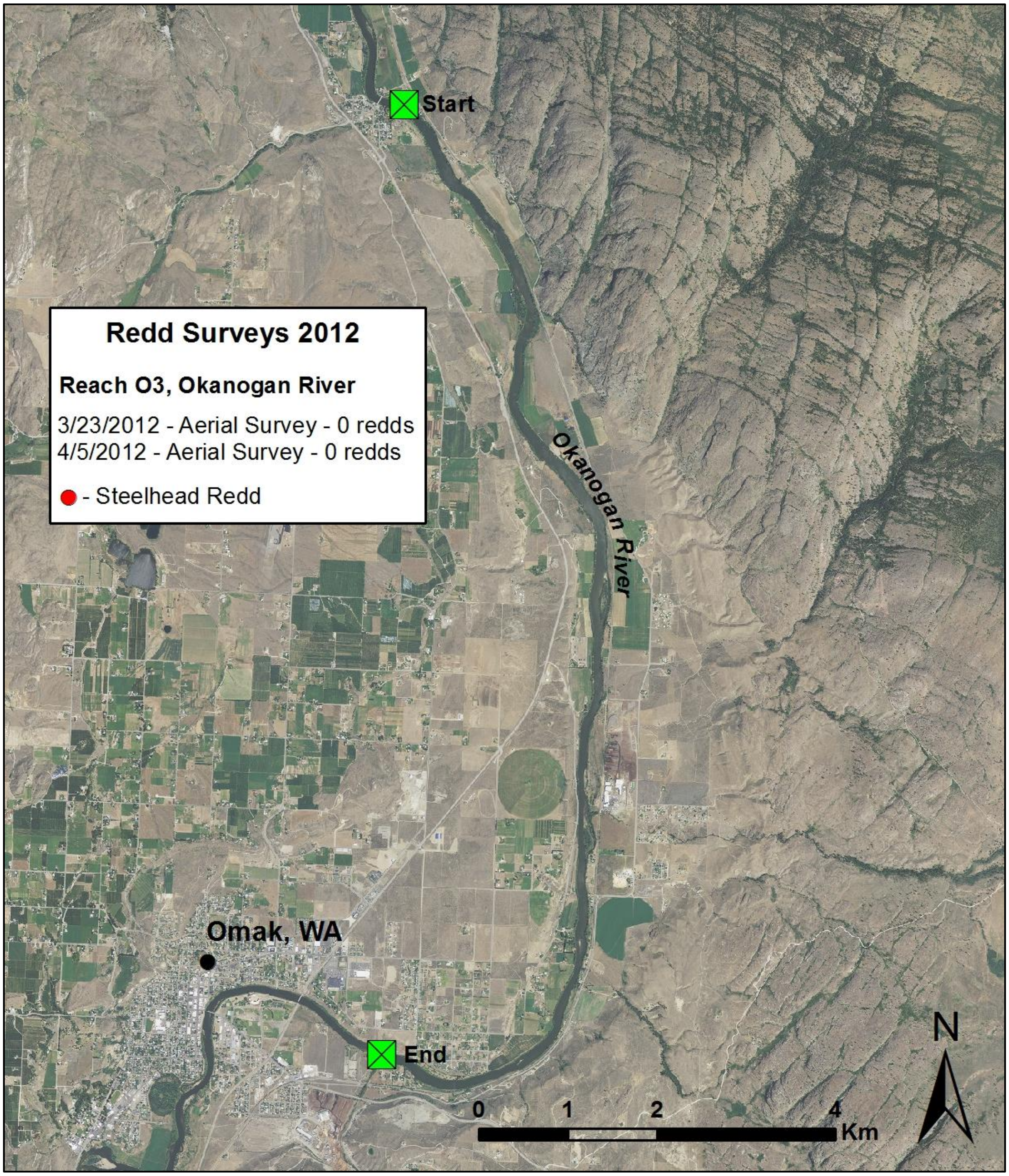

Figure 37. Okanogan River reach O3, from the confluence of Johnson Creek in Riverside, WA downstream to the confluence of Omak Creek.

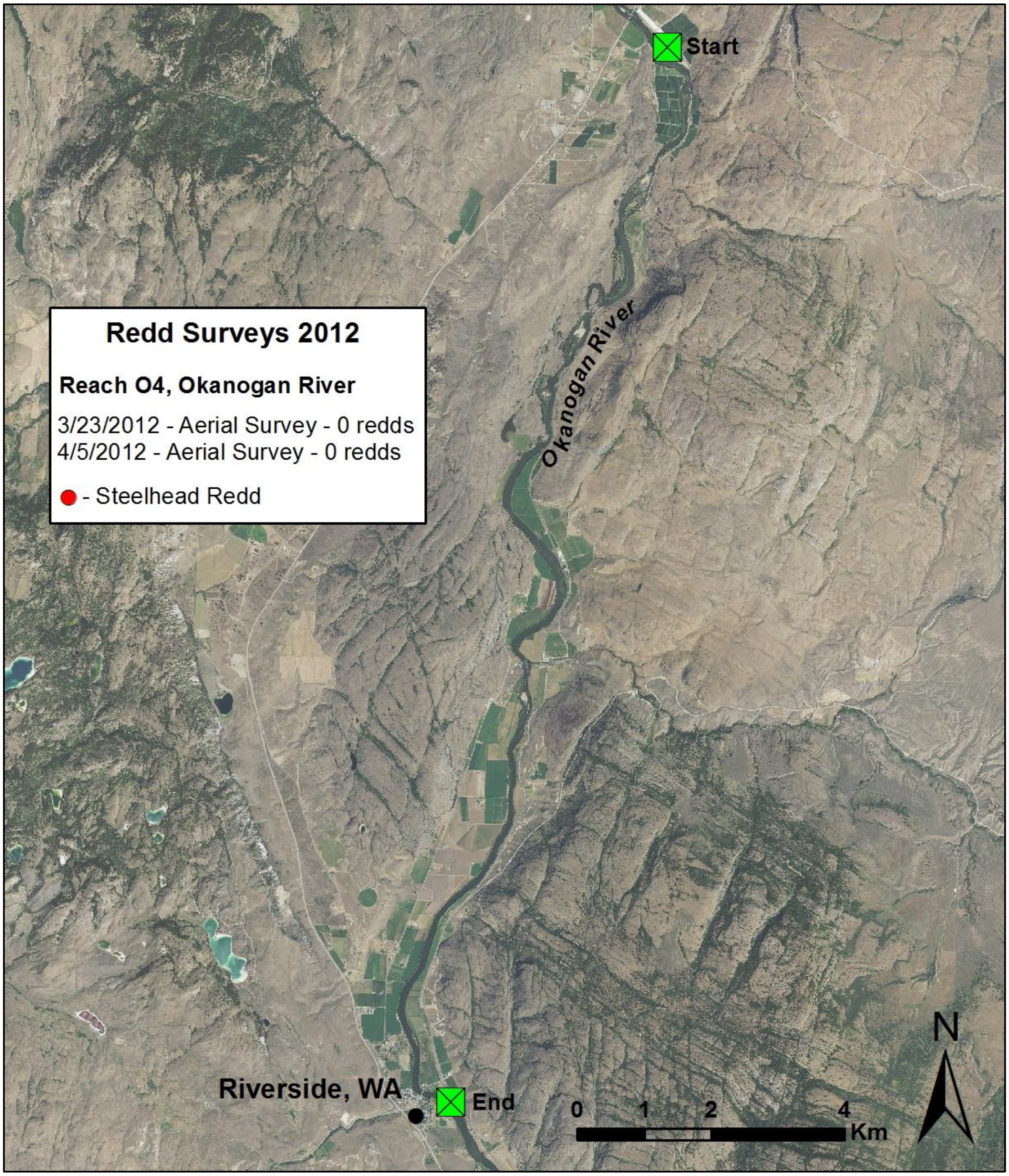

Figure 38. Okanogan River reach O4, from Janis Bridge downstream to the town of Riverside, WA.

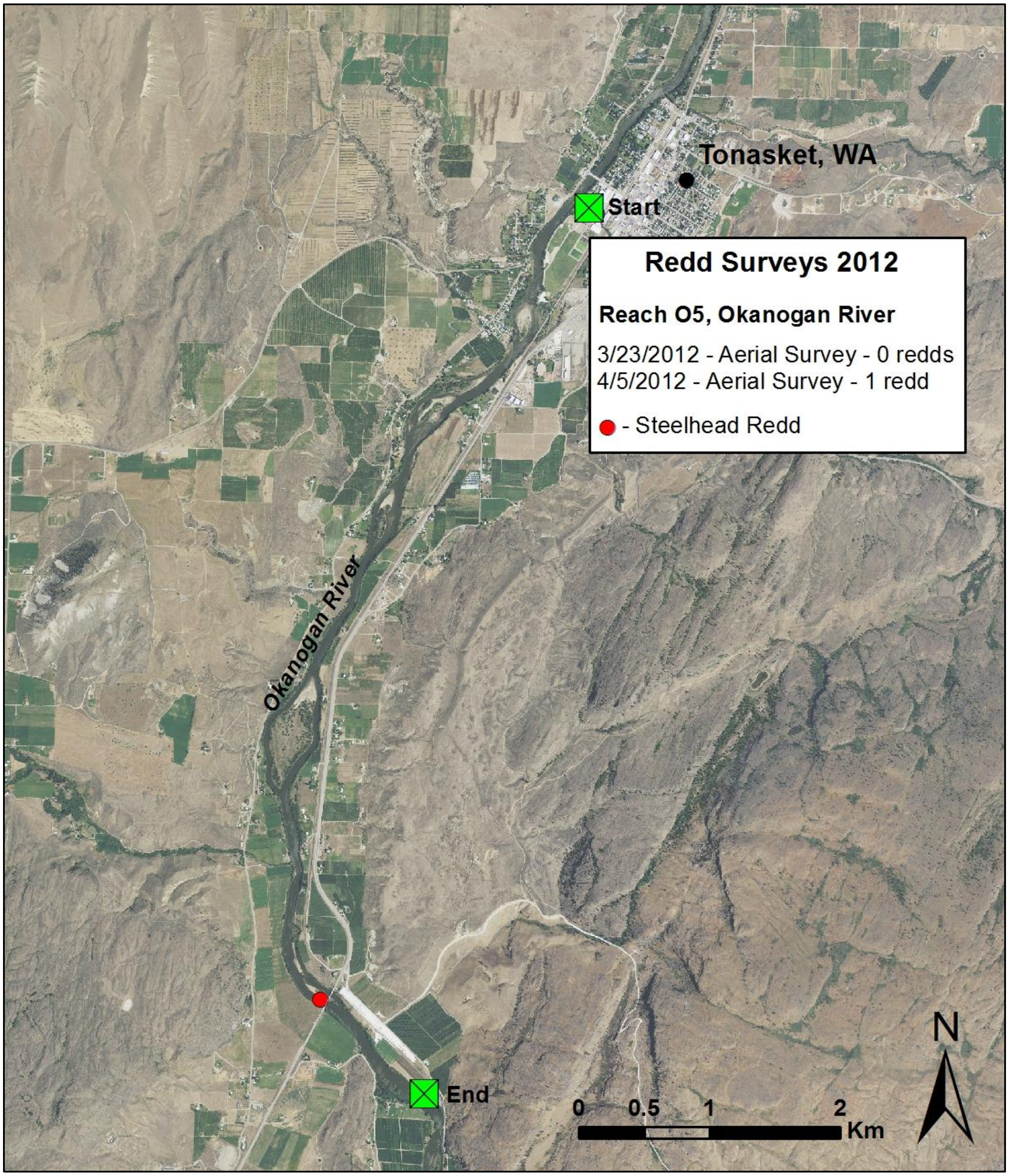

Figure 39. Okanogan River reach O5, from the Chief Tonasket Park in the town of Tonasket, WA downstream to the Highway 97 Bridge at Janis, WA.

Figure 40. The only redd observed during aerial redd surveys in Okanogan reach O5, before water clarity obscured observation. The redd pictured above was located 45 m above Janis bridge, south of Tonasket, WA, in the river right channel. Old Chinook redds can also be seen in this image for size comparison.

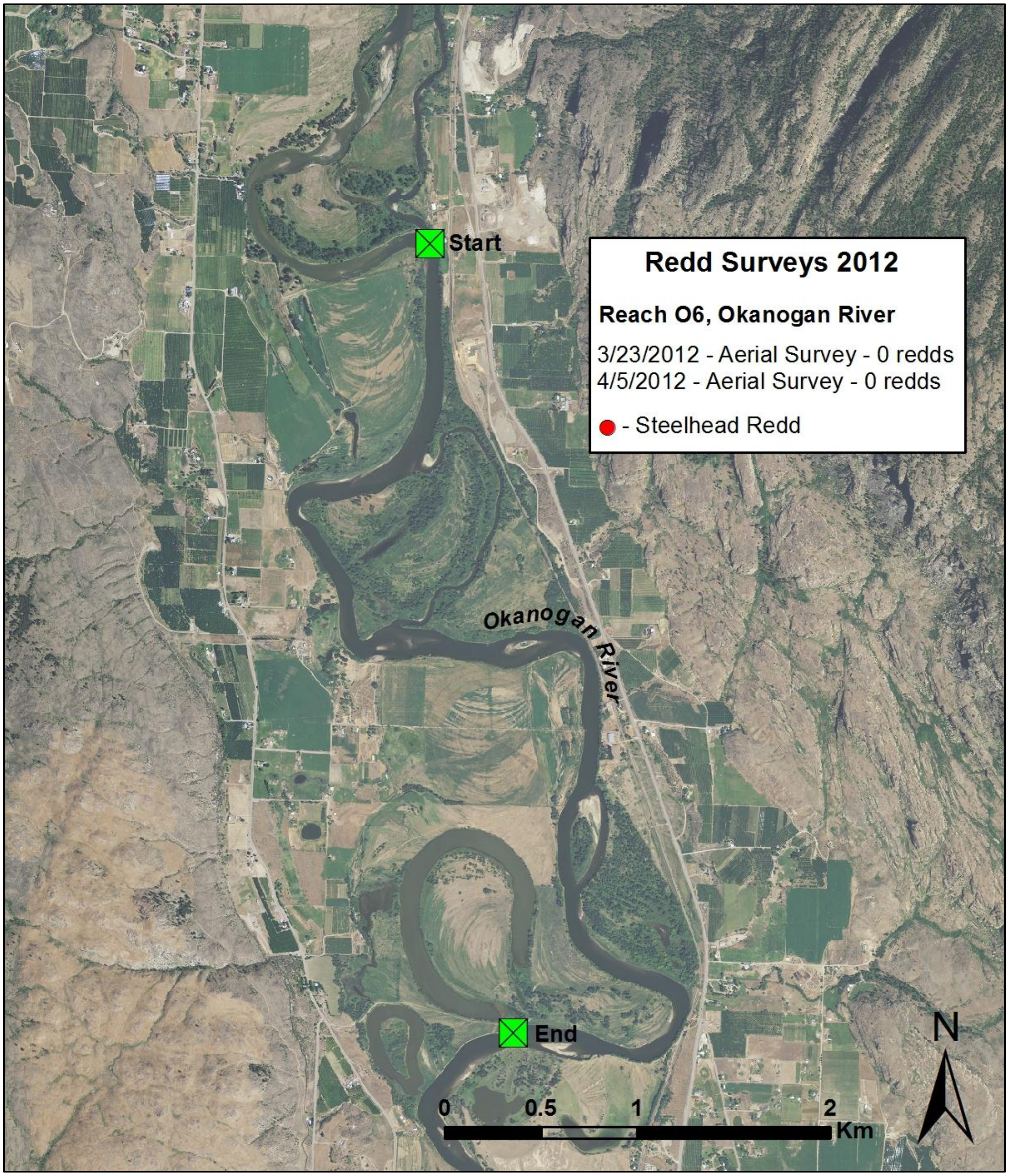

Figure 41. Okanogan River reach O6, from the confluence of the Okanogan and Similkameen Rivers to Horseshoe Lake.

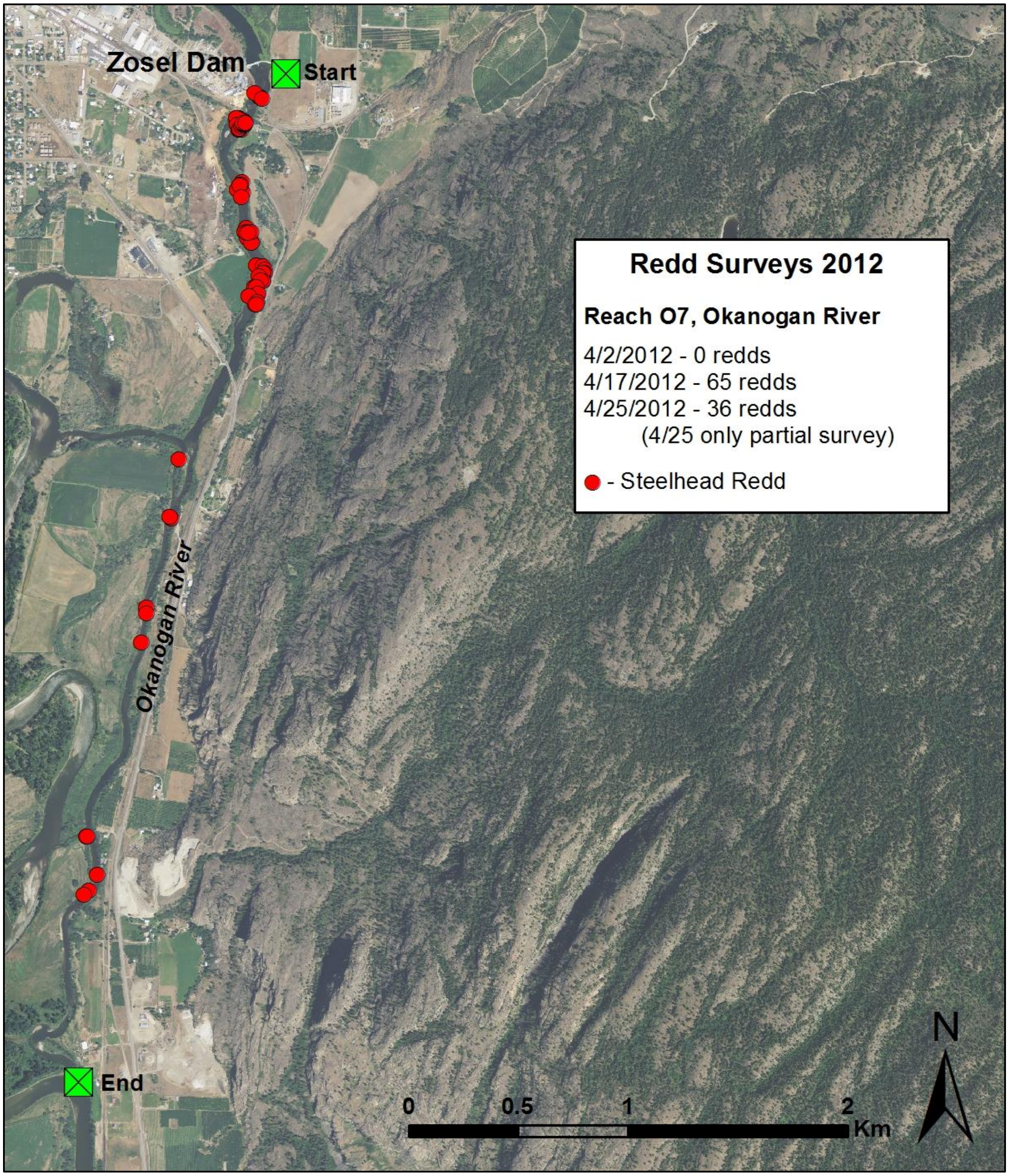

Figure 42. Okanogan River reach O7, which extends from Zosel Dam downstream to the confluence with the Similkameen River.

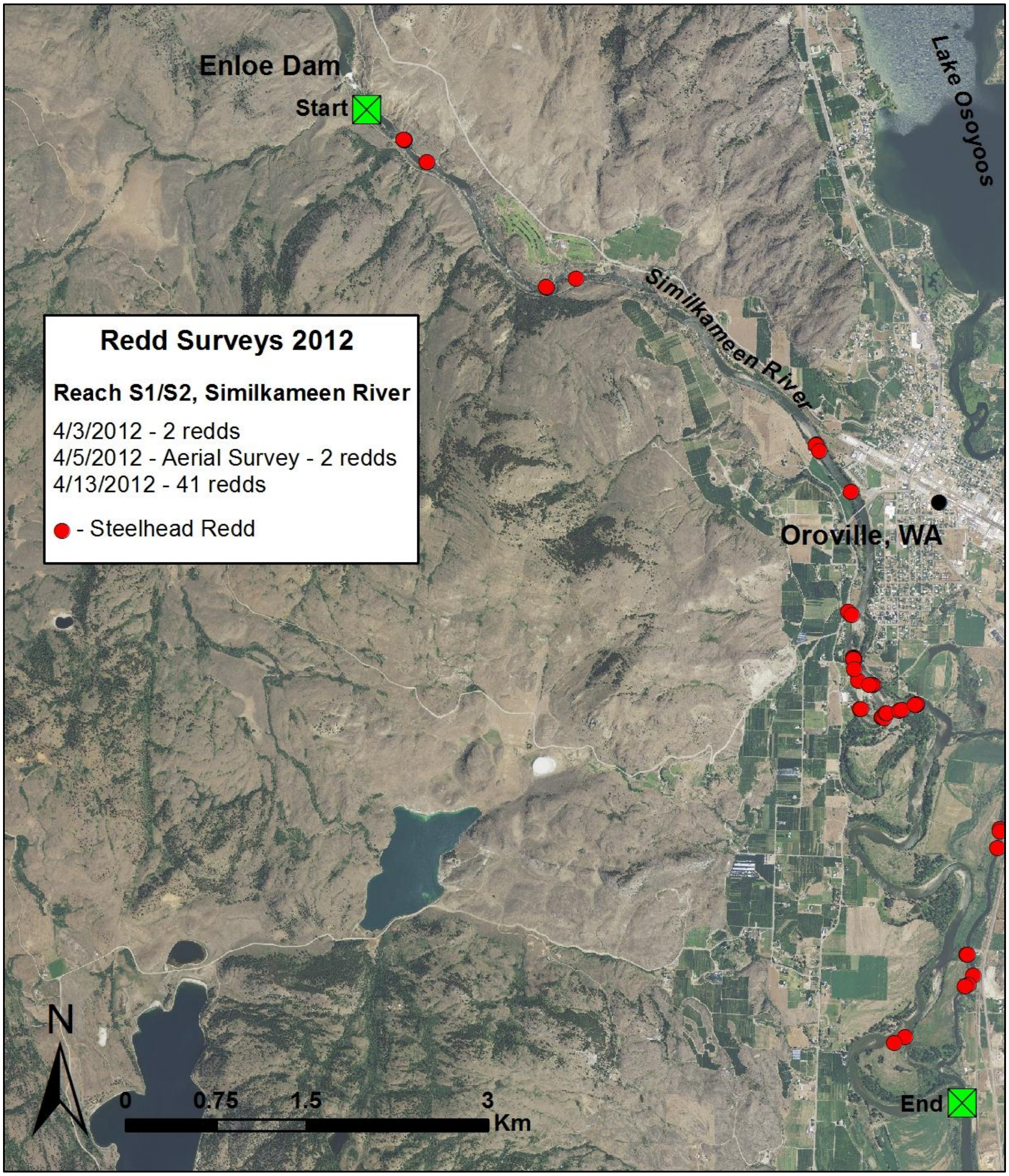

Figure 43. Similkameen River reach S1 and S2. Reach S2 extends from the base of Enloe Dam downstream to the water treatment plant in Oroville, WA. Reach S1 encompasses the section between Oroville and the lower confluence with the Okanogan River.

Figure 44. Two redds observed during aerial redd surveys in the lower Similkameen River, before water clarity obscured observation. Located just upstream of the lower confluence with the Okanogan River. Two steelhead can be seen on the redd in the second image.

Appendix B. Okanogan Basin Steelhead Population Trend, 2005-2012.

Effective fish management occurs at relatively small scales and the diagnostic unit is the finest scale of data collection within OBMEP. The diagnostic unit scale is the scale at which stories can be effectively told and responses managed. The following graphs depict the number of adult steelhead that spawned in each diagnostic unit with the United States portion of the Okanogan River, during the period from 2005 through 2012, plus the trend for these areas over the same period. If an R^2 of > 0.1 was calculated for a given dataset, we felt comfortable saying that a certain measure of trend existed, either positive or negative, based on the slope of the line. If the R^2 was < 0.1, it was presumed that no trend existed. Trends across all mainstem river diagnostic unit reaches located in the United States portion of the Okanogan River 33% had an upward trend, 11% had a downward trend, and 56% had no trend or remained stable between 2005 and 2012. Figure 67 represents the cumulative total of all mainstem river spawning habitats and is very characteristic of the largest mainstem spawning aggregate that is located in diagnostic unit O7 (Figure 57). However, the trend is very different when results are examined from lesser utilized diagnostic units, e.g. Reach O4 (Figure 51).

Many assumptions have been made when developing local escapement estimates. These data should be used with caution, as on-the-ground surveys have only been conducted over short periods in the Okanogan basin, from 2005-2012. Occasionally, modeled escapement data were used when discharge rates were not conducive for visual surveys. Other methods, such as PIT tag estimates and redd sex ratio expansion estimates, rely heavily on calculated escapement values. Additionally, relatively low returns in 2005 and 2006, when coupled with a very large return in 2010, likely skewed the 8-year trend data in an upward direction. We encourage readers to examine the following graphs with prudent consideration, as parsing out observations of steelhead into small discrete systems has been an intricate task.

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Mainstem Steelhead Trend Graphs

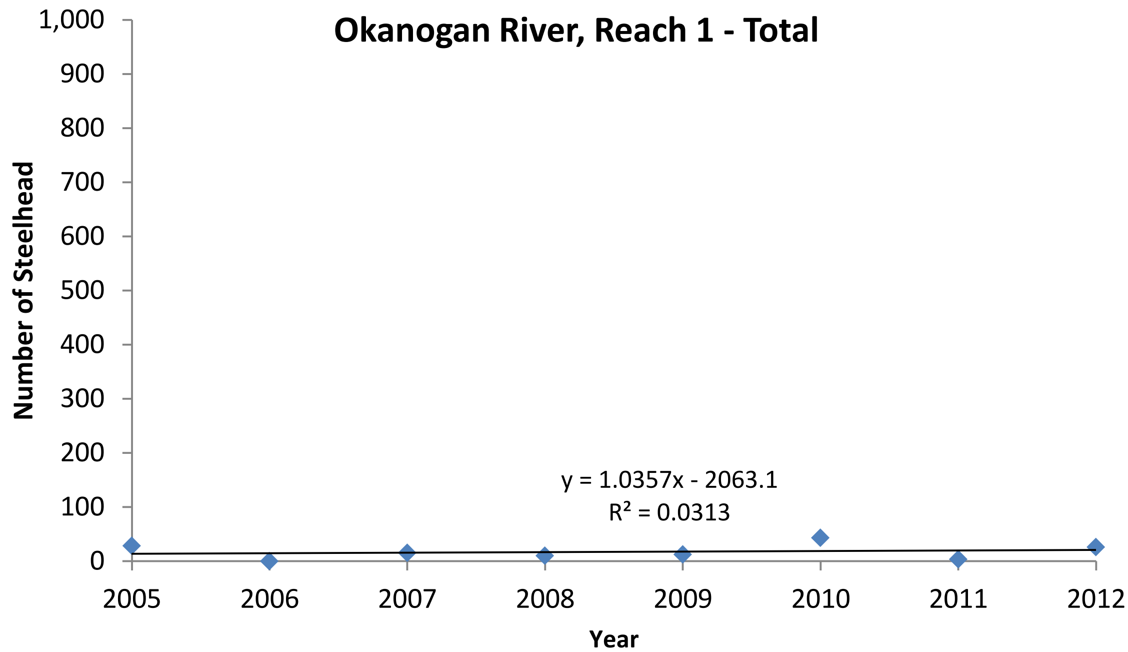

Figure 45. Total spawning estimates for Okanogan River, Reach 1. The reach extends from Chiliwist Creek upstream to Salmon Creek.

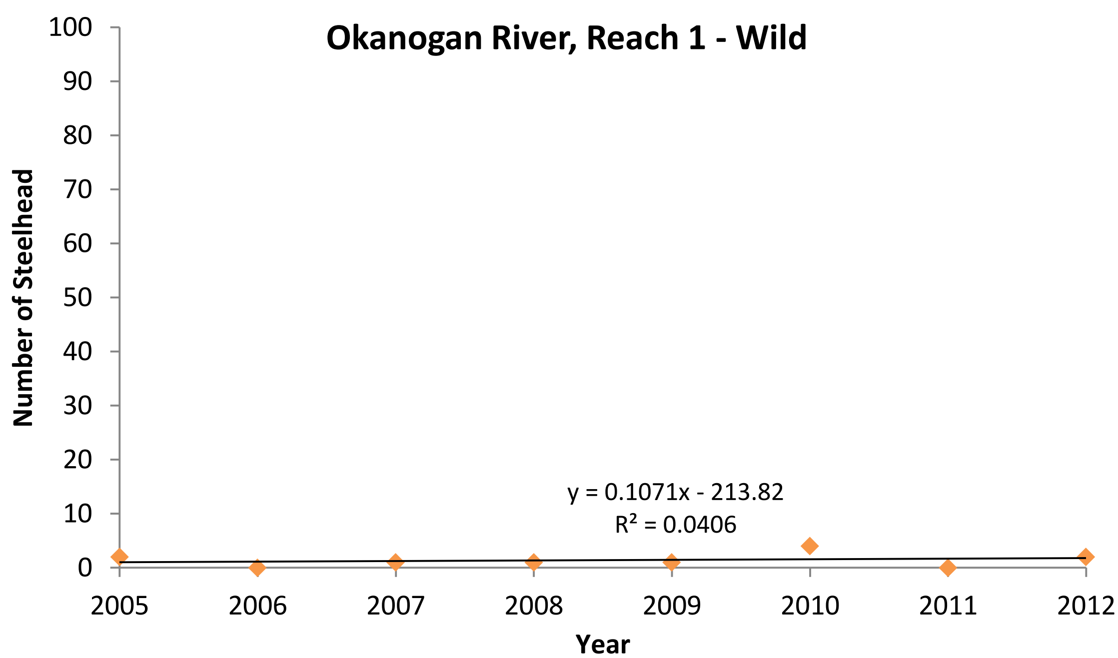

Figure 46. Wild spawning estimates for Okanogan River, Reach 1. The reach extends from Chiliwist Creek upstream to Salmon Creek.

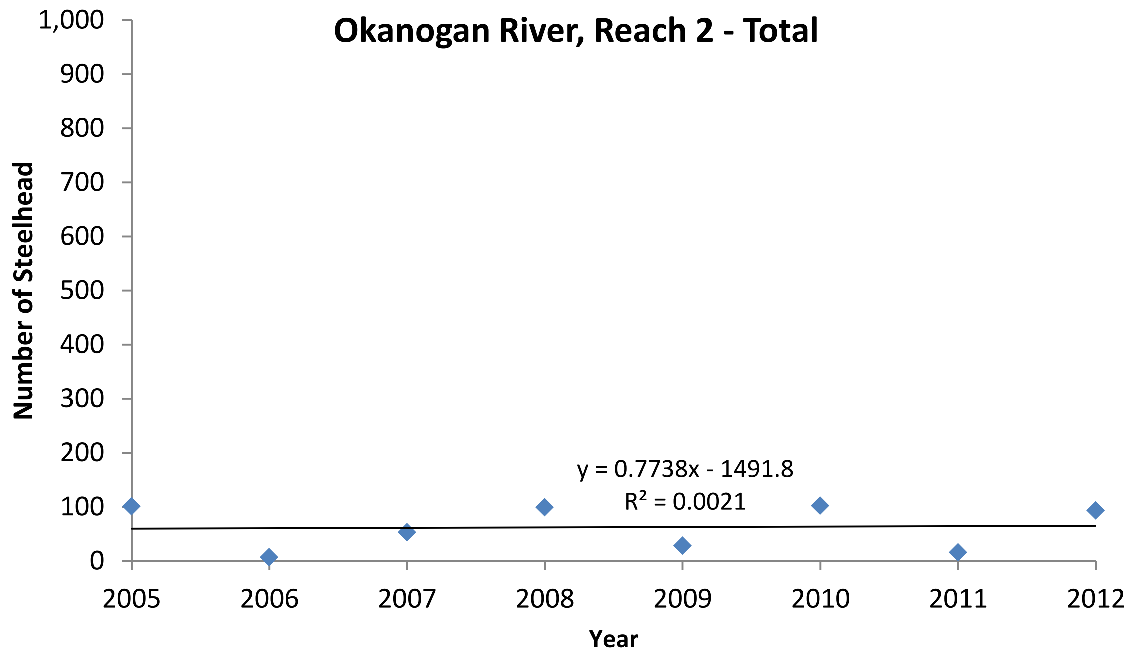

Figure 47. Total spawning estimates for Okanogan River, Reach 2. The reach extends from Salmon Creek upstream to Omak Creek.

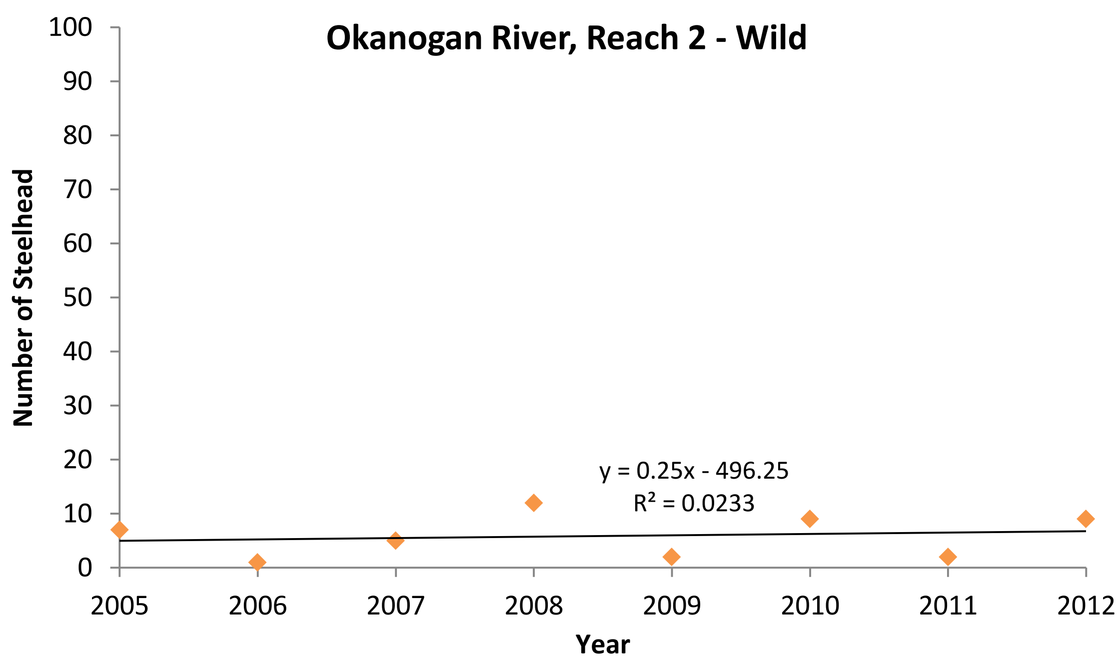

Figure 48. Wild spawning estimates for Okanogan River, Reach 2. The reach extends from Salmon Creek upstream to Omak Creek.

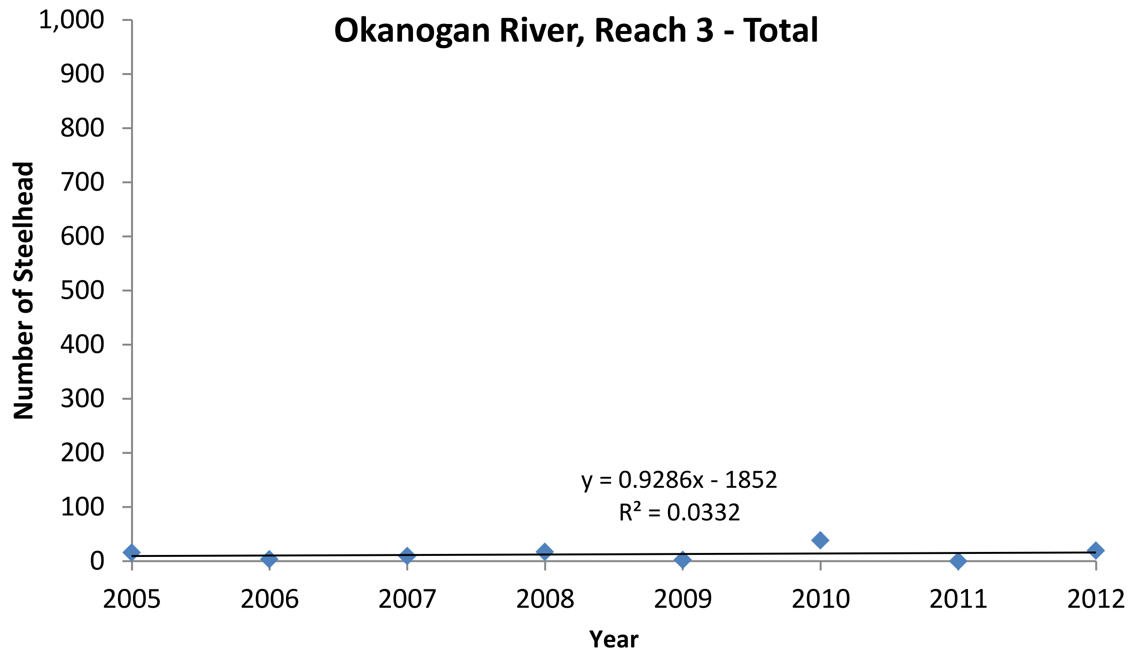

Figure 49. Total spawning estimates for Okanogan River, Reach 3. The reach extends from Omak Creek upstream to Riverside, WA.

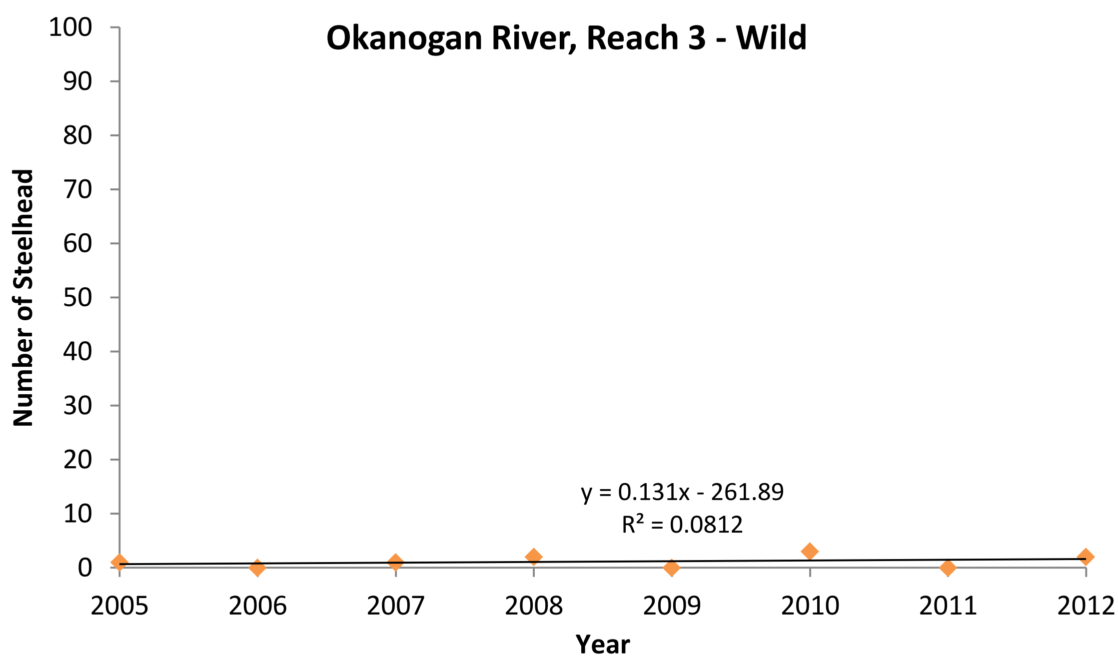

Figure 50. Wild spawning estimates for Okanogan River, Reach 3. The reach extends from Omak Creek upstream to Riverside, WA.

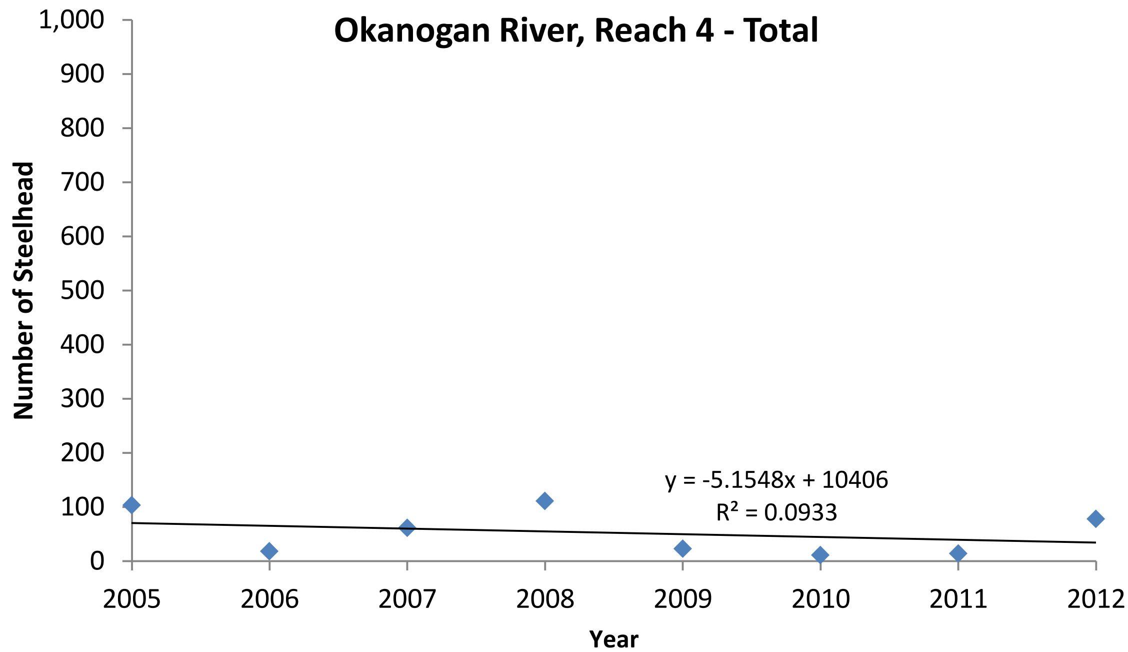

Figure 51. Total spawning estimates for Okanogan River, Reach 4. The reach extends from Riverside, WA upstream to Janis Bridge.

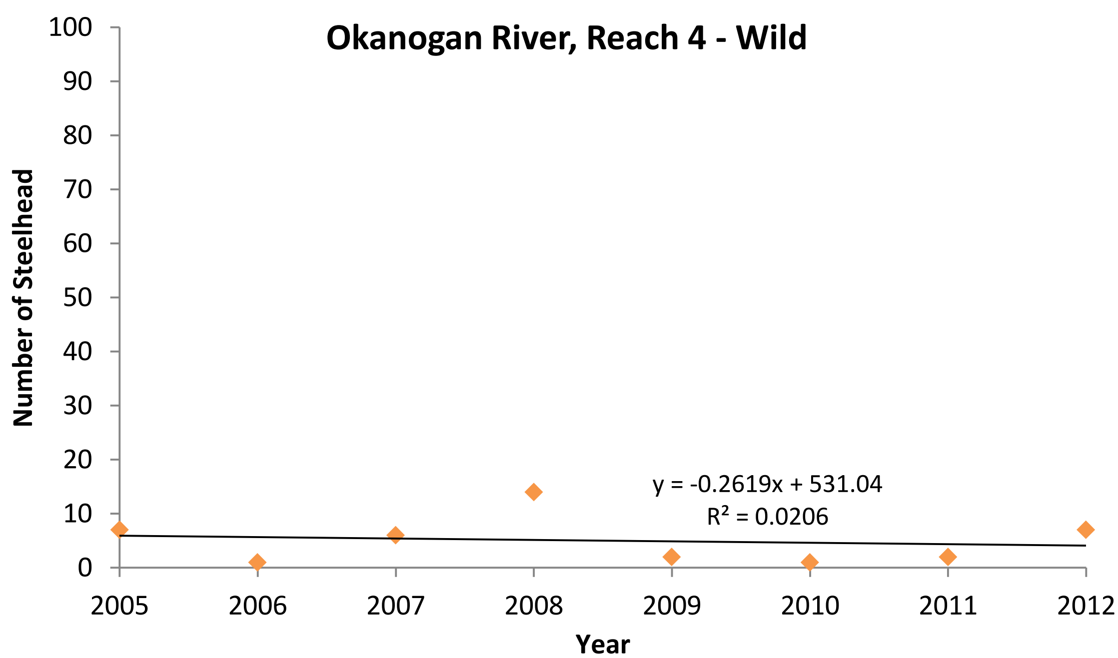

Figure 52. Wild spawning estimates for Okanogan River, Reach 4. The reach extends from Riverside, WA upstream to Janis Bridge.

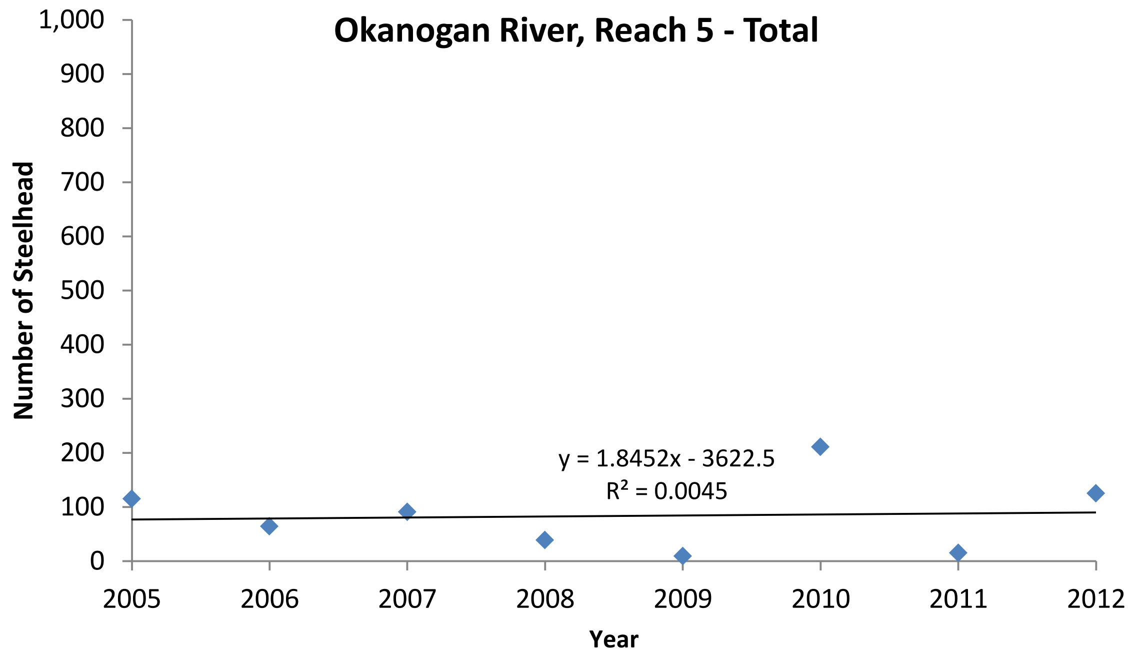

Figure 53. Total spawning estimates for Okanogan River, Reach 5. The reach extends from Janis Bridge upstream to Tonasket, WA.

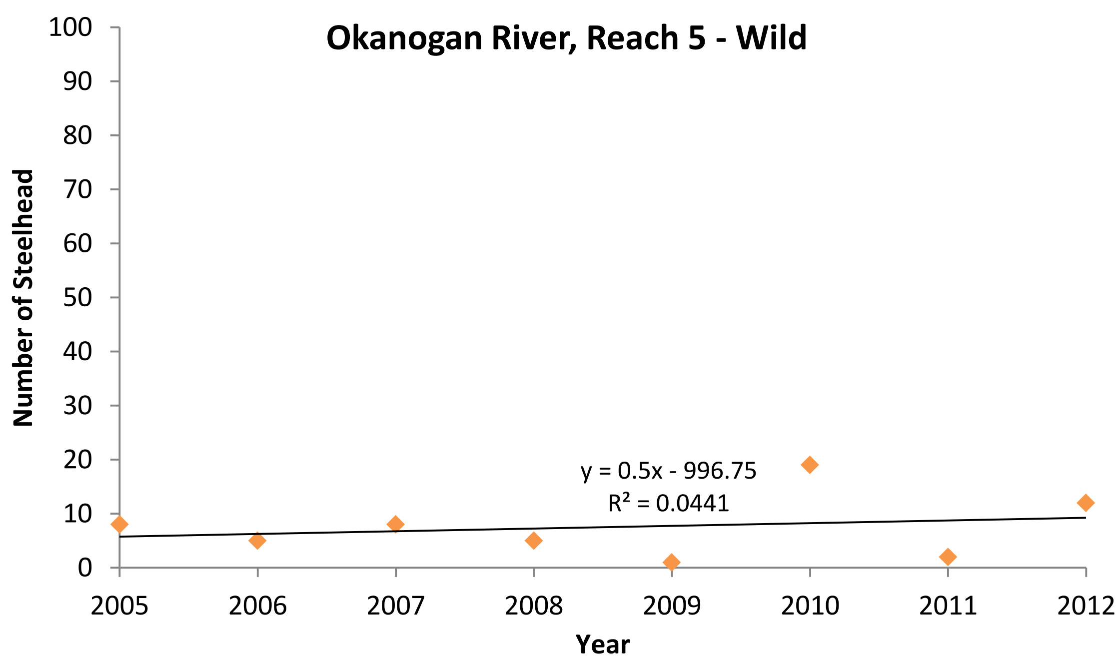

Figure 54. Wild spawning estimates for Okanogan River, Reach 5. The reach extends from Janis Bridge upstream to Tonasket, WA.

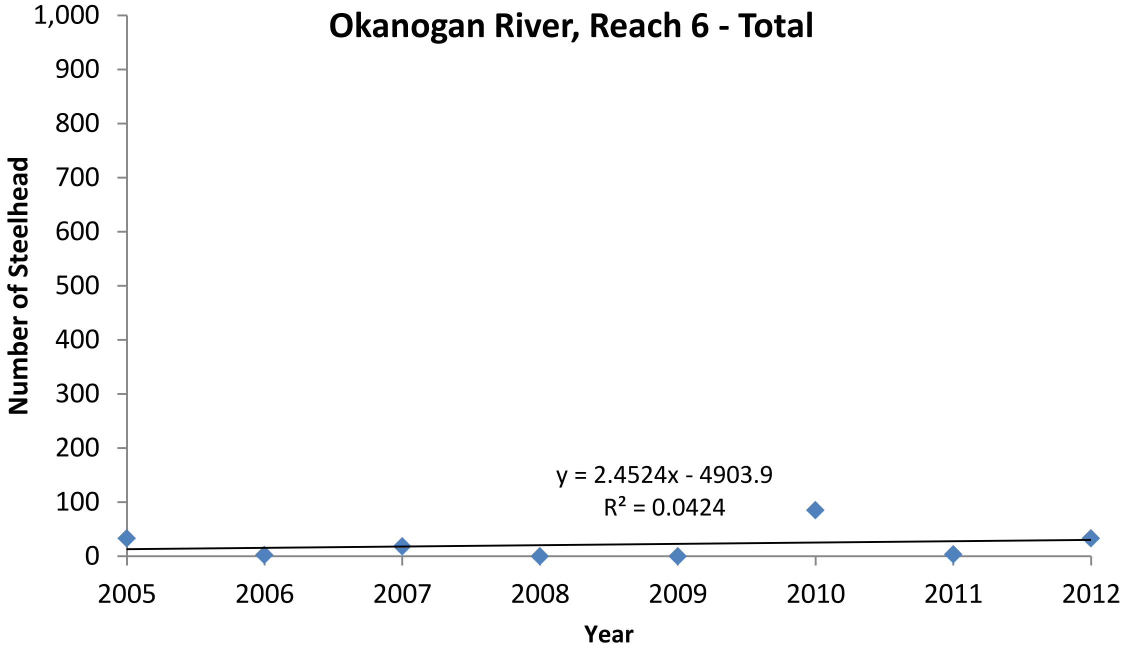

Figure 55. Total spawning estimates for Okanogan River, Reach 6. The reach extends from Horseshoe Lake upstream to the confluence of the Similkameen and the Okanogan River.

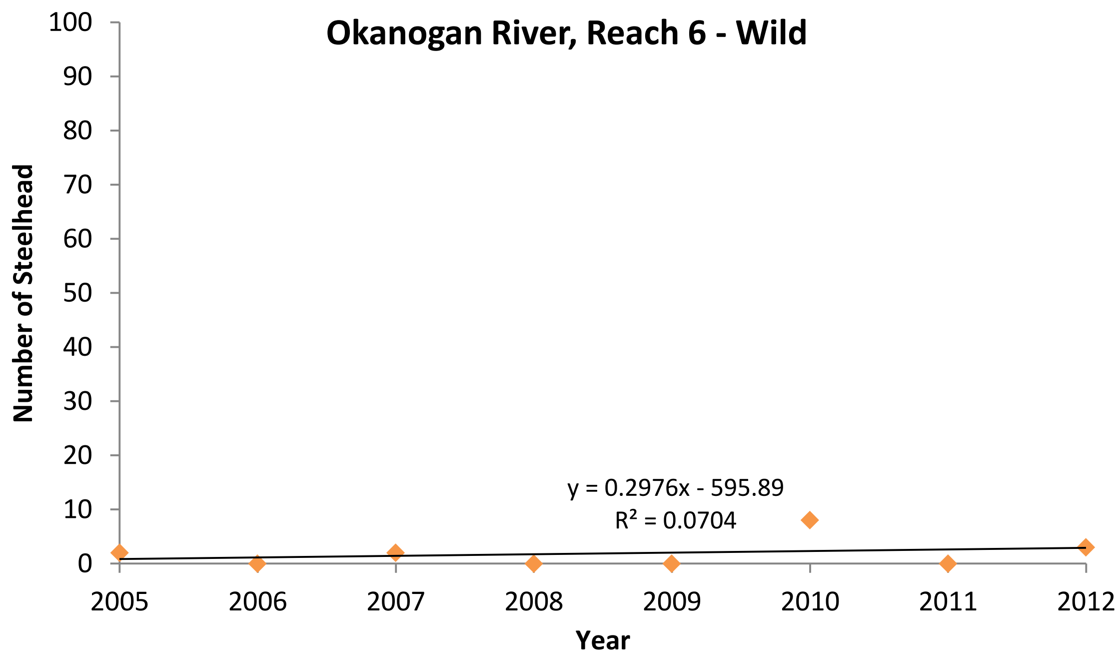

Figure 56. Wild spawning estimates for Okanogan River, Reach 6. The reach extends from Horseshoe Lake upstream to the confluence of the Similkameen and the Okanogan River.

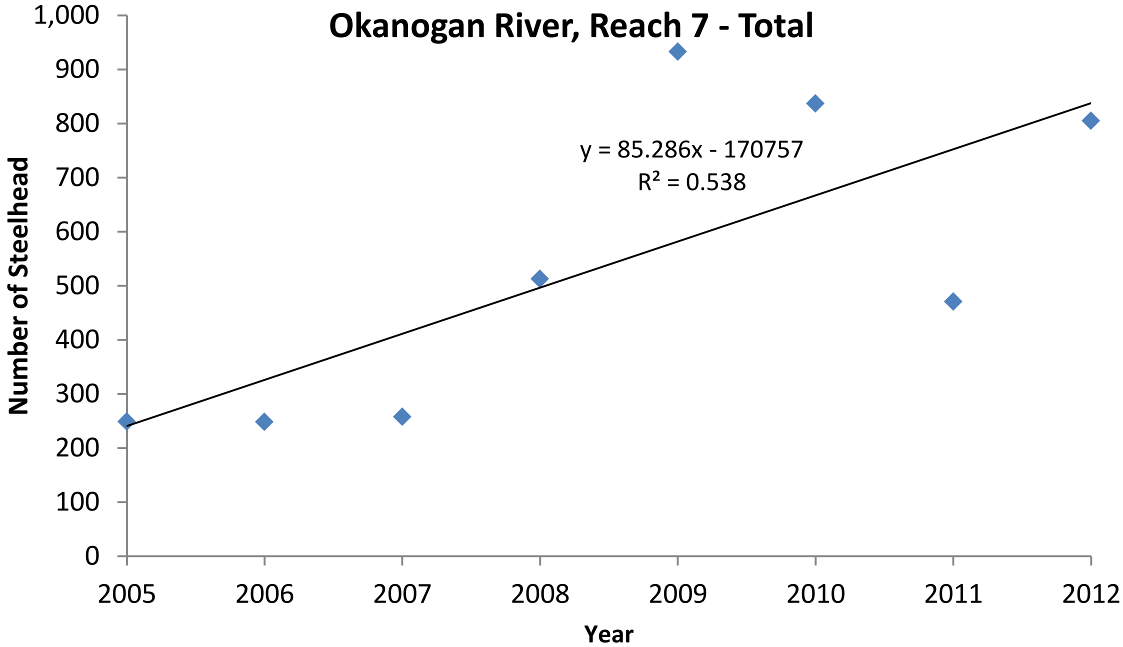

Figure 57. Total spawning estimates for Okanogan River, Reach 7. The reach extends from the confluence of the Similkameen and Okanogan River upstream to Zosel Dam.

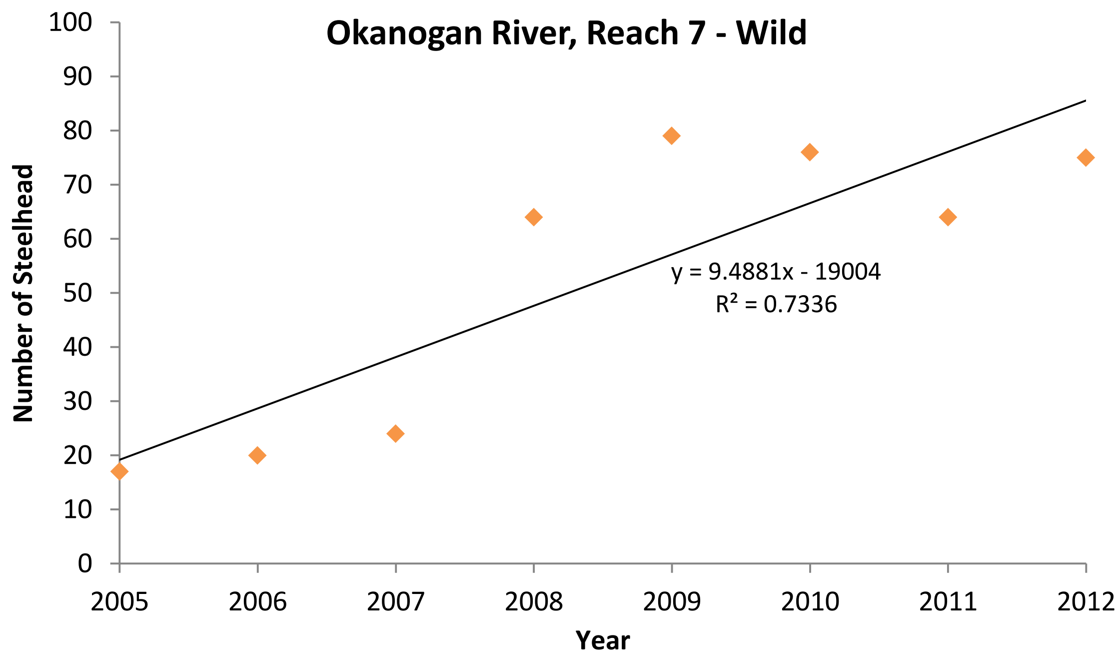

Figure 58. Wild spawning estimates for Okanogan River, Reach 7. The reach extends from the confluence of the Similkameen and Okanogan River upstream to Zosel Dam.

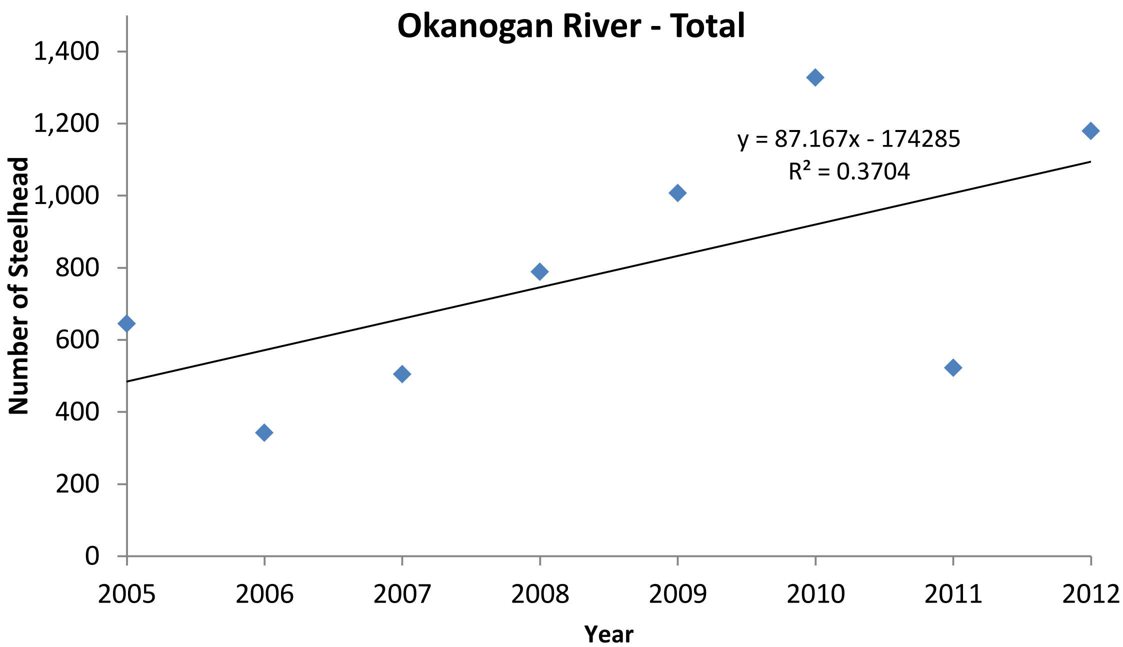

Figure 59. Total spawning estimates for the Okanogan River from the confluence with the Columbia River upstream to Zosel Dam.

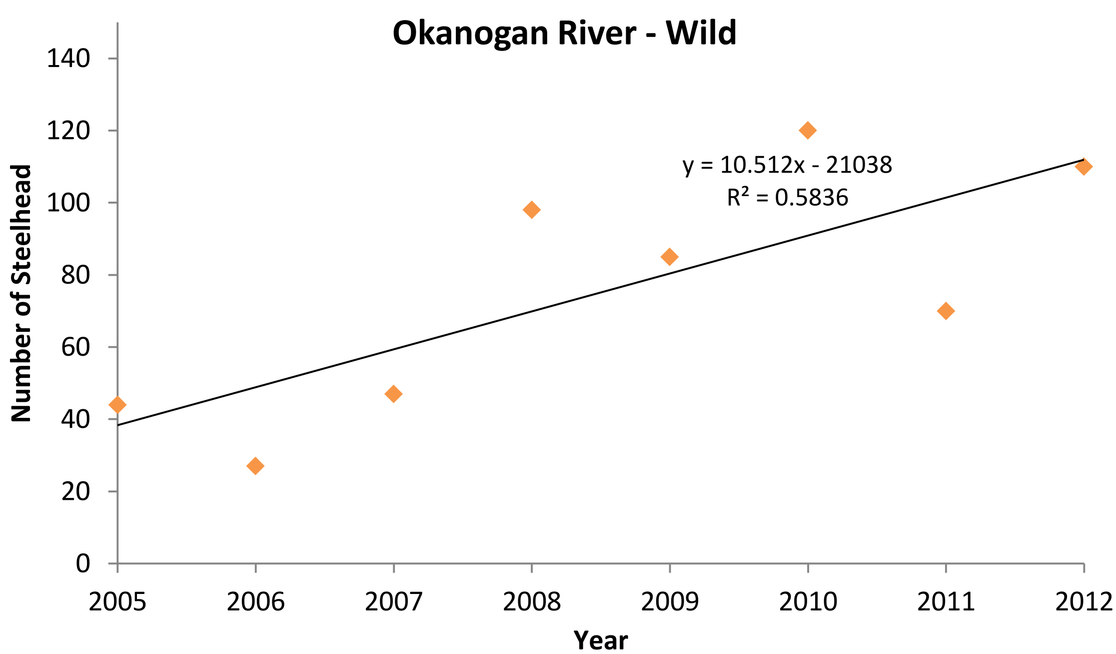

Figure 60. Wild spawning estimates for the Okanogan River from the confluence with the Columbia River upstream to Zosel Dam.

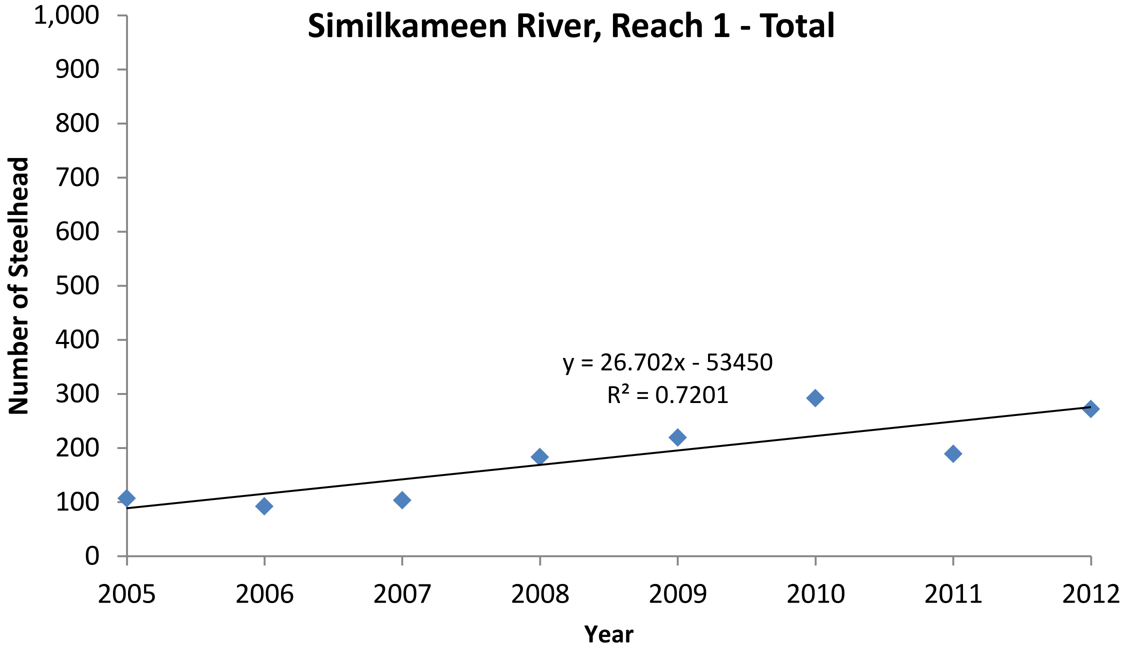

Figure 61. Total spawning estimates for Similkameen River, Reach 1. The reach extends from the confluence of the Similkameen and Okanogan River upstream to the treatment plant in Oroville, WA.

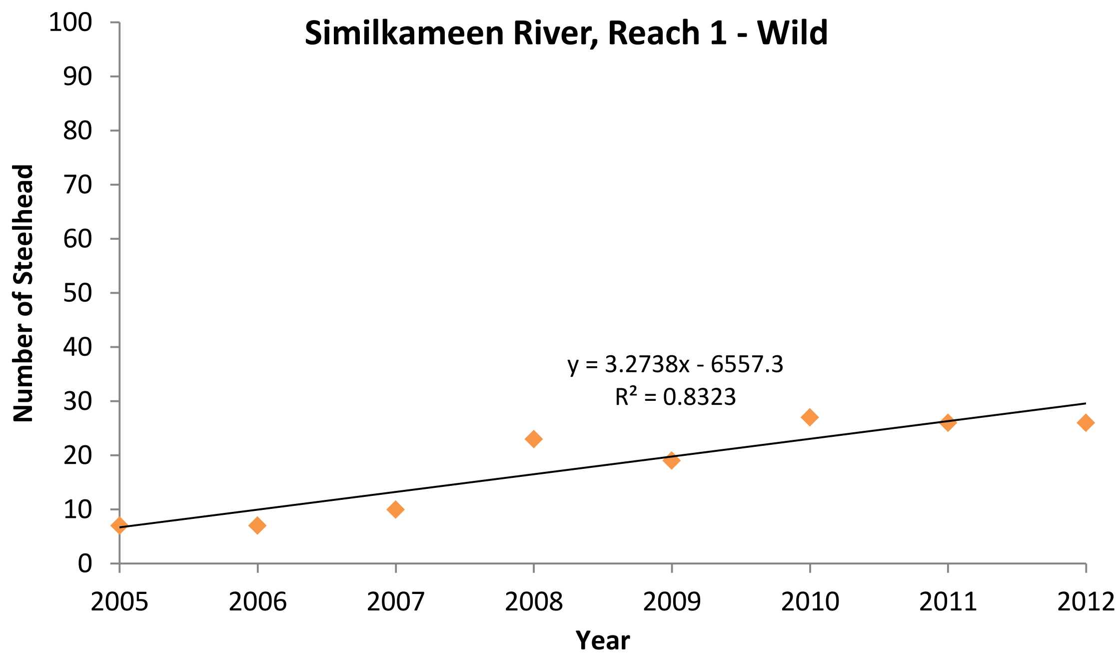

Figure 62. Wild spawning estimates for Similkameen River, Reach 1. The reach extends from the confluence of the Similkameen and Okanogan River upstream to the treatment plant in Oroville, WA.

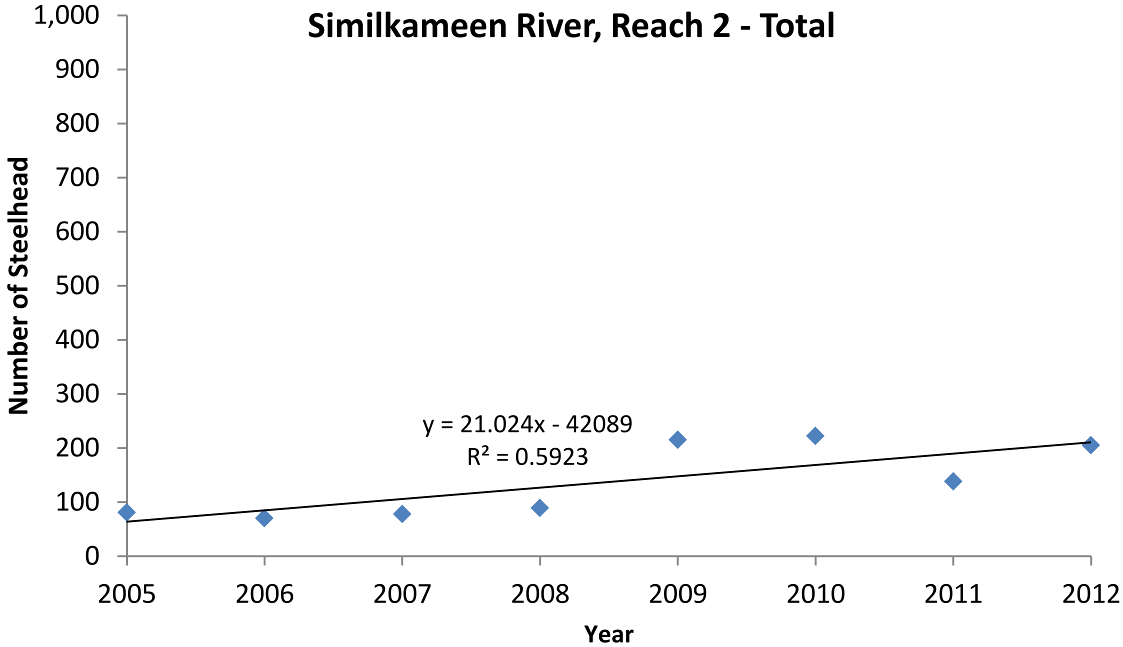

Figure 63. Total spawning estimates for Similkameen River, Reach 2. The reach extends from the treatment plant in Oroville, WA upstream to Enloe Dam.

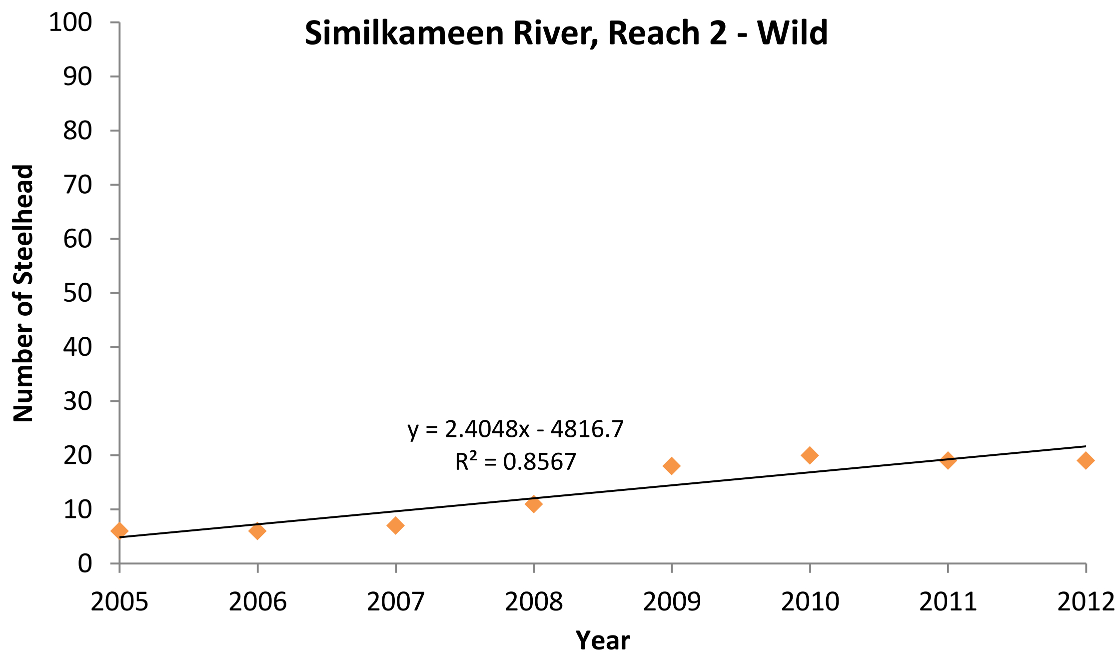

Figure 64. Wild spawning estimates for Similkameen River, Reach 2. The reach extends from the treatment plant in Oroville, WA upstream to Enloe Dam.

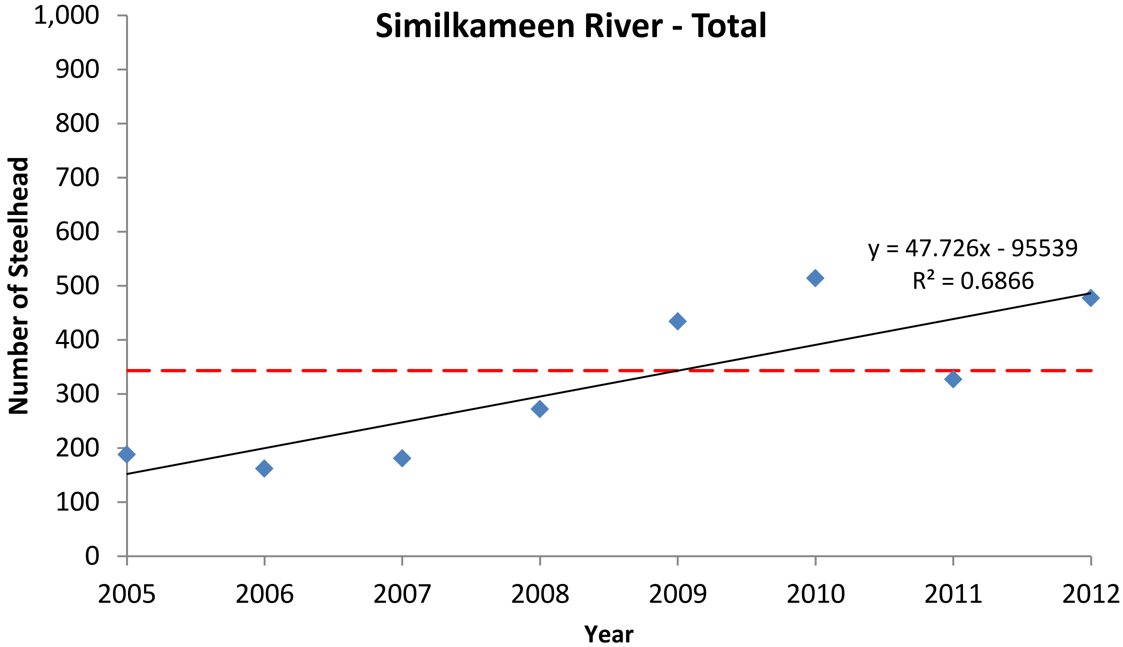

Figure 65. Total spawning estimates for Similkameen River from the confluence of the Similkameen and Okanogan River upstream to Enloe Dam. The red line represents habitat capacity.

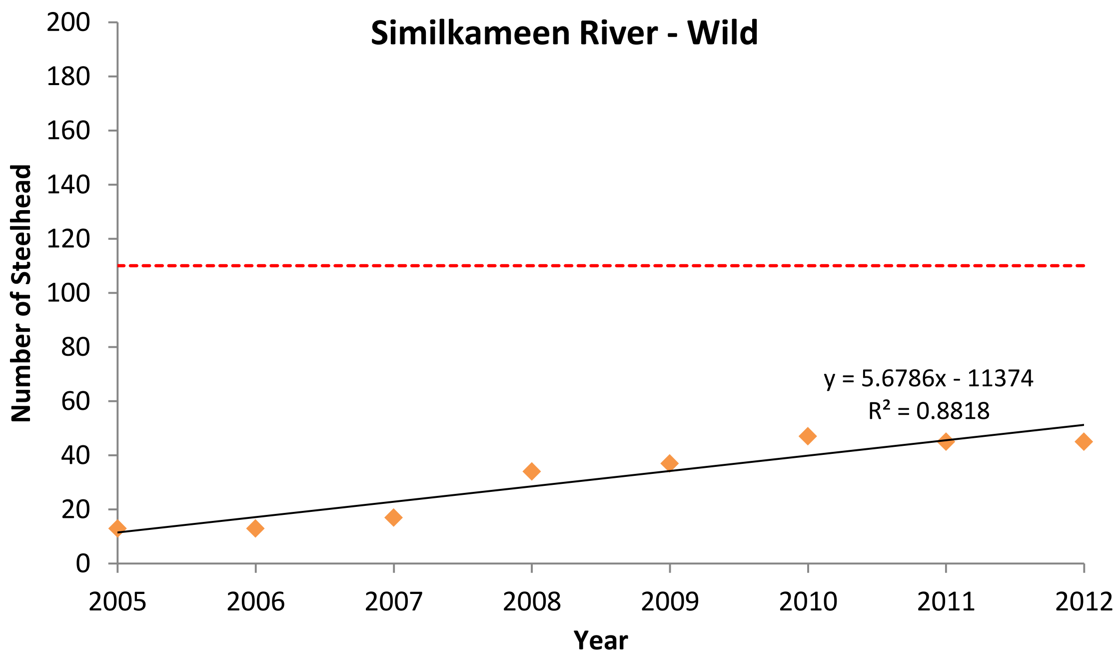

Figure 66. Wild spawning estimates for Similkameen River from the confluence of the Similkameen and Okanogan River upstream to Enloe Dam. The dashed line represents the proportional contribution to minimum recovery goal for the stream.

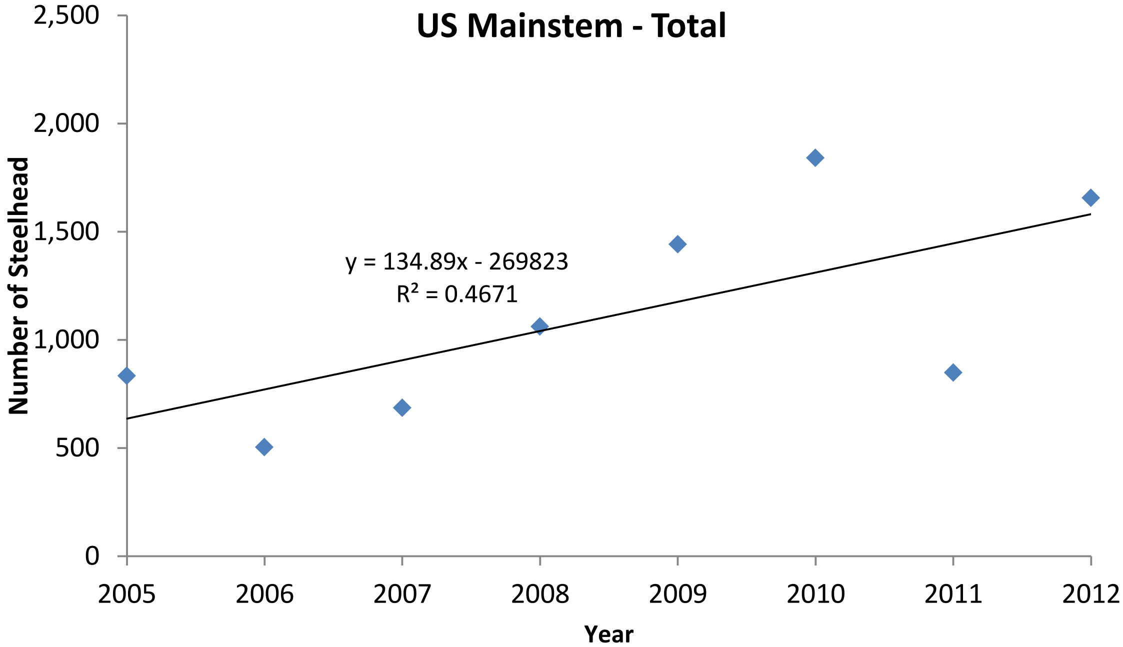

Figure 67. Total spawning estimates for Similkameen and Okanogan Rivers.

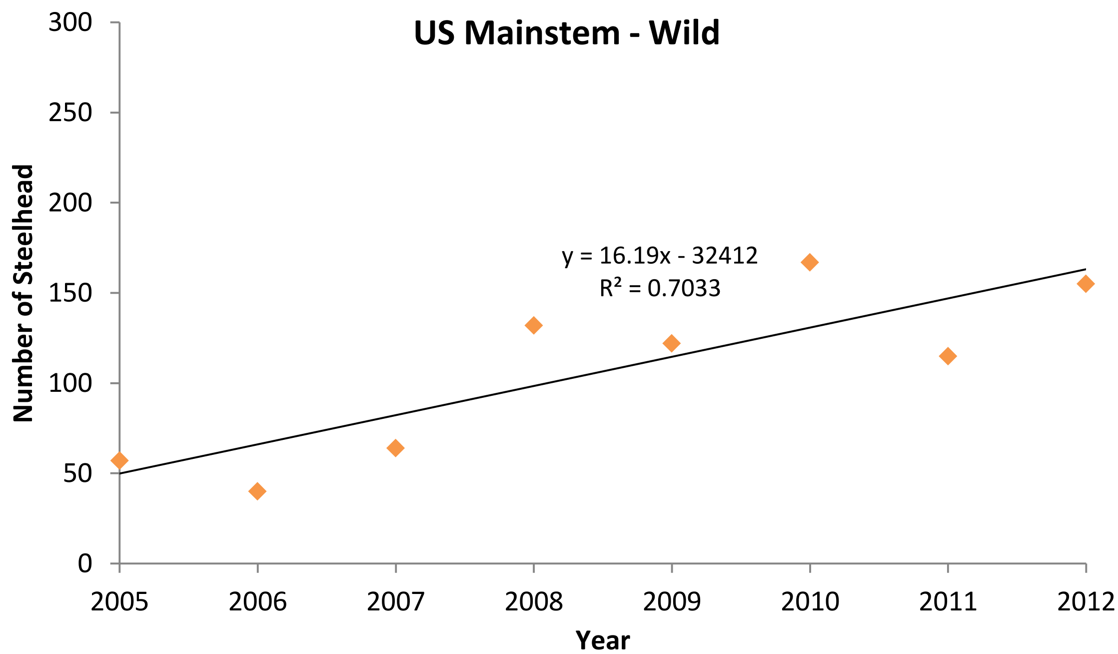

Figure 68. Wild spawning estimates for Similkameen and Okanogan Rivers.

Tributary Steelhead Trend Graphs

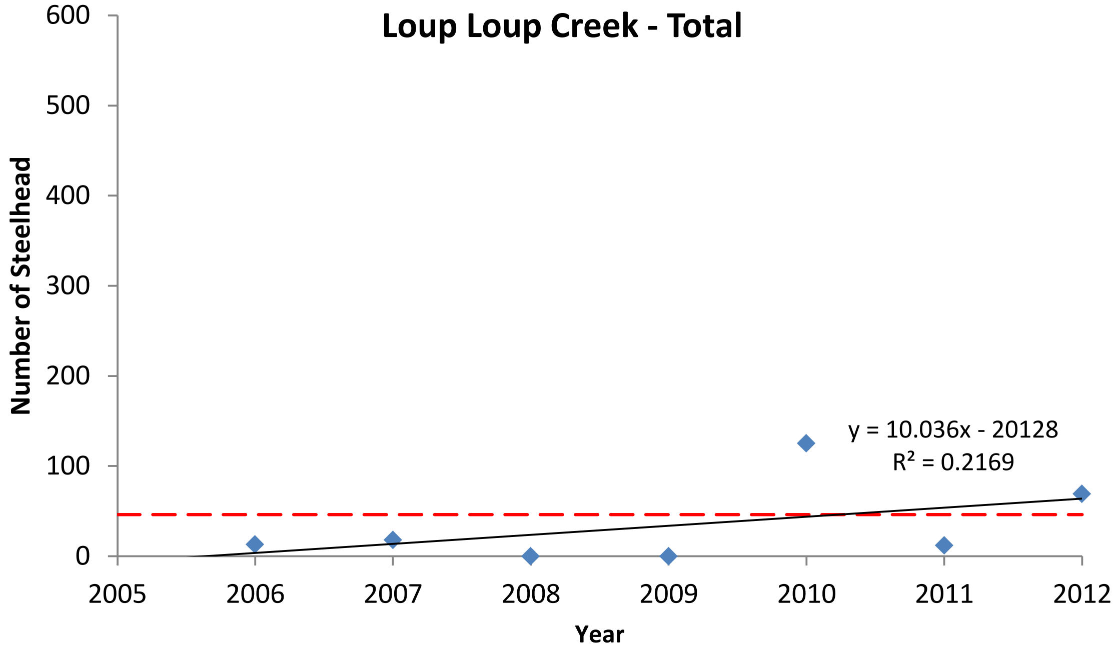

Figure 69. Total spawning estimates for Loup Loup Creek. The dashed line represents habitat capacity (IP) for the stream.

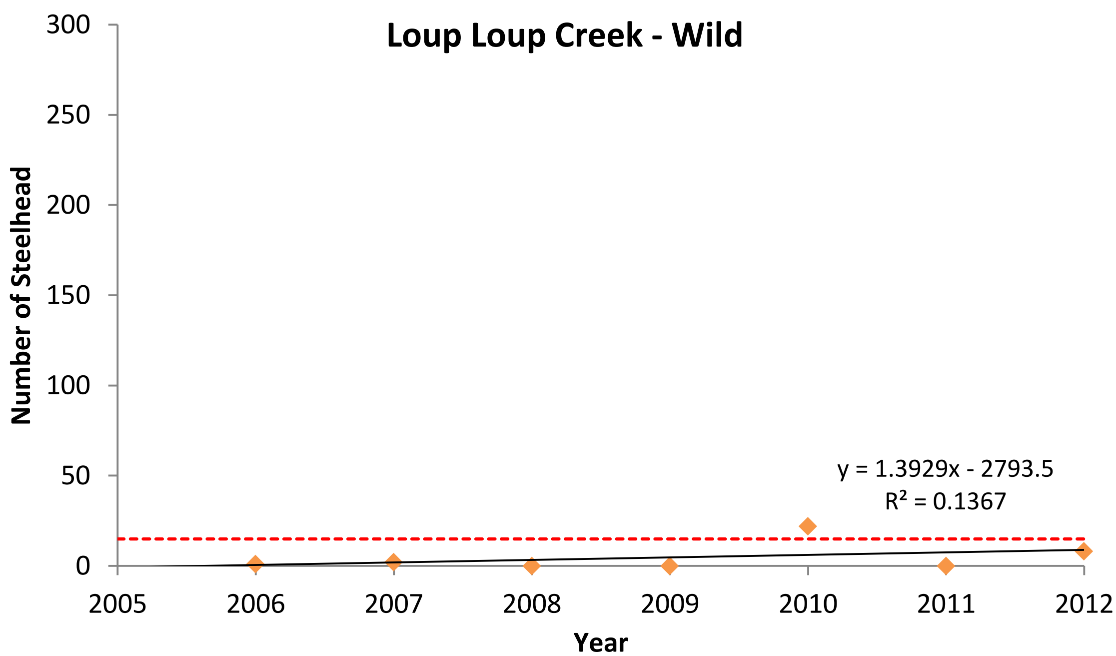

Figure 70. Wild spawning estimates for Loup Loup Creek. The dashed line represents the proportional contribution to minimum recovery goal for the stream.

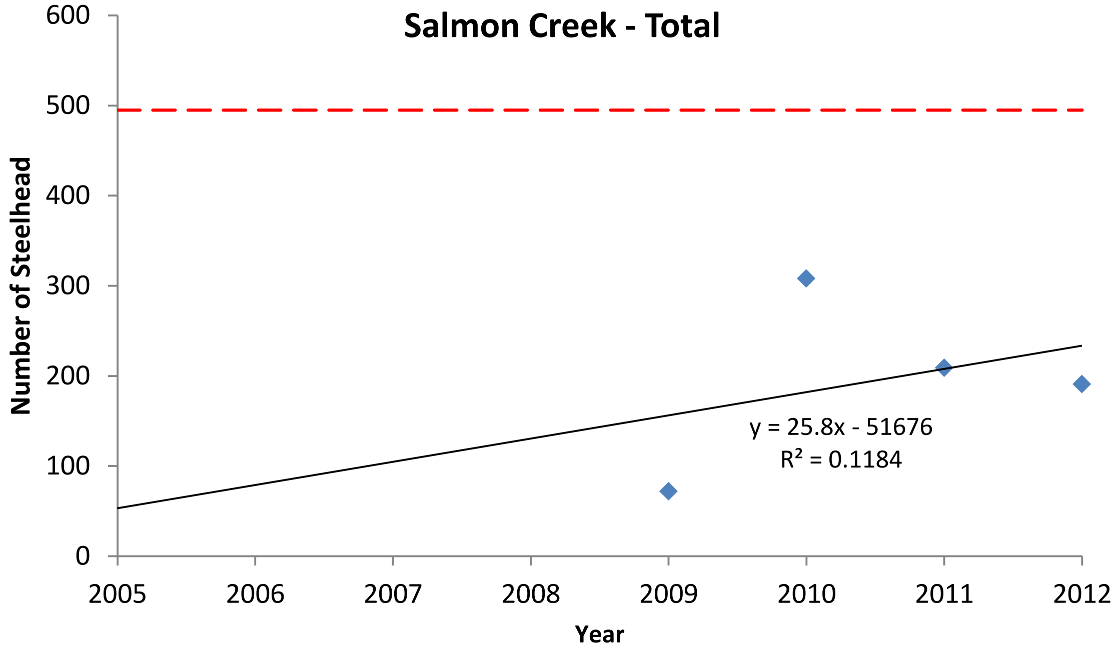

Figure 71. Total spawning estimates for Salmon Creek. The dashed line represents habitat capacity (IP) for the stream.

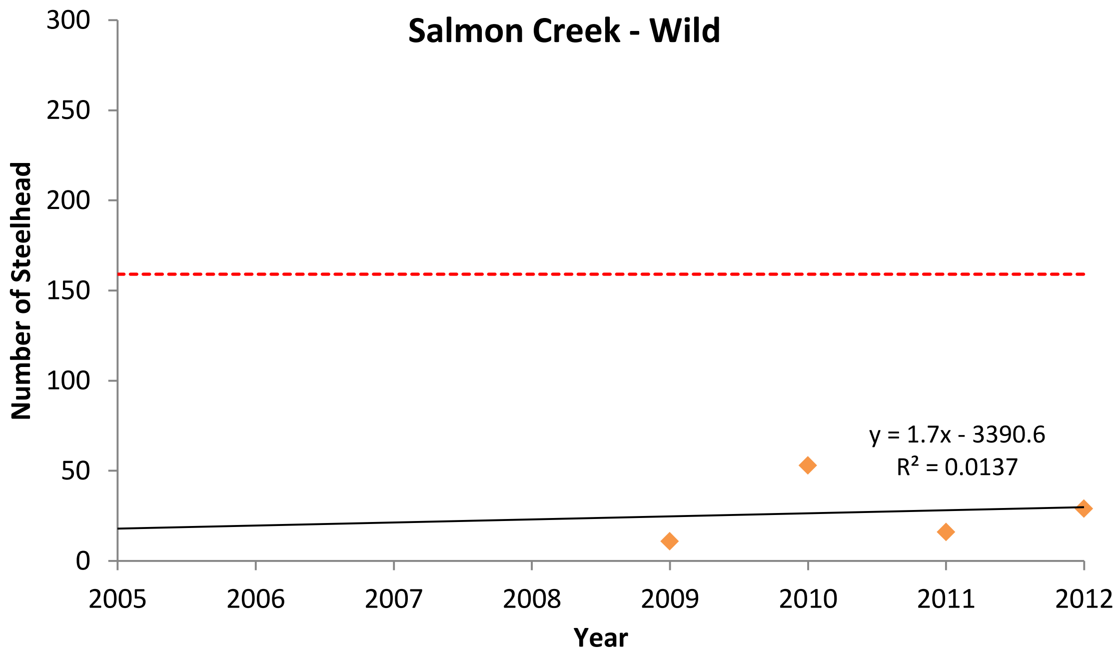

Figure 72. Wild spawning estimates for Salmon Creek. The dashed line represents the proportional contribution to minimum recovery goal for the stream.

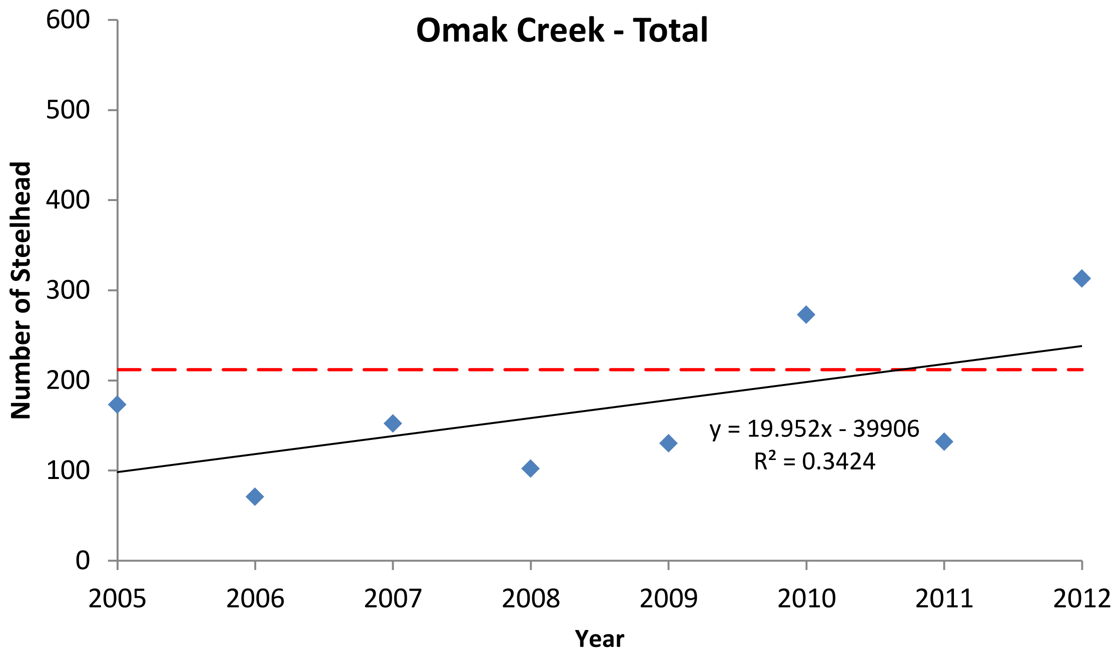

Figure 73. Total spawning estimates for Omak Creek. The dashed line represents habitat capacity (IP) for the stream.

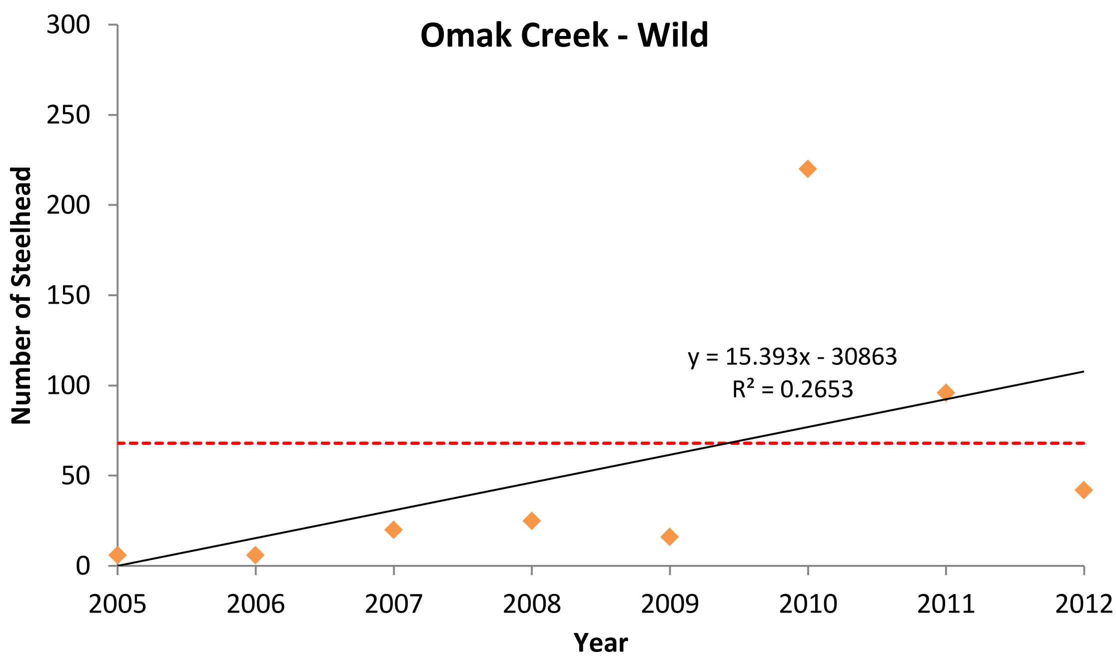

Figure 74. Wild spawning estimates for Omak Creek. The dashed line represents the proportional contribution to minimum recovery goal for the stream.

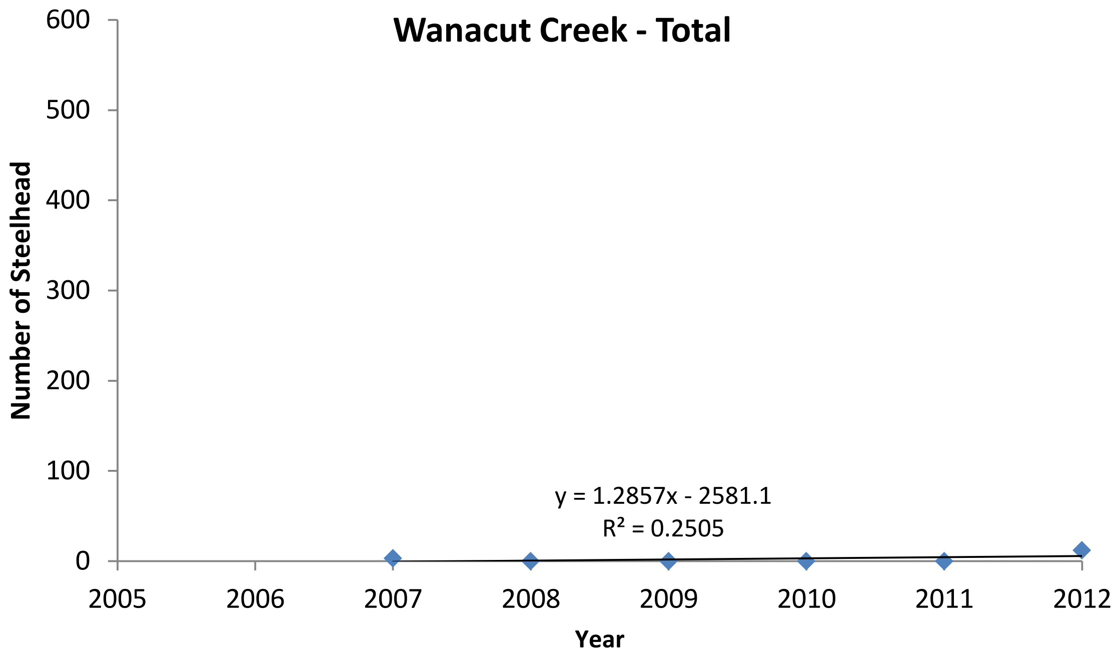

Figure 75. Total spawning estimates for Wanacut Creek.

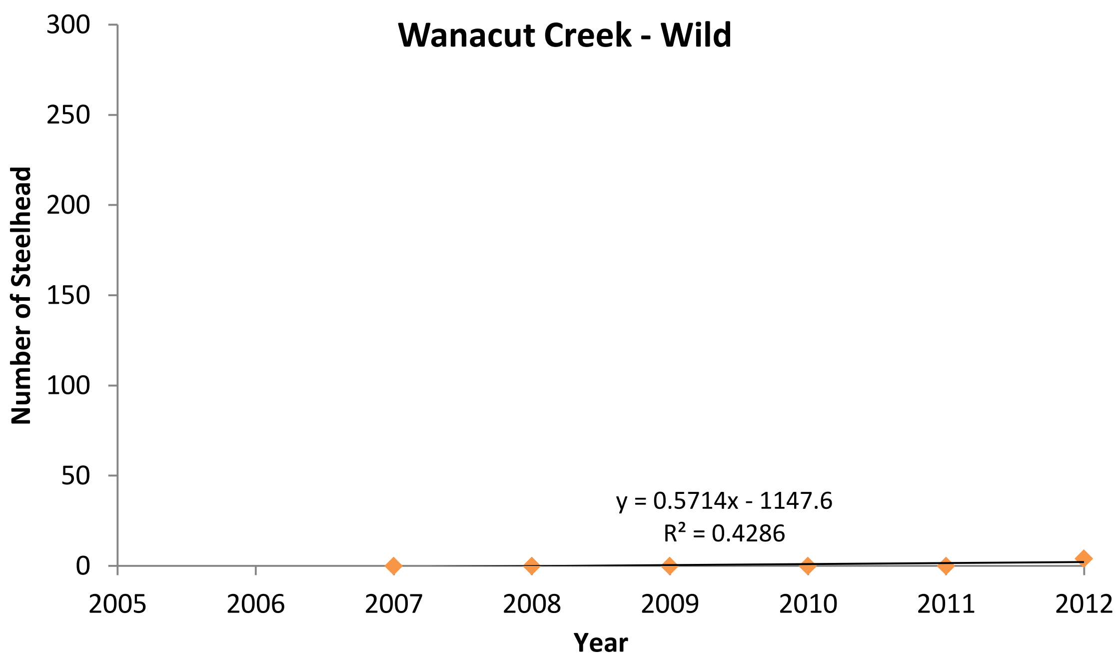

Figure 76. Wild spawning estimates for Wanacut Creek.

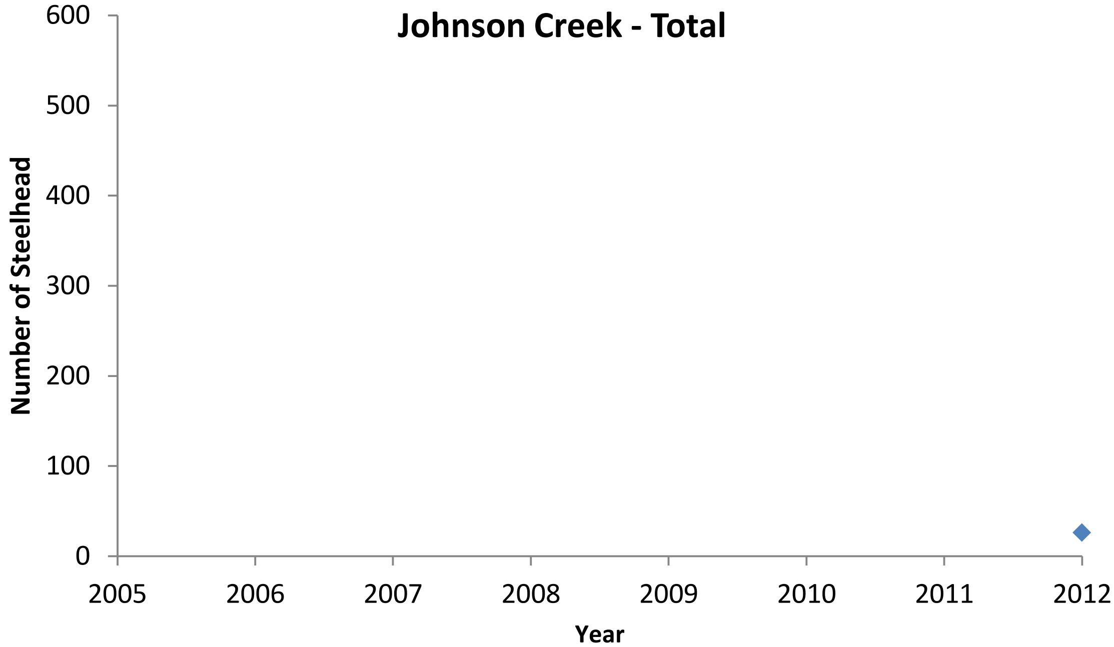

Figure 77. Total spawning estimates for Johnson Creek.

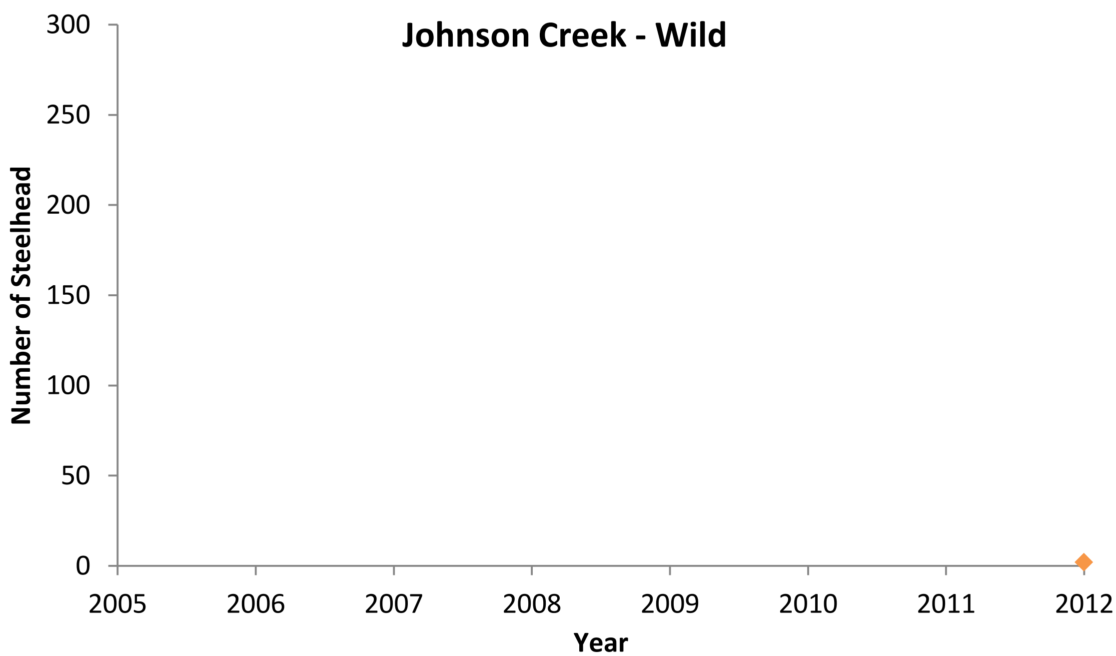

Figure 78. Wild spawning estimates for Johnson Creek.

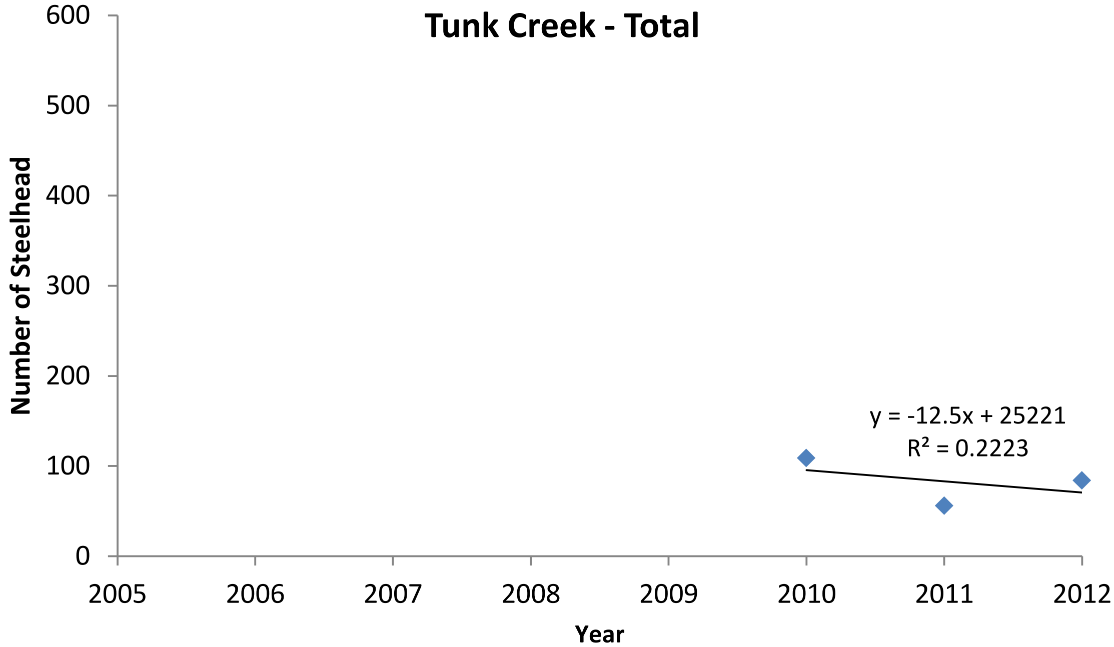

Figure 79. Total spawning estimates for Tunk Creek.

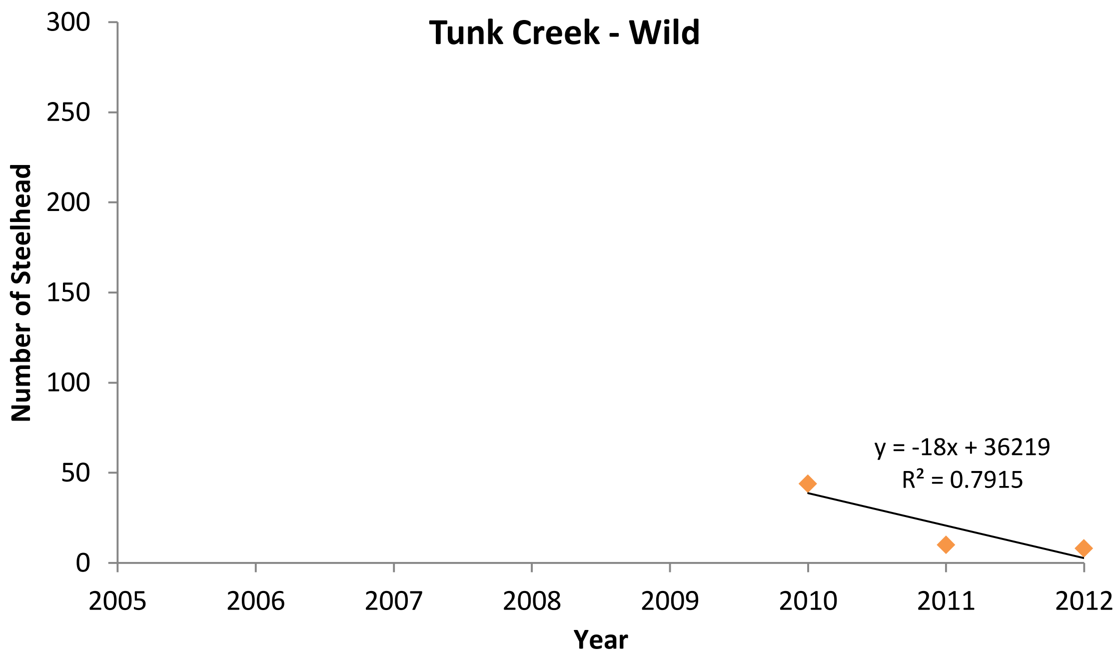

Figure 80. Wild spawning estimates for Tunk Creek.

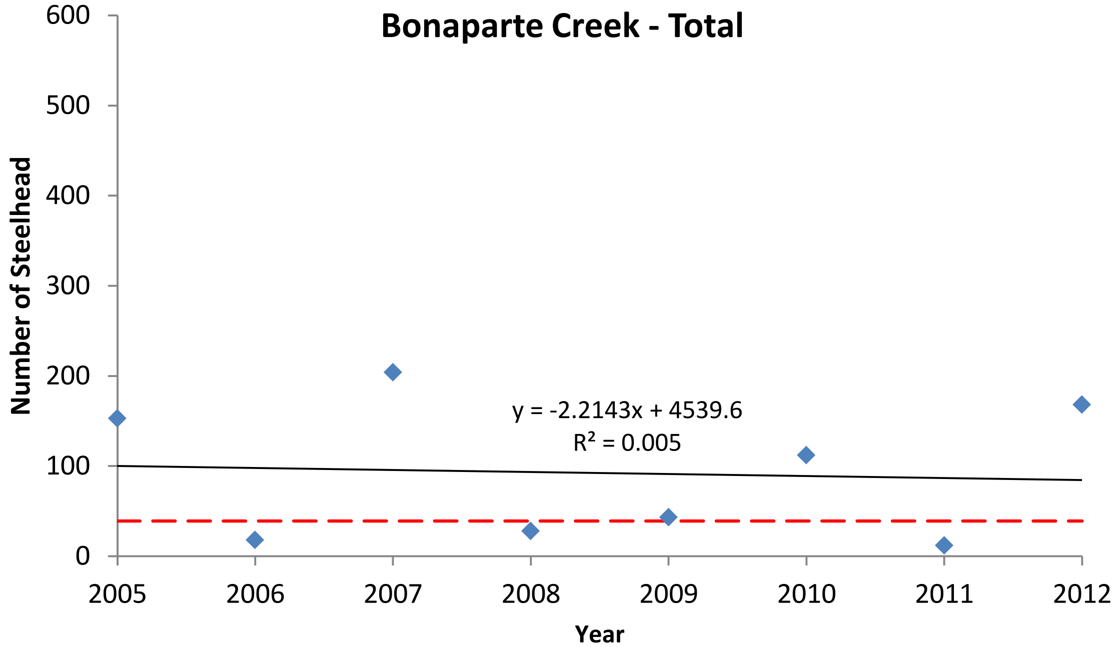

Figure 81. Total spawning estimates for Bonaparte Creek. The dashed line represents habitat capacity (IP) for the stream.

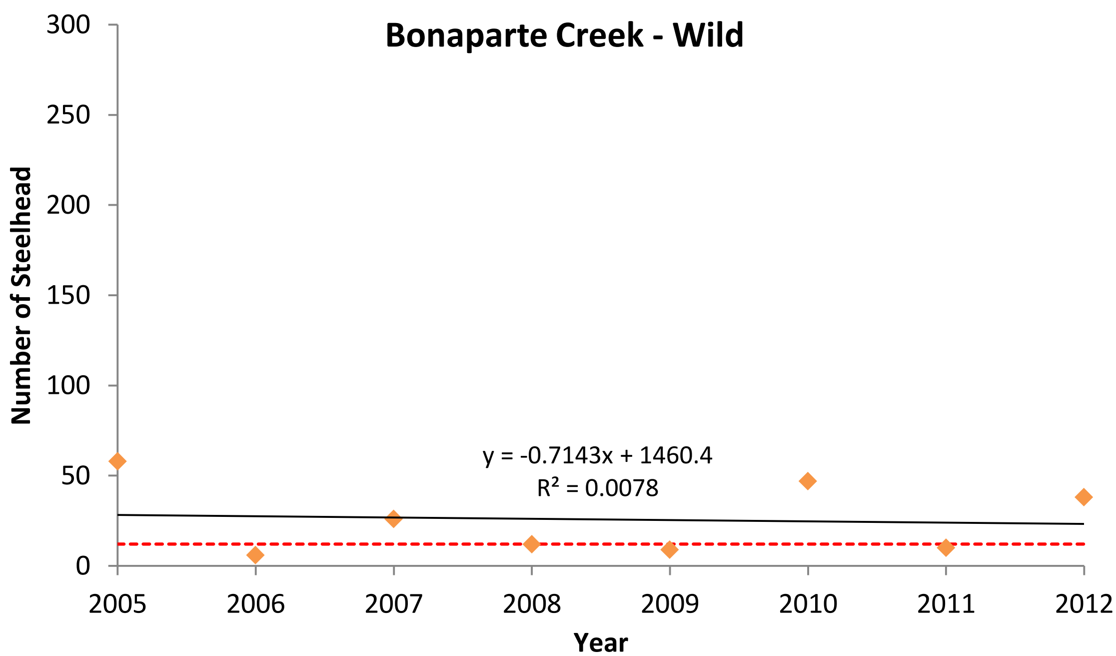

Figure 82. Wild spawning estimates for Bonaparte Creek. The dashed line represents the proportional contribution to minimum recovery goal for the stream.

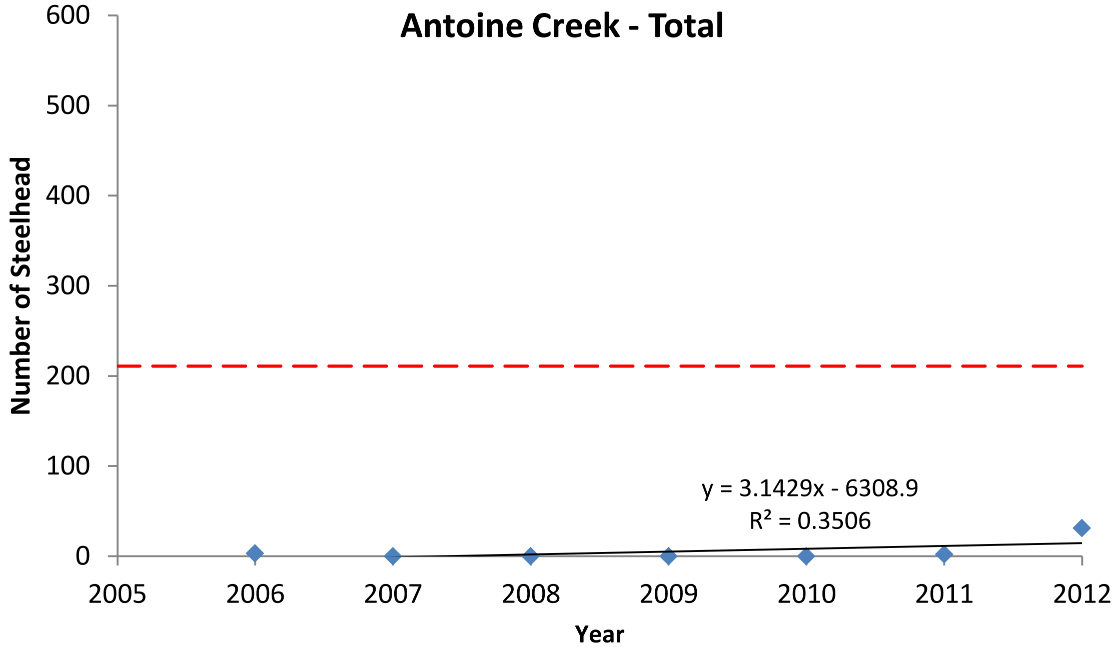

Figure 83. Total spawning estimates for Antoine Creek. The dashed line represents habitat capacity (IP) for the stream.

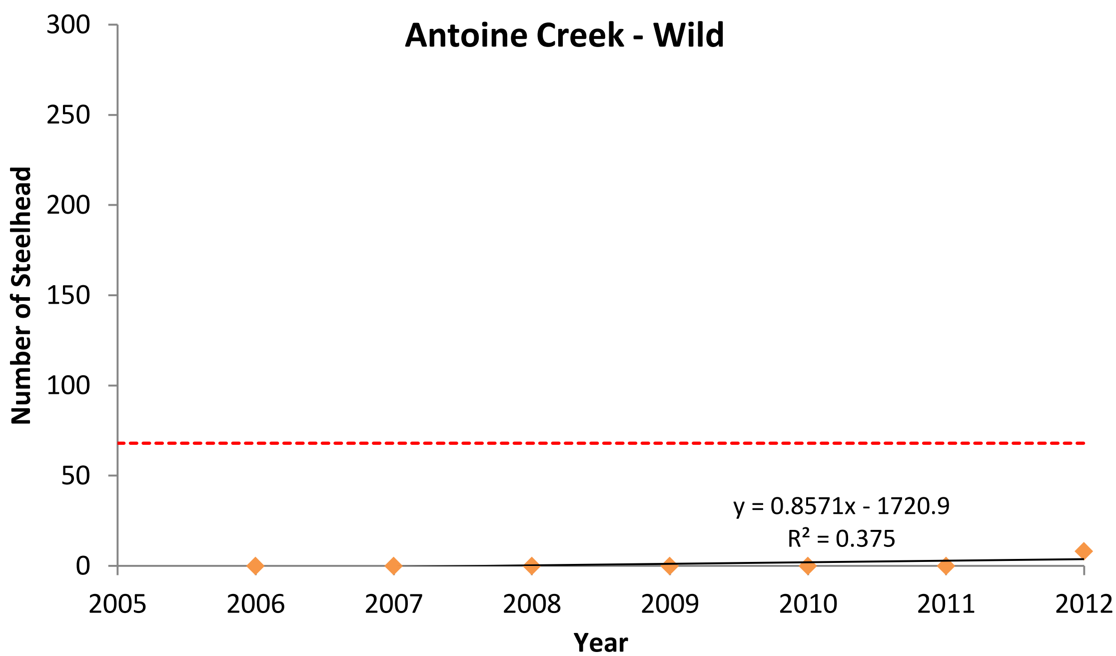

Figure 84. Wild spawning estimates for Antoine Creek. The dashed line represents the proportional contribution to minimum recovery goal for the stream.

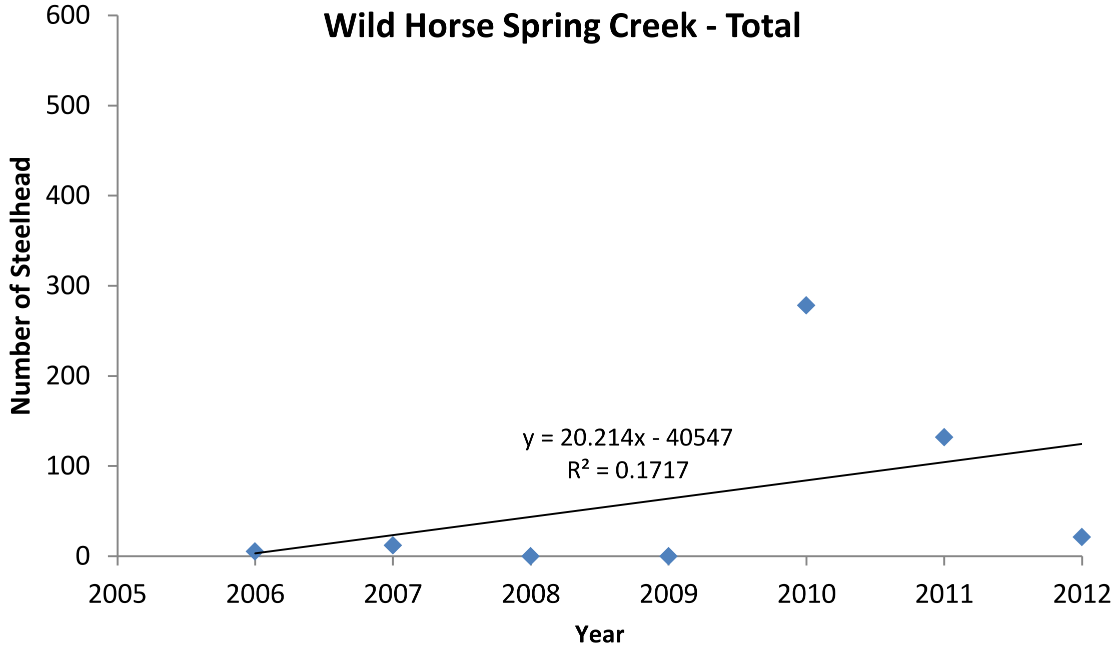

Figure 85. Total spawning estimates for Wild Horse Spring Creek.

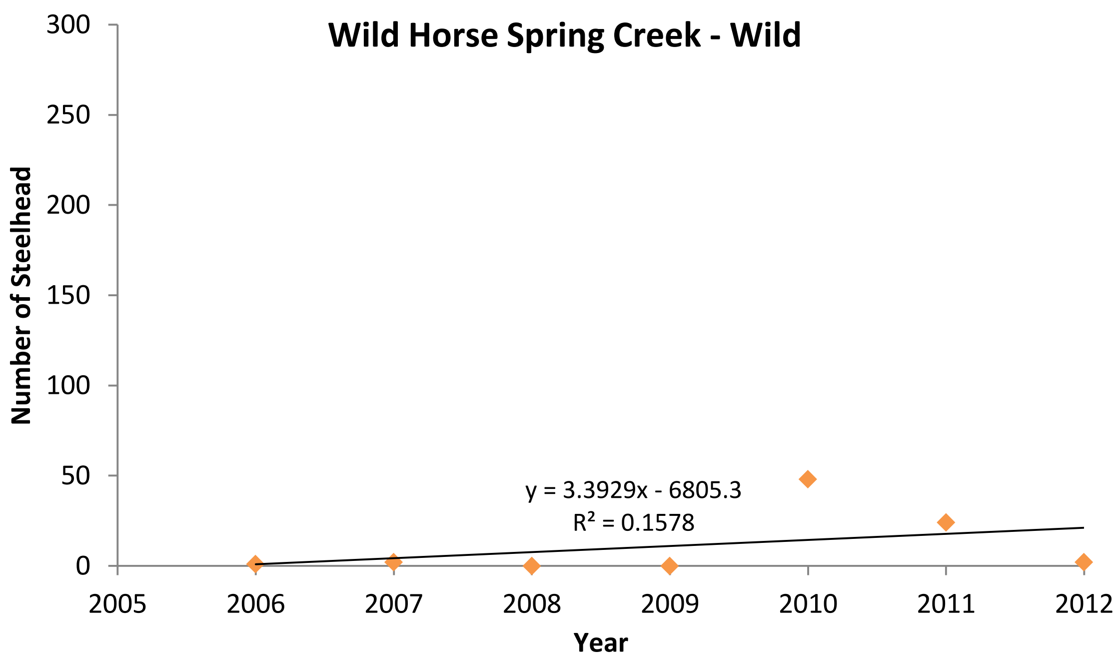

Figure 86. Wild spawning estimates for Wild Horse Spring Creek.

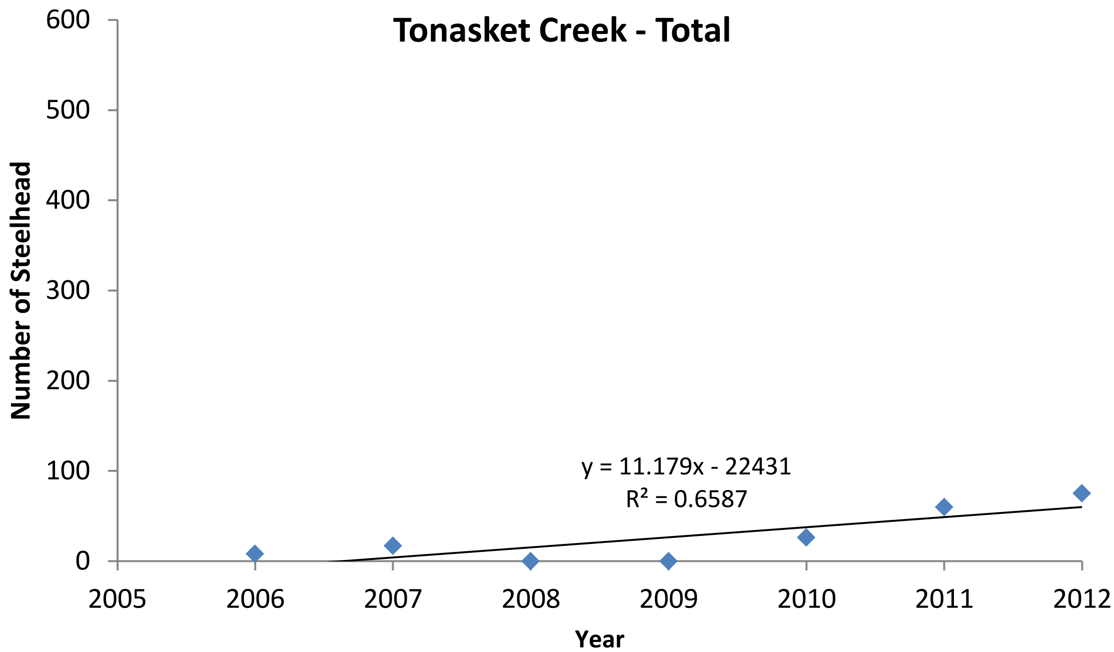

Figure 87. Total spawning estimates for Tonasket Creek.

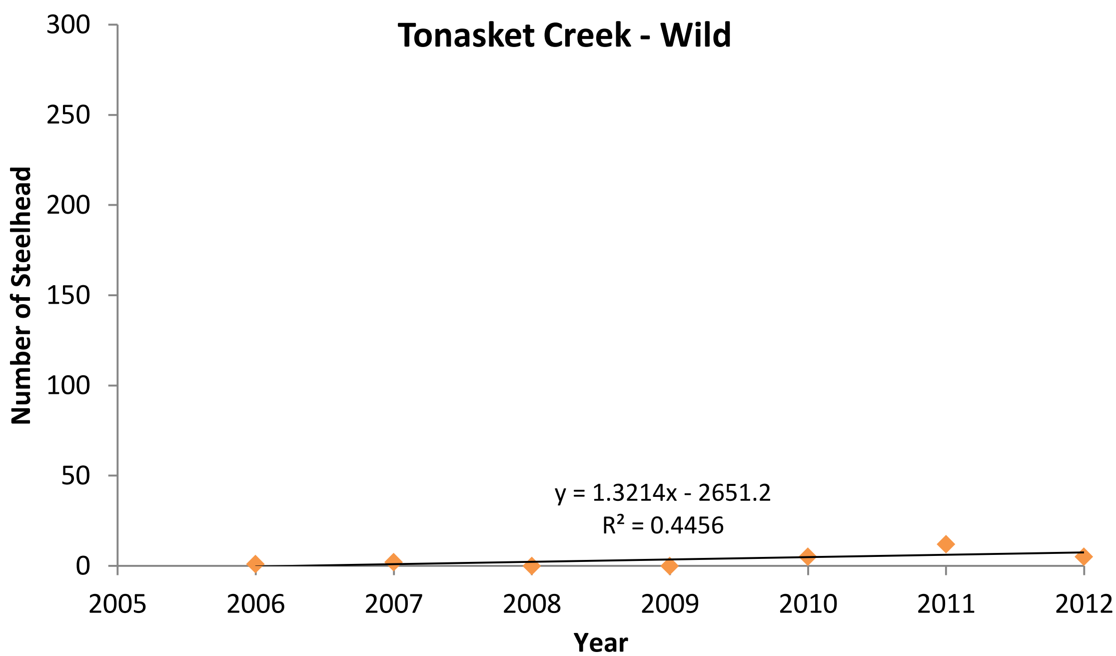

Figure 88. Wild spawning estimates for Tonasket Creek.

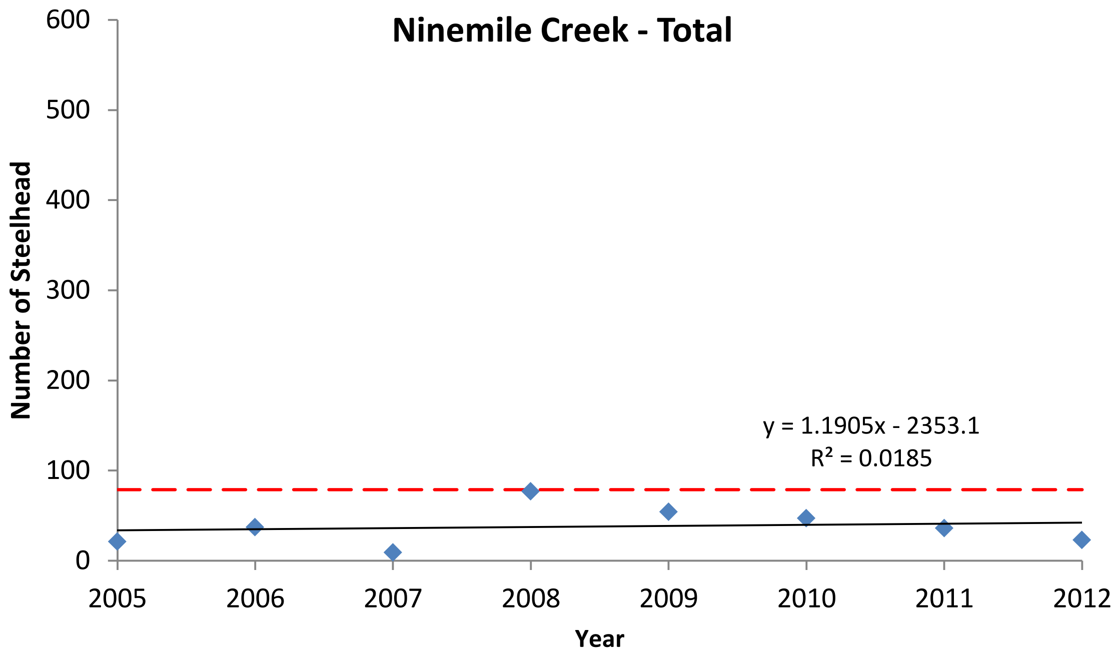

Figure 89. Total spawning estimates for Ninemile Creek. The dashed line represents habitat capacity (IP) for the stream.

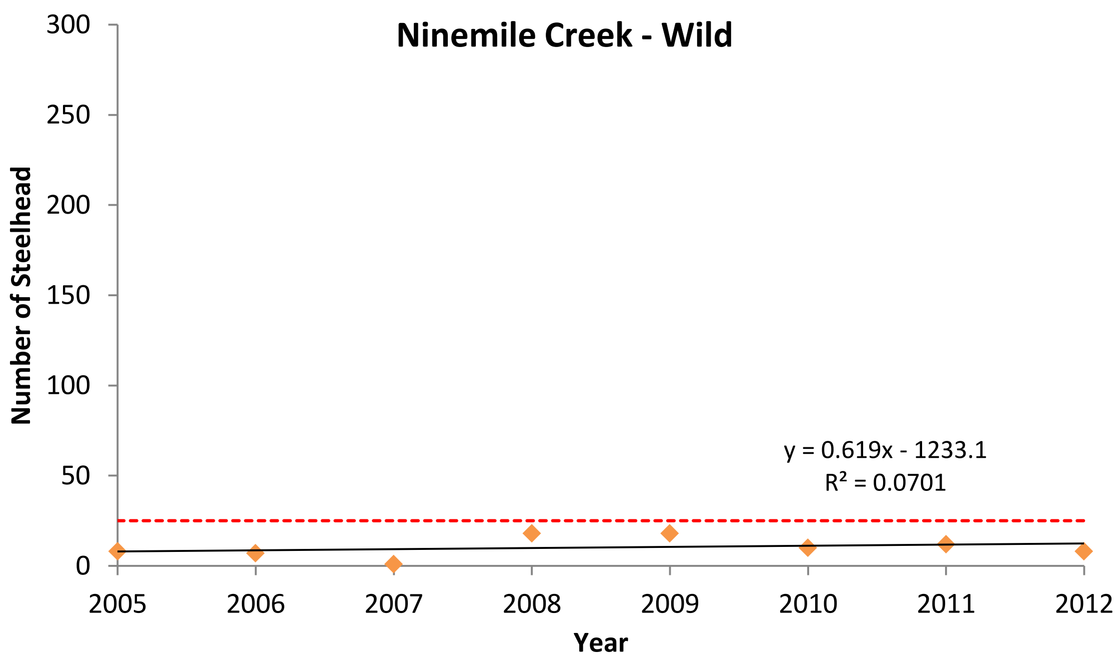

Figure 90. Wild spawning estimates for Ninemile Creek. The dashed line represents the proportional contribution to minimum recovery goal for the stream.

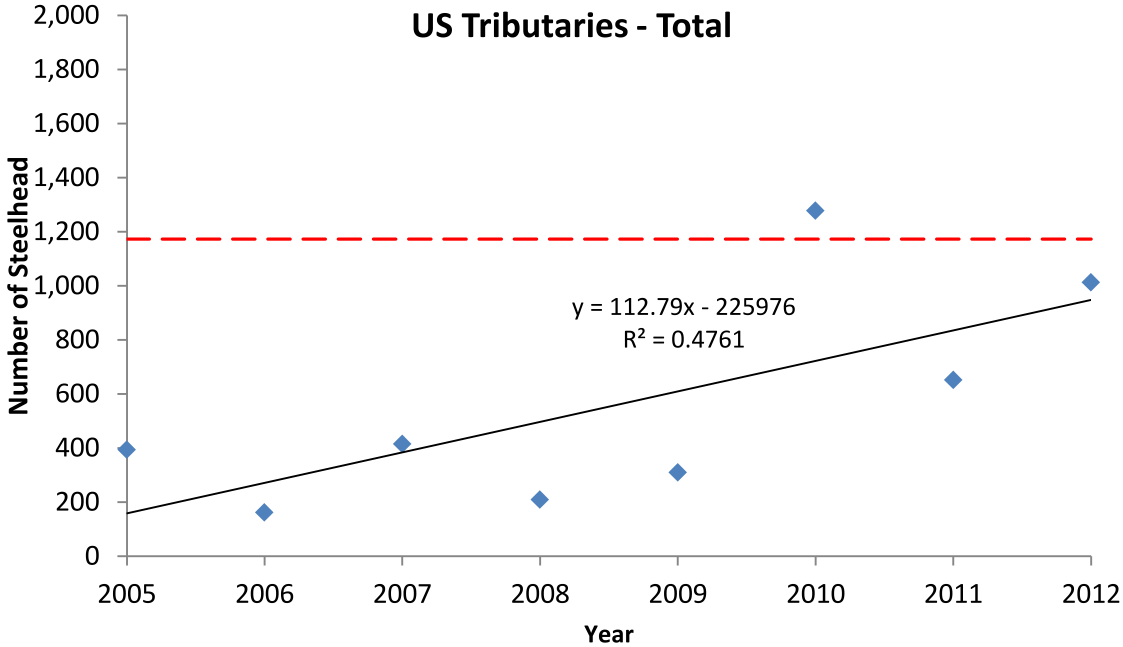

Figure 91. Total spawning estimates for all tributaries to the Okanogan River. The dashed line represents tributary habitat capacity (IP).

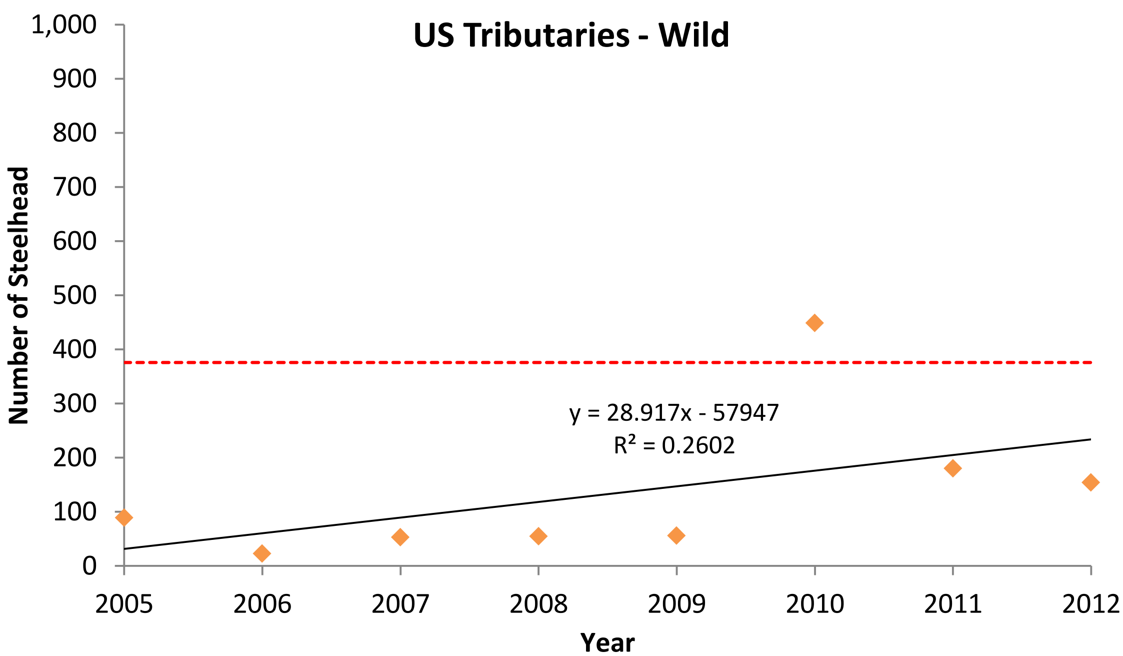

Figure 92. Wild spawning estimates for all tributaries to the Okanogan River. The dashed line represents the proportional contribution to minimum recovery goal for the stream.

Okanogan Basin Steelhead Trend Graphs

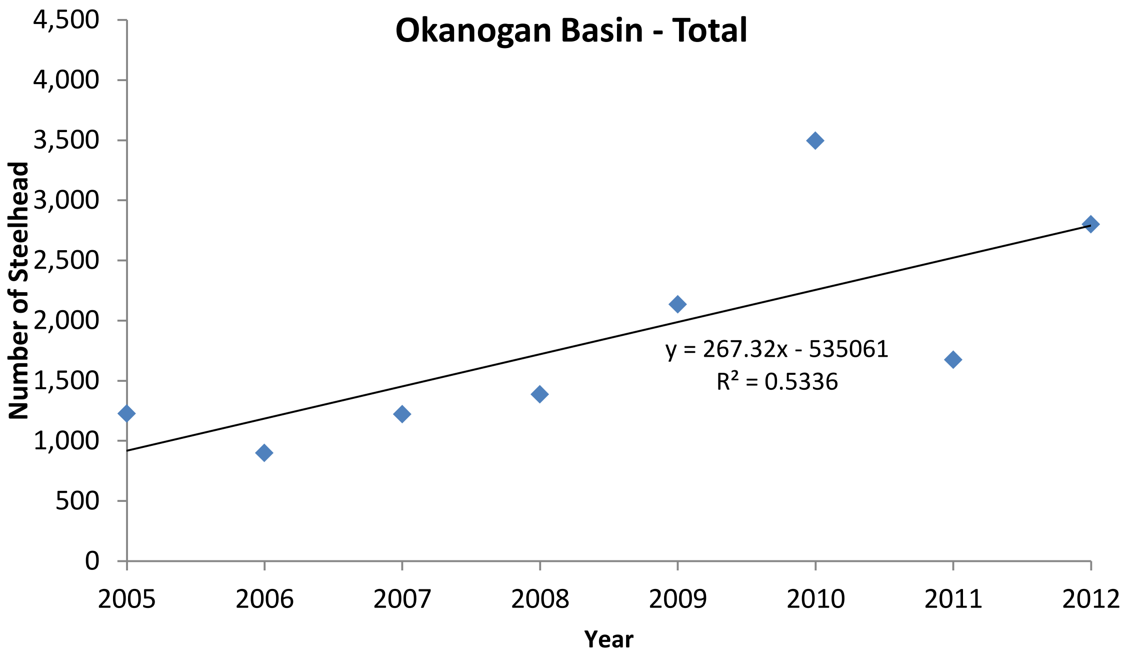

Figure 93. Total spawning estimates for the Okanogan Basin.

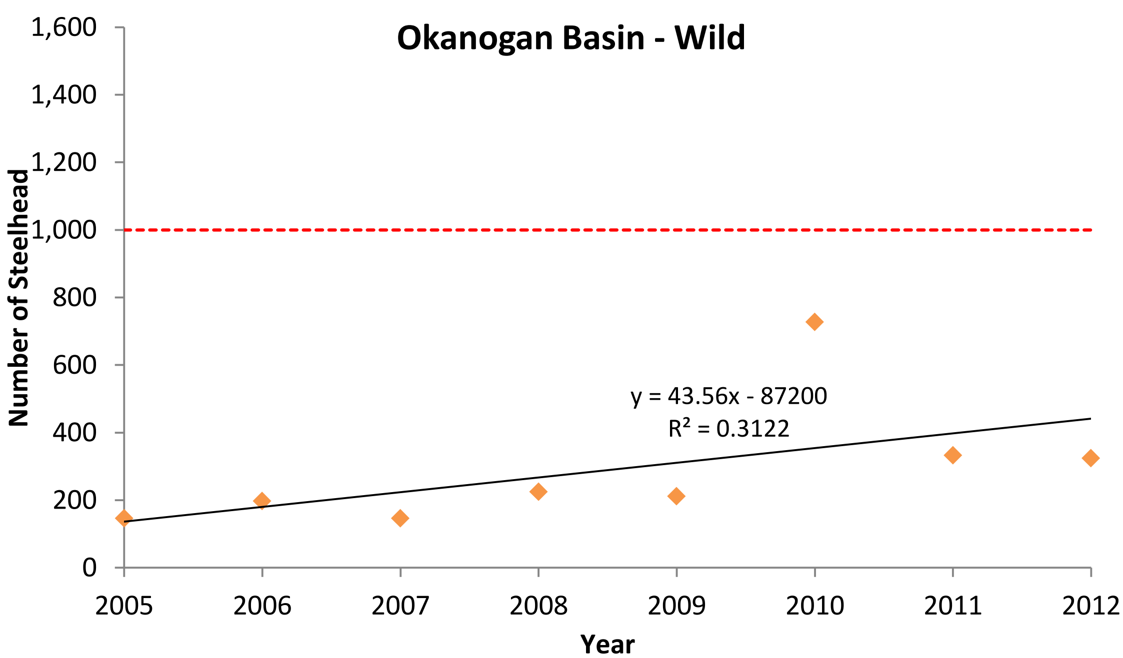

Figure 94. Wild spawning estimates for the Okanogan Basin. The dashed line represents the 1,000 total wild steelhead needed for NOAA's delisting (US and Canada).