Okanogan Summer Steelhead Broodstock, Acclimation and Monitoring (BAM), Annual Report, 2013

Report covers work performed under GPUD Contract No. 430-3559
1/1/2013 – 12/31/2014

Tibbits, W.T., C. Baldwin, R.E. Dasher, B. Hudson and J.E. Arterburn. 2015.

Colville Confederated Tribes (CCT)
Department of Fish & Wildlife
Anadromous Fish Division - Omak Office
Omak, WA 98841
Phone: 509.422.7521

Suggested citation:
Tibbits, W.T., C. Baldwin, R.E. Dasher, B. Hudson and J.E. Arterburn. 2015. Okanogan Steelhead Broodstock, Acclimation and Monitoring (BAM) Program, Annual Report 2013. Colville Confederated Tribes Fish and Wildlife Department, Nespelem, WA. Project No. 430-3559.

For an overview of Colville Tribes information products, including maps, imagery, and publications, *http://www.colvilletribes.com/obmep_publications.php*

List of Tables

List of Figures

I. Acknowledgements

The authors would like to thank: 1) Grant County PUD for funding the Okanogan Summer Steelhead Broodstock, Acclimation and Monitoring project and Dave Duvall for all of his help managing this project. 2) Constructive comments and editorial changes provided during multiple draft reviews of this report by Todd Pearsons and Jennifer Miller. 3) The Okanogan Basin Monitoring and Evaluation Program, and specifically Brian Miller and Darin Hathaway for contributing information regarding adult spawner estimates. 4) Oliver Pakootas, Rocky Timentwa, Oly Zacherle, and Byron Sam for all the outstanding field data collection assistance. 5) Charlie Snow, Charles Frady and Alex Repp for their help in formatting results and data analysis collaboration. 6) The Washington Department of Fish and Wildlife for collaboration with spawning and rearing our fish at the Wells Fish Hatchery Facility.

II. Introduction

Upper Columbia summer steelhead populations have had a long history of decline resulting in protection under the Endangered Species Act (ESA) since 1997 (NMFS 2009, 2012). Several reasons for this decline include overharvest, habitat degradation/alteration, hydro-system mortality and past hatchery practices. The Okanogan steelhead population continues to be at high risk of extinction based on current abundance, productivity, spatial distribution and diversity (Ford et al. 2011, NFMS 2009, 2012). As of 2012, the eight year geometric mean abundance of natural origin returns (NOR) was 250 steelhead, compared to the recovery abundance minimum threshold of 500 in the United States portion of the Okanogan watershed (UCSRB 2007; OBMEP 2013). The recovery plan identifies genetic diversity and spatial distribution as high risk, due to large hatchery influences from non-local stocks (Wells stock) and spawner escapements that are limited to only Omak and Salmon creeks (Ford et al. 2011, NFMS 2009, 2012).

The Priest Rapids Salmon and Steelhead Settlement Agreement requires 100,000 steelhead smolts are released into the Okanogan basin to satisfy steelhead mitigation to address unavoidable losses associated with the operation of Wanapum and Priest Rapid dams (PRD) (GPUD 2005). Additionally, the 2008 *US v. Oregon* agreement requires the release of 100,000 steelhead smolts into the Okanogan basin (*US v. Oregon* 2012). Grant County PUD provides funding to develop and support hatchery programs (O&M) coupled with comprehensive monitoring and evaluation (M&E) plans that are intended to satisfy these requirements. The Public Utility District No. 2 of Grant County funds hatchery programs intended by the Joint Fishery Parties to supplement natural populations of summer steelhead, and to produce summer steelhead for harvest augmentation. These hatchery programs collect, rear, and release salmonids in accordance with the Salmon and Settlement Agreement and annual Upper Columbia River salmon and steelhead broodstock objectives and site-based broodstock collection protocols developed by the Mid-Columbia Habitat Conservation Plan Hatchery Committees (HCPHC) and the Priest Rapids Salmon and Steelhead Settlement Hatchery Sub-committee (PRCC HSC), specifying the number, origin, and timing of adult salmon and steelhead collected for broodstock, thereby affecting the subsequent number and genetic composition of the juveniles released. The Colville Tribes and WDFW jointly manage the Okanogan River summer steelhead population and the Colville Tribes implement management, monitoring, and evaluation under contract with GPUD. The guiding principles for the development of the M&E plans are consistent with the Hatchery Scientific Review Group recommendations (HSRG 2014), Priest Rapids Coordinating Committee-Hatchery Sub -Committee (PRCC HSC 2013) and monitoring and evaluation strategies for the Methow and Wenatchee basins (Hillman 2013, Hillman 2006, and Pearsons and Langshaw 2009).

Hatchery supplementation has been identified as one of the recovery strategies for Upper Columbia summer steelhead (UCSRB 2007, and UCRTT 2013). In 2002, the Colville Tribes, with support from NOAA Fisheries and funding from the Pacific Coast Salmon Recovery Fund, initiated a conservation pilot broodstock program in Omak Creek, a tributary to the Okanogan River Basin. The Tribes initial intent was to see if it was possible to support a hatchery effort in the Okanogan River using conservation steelhead. Beginning in 2007, Grant County Public Utility District (GPUD) through the Priest Rapids Project Salmon and Steelhead Settlement Agreement process, began providing the operation and maintenance funding for a conservation steelhead production program at Cassimer Bar Fish Hatchery (CBFH).

Production targets at CBFH were 20,000 yearling steelhead smolts for release into Omak Creek. In conjunction with the CBFH, the Wells Fish Hatchery (WFH) fulfilled the remaining 80,000 smolts to meet the District's 100,000 smolt production obligation for the Okanogan River Basin. The program was permitted under ESA through Section 10(a)(1)(A)(Permit 1412). In 2010, the CBFH was closed and the entire 100,000 GPUD hatchery program component for the Okanogan basin was moved to WFH. However; brood collection, acclimation and release of the Omak Creek conservation portion of the program continued. An agreement with the WDFW and WFH (Wells project No. 2149 and Section 10 (a)(1)(A) permit number 1395) states that all spawning, rearing and transporting of juvenile steelhead to the Okanogan basin shall be managed by WFH under the guidance of the Colville Tribes. However, the Hatchery Scientific Review Group (HSRG) identified the mixed origin broodstock protocol at WFH as a risk to diversity for the population (HSRG 2009). Subsequently, a new HGMP was developed in 2013-2014 to guide the BAM program implementation and obtain the necessary permits from the National Marine Fisheries Service. This draft HGMP is currently still under review by the NMFS (CCT 2014). Currently, CTCR has ESA-authorization for BAM Program take of listed UCR steelhead by extension of NMFS permit 1412. Additionally, CTCR has ESA-authorization to manage the proportion of hatchery-origin adult steelhead spawning in Omak Creek as WDFW's designated agent under NMFS permit number 1395. CTCR also possesses WDFW Scientific Collection Permit 15-123 for adult steelhead collection in all tributaries to the Okanogan sub-basin located off-Reservation on state and private lands. With support from the Priest Rapids Coordinating Committee Hatchery Sub-Committee (PRCC HSC) and the National Marine Fisheries Service (NMFS), GPUD has agreed to fund a multi-year transition from the current production of 20,000 conservation steelhead smolts in Omak Creek to 100,000 yearling smolts for the Okanogan Basin and released in various tributaries to fully meet their steelhead hatchery compensation mitigation obligations under the Priest Rapids Salmon and Steelhead Settlement Agreement (PRCC HSC 2013).

The purpose of the Okanogan summer steelhead program is to:

1. Contribute to the recovery of the Okanogan steelhead population through implementation of a conservation hatchery program consistent with HSRG guidelines.
2. Support sustainable fisheries when consistent with achieving conservation objectives.
3. Achieve the GPUD mitigation obligation for 100,000 steelhead smolt released in the Okanogan.

Components of the 2013 Scope of Work funded by GPUD includes:

1. Annual broodstock collection of up to 16 natural and 42 hatchery adults from Omak Creek.
2. Transfer of broodstock from Omak Creek to WFH.
3. A marking and stocking strategy at WFH.
4. Acclimation of up to 20,000 Okanogan natural origin steelhead in Omak Creek.
5. Release of approximately 100,000 +/-10% hatchery steelhead smolts in the Okanogan River Basin.
6. Monitoring to determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target goals.
7. Evaluation of out-migrating steelhead smolt survival in Omak Creek.
8. Estimation of juvenile abundance in Omak and Salmon creeks ((Estimates for Omak Creek from RST and Salmon Creek mark-recap study (Appendix A)).
9. Monitoring to determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.
10. Monthly and annual reports of the program to GPUD and Hatchery Sub-committee.

The Priest Rapids Coordinating Committee Hatchery Sub-Committee provided the following objectives in their guidance for monitoring and evaluation plans:

<u>Objective 1</u>: Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.

<u>Objective 2</u>: Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.

<u>Objective 3</u>: Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.

<u>Objective 4</u>: Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.

<u>Objective 5</u>: Determine if the run timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.

<u>Objective 6</u>: Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.

<u>Objective 7</u>: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.

Objective 8: **Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.**

Objective 9: **Determine if hatchery fish were released at the programmed size and number.**

Objective 10: **Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.**

The data provided herein is intended to provide information for the above objectives. For some objectives, multiple years of data will be required to address the objectives (1,2,7,8). For the remaining objectives (3,4,5,6,9,10), an individual year can be used to evaluate an individual year performance relative to the objective, but ultimately a multi-year analysis is more useful and appropriate to evaluate the performance of the hatchery and risk to the natural population. Finally, the hatchery program will be in transition over the next several years to implement hatchery reform recommendations and achieve a population-level conservation program objective (rather than just Omak Creek). Therefore, it will likely be several steelhead generations (10+ years) before it is reasonable to expect population response to the changes and detection of possible effects by the monitoring program.

III. Study Area

The Okanogan River is a tributary of the Columbia River at rkm 858 and extends far into British Columbia near Vernon, B.C. The spawning and rearing habitat for summer steelhead is currently limited in the Canadian Okanogan River and its tributaries primarily due to irrigation diversions, channel modification, water withdrawals, and other habitat degradation (Enns 2012). Within the U.S. portion of the Okanogan, considerable efforts by CCT, WDFW, and project partners and funding organizations to maintain the hatchery program and restore habitat access and instream flow are responsible for recovery from near extinction in the mid1990s to an average of several hundred wild spawners per year (OBMEP 2010, 2011 and 2012). Due to the extensive habitat restoration program, important spawning and rearing tributaries in the U.S. portion of the Okanogan now include Omak, Salmon, Nine mile, Loup Loup and Bonaparte creeks. Other tributaries within the Okanogan Basin are utilized by steelhead, such as Antoine and Johnson creeks, but need restoration or are in the process of project development and implementation to enhance steelhead productivity.

Omak Creek is a unique tributary to the Okanogan River because it is located entirely within the Colville Indian Reservation and offers perennial flow. For this reason Omak Creek has been a priority in the Colville Tribes recovery efforts for summer steelhead within the Okanogan River Basin. Since the early 1990’s, the Colville Tribes Fish and Wildlife Department has been evaluating and restoring riparian and in-stream habitat in Omak Creek. Beginning in 2005, multiple long-term monitoring sites were established in Omak Creek. Habitat and water quality data collected at these sites over multiple years are being included in an ongoing, basin-wide analysis of fish habitat status and trends *http://www.colvilletribes.com/obmep.php*.

The Wells Fish Hatchery (WFH) is located in North Central Washington at Wells Dam on the Okanogan County side of the Columbia River (rkm 825; 47°56'50.85"; N 119°52'29.77"W) (Figure 1). Since 2007, acclimation of summer steelhead for the conservation program has occurred at the St. Mary's Acclimation Pond on Omak Creek. St. Mary's Acclimation pond is located on Omak Creek (rkm 5.1; 48°21'58.52"; N 119°26'43.97"W) just north of the Paschal Sherman Indian School. Any non-migrants were removed and transported to the mouth of the Okanogan River and released at Mosquito Park near the Hwy 97 Bridge (rkm 1.8; 48°06'05.59"; N 119°42'31.61"W). All other fish releases were direct planted by Wells Hatchery staff according to stocking management plans. These sites included Salmon Creek (rkm 21.0; 48°21'35.40"; N 119°34'55.68"W) below the culvert off of Salmon Creek Road; Aeneas Creek (rkm 2.1; 48°39'33.54"; N 119°28'46.01"W) off old Hwy 97 Road below the culvert and in the Similkameen River (rkm 2.1; 48°55'15.32"; N 119°26'34.89"W) near the outflow to the WDFW summer Chinook acclimation pond off Hwy 7 near Oroville, WA (Figure 1).

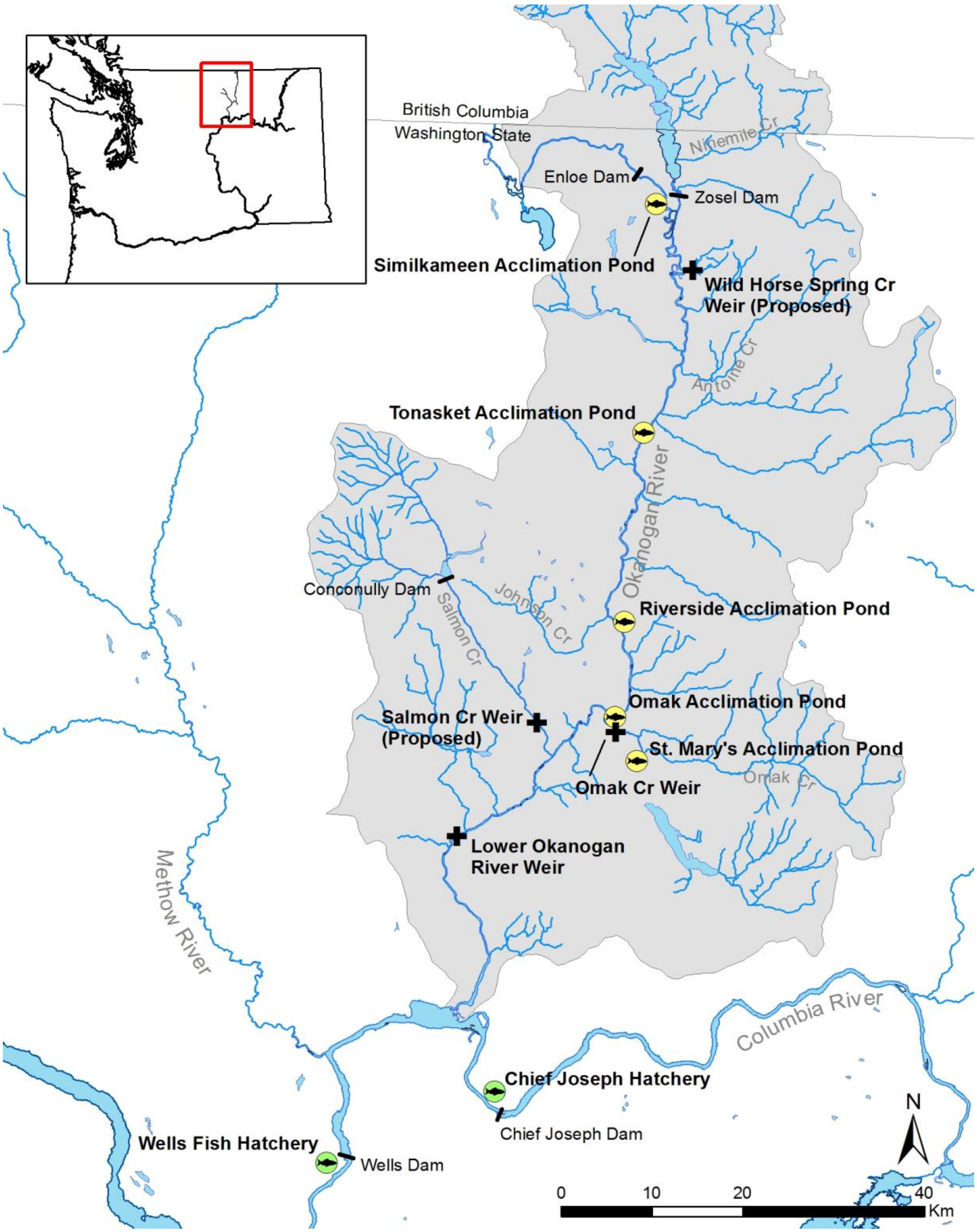


Figure 1. Okanogan basin and its connection to Canada and the Columbia River through the United States. Omak, Riverside, Tonasket and Similkameen acclimation ponds are for Chinook Salmon under the Chief Joseph Hatchery Program.

IV. Chapter 1. Adult Hatchery and Natural Steelhead

Chapter 1 addresses hatchery activities related to the 2013 Okanogan summer steelhead Broodstock, Acclimation and Monitoring (BAM) program and the key objectives outlined in the PRCC HSC 2013 hatchery recommendations. Specifically addressed are: Hatchery Return Rates (HRR); Natural Return Rates (NRR); Proportion of Hatchery Origin Spawners (pHOS); Proportion of Natural Influence (PNI); Smolt to Adult Returns (SAR); and number of fish released and size of fish released from Omak Creek. Additionally, adult abundance estimates for Omak and Salmon creeks, spawn timing, and age specific life history patterns for Omak Creek are reported. Data collected and reported herein is intended to contribute to a multi-year assessment to address the following M&E objectives:

Objective 1: Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.

Objective 3: Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.

Objective 4: Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting management target.

Objective 5: Determine if the run timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.

Objective 6: Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.

Objective 8: Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

Objective 10: Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.

Methods

Broodstock Collection and Spawning

Broodstock were collected in Omak Creek (48°24'24.54"N; 119°30'5.73"W) (Figure 1), with a gravity-style weir located at rkm 2.1. The Omak weir was operated seven days a week 24 hours a day from February 28 to May 18, 2013. A flotation system used to keep a picket fence above water directed fish into a holding box. Fish were held in the box by a v-shaped entrance and cod triggers discouraged fish from backing out of the trap. Collection occurred once every morning except during peak flows when a second visit occurred in the afternoon to clear debris from the trap and check for additional fish. At the time of collection, CCT staff recorded the size, marks/tags, origin, sex and maturation state (i.e., visual inspection of spawning condition) and scale samples. Each fish was scanned for a Coded Wire Tag (CWT) and a Passive Integrated Transponder (PIT) tag. Fish without a PIT tag were inserted with one to provide additional spawning and passage monitoring in Omak Creek.

Up to six adult steelhead collected from Omak Creek were transported to Wells Fish Hatchery Facility (WFH) daily, each transport truck has a 500-gallon fiberglass tank with emergency release valves and circular pumps to move water inside the tank. One hundred-gallon oxygen tanks on board were used to aerate the water during transportation to WFH. Upon delivery adults were held outdoors in a covered vinyl raceway until they were spawned.

WFH staff checked all fish and spawned them as needed (at a minimum of once a week), examined fish for marks, scanned for PIT and CWT tags for origin determination, and made the appropriate parental-origin crosses. Spawn date, parental cross(s) and estimated number of green-eggs per cross were recorded by WDFW staff. Spawning protocol for the conservation program (Omak Creek) is to only use W x W crosses and for the Okanogan hatchery program to use H x W crosses, preferably returning conservation hatchery offspring. Because only 16 adults are permitted to be removed from the Okanogan, natural origin adults were selected for the conservation program in Omak Creek and therefore the Okanogan hatchery program is back filled with Wells stock of unknown origin. If sufficient males were available on the spawning day, factorial spawning was conducted. Female eggs were equally divided and fertilized with two separate males and incubated separately until virology results were available. Females were kill-spawned but males were live-spawned and used multiple times for fertilization, when required. At the end of spawning, males were sacrificed for virology sampling. Virology for all natural origin steelhead was kept separate from the remainder of the hatchery steelhead at WFH.

Adult Abundance

Adult abundance for Omak Creek was estimated from fish collected moving upstream at the Omak weir and expanded using the percent of kelts without a PIT tag. Adults below the weir were enumerated using an expanded Priest Rapid Dam (PRD) PIT tag count from the PIT Tag Interrogation System (PTIS) in Omak Creek (OMK). A combined above and below the Omak weir was determined to provide a total adult abundance estimate for Omak Creek. A full description of the methods and results can be found in OBMEP (2014) that is also included as Appendix A of this report.

Adult abundance in Salmon Creek was estimated from redd counts below the Okanogan Irrigation Ditch (OID), expanded PRD PIT tag detections at the Salmon Creek Array (SA1) and expanded video counts above the OID. A full description of the methods and results can be found in OBMEP (2014) that is also included as Appendix A of this report.

Counts of summer steelhead spawning downstream of anadromous fish migration barriers in the mainstem and all accessible tributaries of the Okanogan and Similkameen River drainages were conducted within the United States (Arterburn et al. 2007, 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. A full description of the methods and results can be found in OBMEP (2014) that is also included as Appendix A of this report.

Proportion of Hatchery Origin Spawners (pHOS) and Proportionate Natural Influence (PNI)

The proportion of hatchery origin spawners (pHOS) was calculated using the formula:

$$pHOS = HOS / (HOS + NOS)$$

where HOS was the estimated number of hatchery origin spawners and NOS was the number of natural origin spawners. This metric is calculated on an annual basis and can be used at any spatial scale where abundance estimates exist for known origin spawners. However, it is generally used as an indicator of program or population performance when averaged over a five year period across the entire population. This report will provide a summary of pHOS at three spatial scales that are relevant to this project and steelhead conservation in the Okanogan Basin; 1) Omak Creek 2) Salmon Creek and 3) the Okanogan population.

The Proportionate Natural Influence (PNI) was calculated from pHOS described previously and broodstock collected at the adult weir in Omak Creek. Proportion of Natural Influence (PNI) is a combination of the number of hatchery and natural origin spawners on the spawning ground and those broodstock that are of natural origin. PNI was calculated using the formula:

$$PNI = pNOB/(pNOB+pHOS)$$

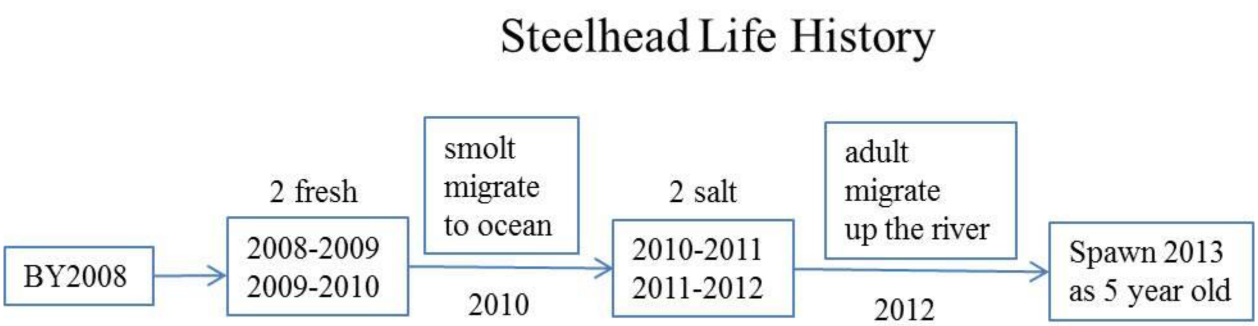
where pNOB was the proportion of natural origin fish in the broodstock and pHOS was the proportion of spawners in the stream that were of hatchery origin (Paquet et al. 2011).

PNI was calculated for both Omak and Salmon creeks and the Okanogan Basin, where the Okanogan Basin includes all tributaries to the Okanogan River including the Okanogan River. Omak Creek PNI only includes those broodstock and spawners from Omak Creek.

Age and Size Structure

Scale samples were collected from wild and hatchery pre-spawn adult steelhead returning to Omak Creek during the months of March and April. A total of six to ten scales were collected, three to five scales from each side of the fish. Still images were taken of non-regenerated scales with the least resorption using 48 X magnification. Each scale was read by two different viewers to ensure accuracy. Number of years in both fresh water and ocean were determined for each scale. If a freshwater age could not be determined, scale readers still assigned a salt water age. Due to the low number of readable adult scales we used natural juvenile steelhead captured at the Omak Creek rotary screw trap to determine age at migration. Salt water age was determined from the onset of ocean life cycle marked by growth to noticeable scale absorption due to lack of growth in fresh water. Total age is the spawn year minus the brood year. Summer steelhead return one calendar year prior to spawning, so total age is one year greater than the sum of the juvenile fresh water age and the salt water age (e.g., 2 fresh + 2 salt + 1 Yr. = 5 Yr. old steelhead) (Figure 2).

Figure 2. Diagram of five year old steelhead life history with two years in freshwater and two years in the ocean.



For each adult fish collected in Omak Creek the fork length was taken to provide a size at maturity. To determine a measurement of fitness between hatchery and natural fish we used a mean fork length, number and standard deviation (SD) of returning adults. Passive Integrated Transponder (PIT) tags were also used to evaluate spawner age and life history. Twelve mm full duplex PIT tags were inserted into juvenile hatchery and wild steelhead and detected at various tributary and mainstem Columbia River detection facilities (Table 1).

When a juvenile with a known brood year was detected leaving a tributary in the spring or at a mainstem Columbia River site in the spring or summer it was considered a smolt migrant and its freshwater age was calculated as:

Freshwater age = juvenile migration year – brood year

When an adult with a known migration year was detected in a mainstem Columbia River PIT array then its salt age was calculated as:

Salt age = adult return year – migration year

When an adult with a known salt age was detected in an Okanogan tributary PIT array then its age at maturity was calculated as:

Age at maturity = freshwater age + salt age

Table 1. Release locations, number released, and number of PIT smolts released by site for the Okanogan summer steelhead program. Stapaloop, Haley, and Lobe creeks are tributaries of upper Omak Creek above Mission Falls. St. Mary's Pond is an acclimation site on Omak Creek just below Mission Falls.

Program	Release Year	Location	Release rkm	Number Smolts Released	Number PIT Smolts Released
Omak Ck. Conservation	2004	Stapaloop Cr.	1.2	3,450	-
	2005	Stapaloop Cr.	1.2	19,071	19,071
	2006	Omak Cr. Stapaloop Cr.	5.6	19,862	9,898
	2007	St. Mary's Pond/Omak	0.52/1.6/0.31	19,772	19,772
	2008	Omak Cr. Cr./Haley/Lobe	5.6	19,914	13,532
	2009	St. Mary's Pond	5.6	15,505	14,174
	2010	St. Mary's Pond	5.6	23,618	19,889
	2011	St. Mary's Pond	5.6	32,333	16,887
	2012	St. Mary's Pond	5.6	41,285	17,390
	2013	St. Mary's Pond	5.6	9,070	9,070

Smolt to Adult Return (SAR)

The SAR was calculated using PIT tags from smolts leaving Omak Creek to adults back to Wells Dam. The survival estimate was generated by dividing the total number of PIT tagged returning adults from each year of PIT tagged juveniles released using the formula:

$$SAR = 100 * [(A_{RYx+1})+(A_{RYx+2})+(A_{RYx+3}) / J_{RYx}]$$

where A = adult steelhead with a PIT tag, RY = release year, x = the year juveniles were released, and J = juveniles released with a PIT tag.

Adult Return Rate (HRR and NRR)

The hatchery return rate (HRR) was calculated by dividing the estimated number of returning adults from that brood year by the number of broodstock collected using the formula:

$$HRR = [(HOR_{x+2})+(HOR_{x+3})+(HOR_{x+4})] / HOB_x$$

where HOB was the number of hatchery origin broodstock in year x and HOR was the number of returning hatchery origin returns in years x+2, x+3 and x+4.

The natural return rate (NRR) was calculated by dividing the number of returning natural origin fish from that brood year by the total number of parent spawners (H+W) in the natural environment using the formula:

$$NRR = [(NOR_{x+2})+(NOR_{x+3})+(NOR_{x+4})] / TS_x$$

where TS was the number of total spawners in year x and NOR was the number of returning natural origin adults in years x+2, x+3 and x+4.

Returning adults were assigned back to brood years based on PIT tag evaluations. We averaged the proportion of returns by salt year for 2012 and 2013 and applied the average to each brood year to calculate return rates for hatchery and natural origin steelhead in Omak Creek and the Okanogan Basin. We will use the average of 2012 and 2013 for all years until we have more age data. Recognizing adults in Omak Creek may include natural origin fish from unknown sources we are not able to exclude these from our estimate for Omak Creek (e.g., Wells or Methow stock).

Run Timing, Spawn Timing and Distribution

Run timing, spawn timing and distribution were determined from redd surveys, video counts and PIT tag detection data collected following OBMEP protocols (Arterburn et al. 2004; Arterburn et al. 2007c). Between year 2006 to date, in-stream PIT-tag antenna arrays were installed in the majority of potential steelhead tributaries to the Okanogan River within the United States to assess the distribution and migration timing of adult hatchery and natural origin steelhead (Figure 3). The Omak Creek array has been in place since 2006 and the Salmon Creek array since 2011. Run timing was estimated from PTAGIS recapture data from Bonneville Dam, Wells Dam, Omak Creek and Salmon creek (OBMEP 2014). Run timing into spawning tributaries was determined by PIT tag detections and video monitoring in tributaries where those monitoring methods were available. Spawn timing was estimated based on redd surveys in Salmon Creek. No steelhead spawning ground surveys occurred on Omak Creek due to turbid water conditions. To measure spawn time for Omak Creek we used a method of subtracting the number of days between our first adult steelhead capture and the first kelt collected at the Omak weir.

Detection at other Okanogan tributary arrays were used to evaluate the homing fidelity and basin-wide distribution of fish released in Omak. Homing fidelity to release location was evaluated by dividing the number of PIT tagged fish that returned to Omak by the number of PIT tagged fish that returned to other areas in the Okanogan for each release group from Omak Creek. The sample size of PIT tagged fish released in tributaries other than Omak Creek was too small to facilitate meaningful homing fidelity evaluation.

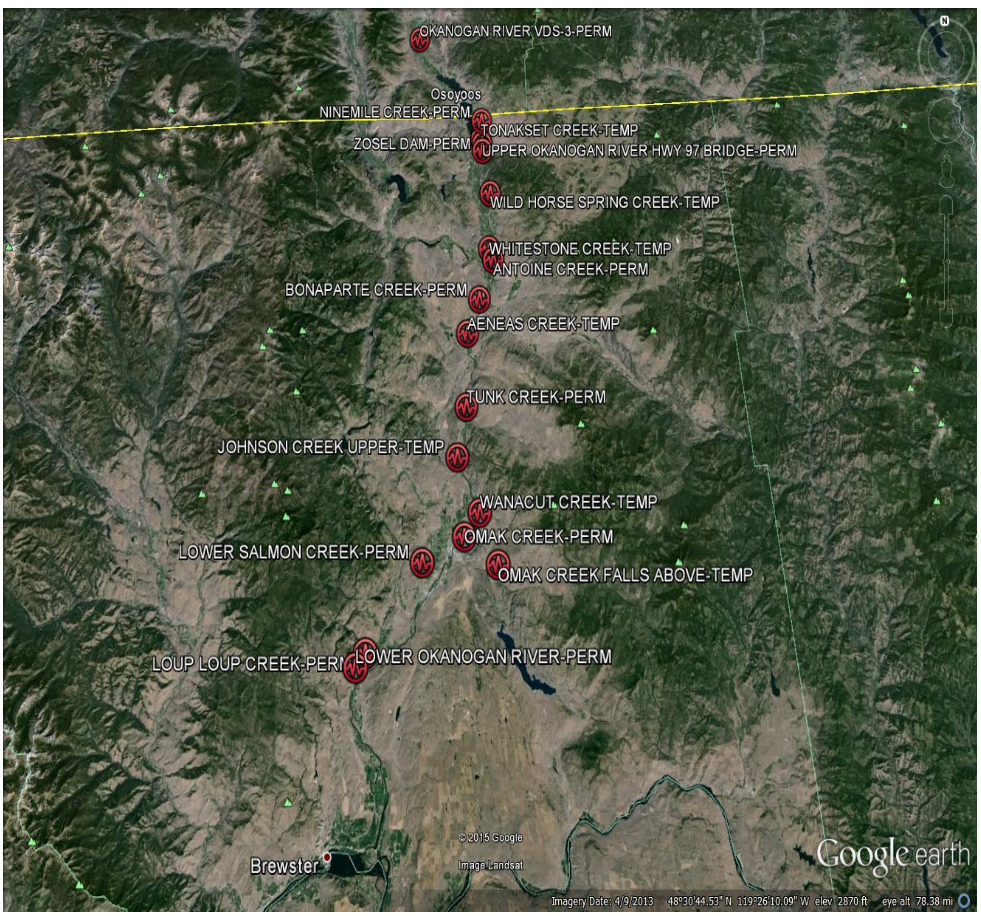


Figure 3. Passive interrogation sites for detection of PIT tagged fish in the Okanogan Basin. Perm = Permanent site and Temp = Temporary site.

Stray Rate and Homing Fidelity

The stray rate was determined based on the number of unique and final PIT tag detections in other basins (e.g., Methow) divided by the number of unique and final PIT tag detections in the Okanogan basin. The stray rate provides an assessment of homing fidelity (1-stray rate) to the target population (Okanogan), but does not determine the risk level of the strays to non-target populations. To determine the risk level of the Omak Creek and Okanogan hatchery programs we calculated the percent spawner composition in non-target areas. The first step was to expand PIT detections in non-target spawning areas based on the mark rate of PIT tagged to non-PIT tagged individuals in the release group using the formula:

$$EN_{PIT} = N_{PIT.recap} * (N_{PIT.released} / N_{Total\ released})$$

where EN_{PIT} was the expanded number of PIT tagged fish in the non-target spawning area, $N_{PIT.recap}$ was the number of PIT tagged fish detected in the non-target spawning area, $N_{PIT.released}$ was the sample size of PIT tagged juveniles released and $N_{Total\ released}$ was the number of untagged juveniles released.

The second step was to estimate the percent spawner composition in the non-target area by dividing the expanded number of fish in the non-target area (EN_{PIT}) by the total spawners of all origins in the non-target area. Total spawners for the non-target areas in the Upper Columbia were obtained from annual reports of steelhead monitoring in the Methow, Entiat, and Wenatchee Rivers (Hillman et al. 2014; Snow et al. 2013).

Within-basin homing fidelity was calculated as:

Homing fidelity = 1-(PIT detections outside release tributary / PIT detections within release tributary)

Harvest

A cumulative summary for the months of October, 2013 through March, 2014 for the upper Columbia River steelhead fishery were reported by WDFW to NOAA fisheries in a monthly report on April 13, 2014 (WDFW Report NOAA in-season sampling data, April, 2013). Data collected from creel surveys in general can be considered systemically biased low and therefore often managers will expand this data based on an estimate of the total number of steelhead counted over Wells Dam (Bob Jateff, personal communication). Expanded estimates are based on a 0.324 escapement estimate for the Okanogan basin. Estimates include broodstock, harvest, and incidental mortality (WDFW 2013). Harvest by CCT in the CJD tailrace fishery was estimated by a creel survey conducted by the CCT selective harvest program (Rayton 2014). The CJD tailrace fishery was open from July 1 to November 15, 2013. This fishery targets summer/fall Chinook salmon but does encounter steelhead in September and October.

Results

Broodstock Collection and Spawning

During 2013, 126 adult summer steelhead were captured in Omak Creek (Table 2), of which 21 were natural origin and 105 were hatchery origin. Four natural origin fish were collected for broodstock and two natural females and two natural males were spawned by a factorial cross to enhance genetic variation (Table 2). Broodstock collected at Wells Dam added 46 of the 58 total fish needed for the Okanogan broodstock program. These fish were used to generate the remaining smolts for stocking areas in the Similkameen River and Salmon and Aeneas creeks.

Table 2. Summary of adult steelhead collected at the Omak weir between the years 2004-2013. Total number trapped by origin and gender and number of broodstock collected for the Okanogan conservation steelhead program. HM = Hatchery Male, HF = Hatchery Female, WM = Wild Male, WF = Wild Female, M:F = Male:Female.

Year	HM	HF	WM	WF	Total Trapped	Hatchery Brood	Wild Brood	Total Brood	Ratio M:F
2004	63	33	8	2	106	16	0	16	1.27:1
2005	83	62	0	3	148	13	3	15	1.27:1
2006	21	76	2	6	105	8	3	11	0.27:1
2007	39	37	15	5	96	7	5	12	1.28:1
2008	39	15	15	9	78	1	7	8	2.25:1
2009	22	9	12	4	47	2	5	7	2.61:1
2010	25	16	111	54	206	1	15	16	1.91:1
2011	5	3	20	28	36	0	11	11	0.77:1
2012	91	32	33	15	171	5	4	9	2.27:1
2013	55	50	14	7	126	8	4	12	1.17:1

Adult Abundance

Omak Creek

Redd surveys were attempted weekly in Omak Creek during 2013; however, turbid water and high flows prevented the observation of redds between the confluence with the Okanogan River and the adult weir trap. Although the weir was not operational for 15 out of the total 101 days we estimated 35 natural and 264 hatchery origin steelhead passed the weir based on a weir efficiency estimate (0.40) from PIT tagged kelt returns (Figure 4). Using only data from the PIT tag array (OMK) and a marked group of steelhead tagged as returning adults at Priest Rapids Dam (PRD), an estimated 37 wild and 238 hatchery steelhead spawned in Omak Creek (OBMEP 2014) (Table 3).

Table 3. PIT tag expansion estimates at detection sites in the Okanogan subbasin, 2013. PIT tag detections in tributaries were divided by the proportion of wild (0.1339) or hatchery (0.1343) steelhead observed in the Priest Rapid Dam (PRD) mark group. PIT Tag Interrogation Site (PTIS).

PTIS	A. PRD Wild PIT Tags	B. PRD Hatchery PIT Tags	C. Expanded Wild (C=A/0.1339)	D. Expanded Hatchery D=B/0.1341)	E. Expanded Total (E=C+D)
Loup Loup (LLC)	3	7	22	52	74
Salmon Cr. (SA1)	0	14	0	104	104
Omak Cr. (OMK)	5	32	37	238	275
Wanacut Cr. (WAN)	0	0	0	0	0
Johnson Cr. (JOH)	0	3	0	22	22
Tunk Cr. (TNK)	0	2	0	15	15
Aeneas Cr. (AEN)	0	0	0	0	0
Bonaparte Cr. (BPC)	3	8	22	60	82
Antoine Cr, (ANT)	0	0	0	0	0
Wildhorse Spring Cr. (WHS)	2	6	15	45	60
Tonasket Cr. (TON)	1	8	7	60	67
Ninemile Cr. (NMC)	1	3	7	22	29
Total	15	83	110	618	728

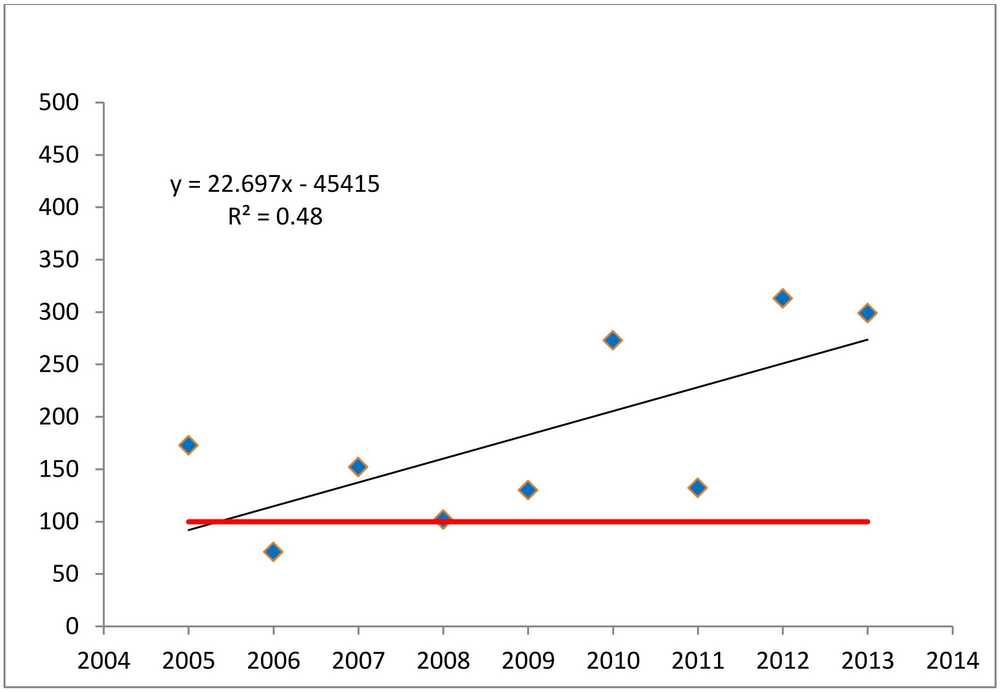


Figure 4. Status and trend of abundance from 2004 to 2013 for hatchery and natural origin adult steelhead in Omak Creek below Mission Falls. The red line is the escapement objective for lower Omak Creek (proposed by CCT in the HGMP).

Salmon Creek

Weekly redd surveys documented 17 redds between the confluence of Salmon Creek with the Okanogan River to the upstream OID water diversion. A Wells Dam estimate of sex ratio (0.648 males per female or 1.648 fish per redd) was used to expand the redd count to a total estimate of 28 spawning steelhead below the Okanogan Irrigation District (OID) diversion, in 2013 (OBMEP 2014). At the diversion, an underwater video monitoring site captured a total of 98 upstream migrants (26 adipose fin-present and 72 hatchery steelhead). The combined estimate from downstream of the OID diversion and video counts above the diversion was 126 steelhead (Figure 5). The PIT tag array (SA1) documented 14 PRD PIT tags of hatchery origin that expands to 104 hatchery steelhead based on a tag rate of 13% (Table 3) (OBMEP 2014). No wild PRD tags were detected at this site. Because 26 adipose fin-intact steelhead were documented passing at the video site, a combined estimate of 104 hatchery and 26 wild steelhead, from the PIT expansion and video monitoring, represented the best estimate for Salmon Creek in 2013 (OBMEP 2014).

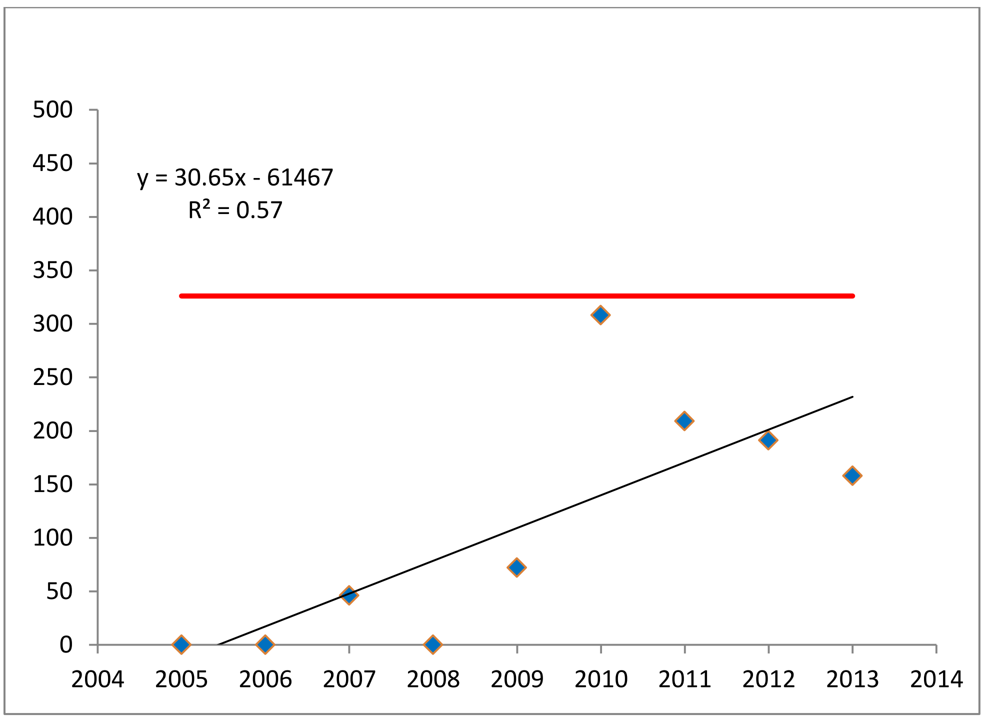


Figure 5. Status and trend of abundance from 2004-2013 for adult hatchery and natural-origin steelhead in Salmon Creek based on PIT tag detections, video and redd counts. The red line is the escapement objective for Salmon Creek (proposed by CCT in the HGMP).

Okanogan River

Redd surveys were largely unsuccessful at documenting the spawning activity of steelhead in the Okanogan River mainstem reaches in the spring of 2013. Due to an early onset of runoff in the Okanogan and Similkameen Rivers, only one preliminary survey could be completed on most mainstem reaches. Although a number of redds were documented in Okanogan River Reach 7 and Similkameen River Reach 2, it is unknown what proportion of the population they represented. Flows remained high through the end of July, when spawning had long since concluded and steelhead redds were indistinguishable. Population estimates derived from PIT tag detections were calculated following Murdoch et al. 2011. In the 2013 migration year, a random representative sample of steelhead were captured at Priest Rapids Dam, two to three days per week over the course of the run, from July through November. A proportion of fish, approximately 14.5%, were tagged and released above Priest Rapids Dam (Ben Truscott, WDFW, pers. comm.). The mark-rate was used to expand the number of detections into escapement estimates for the Okanogan with PIT tag arrays (Table 10 and Figure 6).

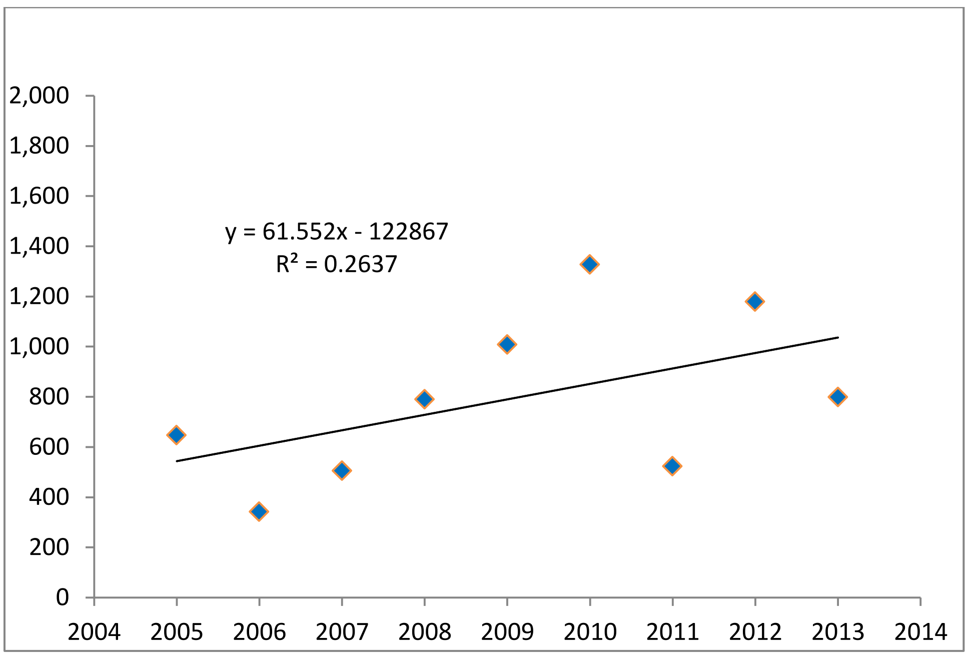


Figure 6. Status and trend of abundance from 2004-2013 for adult hatchery and natural-origin steelhead in the Okanogan and Similkameen rivers based on expanded redd counts.

Proportion of Hatchery Spawners (pHOS) and Proportionate Natural Influence (PNI)

Omak Creek

Proportion of hatchery spawners (pHOS) and natural spawners (pNOS) on the spawning ground has been measured from weir activities in Omak Creek since 2005 (Table 5 and Figure 7). However, weir captures may be a biased estimate of pHOS due to differences in run timing interacting with weir capture efficiencies. Based on total escapement estimates, the pHOS in Omak Creek in 2013 was 0.88 (Table 5). A five year average indicates 37% of the return is of natural origin and 63% is hatchery origin for Omak Creek (Table 5). Proportion of hatchery origin spawners in the last two years has been greater than 0.89 of the population, resulting in a PNI rolling five year mean of 0.545 (Table 5). Natural influence for Omak Creek exceeded the 0.67 objective in only two of the last 10 years and the rolling five year mean has yet to meet the objective of 0.67 (Table 5).

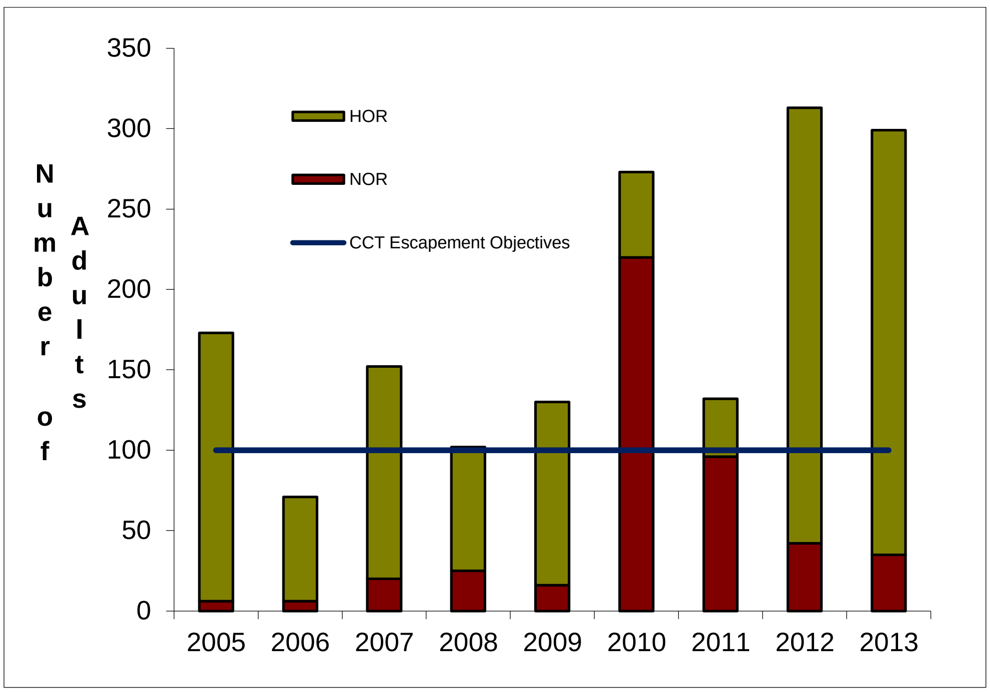


Figure 7. Number of hatchery and natural origin adult returns to Omak Creek based on expandaed adult collections at the Omak weir and PRD PIT tag detections in Omak Creek.

Table 4. Omak Creek expanded weir data for Hatchery Origin Spawner (HOS) and Natural Origin Spawners (NOS), and total numbers of Hatchery Origin Broodstock (HOB), Natural Origin Broodstock (NOB) collected at the Omak weir for 2004-2013.

Omak Creek					
BY	HOS	HOB	NOS	NOB	Total
2004	95		10		105
2005	167	13	6	3	189
2006	65	8	6	3	82
2007	132	7	20	5	164
2008	77	1	25	7	110
2009	114	2	16	5	137
2010	53	1	220	15	289
2011	36	0	96	11	143
2012	371	5	42	4	422
2013	264	8	35	4	311
Average	139	4	60	8	210

Table 5. Proportion of hatchery spawners (pHOS), proportion of hatchery broodstock (pHOB), proportion of natural origin spawners (pNOS), proportion of natural origin broodstock (pNOB), annual proportion of natural influence (PNI) and five year mean for years 2004 – 2013 from Omak Creek. BY = Brood Year.

Omak Creek						
BY	pHOS	pHOB	pNOS	pNOB	PNI	5-year mean
2004	0.90	0.00	0.10	0.00	0.00	
2005	0.97	0.81	0.03	0.19	0.16	
2006	0.92	0.73	0.08	0.27	0.23	
2007	0.87	0.58	0.13	0.42	0.32	
2008	0.75	0.13	0.25	0.88	0.54	0.25
2009	0.88	0.29	0.12	0.71	0.45	0.34
2010	0.19	0.06	0.81	0.94	0.83	0.47
2011	0.27	0.00	0.73	1.00	0.79	0.58
2012	0.90	0.56	0.10	0.44	0.33	0.59
2013	0.88	0.67	0.12	0.33	0.27	0.53
Average	0.63	0.21	0.37	0.79	0.56	0.49

Salmon Creek

Steelhead did not have consistent access to Salmon Creek until 2007 when a water lease agreement ensured that there was enough flow from March to June to allow adult migration and juvenile emigration; therefore, the management strategy for Salmon Creek has been a recolonization strategy using hatchery origin broodstock and release of hatchery smolts to re-colonize Salmon Creek (CCT HGMP 2013). In the last five years pHOS in Salmon Creek has been 0.82 to 0.93 (Table 6). It is possible that 2012 and 2013 NORs included some natural origin returns from the hatchery origin spawners released in Salmon Creek in 2007. Conversely, it is unlikely that the natural origin returns in 2007-2011 were progeny of the hatchery releases, meaning that natural origin fish from other areas were colonizing Salmon Creek.

Table 6. Proportion of hatchery spawners (pHOS), proportion of hatchery broodstock (pHOB), proportion of natural origin spawners (pNOS), proportion of natural origin broodstock (pNOB), annual proportion of natural influence (PNI) for years 2004 – 2013 from Salmon Creek. BY = Brood Year.

Salmon Creek					
BY	pHOS	pHOB	pNOS	pNOB	PNI
2004	0.00	0.00	0.00	0.00	0.00
2005	0.00	1.00	0.00	0.00	0.00
2006	0.00	1.00	0.00	0.00	0.00
2007	0.87	1.00	0.13	0.00	0.00
2008	0.00	1.00	0.00	0.00	0.00
2009	0.85	1.00	0.15	0.00	0.00
2010	0.83	1.00	0.17	0.00	0.00
2011	0.92	1.00	0.08	0.00	0.00
2012	0.85	1.00	0.15	0.00	0.00
2013	0.84	1.00	0.16	0.00	0.00
Average	0.52	0.90	0.08	0.00	0.00

Okanogan Basin

For the purpose of reporting pHOS and PNI, the Okanogan basin reporting unit includes the Okanogan River and all tributaries excluding Omak and Salmon creeks. The program has not yet transitioned to natural origin brood outside of Omak Creek. Therefore pNOB is zero outside of Omak Creek and the resulting population level PNI remains low. The trend in pHOS for the Okanogan basin has been consistent between 0.80 and 0.92 (Table 7).

Table 7. Okanogan Basin (excluding Omak and Salmon Creeks) Proportion of hatchery spawners (pHOS), proportion of hatchery broodstock (pHOB), proportion of natural origin spawners (pNOS), proportion of natural origin broodstock (pNOB), annual proportion of natural influence (PNI) for years 2005 – 2013. BY = Brood Year.

Okanogan River					
BY	pHOS	pHOB	pNOS	pNOB	PNI
2004	0.00	1.00	0.00	0.00	0.00
2005	0.93	1.00	0.07	0.00	0.00
2006	0.92	1.00	0.08	0.00	0.00
2007	0.91	1.00	0.09	0.00	0.00
2008	0.88	1.00	0.12	0.00	0.00
2009	0.92	1.00	0.08	0.00	0.00
2010	0.91	1.00	0.09	0.00	0.00
2011	0.87	1.00	0.13	0.00	0.00
2012	0.90	1.00	0.10	0.00	0.00
2013	0.91	1.00	0.09	0.00	0.00
Average	0.90	1.00	0.10	0.00	0.00

<u>Age and Size Structure</u>

Fresh water years for hatchery fish were assumed 100% age one at migration to ocean. The majority (89%) of fresh water years for natural juvenile steelhead (n = 52) scale samples collected in 2011 and 2012 was two years of age at migration (Figure 8).

The number of salt years for natural origin steelhead from Omak Creek has ranged from one to three years (Figure 9). Scale absorption and degeneration is very common when adults enter fresh water, resulting in unreadable scales and low sample size. Due to low sample size for years reported, caution should be taken when interpreting results.

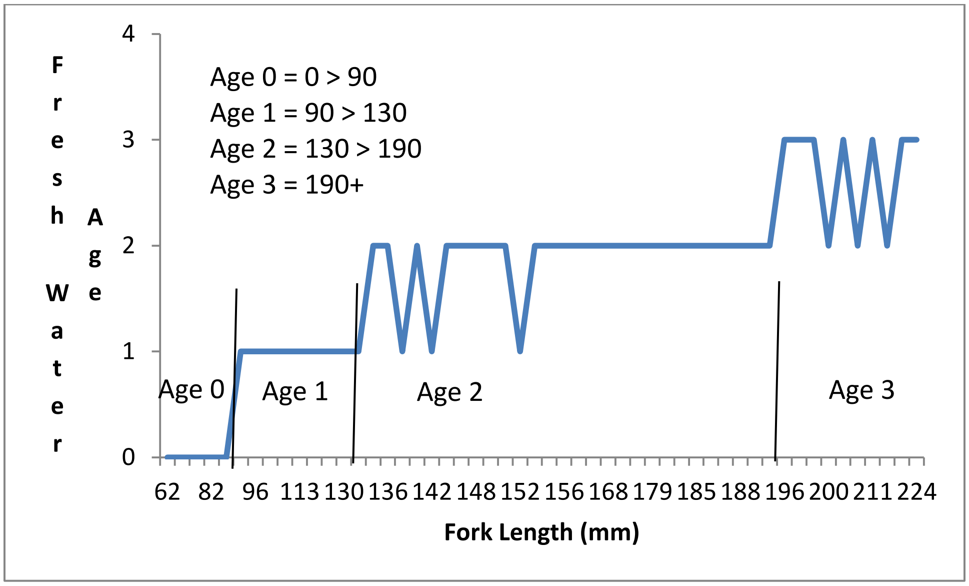


Figure 8. Natural juvenile steelhead of different fresh water ages (age at migration) based on scale samples from the Omak Creek RST in 2011 and 2012.

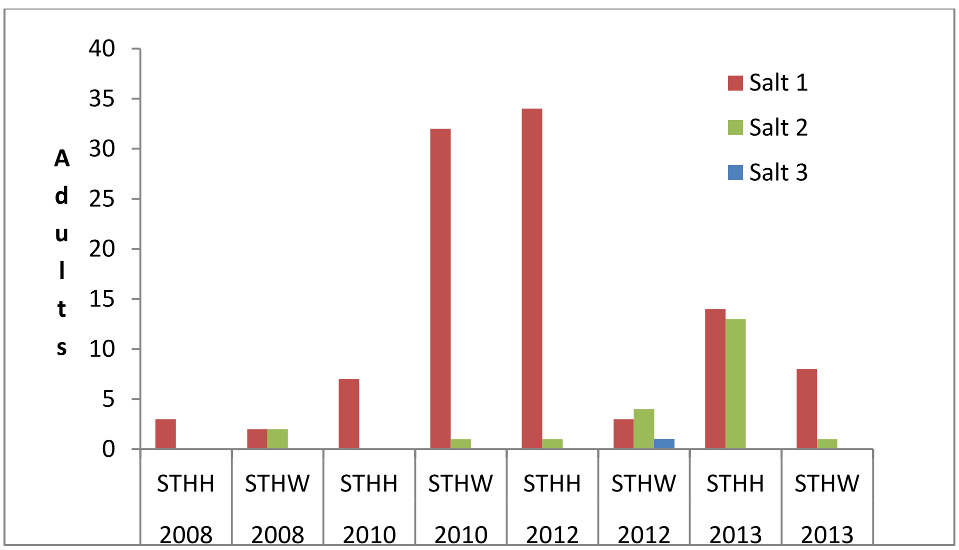


Figure 9. Number of natural and hatchery adult steelhead of different salt (ocean) years sampled at the Omak Creek weir in 2008, 2010, 2012 and 2013. *Due to scale degeneration and scale reabsorption at time of collection (spawning) many scales cannot be read and therefore reduce sample size. Missing years (2009 and 2011) are for those years when scales were not readable and/or sent outside the CCT and awaiting data.

In 2013, proportion of salt years for hatchery adult steelhead ranged from one to four years, with 1-salt , 2-salt and 3-salt representing 40%, 30% and 25% of the spawning population for Omak Creek, respectively (Figure 10). The remaining 5 % of the population were 4-salt and 5-salt fish (or possibly adfluvial). The sample size of natural origin PIT tags was limited and not adequate for comparison purposes at this time. Return year only reflects the percentage of salt years from individual run-cycle return and does not represent brood year salt-age at return.

Three year old (1 fresh, 1 salt) hatchery fish have represented the greatest portion (68%) of the adult return to the Okanogan Basin (Figure 11). Return data is not complete for 2010 and 2011. The number of natural origin PIT tags is limited and not valid for comparison purposes at this time. From 2008 to 2013 in Omak Creek, the number of salt years were approximately 60% 1-salt, 34% 2-salt and 7% 3-salt (Figure 12).

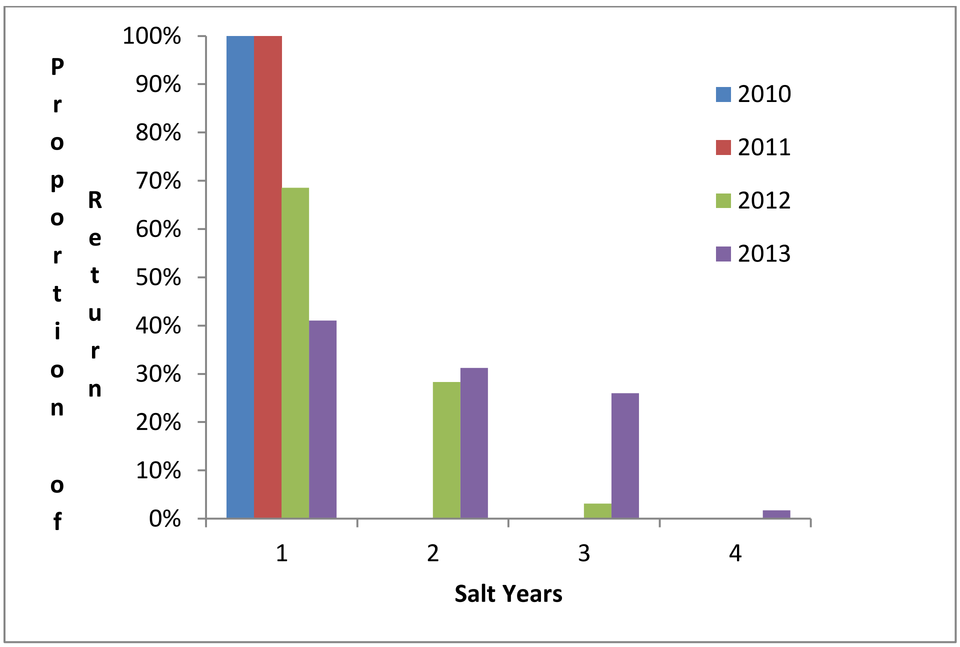


Figure 10. Proportion of salt years based on return year from PIT tagged hatchery steelhead released in Omak Creek and detected at Wells Dam.

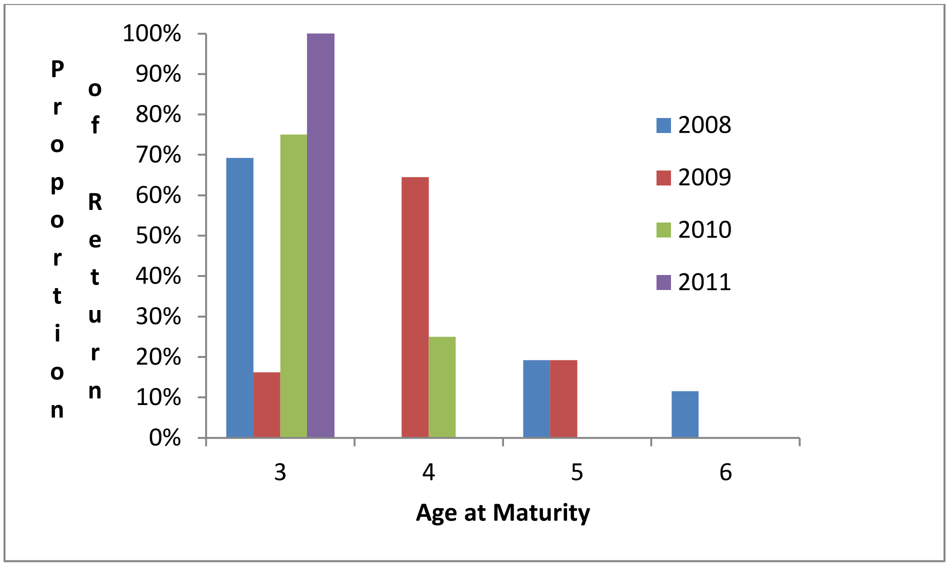


Figure 11. Proportion of age at maturity based on brood year from PIT tagged hatchery steelhead detected in tributaries to the Okanogan River. *2010 data only includes 2 years of returns and 2011 data only includes 1 year of returns.

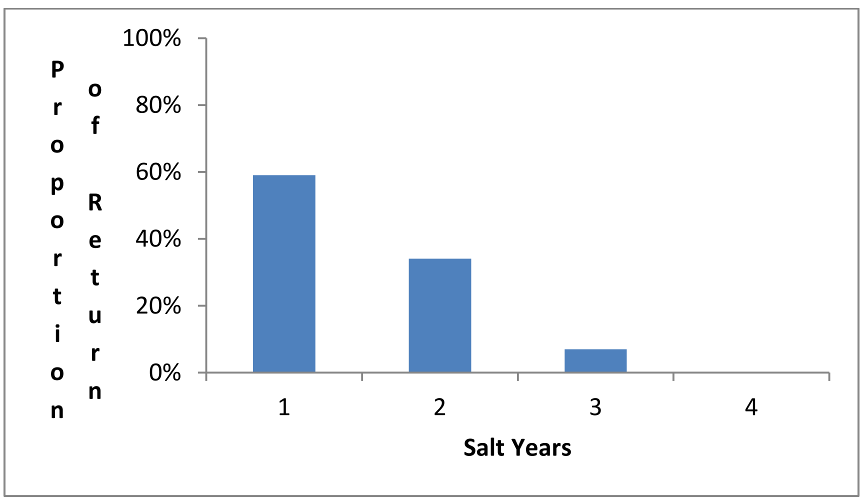


Figure 12. The proportion of each salt age for adult steelhead sampled in Omak Creek between 2008 and 2013.

The average size of adult hatchery fish (619 mm) was larger than natural fish (591 mm) in 2013 (Table 8). When evaluated across all brood years, natural origin fish were slightly larger size at maturity (626 mm) than hatchery origin fish (607 mm) (Table 8). However, we did not perform statistical tests to determine if the differences were significant. Of course, mean size was influenced by age structure within each origin and year and we do not believe that meaningful statistical comparisons of size between hatchery and natural fish can be made until we have an adequate sample size of known age fish from each origin for each return year.

Table 8. Average size (mm) of hatchery and natural adults collected at the Omak weir between 2007-2013. FL = Fork Length (mm), Wt = Weight (g).

	Hatchery		Natural	
Brood Year	Mean (FL)	Mean (Wt)	Mean (FL)	Mean (Wt)
2007	641	381	646	381
2008	632	368	606	419
2009	581	355	635	203
2010	608	204	610	438
2011	609	410	707	533
2012	563	360	586	445
2013	619	505	591	405
Average	607	574	626	535

Smolt to Adult Survival (SAR)

Complete SAR for BY 2012 or 2013 cannot be reported because age 2 and 3 salt fish have not returned. However, even with only 1 and 2 years of adult returns the trend of improved SAR has continued when compared to the previous program at Cassimer Bar (Table 9). The number of adult steelhead that returned to Wells Dam from hatchery reared fish released in Omak Creek has increased since moving to Wells Fish Hatchery in 2010 (Table 9).

Table 9. Smolt to Adult Returns (SAR) for PIT tagged hatchery summer steelhead smolts released from Omak Creek and adults detected at Wells Dam.

Hatchery Reared	Brood Year	Juveniles PIT Tagged	Adults Returned	SAR %
Cassimer Bar				
	2004	19,071	22	0.12
	2005	19,887	7	0.04
	2006	19,916	15	0.08
	2007	6,735	0	0
	2008	13,365	8	0.06
	2009	14,174	10	0.07
	2010	19,898	155	0.77
Wells Facility				
	2011	16,887	82	0.48
	2012**	17,390	115	0.66
	2013*	9,070	20	0.22

Note: Results assume no PIT tag loss, complete anadromy and no strays beyond Wells Dam.
NA = No adult return year data.
*Only one year (2014) of adult return data. **Only two years (2013, 2014) of adult return data

Adult Return Rate (HRR and NRR)

The majority of returning adult steelhead in the Okanogan Basin was of hatchery origin. In 2013, the Okanogan Basin generally had more steelhead than the nine-year average, with numbers of NOS very similar to the average (Table 10). Omak Creek continues to support natural origin steelhead with 35 natural spawners in 2013 (Table 10). Although 2013 was below the nine-year average for natural origin returns in Omak Creek, 2010 was an exceptional year that is inflating the average to some degree. Salmon Creek, another key tributary for steelhead production in the Okanogan basin, has been largely comprised of hatchery origin spawners (Table 10).

Table 10. Estimated number of hatchery and natural return by year for Omak and Salmon creeks, the Okanogan River and Okanogan basin. Estimates are derived from expanded redd surveys, video counts and PIT tag detections (OBMEP 2013). HOS = Hatchery Origin Spawners, NOS = Natural Origin Spawners TS= Total Spawners.

	Salmon Creek			Omak Creek			Okanogan River			Okanogan Basin		
Spawn Yr.	HOS	NOS	TS	HOS	NOS	TS	HOS	NOS	TS	HOS	NOS	TS
2005	0	0	0	167	6	176	602	44	646	769	50	819
2006	0	0	0	65	6	71	314	2	342	379	34	413
2007	40	6	46	132	20	152	458	47	505	630	73	703
2008	0	0	57	77	25	102	691	98	789	768	123	948
2009	61	11	72	114	16	130	922	84	1,006	1,097	111	1,208
2010	255	53	308	53	220	273	1,207	120	1,327	1,515	393	1,908
2011	193	16	209	36	96	132	452	70	522	681	182	863
2012	162	29	191	371	42	413	1,131	72	1,203	1,664	143	1,807
2013	132	26	158	264	35	299	726	72	798	1,122	133	1,255
Average	99	16	80	142	52	134	723	71	549	1,078	139	763

* Data for Omak Creek include above and below the weir. Data for Salmon Creek include above and below the diversion.

To better estimate the adult return rate for the Okanogan each brood year was reconstructed based on the average number of salt years between those returned in 2012 and 2013 (Table 11). The average of 2012 and 2013 show 55% and 30% of adults return in their first and second salt year, respectively (Table 11).

Table 11. Percent of hatchery returns by salt year to Omak Creek from PIT tagged juvenile steelhead released in Omak Creek.

	Number of Salt Years			
Return Year	1	2	3	4
2012	0.69	0.28	0.03	0.00
2013	0.41	0.31	0.26	0.02
Average	0.55	0.30	0.15	0.01

Adult return rates to Omak Creek and the rest of the Okanogan Basin including all tributaries were the reporting units because PIT tag releases in other tributaries were too low to facilitate the analysis (e.g., Salmon Creek could not be analyzed separately for HRR/NRR in 2013 but will be in the future). HRR for the Okanogan Basin (excluding Omak Creek) has been consistently near 20 since 2006 and between 7 and 24 for Omak Creek (Table 12). NRR for both Omak Creek and the Okanogan Basin have averaged less than 1 (Table 12). Due to adult returns not complete for years after 2010 to date return rates for Omak Creek and the Okanogan basin were not calculated.

Table 12. Hatchery and natural return rates based on estimated number of hatchery and natural return for Omak and the Okanogan basin. Natural Return Rate (NRR), Hatchery Return Rate (HRR).

	Omak Creek		Okanogan Basin	
Brood Yr.	HRR	NRR	HRR	NRR
2006	7.0	0.7	18.5	0.4
2007	7.3	0.6	21.6	0.3
2008	11.9	1.5	25.7	0.3
2009	23.9	0.5	21.0	0.1
[a] 2010	17.6	0.1	21.5	0.1
[a] 2011	13.2	0.1	11.6	0.1
Average	13.5	0.5	19.9	0.2

[a] Preliminary data, fish are still migrating upstream from previous broodyear.

Run Timing, Spawn Timing and Distribution

Run timing was based on PIT tag detections within tributaries and to date only a small number of PIT tags have been released in tributaries other than Omak Creek (Figure 11). No detection of PIT tags were found in Salmon Creek and few in other tributaries to the Okanogan and therefore only Omak Creek run timing were determined for 2013. We detected our first PIT tag return to Omak Creek on March 7, 2013 and last upstream adult PIT detection on May 28, 2013. The first adult captured at the Omak Creek Weir was on March 14, 2013 and the last adult steelhead captured moving upstream was on May 18, 2013. In the last three years adult steelhead run time started previous to the seven year average for Omak Creek (Figure 12).

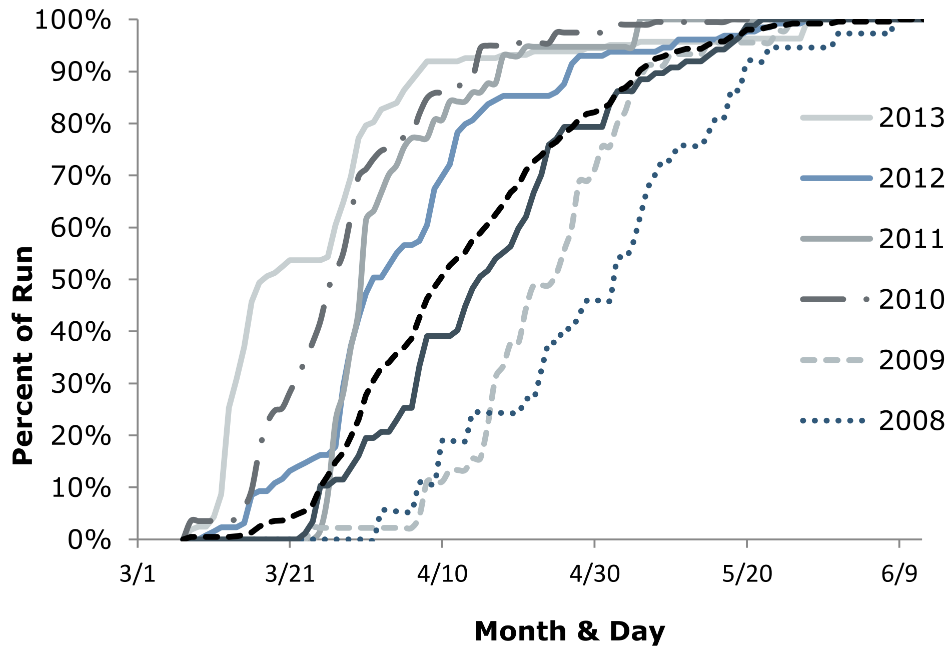


Figure 13. Run timing for adult hatchery steelhead into Omak Creek between March and June 2007-2013 based on passage at the Omak Creek weir and PIT tag detections at the mouth of Omak Creek.

Omak Creek

In 2013, no steelhead spawning ground surveys occurred on Omak Creek due to turbid water conditions. Although adult collections at the weir do not indicate actual spawning, past observations indicated that they generally spawn within a few days of entering the creek. Steelhead entered Omak Creek between March 14 and June 13, 2013 for a total range of spawn timing of 92 days (Figure 13). Modes in run timing between hatchery and natural origin steelhead were similar; however, a few hatchery fish arrived previous to natural origin steelhead and continued to arrive after the last natural origin steelhead was encountered at the Omak Creek Weir (Figure 14). Full operation of the Omak Creek weir is dependent on flow. In years where flow reaches 100 cfs or greater trap efficiency is reduced.

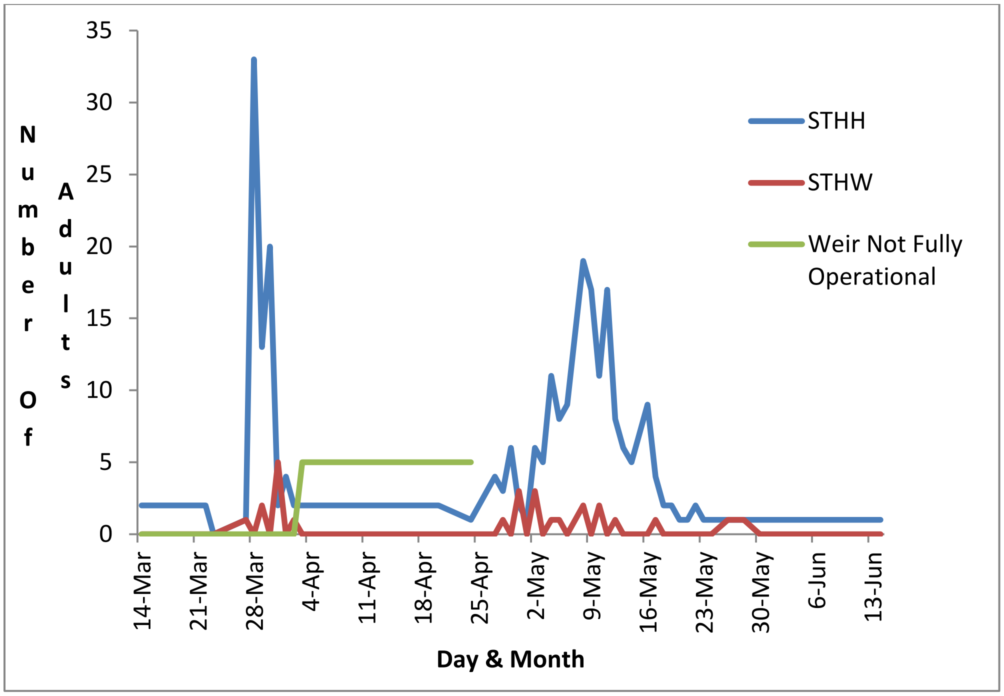


Figure 14. Number of hatchery and natural origin adults captured at the Omak Creek weir between March 14, and June 13, 2013.

Salmon Creek

Salmon Creek redd surveys were only taken below the Okanogan Irrigation District water diversion (7.2 rkm) to the mouth. Above the irrigation ditch video counts were used to enumerate the number of spawning adults. Redd counts by date were used to determine spawn time in Salmon Creek. The first redd detection in Salmon Creek was on March 26, 2013 and the last redd was found on May 21, 2013 for a total spawn time of 56 days (Figure 15).

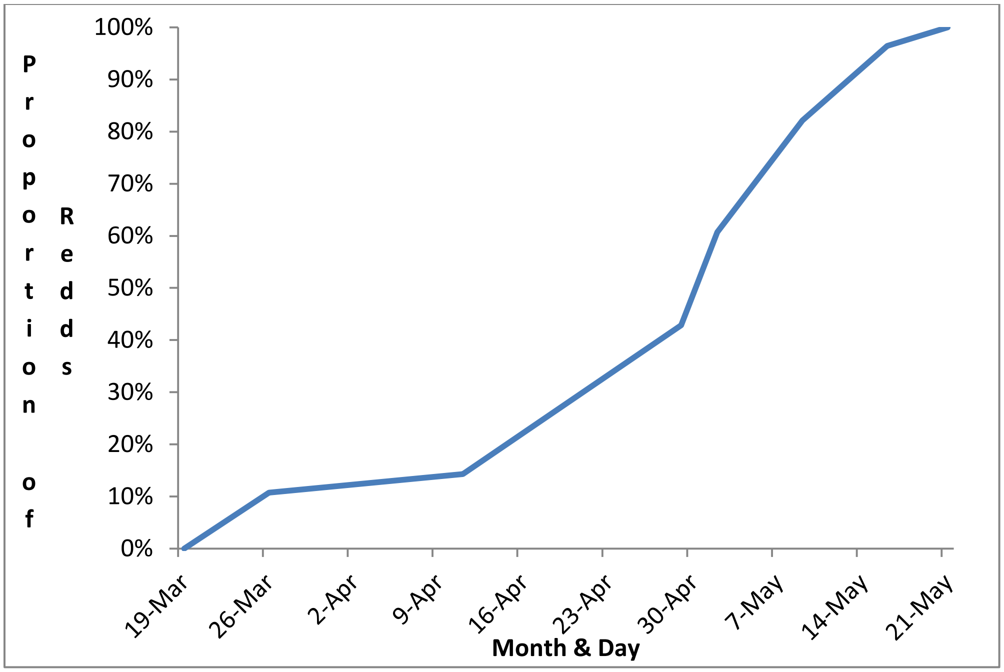


Figure 15. Proportion of the total number of redds observed in Salmon Creek below the OID diversion between March 19 and May 21, 2013.

Stray Rate and Homing Fidelity

There were 105 PIT tag detections of adult hatchery steelhead in 2013 from the releases in Omak Creek between 2010 and 2012. After expansion for the mark rate of the releases each year, there were an estimated 208 adult PIT tag detections. Homing fidelity back to Omak Creek was high (97%), with only two (2%) fish detected within the Okanogan Basin but outside of Omak Creek (Zosel Dam) and one (1%) stray was detected outside the Okanogan Basin (at WNFH). The spawning abundance of steelhead in the Methow was 3,580 in 2013, so the spawner composition of Omak fish in the Methow was 0.05%. Therefore the Omak conservation program met its target of less than 5% stray rate and less than 5% spawner composition of adjacent populations.

These analyses could not be conducted for the steelhead releases from the Wells Fish Hatchery program releases that occurred in the Okanogan and Similkameen Rivers and Salmon Creek because they were not PIT tagged in previous years.

Table 13. Actual and expanded number of PIT tag detections from Omak Creek releases from 2010-2012 recaptured within Omak Creek and in other areas.

Release Year	Number PIT Released	Total Release	Tag Rate	Omak Recaps	Expanded Omak Recaps	Within Okanogan Recaps	Outside Okanogan Recaps
2010	14,174	23,618	0.60	3	5.0	0	1
2011	19,898	32,333	0.62	46	74.2	2	0
[a]2012	16,887	41,285	0.41	53	129.3	-	-
Total				105		2	1

[a] Preliminary data, fish are still migrating upstream from previous broodyear.

Harvest

Harvest in the Columbia River upstream of Wells Dam and Okanogan Basin was 1,636 steelhead (Table 15) with a run estimate of 10,175 fish at Wells Dam (Table 14). The harvest rate was 16% of the total run above Wells Dam (Table 14) (WDFW NOAA in-season sampling data, April, 2013). The total number of adult steelhead caught in the Okanogan and Similkameen rivers for 2013 was 534 fish (Table 15). The number of hatchery fish captured in the Okanogan was 444 and the number of natural origin fish captured was 90 steelhead (Table 15). Proportion of natural origin steelhead captured for 2013 was 18% of the total Okanogan River fishery.

Table 14. 2001-2013 adult steelhead counts at Wells Dam and harvest in the Columbia River above Wells Dam and the Okanogan River for the Colville Tribes and the Washington Department of Fish and Wildlife (WDFW).

Year	Wells Dam Total Count	CCT Steelhead Harvest	WDFW Steelhead Harvest: Columbia River Upstream of Wells Dam	WDFW Steelhead Harvest: Okanogan River	WDFW Steelhead Harvest: Similkameen River
2001-2002	-	269	-	-	-
2002-2003	9,475	234	-	-	-
2003-2004	9,963	45	-	304	54
2004-2005	9,317	279	389	229	280
2005-2006	7,203	57	427	209	256
2006-2007	6,674	80	518	0	0
2007-2008	7,500	134	857	216	60
2008-2009	9,808	303	436	394	34
2009-2010	25,443	868	1,025	2,244	831
2010-2011	12,763	184	1,096	602	268
2011-2012	12,069	266	543	226	167
2012-2013	9,778	332	914	320	206
2013-2014	10,175	288	366	273	291

Table 15. Catch per unit effort and catch by area for the upper Columbia River steelhead fishery, October, 2013 through March, 2014 (WDFW, NOAA 2013-2014 April Monthly Report). NOR= Natural Origin Return. Ad = Adipose fin. RI= Rock Island dam. RR= Rocky Reach dam. CJD= Chief Joseph dam.

Fishery Area	**Fishing Effort**		**Total Steelhead Catch**	**Steelhead Catch Composition**			
	Anglers	**Angler Hours**		**Ad-clipped Hatchery Retained**	**Ad-clipped Hatchery Released**	**Ad-present Hatchery Released**	**NOR Released[1]**
RI to RR	529	1,846	112	48	0	21	43
RR to Wells	2,249	7,285	171	111	0	28	32
Wells to CJD	1,639	7,671	720	366	25	215	114
Wenatchee	2,872	7,548	582	126	0	170	286
Methow	3,438	14,651	2,055	742	18	841	454
Okanogan/ Similkameen	1,234	4,335	534	273	4	167	90
Total	**11,961**	**43,336**	**4,174**	**1,636**	**47**	**1,442**	**1,019**

Discussion

Adult steelhead return to the Okanogan River Basin in September the year before spawning and do not enter the spawning tributaries until late winter and early spring. Fish movements in and out of the Okanogan River and its spawning tributaries are affected by stream flow and water temperature. Additionally, trap efficiency is also affected by flow and debris load and can be variable between years and within a particular stream. Therefore, static or systematic broodstock collection is difficult for steelhead in small tributaries. Recent improvements to the weir and trap in Omak Creek have improved trap efficiency, but the ability to collect desired broodstock numbers is still dependent upon the interaction between run timing, abundance and environmental conditions.

Proportion of natural origin spawners is a measurement needed to determine Objective 4 (i.e., is pHOS or PNI meeting management targets). In recent years, hatchery origin steelhead have dominated the spawning aggregate in Salmon Creek and the Okanogan Basin as a whole. Within the Okanogan basin the proportion of natural influence has not changed over the last seven years. In Omak Creek, however, numbers of hatchery returns compared to the number of natural returns does provide promise toward meeting management targets; however, weir efficiency and permit limitations (i.e., limitations to the number of NORs removed for broodstock and no authorization to remove excess adults at the weir) have limited management actions that could have achieved even higher PNI in Omak Creek. Actions within the HGMP propose to increase the number of NORs in broodstock (increased pNOB) and reduction in the number of hatchery fish on the spawning grounds in Omak Creek (reduced pHOS), consistent with spawn escapement objective (CCT HGMP, 2014). Initiation of actions to increase the pNOB and reduction of pHOS are expected to increase the PNI for the Okanogan steelhead population.

Total spawner escapement has exceeded the Colville Tribes goals over the last three years in Omak Creek and has increased since 2010. Adult management at the weir in Omak Creek is outlined in the Okanogan River summer steelhead HGMP, (CCT HGMP, 2014) to include adult management at the Omak Creek Trap. In 2013, only 4 of the 12 broodstock were natural origin for the Okanogan conservation program however the remaining 8 fish were hatchery origin conservation steelhead from previous wild x wild cross. Fish capture at the Omak Creek weir has become increasingly difficult due to gravel sized material accumulating on the trap and enabling fish to swim past[1]. The Okanogan Basin summer steelhead HGMP submitted by the Colville Tribes in February of 2013 has been reviewed by NOAA with a letter of acceptance delivered in May of this year (2014). Until such time as a new permit is issued by NOAA fisheries in conjunction with the new HGMP broodstock collection goals will remain at 16 NOB and 42 HOB from the Okanogan basin.

[1] In an effort to improve trapping efficiency, the Omak Creek weir was modified in the fall of 2015 to help reduce sediment load.

The adult escapement trend in Salmon Creek suggests increased escapement, dominated by hatchery origin adults and that escapement objectives may be met in the near future. Additionally, near-term ocean survival is expected to decrease due to decreased ocean productivity and warming ocean conditions. Considering the uncertainty of future SARs, reductions in stocking densities may increase the risk of under escapement and inhibit the recolonization effort in Salmon Creek. Removal of returning hatchery origin adults and cautious reductions in stocking rates is the preferred strategy to address over-escapement of hatchery fish to Salmon Creek and is considered to be the most risk-adverse strategy toward achieving the spawn escapement objective and reduced pHOS, as it reduces the risks associated with the uncertainty of future SARs. An adult steelhead weir somewhere in lower Salmon Creek would provide a mechanism for adult management, including broodstock collection, consistent with the HGMP. Controlling the pHOS on the spawning grounds of Salmon Creek will have important contributions towards steelhead conservation by lowering population level pHOS, as recommended by the HSRG (HSRG, 2009; Paquet et al., 2011), while minimizing the probability of under escapement.

Salmon Creek is also recommended as a brood source to increase the number of natural origin broodstock to support the District's mitigation obligation of 100,000 smolts for the Okanogan Basin. Gametes from these expanded numbers of natural origin broodstock would be used to replace the current WFH brood offspring to fulfill the recommended stocking levels based on spawner objectives as outlined in the HGMP (CCT, 2014). The combination of using natural origin brood for hatchery production, reducing stocking rates as more NORs return, and the removal of hatchery fish in excess of escapement objectives is the recommended prescription for successfully achieving recovery objectives in Salmon Creek and the Okanogan population. Additionally, the extension or expansion of the existing long-term water lease from OID is needed to ensure future passage of both juvenile and adult steelhead and is essential to successful recovery efforts.

Data collection is a collaborative effort between the Okanogan Basin Monitoring and Evaluation Program (OBMEP) and BAM CCT programs. In 2013, the BAM program provided additional help with Omak and Salmon creek's PIT tag arrays and the installation and maintenance of the Okanagan (OKL) PIT tag array located below Malott in the Okanogan River. Ongoing efforts between the OBMEP and BAM programs provide data and analysis used to meet the M&E objectives outlined in the PRCC HSC 2013. PIT tag arrays have become increasingly more useful with respect to abundance, production, and survival estimates and run timing. Therefore, expanding numbers of PIT-tagged fish can provide a wealth of useful information more efficiently than in the past.

Scales and PIT tags were used to understand steelhead life history strategies in Omak Creek (Objective 8). Sample sizes for most years were small for both wild and hatchery steelhead due to a large number of scales in poor condition (i.e., resorption). Issues such as false annuli, scale regeneration, resorption and cracking of adult scales upon their return to fresh water can lead to inaccurate estimates (Schrader et al. 2013). In the future, more scales should be collected from each returning fish to increase the odds of obtaining non-regenerated scales. Although kelt scales are easy to collect and seemingly harmless given the majority of these fish will soon die, almost 100% percent of these scales were not readable due to resorption so scale collection from kelts in the future will not continue. Consideration should be taken to collect scale samples at Wells dam or Priest Rapid dam prior to spawn to help recognize ponding checks and number of salt years. Alternatively, hatchery and natural ages could be determined from juveniles PIT tagged at a known migration age and return year. Based on these results we found hatchery salt ages to include 1-salt, 2-salt, and 3-salt fish, which is not consistent with the scale analysis for 2013 that includes only 1-salt and 2-salt fish. Missing salt years from scale analysis may be due to the low sample size for those years. However, not fully understanding the proportion of those within the PIT tagged population that may residualize and add assumed salt years to the data would overestimate salt years.

Size at maturity is another metric we used to provide indication of hatchery effects on natural origin stock (Objective 8). The physiological make up of a fish can be directly related to its fitness, or the ability to survive and pass on their genes. The average length of the spawning population is affected by age structure, specifically the number of years spent in the ocean. We do not yet have a good estimate of the salt age structure for natural origin fish. Without good age structure data we cannot make a fair comparison between hatchery and natural origin steelhead at maturity. In 2013, the proportion of salt years for hatchery origin fish was between one and three salt years. Preliminary data from adult scale analysis also may suggest that natural origin adults select a longer ocean life history pattern than hatchery origin fish from Omak Creek. These results need to be confirmed with PIT tag data and or a larger scale sample size in the future.

This report offers the first attempt to calculate and document HRR and NRR for the Okanogan steelhead population and hatchery program. Due to the short time series of available data and ongoing program changes to implement hatchery reform we did not attempt to draw a conclusion for Objectives 1 and 3 in this report. Harvest was not included in our estimates of HRR and NRR because of uncertainty regarding fish captured in mixed fisheries in the Columbia River. We recommend that CCT work with WDFW to determine agreed to methods for partitioning Columbia River steelhead catches to particular populations (Okanogan, Methow, Wenatchee) so that future reports can include HRR and NRR with and without harvest. Including harvested fish in the HRR and NRR would increase the HRR more than the NRR because the Columbia River sport fisheries are mark selective. However, we do not believe that including harvest would change the trend or conclusions from the HRR and NRR analyses presented in this report. The hatchery program has been successful at returning hatchery adults to the Upper Columbia, but natural production in the Okanogan Basin has been below objectives and stable to slightly increasing (OBMEP 2014). For both Omak Creek and the Okanogan Basin, replacement rates for naturally spawning fish have been less than 1. In other areas, the relative reproductive success of hatchery fish has been less than that of natural origin fish (Kostow et al. 2003; Araki 2007; Williamson et al. 2010). Assuming that is also the case in the Okanogan, we expect that the ongoing and future efforts to reduce pHOS, increase pNOB and improve hatchery fish spawning distribution will lead to a more productive population of natural spawners. Additionally, considerable effort has gone into habitat improvement projects throughout the Okanogan Basin that intend to increase the capacity and productivity of the tributaries where steelhead spawn and rear. The combined habitat and hatchery reform efforts are expected to increase the NRR, unless outmigration and ocean conditions decrease.

Hatchery adults that spawn at different times or locations than naturally produced fish may result in decreased productivity of hatchery fish in the natural environment and reduced efficacy of the supplementation effort (i.e., less optimal spawn time period and habitat compared to natural origin spawners). Assessment of spawn time and location of hatchery and natural origin adults in Omak and Salmon creeks (Objective 5) during 2013 was difficult. Due to adverse environmental conditions in 2013 (turbidity), no redd surveys were conducted for Omak Creek; therefore, we made the assumption fish collected at the Omak weir would spawn shortly thereafter. It is recognized that this is not the preferred measurement to determine spawn time however given constraints in 2013 this was the only measurement to allow us to estimate spawn time in Omak Creek. Hatchery fish in Omak Creek arrived previous to natural fish and lasted longer into the spawning period. For Omak Creek, four out of the last five years spawning has occurred earlier than the seven year mean. No statistical tests were conducted on spawn timing or trends between or among years so it is unclear if the differences were real. It is a goal of the CCT program to select broodstock throughout the run timing. However, in years with low natural returns and or low adult collections this can be difficult and therefore broodstock can be opportunistic and favor steelhead that enter Omak Creek during periods of high trap efficiency, which tends to be early in the season. Salmon Creek was largely made up of hatchery origin fish and the number of PIT tags in natural origin fish that returned to Salmon Creek was limited. This prohibited us from doing an analysis of run or spawn timing of natural origin spawners in Salmon Creek.
Part of Objective 6 was to determine the risk to genetic variation of adjacent populations from stray rates of Okanogan hatchery fish. Only one stray was detected outside of the Okanogan basin from Omak Creek conservation release groups (2010–2012). Therefore, the conservation program stray rate was below the suggested 5% between-population stray contribution (PRCC HSC 2013). There were too few PIT tags released outside of Omak Creek to facilitate assessment of the within population homing fidelity of the Okanogan steelhead program. In the future we recommend the release of 5,000 PIT tags per release site to improve estimates of within population homing fidelity and between population stray rates for the entire program.

Included in Objective 1 to determine the effects of the supplementation program on the natural populations and objective 10, harvest rates; we used creel census for the steelhead fishery above Wells Dam, which includes the mainstem Columbia, Methow, Okanogan, and Similkameen Rivers. An estimated 1,636 ad-clipped hatchery steelhead were harvested, thus precluding them from spawning in 2013 (WDFW NOAA in-season sampling data, April, 2013). This represents a 16 % reduction of the hatchery origin steelhead above Wells Dam and is considered an important contribution to reducing pHOS in the Okanogan Basin. Despite this reduction, pHOS remained high in both the Okanogan basin including all tributaries and in Omak Creek. It is clear that additional hatchery fish removal efforts are needed to meet population objectives for pHOS and PNI and or reduction of hatchery plants as suggested (CCT HGMP 2013).

Genetic diversity has become widely accepted as a critical component to the persistence of a natural population and the direct measurement to Objective 7 of the hatchery committee standards for hatchery monitoring and evaluation (McElhany et al. 2000). Historically, broodstock collection for the Okanogan basin was 20% Okanogan and 80% Wells stock which included an undetermined mixture of Methow, Okanogan, and other stocks (including strays from the Wenatchee program). In the future, under the proposed HGMP, 100% of the broodstock for the Okanogan basin will be collected from Omak Creek and other locations in the Okanogan Basin. A conservation broodstock has been the focus of the Omak Creek program since the construction of a trap on Omak Creek made collection of adults possible. However, broodstock collection is needed at multiple locations throughout the Okanogan basin to ensure adequate broodstock numbers (in years when Omak Creek escapement is low) and to capture a broader representation of the genetic diversity of the Okanogan population. Locations such as Wildhorse Spring or Whitestone creeks can go dry mid-summer or reach water temperatures that exceed juvenile steelhead survival limits. These sites provide potential locations for broodstock collection that can help achieve the pNOB objectives of the Okanogan summer steelhead program while avoiding natural mortality of juveniles in these harsh environments.

V. Chapter 2. Juvenile Hatchery and Natural Steelhead

Chapter two reports acclimation and release of Okanogan hatchery steelhead, hatchery survival, natural migration estimates, and smolt timing. The focus is on monitoring hatchery released steelhead from St. Mary's acclimation pond and natural steelhead from Omak Creek using a rotary screw trap and PIT tag arrays. Additional information is provided on rearing and release of smolts in other areas of the Okanogan, primarily Salmon Creek and the Similkameen River. The data collection efforts reported in this chapter were intended to contribute to addressing the following M&E guidance objectives identified by the Priest Rapids Coordinating Committee and Hatchery Sub-Committee (PRCC HSC, 2013):

Objective 2: Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.

Objective 8: Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

Objective 9: Determine if hatchery fish were released at the programmed size and number.

Methods

Hatchery Survival

Survival rates were calculated based on the complete inventory of the hatchery steelhead population at Wells Fish Hatchery and any mortality that occurred prior to release from St. Mary's acclimation pond. These data were collected by WDFW staff and reported to us on a monthly basis, further detail on methods and results can be found in their 2013 annual report (Snow et al. 2013). Percent survival from green egg to eyed egg stage was calculated by dividing the number of eyed eggs by the total number of estimated green eggs based on an average number of eggs per female. Fry survival was calculated by using a weight measurement to estimate the total population minus mortality counts. Juvenile fish abundances were calculated using a fish per pound (FPP) measurement and subtracted mortalities to develop monthly survival estimates. Total number of juveniles released was calculated by subtracting known mortality at St. Mary's acclimation pond from the estimated number of fish transferred from WFH. Percent survival is a cumulative calculation from the estimated number of fry to the total number of fish released from St. Mary's acclimation pond.

Number, Size, Location, and Timing of Fish Released

A water displacement method was used to estimate the number of fish released for each direct release location. The total number of juvenile fish released was calculated by subtracting any mortality that occurred during the rearing process or stocking effort from the total number of fish at ponding. Prior to ponding, three fish per pound (FPP) measurements were taken and averaged to determine a mean weight and total number of FPP. A water displacement method was then used, based on volume and the known number of FPP to determine the total number of fish ponded. Each month weight samples were taken by hatchery personnel using feed to attract fish and then capture using a net. Three separate FPP measurements are taken and then averaged. Prior to moving fish to be stocked or be acclimated, a final measurement of three separate FPP estimates were calculated and water displacement method was employed to estimate the total number of fish transferred to acclimation and to direct release locations.

Size at release targets specified in the Priest Rapid Hatchery M&E Plan, were derived from weight at release based on FPP. Corresponding length at release targets were derived from pre-release length and weight data taken at WFH. Fork length was measured to the nearest millimeter and weight was measured to the nearest 0.1 gram. A coefficient of variation was then derived based on the variation from the mean of these lengths. Mean length was estimated from 100 fish randomly sampled each month. Prior to each stocking event a FPP estimate was taken from 30 fish to calculate truck densities.

Release locations were pre-determined at a planning meeting between CCT, WDFW, and GPUD. Smolts generated from broodstock collected at the Omak weir were acclimated and released at the St. Mary's acclimation pond (rkm 5.6; 48°22'13.38"N; 119°26'29.37"W) (Figure 1). The target acclimation period was one month, from mid-late March to mid-late April, with exact transfer and release dates dependent on fish condition and hatchery operations scheduling. Steelhead acclimated at St. Mary's acclimation pond were held on a mix of Omak Creek and well water at a ratio of approximately 20% creek and 80 % well water. A maintenance diet was used to avoid growth and encourage outmigration. A volitional release strategy was implemented in late April by not feeding to encourage migration and removing the outflow screen to allow migration. In early to mid- May, non-migrants were transferred and released in the lower Okanogan River (at Mosquito Park, rkm 1.8) to reduce competitive interactions with natural origin steelhead in Omak Creek.

Steelhead smolts generated from broodstock collected at WFH were direct planted in Salmon Creek (~40,000), Aeneas Creek (~2,000) and the Similkameen River (the remainder, ~50,000). The timing of transfer and direct plants to Salmon Creek, Aeneas Creek, and the Similkameen River were based on size at release and coincided with Columbia River dam spill.

Smolt to Smolt Survival

Smolt-to-smolt survival was estimated for hatchery steelhead from the St. Mary's Acclimation pond and for natural steelhead collected at the RST in Omak Creek (Omak Creek, OMK) to the juvenile bypass facility at Rocky Reach Dam (RRJ). The data for this calculation was collected using the "Live Recaptures" Cormack/Jolly-Seber Estimates feature in the program Dart (Columbia River Dart, 2015) to determine estimates of survival over distance and detection probability.

Natural Origin Migrants

A five foot diameter RST was used in Omak Creek near its confluence (rkm 1.5) with the Okanogan River. The RST was deployed on March 20, 2013 and operated seven days a week 24 hours a day. On March 23 and 26, the trap was not fished due to low flow. There was uninterrupted operation of the trap between March 27 and June 16. The trap was removed on June 17 due to low water conditions (discharge less than 30 ft^3/s). The trap was checked at least daily and as often as every four hours when required by high discharge, debris loads and to ensure fish health. Fish were handled and sampled following standard operating procedures as described in the ISEMP field protocols for operation of a RST in the upper Columbia basin (protocol available at www.Monitoringmethods.org).

Natural origin steelhead size at migration was estimated from fork lengths taken at the RST in Omak Creek. All natural origin steelhead were measured to the nearest millimeter (mm) and weighed to the nearest tenth of a gram (g). The mean length and standard deviation (SD) were calculated for each age class and the coefficient of variation (CV) was calculated using the formula:

$$CV = SD / mean$$

Length frequency histograms were used to determine age breaks for juvenile natural steelhead from Omak Creek. Age 0 fish (fry) were counted as anything less than 65 mm, although the RST was not effective at capturing this size fish and therefore did not produce a valid estimate. Age 1 steelhead were considered parr in their second year of growth. Age 2 were considered transitional parr-smolts and age 3 and 4 we refer to as smolts and assumed actively migrating to the ocean. To validate the length frequency age breaks we took scales (n = 52) from natural origin steelhead at the RST on Omak Creek. Natural juvenile scale patterns were examined between the years 2010 and 2012 from the Omak RST to validate these size breaks.

Natural Migration Estimate

The abundance of juvenile outmigrants was estimated using capture efficiency from the Omak RST. To determine trap efficiency we released seven groups of no less than 30 PIT-tagged steelhead 2.5 rkm upstream of the trap, hereafter referred to as "efficiency release" at various flows. Efficiency releases were made when 30 or more fish were collected within a 48-hour holding period. Abundance estimates were calculated for migrating steelhead based on a 95% confidence interval. The following methods description and equations were taken from Snow *et al.* 2013.

Seasonal juvenile migration, N, is estimated as the sum of daily migrations, N_i, i.e., $N = \sum_i N_i$, and daily migration is calculated from catch and efficiency,

$$\hat{N}_i = \frac{C_i}{\hat{e}_i},$$

where C_i = the number of fish caught in period *I*;

$\hat{e}_i$ = trap efficiency estimated from the flow-efficiency relationship $\sin^2(b_0 + b_1 flow_i)$, where b_0 is estimated intercept and b_1 is the estimated slope of the regression;

The regression parameters b_0 and b_1 are estimated using linear regression for the model

$$\arcsin\left(\sqrt{e_k^{obs}}\right) = \beta_0 + \beta_1 flow_k + \varepsilon,$$

where e_k^{obs} = is the observed trap efficiency of Eq. 2 for trapping period *k*;

β_0 = the intercept of the regression model;

β_1 = the slope parameter;

ε = the error with mean 0 and variance σ^2.

The observed trap efficiency, e_k^{obs}, is calculated as follows,

$$e_k^{obs} = \frac{r_k + 1}{m}.$$

The variance of total abundance is more complex than previously with the inclusion of covariance between daily estimates that arises from using the same regression model. The variance of seasonal migration is calculated from daily estimates as,

$$Var\left(\sum_{i=1}^{n} \hat{N}_i\right) = \underbrace{\sum_i Var(N_i)}_{Part\,A} + \underbrace{\sum_i \sum_j Cov(N_i, N_j)}_{Part\,B},$$

or,

$$Var\left(\sum_{i=1}^{n} \hat{N}_i\right) = \underbrace{\sum_i Var\left(\frac{(C_i + 1)}{\hat{e}_i}\right)}_{Part\,A} + \underbrace{\sum_i \sum_j Cov\left(\frac{(C_i + 1)}{\hat{e}_i}, \frac{(C_j + 1)}{\hat{e}_j}\right)}_{Part\,B}.$$

Part A is the variance of daily estimates. Part B are the between day covariance. Note that the between day covariance exists only for days that use the same trap efficiency model. If, for example, day 1 is estimated with one trap efficiency model, and day 2 estimated from a different model, then there is no covariance between day 1 and day 2. The full expression for the estimated variance

$$\hat{Var}\left(\sum_{i=1}^{n}\hat{N}_i\right) = \underbrace{\sum_i \hat{N}_i^2\left(\frac{N_i\hat{e}_i(1-\hat{e}_i)}{(C_i+1)^2} + \frac{4(1-\hat{e}_i)}{\hat{e}_i}\hat{Var}(b_0 + b_1\,flow_i)\right)}_{PartA} +$$
$$\underbrace{\sum_i\sum_j 4\left(\hat{N}_i(1-\hat{e}_i)\right)\left(\hat{N}_j(1-\hat{e}_j)\right)\cdot\left[\hat{Var}(b_0) + flow_i\,flow_j\hat{Var}(b_1)\right]}_{PartB}$$

where $\hat{Var}(b_0 + b_1\,flow_i) = M\hat{S}E\left(1 + \frac{1}{n} + \frac{\left(flow_i - \overline{flow}\right)^2}{(n-1)s^2_{flow}}\right)$, and $\hat{Var}(b_0)$ and $\hat{Var}(b_1)$ are obtained from

regression results. In Excel, the standard error (SE) of the coefficients is provided. The variance is calculated as the square of the standard error, SE^2.

The migration model uses discharge to estimate daily catch rates. The model assumes discharge has a direct relationship to the efficiency of the RST. Efficiency trials validate this at various flows. Daily trap efficiency estimates were then calculated based on efficiency releases. To estimate missed daily catches, we took the average fish abundance of the two days before and the two days after the missing period. Daily estimates were then combined into total abundance estimates (Snow *et al*. 2013). Omak Creek discharges were taken from USGS monitoring site (#12445900) at rkm 5.7 on Omak Creek.

A migrant per spawner (M/S) was the metric used to evaluate within tributary productivity. The migration estimate was derived from the RST trap in Omak Creek. Number of total steelhead spawners in Omak Creek was determined from an adult escapement estimate formulated by combing PIT detections, weir collections and redd survey counts following protocols defined in OBMEP (2014) (Appendix A). Because the number of M/S was based on the total number of spawners for a given year we used the average length at age to determine the percent number of outmigrants for age 1, 2 and 3 fresh steelhead from Omak Creek. Migrants per Spawner were calculated using the number of spawners in brood year x (S_{BYx}) and the number of age class specific migrants M_{BY} from the outmigration years x + 1, x+2, and x+3 using the formula: $M/S = [(M_{BYx+1}) + (M_{BYx+2}) + (M_{BYx+3})] / S_{BYx}$

<u>*Juvenile Migration Timing*</u>

In 2013, PIT tagged hatchery steelhead were released from St. Mary's acclimation pond near rkm 5.4 and natural origin steelhead with PIT tags captured from the RST in Omak Creek near rkm 1.2. Those PIT tagged fish detected at both the Omak in-stream array (OMK) and the Rocky Reach juvenile bypass PIT tag interrogation system were used to estimate smolt migration and timing for the entire run. We queried tagging data and interrogation data, using the PTAGIS database (maintained by Pacific States Marine Fisheries Commission, *http://www.ptagis.org*). A mean travel time for smolts is reported with a minimum and maximum amount of travel time to RRJ from Omak Creek.

Results

Hatchery Survival

Juvenile hatchery steelhead survival from the 2012 brood year between July 2012 to April 2013 was 87.8% (Table 16). After mortality a total of 9,070 steelhead of natural broodstock were released from Omak Creek (Table 16). A monthly mortality rate was determined and cumulative survival rates for Omak Creek wild x wild steelhead between July 2012 and April of 2013 (Table 16).

Average fecundity for natural origin females from 2013 brood year collected in Omak Creek was 5,500 eggs per female (Table 17). Fry-to-smolt survival was 89.0 % and the number of smolts produced is projected to be above stocking goals (~5,000) for Omak Creek in 2014 (Table 17).

Table 16. Monthly and cumulative post ponding in-hatchery survival for brood year 2012 steelhead from Omak Creek natural origin parents from July 2012 to April 2013. Data from April 2013 provided by Confederated Colville Tribe (CCT).

Month	Inventory	Mortality	Monthly Mortality Rate (%)	Cumulative Survival Rate
July	10,015	322	3.2	96.9
August	9,802	213	2.2	94.8
September	9,750	52	0.5	94.3
October	9,700	50	0.5	93.8
November	9,680	20	0.2	93.5
December	9,665	15	0.2	93.4
January	9,654	11	0.1	93.4
February	9,639	15	0.2	93.2
March	9,200	439	4.8	89.0
April	9,070	121	1.3	87.8

Table 17. Omak Creek steelhead egg-take, fecundity and life stage survival of natural origin brood for brood years 2004-2013.

Brood Year	# Females	Total # Green	# Eggs/ Female	# Eyed/ Eggs	Green/ Eyed Eggs (%)	# Fry	Fry/ Smolt (%)	# Smolt
2004	8	31,414	3,927	24,260	77.2	21,500	88.7	19,071
2005	9	32,038	3,560	25,206	78.7	21,452	92.5	19,862
2006	8	36,345	4,543	33,221	91.4	30,895	93.0	27,219
2007	8	43,327	5,416	42,439	98.0	41,447	97.7	32,915
2008	4	19,868	4,967	17,938	90.3	16,771	93.5	15,505
2009	8	33,112	4,139	31,815	96.1	30,505	95.9	23,618
2010	8	39,539	4,942	36,174	91.5	33,748	93.3	32,333
2011	8	55,678	6,960	50,256	90.3	50,256	90.3	41,285
2012	2	11,000	5,500	10,758	97.8	10,521	91.5	9,070
2013	6	33,000	5,500	28,778	87.2	28,778	89.0	25,632
Mean	7	33,532	4,945	30,085	89.9	28,587	93.0	24,651

Number, Size, Location, and Timing of Fish Released

A total of 101,192 juvenile hatchery steelhead were released in the Okanagan basin in 2013, including 9,070 that were released from the St. Mary's acclimation pond (Table 18). Omak Creek fish were transferred from WFH to St. Mary's acclimation pond on March 27, 2013 and a volitional release began on April 23. On May 7, 421 non-migrants were removed and transported to the mouth of the Okanogan River and released at Mosquito Park (near the Hwy 97 Bridge at rkm 1.8). All other steelhead releases in the Okanogan Basin (92,122 smolts) were Wells stock (i.e., hatchery parents collected at Wells Dam) and were direct planted by Wells Hatchery staff in three locations between April 17- 21, 2013. An estimated 40,032; 2,010 and 50,080 juvenile steelhead were released into Salmon Creek (rkm 21.0), Aeneas Creek (rkm 2.1) and the Similkameen River (rkm 6.4), respectively (Table 18). Average fork length at release for Omak Creek (W x W) steelhead was 179 mm with a CV of 17% (Table 19) and for Wells (H X W) stock it was 188 mm and a CV of 14%.

Table 18. Number of hatchery summer steelhead by release year (RY) for the Okanogan Basin from 2004-2013. All release groups were yearling smolts from the previous brood year. Omak Cr. (OMK), Salmon Cr. (SAL), Nine Mile Cr. (NIN), Antoine Cr. (ANT), Tunk Cr, (TUN), Aeneas Creek (ANE), Similkameen River (SIM), Okanogan River (OKA).

RY	OMK	SAL	NIN	ANT	TUN	ANE	SIM	OKA	Total
2004	3,450	-	-	-	-	-	50,860	5,920	60,230
2005	19,071	-	-	-	-	-	57,750	12,000	88,821
2006	19,862	7,447	-	-	-	-	68,940	-	96,249
2007	27,219	13,442	-	-	-	-	139,415	-	160,304
2008	19,914	13,120	5,152	2,856	4,993	-	106,317	16,403	168,755
2009	15,505	26,403	-	-	-	-	79,286	14,200	135,394
2010	23,618	25,657	-	-	-	-	51,868	-	101,143
2011	32,333	40,000	-	-	-	-	61,090	-	133,423
2012	41,285	50,000	-	-	-	-	73,623	3,960	168,868
2013	9,070	40,032	-	-	-	2,010	50,080	-	101,192
Total	203,880	216,101	5,152	2,856	4,993	2,010	741,959	52,483	1,214,379
Mean	20,388	27,012	N/A	N/A	N/A	N/A	74,195	10,496	121,437

Table 19. Average length (mm), weight (g), and coefficient of variation (CV) for broodyear 2012 Okanogan natural origin steelhead.

Month	Length (mm)	Weight (g)	CV Length
August	42.0	0.7	NA
September	65.0	3.3	15.8
October	85.0	7.9	14.1
November	112.0	15.6	13.4
December	140.0	30.2	11.1
January	155.0	41.2	13.4
February	170.0	54.6	9.5
March	187.0	NA	9.5
April	179.0	56.4	16.9

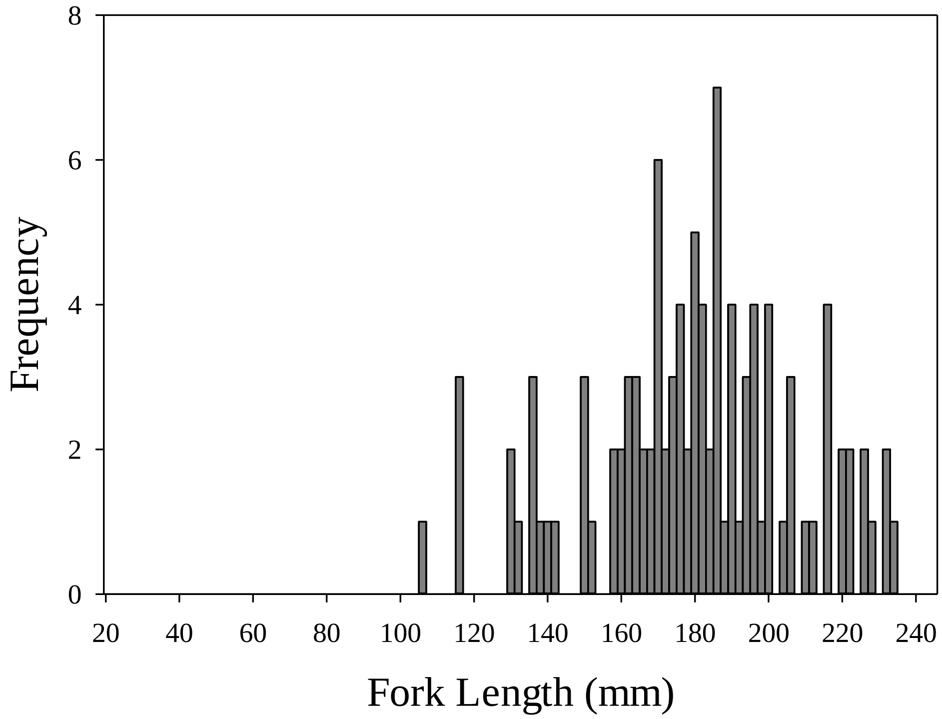


Figure 16. Length distribution for hatchery steelhead juveniles measured before release in April 2013 at the St. Mary's acclimation pond in Omak Creek.

Smolt to Smolt Survival

In 2013, we released 9,070 hatchery smolts into Omak Creek of those 100% were PIT tagged (Table 20). Using the detection efficiency and probability of detection at RRJ the smolt to smolt survival estimate for hatchery reared steelhead from Omak Creek was 0.646 with a standard error of (0.024) in 2013 (Table 21).

Table 20. Release locations, number released and PIT tags released for summer steelhead in the Okanogan River basin. Stapaloop, Haley, and Lobe creeks are tributaries of upper Omak Creek above Mission Falls. St. Mary's Pond is in Omak Creek just below Mission Falls.

Release Year	Location	Release rkm	Number Smolts Released	Number PIT Smolts Released
2004	Stapalop Cr.	12.6	3,450	0
2005	Stapalop Cr.	12.6	19,071	19,071
2006	Stapalop Cr.	12.6	19,862	19,862
2007	St. Marys	5.6	27,219	19,772
2008	Haley Cr.	11.7	32,915	6,735
2009	St. Marys	5.6	15,505	13,532
2010	St. Marys	5.6	23,618	14,174
2011	St. Marys	5.6	32,333	19,898
2012	St. Marys	5.6	41,285	16,887
2013	St. Marys	5.6	9,070	9,070

Table 21. Juvenile survival estimate to Rocky Reach juvenile bypass (RRJ) based on number of hatchery smolts released from St. Mary's Acclimation pond on Omak Creek for 2010-2013. SE = Standard Error.

Release Year	Smolts Released	PIT Tagged	Detected @RRJ	Smolt to Smolt Survival	(SE)
2010	23,618	14,174	4,519	0.654	(0.014)
2011	32,333	19,898	4,031	0.728	(0.012)
2012	41,285	16,887	5,567	0.682	(0.018)
2013	9,070	9,070	2,312	0.646	(0.024)

During 2013, juvenile natural origin steelhead were PIT tagged (n = 1,832) and released from the Omak RST and 317 were recaptured at RRJ. The smolt to smolt survival estimate for PIT tagged natural origin juvenile steelhead emigrating from Omak Creek to RRJ was 0.728 with a standard error of 0.083.

Natural Origin Migrants

Juvenile natural steelhead were captured (n =1,915) in the RST between March 15, 2013 and June 9, 2013. Size at migration for natural steelhead from Omak Creek ranged between 64 mm and 276 mm in fork length (Figure 17). Natural juvenile age 2 steelhead made up the majority (n= 1,378 or 72%) of the emigration during 2013 (Table 22).

Table 22. Number and percent (%) age by migration year (2010-2013) for natural juvenile summer steelhead from Omak Creek.

Year	Age 0 **Number (%)**	Age 1 **Number (%)**	Age 2 **Number (%)**	Age3 **Number (%)**	Age 4 **Number (%)**	Resident **Number (%)**
2010	52 (20%)	17 (1.7%)	142 (58%)	33 (13%)	0 (0.0%)	2 (0.8%)
2011	188 (8.2%)	1,373 (60%)	412 (18%)	217 (9.5%)	86 (3.8%)	0 (0.0%)
2012	8 (1.0%)	1,440 (45%)	1,606 (50%)	121 (3.8%)	6 (0.2%)	0 (0.0%)
2013	1 (0.1%)	368 (19%)	1,378 (72%)	161 (8.4%)	5 (0.3%)	2 (0.5%)
Total	**249 (3.2%)**	**3198 (42%)**	**3,538 (46%)**	**532 (6.9%)**	**97 (1.2%)**	**4 (0.7%)**

Juvenile age breaks were based on scales analysis from 52 natural juvenile steelhead captured at the RST in Omak Creek. Results showed age/length breaks were: Age 0 (<90 mm), Age 1 (90-130 mm), Age 2 (130-190 mm), Age 3+ (190-250 mm), and we assume that those fish over 250 mm are resident fish. Age breaks using scale results do indicate some overlap between age 1 and age 2 steelhead (Figure 18).

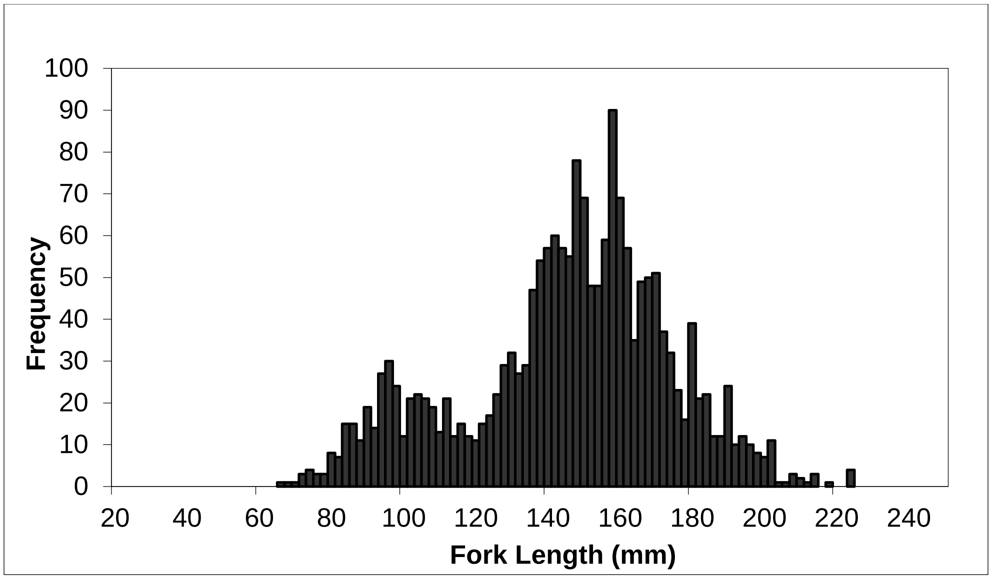


Figure 17. Natural origin out-migrant steelhead length frequency at the rotary screw trap on Omak Creek in 2013.

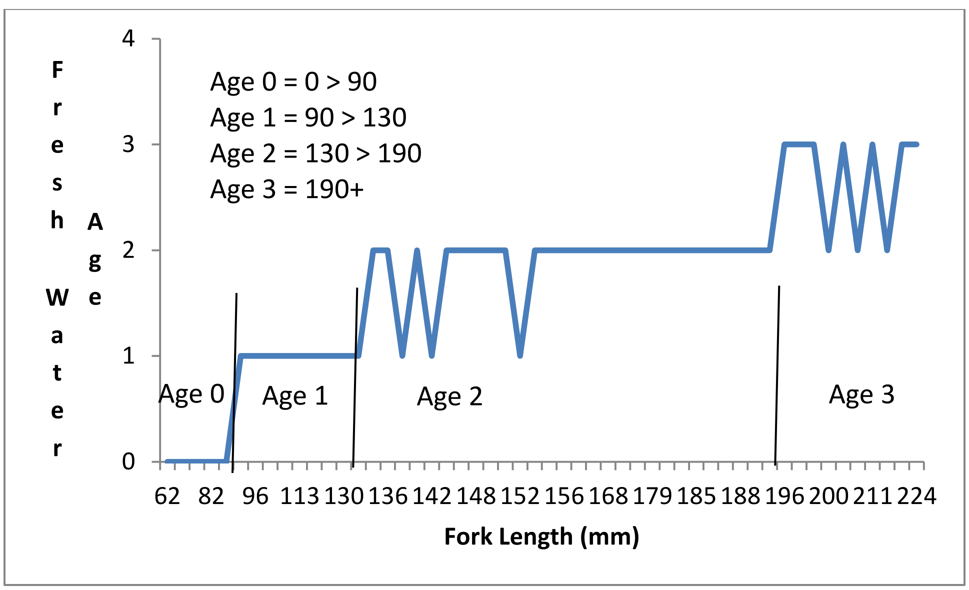


Figure 18. Length at age for natural origin steelhead based on scale analysis between 2010 and 2012 from Omak Creek RST (n=52).

Natural Migration Estimate

We pooled eight mark groups between 2012 and 2013 to develop a migration estimate based on trapping efficiencies from a rotary screw trap on Omak Creek (Table 23). Trap efficiency ranged from 0.21 to 0.46 across a range of flows from 42 and 110 cfs (Figure 19). The juvenile migration estimate for Omak Creek was 6,593 (± 3,945) in 2013 (Figure 20).

Table 23. Number of marked fish between 2012 and 2013 and recaptures for each group with trap efficiency estimate and flow (cfs).

		Number of Fish		Trap Efficiency	
Trial	Date	Marked	Recaptured	Observed	Flow
1	4/20/2013	56	11	0.214	110
2	4/26/2013	43	19	0.465	110
3	4/27/2013	63	23	0.381	110
4	5/5/2013	71	32	0.465	106
5	5/6/2013	55	20	0.382	110
6	6/5/2012	30	6	0.200	54
7	4/10/2012	50	17	0.360	25

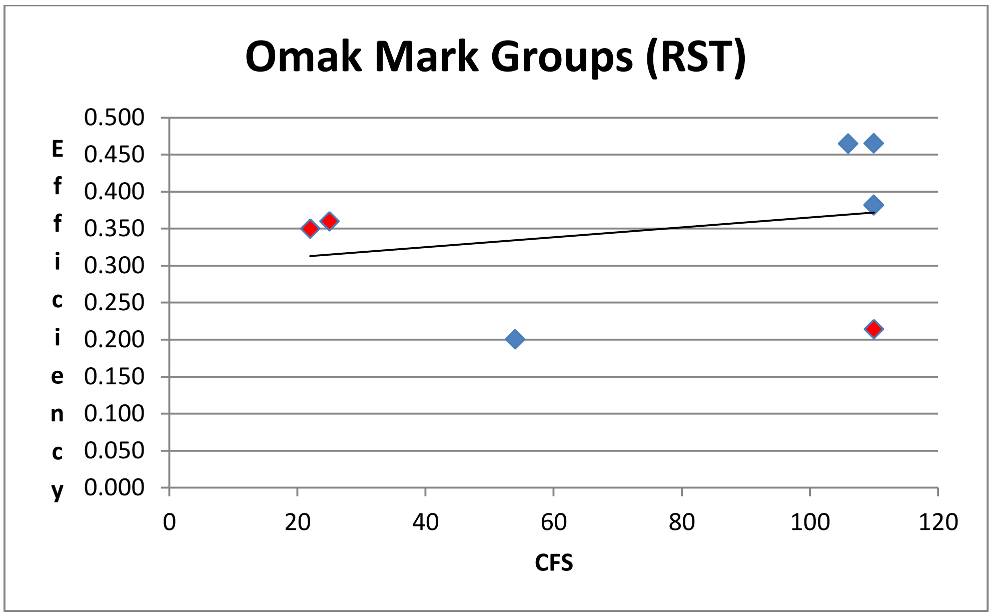


Figure 19. Efficiency measurements from a five foot rotary screw trap using natural juvenile mark recaptures based on discharge (cubic feet per second, CFS) in Omak Creek, WA in 2012 (blue dots) and 2013 (red dots).

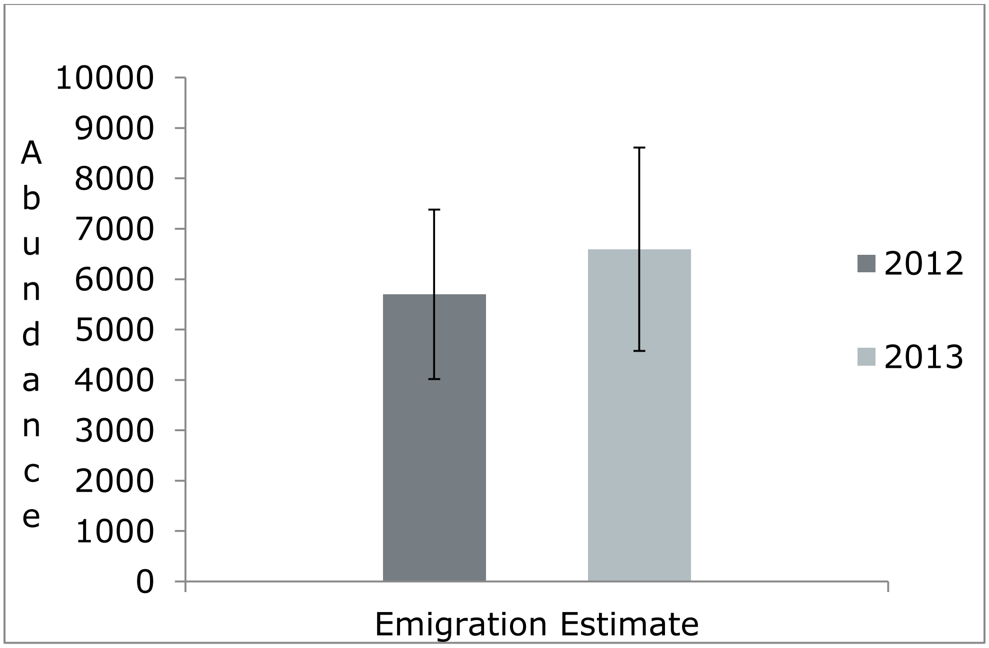


Figure 20. Smolt outmigration estimate for Omak Creek (2012-2013). Estimates based on a 95% confidence interval using R-script values from efficiency trials (2012-2013) at the Omak rotary screw trap.

Migrant per spawner estimate was determined from the % age at migration (Age 1 = 42%, Age 2 = 46%, Age 3 = 6.9%, and Age 4 = 1.2%) (Table 22). This was applied to each year a migrant estimate was determined (2012 = 5,697 and 2013 = 6,593) to provide a migrant per spawner estimate (Table 24). We cannot fully determine the total migrant per spawner for those years (2008-2010) without migration estimates. Each value from 2010 on will increase slightly up to four years of age as migration estimates are collected from the RST in Omak Creek.

Table 24. Number of natural migrant per spawner for Omak Creek. Age-0 and resident fish estimates are excluded from this table. NA = Data Not Available.

Brood Year	Total Spawners	Estimated # Migrants				Total Migrants	Migrant per Spawner
		Age-1	Age-2	Age-3	Age-4		
2008	102	N/A	N/A	N/A	79	79	0.77[1]
2009	130	N/A	N/A	454	68	522	4.0[2]
2010	273	N/A	2,620	393		3,013	11.0[2]
2011	132	2,392	3,032			5,424	41.0[2]
2012	413	2,769				2,769	6.7[1]
2013	299						

[1]Only one cohort spawning year. [2]Only two cohort spawning years.

Juvenile Migration Timing

Juvenile hatchery steelhead were detected at the Omak Creek PIT tag array between April 21 and October 29 (n=5,410), with a median of May 8 (Figure 21). We could not estimate the number of days that hatchery fish spent in Omak Creek after release because there was no date specific PIT detection leaving the acclimation pond[1]. For hatchery fish released from St Mary's pond beginning April 23, 2013 and detected at the lower Omak Creek array in 2013, approximately 37% were detected by April 30, and 97% were detected by May 31, and 99.9% were detected by June 11, 2013 (Figure 21). The highest daily detection occurred on April 29 (22%), approximately 6 days after the beginning of the volitional release period (Figure 21). Seven juvenile hatchery fish from the 2013 releases were detected at the Omak Creek array in the spring of 2014, presumably leaving as 2-fresh migrants.

Juvenile natural origin fish were detected at the Omak Creek PIT array between March 21 and November 19 (n=212), with a median of June 4. There were no detections of natural origin juveniles at the Omak Creek array from mid-April to mid-May. Only 29% of natural origin outmigrants had been detected by May 31 but 94% were detected by June 30, 2013.

There were 318 natural origin and 2,312 hatchery origin juvenile steelhead detected at RRJ in 2013 that had been PIT tagged and released in Omak Creek in 2013. The median passage date at RRJ was May 9 for natural origin juvenile steelhead and May 16 for hatchery origin (Figure 21). Natural origin fish appeared to arrive earlier and peak earlier at RRJ than hatchery origin fish.

There were 1,571 hatchery fish and 25 natural origin fish that were detected at both the Omak Creek array and RRJ. The average number of days for hatchery origin fish to go from the lower Omak Creek PIT array to RRJ was 6.0 days (range 1.7-31.8 days)[2]. The average number of days for natural origin fish to go from the lower Omak Creek PIT array to RRJ was 5.0 days (range 1.9-40.0).

[1] In PITAGIS, the hatchery released fish all had a release date of April 15, although the volitional release did not begin until April 23.

[2] This analysis excludes fish detected in subsequent years (i.e., fish that left Omak Creek in 2013 then reared somewhere else for 1-2 years before being detected at RRJ).

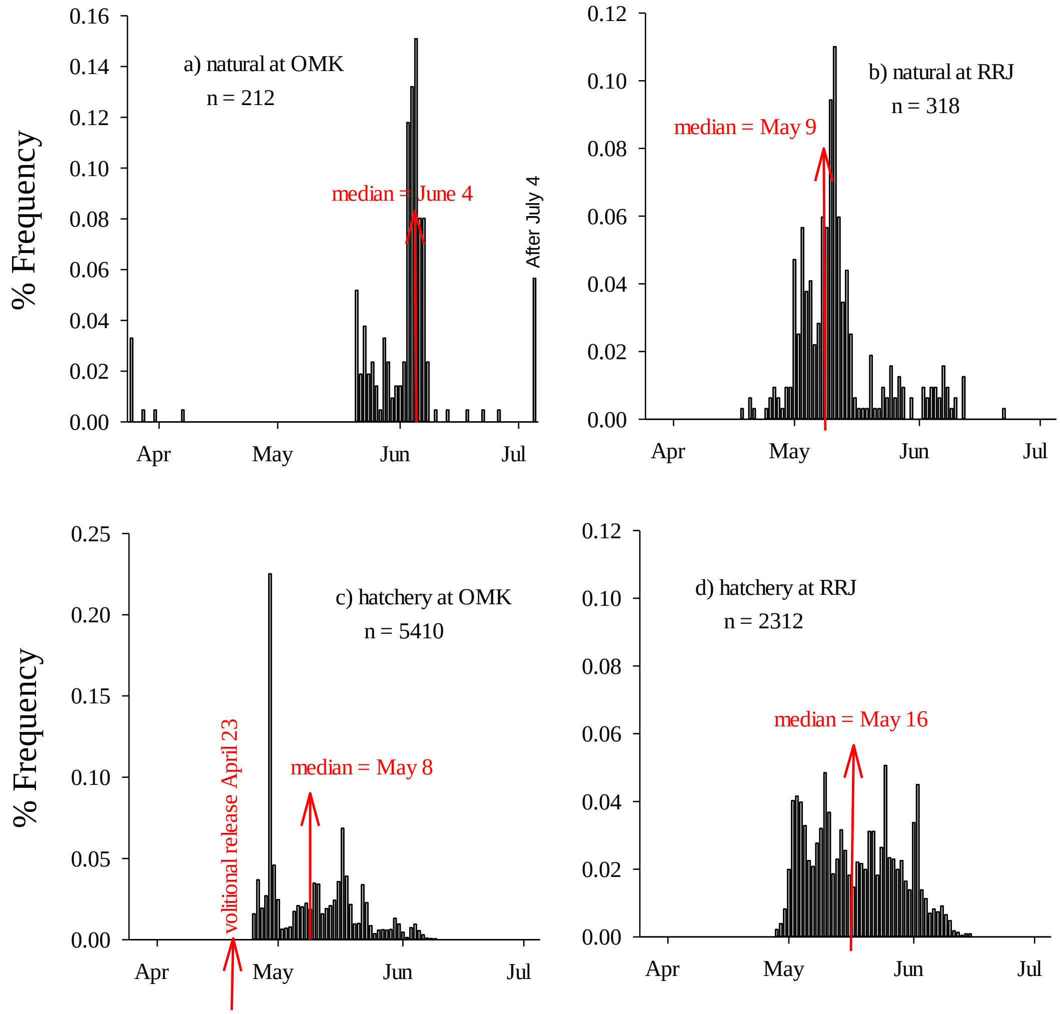


Figure 21. Timing of PIT tag detection for natural-origin (panels a and b) and hatchery-origin (panels c and d) steelhead that were released in 2013 in Omak Creek and detected at either the Omak Creek instream array or the Rocky Reach Juvenile Bypass (RRJ) in 2013.

Discussion

Chapter two provided results that are directly related to objectives 2, 8 and 9 of the PUD monitoring and evaluation plan for hatchery programs (HCP-PRCC, 2103). Within these objectives it was recommended by the hatchery committees to determine if hatchery fish were released at the correct program size, if any phenotypic change has occurred on natural fish from hatchery fish and or hatchery fish have had effects on the freshwater productivity of the supplemented stock. The data reported for 2013, by itself, was not used to determine if there were population level phenotypic changes or effects on freshwater productivity. However, this report provides an annual update that can be combined with more years of data in the future to evaluate these objectives.

The overall hatchery mitigation requirements of GPUD were met in 2013, with over 100,000 hatchery smolts released into the Okanogan Basin. In Omak Creek, 9,070 summer steelhead smolts were released which was only half of the target release objective (20,000). The low release rate was the result of few natural broodstock taken from Omak Creek in 2012. A low natural origin return year and poor collection efficiency at the trap both contributed to a reduced stocking rate in 2013. A management decision was made to release fewer fish in Omak Creek and only use Omak origin broodstock, rather than bringing in smolts derived from broodstock collected at WFH. Given the higher SARs of hatchery fish in recent years, a stocking level 9,070 fish should still provide adequate returns to seed the below Mission Falls habitat and support brood collections in future years in Omak Creek. Additional efforts to minimize risks of the hatchery program included a volitional release and truck and haul for non-migrants.

Length frequency diagrams from the RST in Omak Creek show a wide range of fork lengths indicating multiple life history strategies may be used by natural fish. Length at age data developed from juvenile scale analysis from Omak Creek suggests similar age breaks to length frequency age breaks. There appears to be some age 1 and age 2 overlap in length and even more between age 2 and age 3. It was not possible to accurately differentiate length bins for age 3 and older fish. Further results are needed from both methods and will be addressed in future reports.

Migration estimates using a RST are often problematic given the constraints of the equipment and environmental conditions during spring run-off. However, 2013 flow conditions were very conducive to operation of the RST with only two days of non-trapping due to low flows and zero days due to high flow. The Colville Tribes are working closely with WDFW to refine a flow based R-script production model for the Omak Creek RST. Emigrant abundance estimates for Omak Creek in 2013 (6,593) were similar to 2012 (5,697) and were within acceptable precision standards (± 30% CV) recommended by regional fish management guidelines (Miller et al. 2000). Despite this, gaps in the flow-based regression model need to be filled at mid flows (50-100 cfs) to produce even more precise estimates.

Smolt production estimates are particularly useful for understanding freshwater productivity when considered in context of the number of spawners it took to generate them. 2013 was only the second year that we could generate such an estimate, and it will take one more year before we can complete a full brood year return and start the time series of emigrants per spawner. By using two years of emigration estimates we can determine age-1 and 2 smolt returns for BY 2011 (this value will increase if 2014 emigration data shows any 3 year old smolts). Compared to an emigrant per redd estimate of 4 to 165 with most years being 19 in the Methow, these results are within range but below optimal levels to meet standards within the Methow basin (Snow et al. 2013). In the future a trend analysis can be determined to provide overall spawning and rearing success and perhaps infer potential impacts from hatchery fish on the spawning ground.

The evaluation of strays and homing fidelity of conservation released steelhead provided an evaluation of potential risk to nearby populations. However, because the numbers of PIT tags outside of Omak Creek were limited we have no direct measurement of specific origin within other tributaries or at the basin level. Omak Creek results suggest a stray rate for the conservation program within acceptable range and in fact homing fidelity with in basin was greater than 98% of the total release program (PRCC HSC, 2013). Only two detections were found within the Okanogan basin at Zosel PTIS and one stray beyond the Okanagan for 2013. From this we conclude that in 2013 strays from the Okanogan and Omak hatchery programs did not pose a risk to adjacent populations.

Data collected from 2008-2013 by the OBMEP provided the estimated number of spawners above the Omak weir. There were not enough data to calculate emigrants per spawner for the full juvenile life cycle (3 fresh) of any one brood year because reliable total outmigration estimates were not available until 2012. An estimate of natural production and emigrants using PIT-tags is an emerging technology that BAM and OBMEP are rapidly utilizing. The Colville Tribes, through the OBMEP, obtained a section 10(a) permit in August of 2014 to electrofish and PIT tag natural origin juvenile steelhead parr throughout the Okanogan River basin. These values will prove invaluable during those periods when the Omak RST is not in operation due to low flow and in streams where RST operations are not possible to collect natural origin steelhead. There is limited data at this time using PIT detections for Salmon, Antoine and Aeneas creeks. Future efforts should be made to stock PIT tagged hatchery reared steelhead in those creeks to assess PIT tag detection efficiencies, juvenile survival and smolt to adult returns.

VI. References

Araki, H., W. R. Ardeen, E. Olsen, B. Cooper, and M. S. Blouin. 2007. Reproductive success of captive-bred steelhead trout in the wild: evaluation of three hatchery programs in the Hood River. Conservation Biology 21: 181-190.

Biomark 2010. RRJFB PIT System Detection Efficiency. Memorandum to DPUD on April 2010.

CCT (Colville Confederated Tribes) 2014. Hatchery and genetic management plan for the Okanogan River summer steelhead conservation program. Submitted to the National Marine Fisheries Service on 4 February 2014. Colville Confederated Tribes, Nespelem, Washington.

CCT (Colville Confederated Tribes) 2009-2011. Steelhead Broodstock Acclimation and Monitoring (BAM) Program in the Okanogan Basin, Annual Report 2009-2011. Colville Confederated Tribes Fish and Wildlife Department, Nespelem, WA. Project No. 430-3559.

CPUD (Chelan Public Utility District) 2013. Detection Efficiencies at Rock Island, Rocky Reach, and Tumwater Dam Adult Ladders, 2013. Prepared for: Chelan County Public Utility District No. 1. 12 December 2013 Final Report.

Columbia River DART, Columbia Basin Research, University of Washington. (2015). DART PIT Tag Release and Observation Summary. Available from *http://www.cbr.washington.edu/dart/query/pit_sum_tagfiles*

DCPUD (Public Utility District No. 1 of Douglas County and Washington Department of Fish and Wildlife. 2011. Hatchery and Genetic Management Plan for the Wells Complex Summer Steelhead Program. Submitted to National Marine Fisheries Service on April 6, 2011. Public Utility District No.1 of Douglas County, East Wenatchee, Washington.

Enns, J.D., and L. George. (2013). Okanagan Basin Monitoring and Evaluation Program (OBMEP) 2012 Annual Report for Sites in Canada. Prepared by the Okanagan Nation Alliance Fisheries Department, Penticton, B.C.

Ford, M. J., T. Cooney, P. McElhany, N. Sands, L. Weitkamp, J. Hard, M. McClure, R. Kope, J. Myers, A. Albaugh, K. Barnas, D. Teel, P. Moran, and J. Cowen. 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-113, 281 p. Available online: *http://www.nwr.noaa.gov/Publications/Biological-Status-Reviews/upload/SR-2010-all-species.pdf*

Grant County Public Utility District. 2005. Priest Rapids Salmon and Steelhead Agreement. FERC project # 2114. Grant County Public Utility District. *http://gcpud.org/prcc/Agreeemnts.htm*

Hillman, T. 2006. Monitoring strategy for the Upper Columbia Basin. Second Draft Report for the Upper Columbia Salmon Recovery Board, Bonneville Power Administration, and National Marine Fisheries Service.

Hillman, T., M. Miller, C. Moran, M. Tonseth, M. Hughes, A. Murdoch, L. Keller, C. Willard, B. Ishida, C. Kamphaus, T. Pearsons, and P. Graf. 2014. Monitoring and evaluation of the Chelan and Grant County PUDs hatchery programs: 2013 annual report. Report to the HCP and PRCC Hatchery Committees, Wenatchee, WA.

HSRG (Hatchery Scientific Review Group). 2014. On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest. A. Appleby, H.L. Blankenship, D. Campton, K. Currens, T. Evelyn, D. Fast, T. Flagg, J. Gislason, P. Kline, C. Mahnken, B. Missildine, L. Mobrand, G. Nandor, P. Paquet, S. Patterson, L. Seeb, S. Smith, and K. Warheit. June 2014. Available online: *http://www.hatcheryreform.us/hrp_downloads/reports/columbia_river/system-wide/4_appendix_e_population_reports/cascade-okanogan_summer_steelhead_01-31-09.pdf*

Kostow, K. E., A. R. Marshall, and S. R. Phelps. 2003. Naturally spawning hatchery steelhead contribute to smolt production but experience low reproductive success. Transactions of the American Fisheries Society 132: 780-790.

Marinson, E.C., M.M. Masuda, and J.H.Helle. 2000. Back-calculated fish lengths, percentages of scale growth, and scale measurements for two scale measurement methods used in studies of salmon growth. N. Pac Anadr. Fish Comm. Bull. No. 2: 331-336

McElhany, P.,M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmon populations and the recovery of evolutionary significant units. NOAA Technical Memorandum NMFS-NWFSC-42.

Miller, B. A., J. D. Rodgers, and M. S. Solazzi. 2000. An automated device to release marked juvenile fish for measuring trap efficiency. North American Journal of Fisheries Management 20:284–287.

Murdoch, A. R., T. L. Miller, B. L. Truscott, C. Snow, C. Frady, K. Ryding, J. E. Arterburn, and D. Hathaway. 2011. Upper Columbia Spring Chinook Salmon and Steelhead Juvenile and Adult Abundance, Productivity, and Spatial Structure Monitoring. BPA Project # 2010-034-00. Washington Department of Fish and Wildlife, Olympia, WA.

NMFS (National Marine Fisheries Service). 2009. Listing Endangered and Threatened Species: Change in Status for the Upper Columbia River Steelhead Distinct Population Segment. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register, Volume 74, No. 162, pages 42605-42606. 50 CFR Part 223 Docket No. 0907291194–91213–01. RIN 0648–XQ71

NMFS (National Marine Fisheries Service). 2012. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Sandy River Spring Chinook Salmon, Coho Salmon, Winter Steelhead, and Summer Steelhead Hatchery Programs. NMFS Consultation Number: 2011/02491.

NOAA (National Oceanic and Atmospheric Agency). 2008. Supplemental Comprehensive Analysis of the Federal Columbia River Power System and mainstem effects of the upper Snake and other tributary actions, NOAA Fisheries, May 5, 2008. *http://www.nwr.noaa.gov/Salmon Hydropower/Columbia-Snake-Basin/upload/Final-SCA.pdf*

OBMEP. (Okanogan Biological Monitoring and Evaluation Program) 2014. 2013 Okanogan Subbasin Steelhead Escapement and Spawning Distribution. Colville Confederated Tribes Fish and Wildlife Department, Nespelem, WA. Report submitted to the Bonneville Power Administration, Project No. 2003-022-00.

Paquet, P. J. and 15 co-authors. 2011. Hatcheries, conservation, and sustainable fisheries-achieving multiple goals: Results of the Hatchery Scientific Review Group's Columbia River Basin review. Fisheries 36:547-561.

Pearsons, T.N., and R.B. Langshaw. 2009. Monitoring and Evaluation Plan for Grant County PUDs Salmon and Steelhead Programs, 2009. Grant Public Utility District, in consultation with the Hatchery Sub-committee of the Priest Rapids Coordinating Committee.

PRCC HSC (Priest Rapids Coordinating Committee Hatchery Sub-Committee) 2013. MONITORING AND EVALUATION PLAN FOR PUD HATCHERY PROGRAMS *Prepared by (alphabetically):* T. Hillman, T. Kahler, G. Mackey, J. Murauskas, A. Murdoch, K. Murdoch, T. Pearsons and M. Tonseth. April 17, 2013. *http://www.hatcheryreform.us/hrp_downloads/reports/columbia_river/system-wide/4_appendix_e_population_reports/cascade-okanogan_summer_steelhead_01-31-09.pdf*

Schrader, W.C., M. P. Corsi, P. Kennedy, M. W. Ackerman, M. R. Campbell, K. K. Wright, T. Copeland. 2013. Wild adult steelhead and Chinook salmon abundance and composition at Lower Granite Dam, Spawn Year 2011. Idaho Department of Fish and Game Report 13-15. Annual report 2011, BPA Project 1990-055-00, 1991-073-00, 2010-026-00. *https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/Forms/AllItems.aspx*.

Snow, C., C. Frady, A. Repp, B. Goodman, and A. Murdoch. 2013. Monitoring and evaluation of the Wells Hatchery and Methow Hatchery programs: 2012 annual report. Report to Douglas PUD, Grant PUD, and the Wells HCP Hatchery Committee, East Wenatchee, WA.

Tibbits, W.T., R.E. Dasher, B. Hudson and J.A. Arterburn. 2013. Steelhead Broodstock Acclimation and Monitoring (BAM) Program in the Okanogan Basin, Annual Report 2012. Colville Confederated Tribes Fish and Wildlife Department, Nespelem, WA. Project No. 430-3559.

UCRTT (Upper Columbia Regional Technical Team). 2013 A biological strategy to protect and restore salmonid habitat in the Upper Columbia Region. A Report to the Upper Columbia Salmon Recovery Board from the Upper Columbia Regional Technical Team. *http://www.ucsrb.com/resources.asp*

UCSRB (Upper Columbia Salmon Recovery Board) 2007. Upper Columbia spring Chinook salmon and steelhead recovery plan. 307 pages. Seattle, Washington. *http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Interior-Columbia/Upper-Columbia/upload/UC_Plan.pdf*.

US v. Oregon 2012. United States versus Oregon management agreement 2008-2017 production tables (B1-B7) updated in May of 2012.

WDFW (In season sampling) 2013. Memo: National Oceanic and Atmospheric Administration, NMFS. Cumulative summary for the months of October, 2013 through March, 2014 for the upper Columbia River steelhead fishery.

Williamson, K. S., T. N. Pearsons, E. J. Ward, and M. J. Ford. 2010. Factors influencing the relative fitness of hatchery and wild spring Chinook salmon (*Oncorhynchus tshawytscha*) in the Wenatchee River, Washington, USA. Canadian Journal of Fisheries and Aquatic Sciences 67: 1840-1851.

VII. Appendices

Appendix A

Colville Tribes, Fish & Wildlife Department

2013 Okanogan Subbasin Steelhead Escapement and Spawning Distribution

Prepared for the Bonneville Power Administration,
Division of Fish and Wildlife, BPA Project # 2003-022-00

February 2014

2013 Okanogan Subbasin Steelhead Escapement and Spawning Distribution

BPA Project # 2003-022-00

Report covers work performed under BPA contract #(s) 55926, BPA-6604

Report was completed under BPA contract #(s) 55926, BPA-6604

1/1/2013 - 12/31/2013

B.F. Miller, J.L. Miller, D.T. Hathaway, and J.A. Arterburn
Colville Confederated Tribes, Omak, WA, 98841

2014

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

This report should be cited as follows:

OBMEP. 2014. 2013 Okanogan Subbasin Steelhead Escapement and Spawning Distribution. Colville Confederated Tribes Fish and Wildlife Department, Nespelem, WA. Report submitted to the Bonneville Power Administration, Project No. 2003-022-00.

Executive Summary

OBMEP monitored adult Viable Salmonid Population (VSP) abundance attributes (McElhany et al. 2000) within the subbasin for Okanogan River summer steelhead (*Oncorhynchus mykiss*). Adult monitoring was conducted through redd surveys, underwater video counts, and Passive Integrated Transponder (PIT) tag expansion estimates. Figure ES1 summarizes the total summer Steelhead spawning estimates in the Okanogan subbasin, from 2005 through 2013. Abundance of spawners can be compared to recovery goals, as outlined by the Interior Columbia Basin Technical Recovery Team (ICBTRT). The Upper Columbia Spring Chinook and Steelhead Recovery Plan states 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).

Results from Steelhead adult enumeration efforts in the Okanogan subbasin indicate that the number of spawning Steelhead in the Okanogan River, both hatchery and naturally produced, continued to increase since OBMEP began collecting data in 2005. The slope of the trend line from 2005 to 2013 abundance estimates suggests that the number of total Steelhead spawning in the Okanogan subbasin increased at an average rate of 187 fish per year and the number of naturally produced spawners increased at an average rate of 29 fish per year. Spawning occurred throughout the mainstem Okanogan River, although narrowly focused to distinct areas that contained suitable spawning substrates and water velocities. Steelhead spawning was 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.

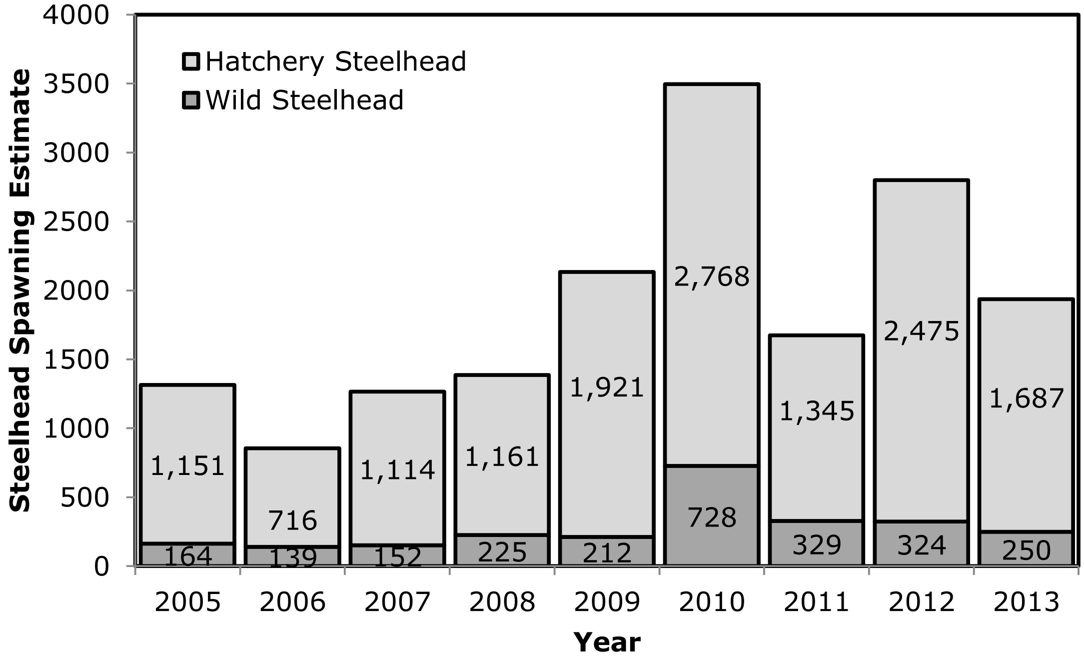


Figure ES1. Spawning estimates for the Okanogan subbasin from 2005 through 2013, as determined by OBMEP.

Steelhead redd surveys can provide a reasonable depiction of spawning distribution and an estimate of escapement on years when spring runoff occurs post-spawning. Defining the physical location of redds informs managers about which, and to what extent, habitats are being used for spawning and allow for tracking of spatial status and trends through time. However, modeling distribution and abundance of spawning on years with early runoff is less objective. Since OBMEP began collecting Steelhead spawning data in 2005, the importance of not relying solely on redd surveys for abundance estimates has become evident. Implementation of an Upper Columbia Basin-wide PIT tag interrogation systems (Project # 2010-034-00), coupled with the representative marking of returning adults at Priest Rapids Dam, allowed managers an additional means to estimate abundance on years with poor water visibility, to validate redd survey efficiency, and describe spatial distribution and upstream extent of spawning, where previously unknown. The Fish and Wildlife Program should consider continuing these efforts to allow managers to more accurately describe the spatial extent of spawning in tributaries, to monitor effectiveness of migration barrier removal, and better define escapement estimates.

Acknowledgements

The authors would like to thank the following people for help in collecting or compiling information used in this report: Jack Roy and Edward Berrigan, for their efforts in collecting underwater video data; Mike Miller and Dennis Papa, who aided in the collection of PIT tag data and performing redd surveys; Chris Fisher, for information related to Salmon Creek; Oliver Pakootas, Byron Sam, Oly Zacherle, Wes Tibbits, Brooklyn Hudson, and Rhonda Dasher, for operation of the adult weir trap on Omak Creek; Dave Duvall, Grant County PUD; the Washington Department of Fish and Wildlife, including Charlie Snow and Charles Frady, for providing downstream data from the Columbia River and Wells Dam, Andrew Murdoch and Ben Truscott for PIT tag array methodology and support. We would like to extend our appreciation to all of the private landowners who allowed us to survey sections of water adjacent to their property. Without their cooperation, many of these surveys could not occur. Funding for the Okanogan Basin Monitoring and Evaluation Program was provided by the Bonneville Power Administration (BPA project number 2003-022-00).

Table of Contents

Introduction

Within the Columbia River Basin, the furthest upstream and northern-most extent of currently accessible anadromous habitat is found in the Okanogan River. Summer steelhead (*Oncorhynchus mykiss*) are listed as threatened in the Upper Columbia Evolutionarily Significant Unit (ESU) under the Endangered Species Act (ESA) (NMFS 2009). To recover this ESU requires that all four populations (Wenatchee, Entitat, Methow, 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 and these methods were later revised in 2007 (Arterburn et al. 2007). In addition to redd surveys, adult weir traps, Passive Integrated Transponder (PIT) tag arrays, and underwater video counting were combined to improve escapement estimates and coordinate with other on-going data collection efforts. In cooperation with the Washington Department of Fish and Wildlife (WDFW), OBMEP expanded the use of PIT tag arrays to enhance monitoring adult summer steelhead use of small tributaries to the Okanogan River.

This document builds upon knowledge and information gained from preceding years' surveys. A 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.colvilletribes.com/obmep.php*.

Methods

OBMEP - Adult Abundance - Redd Surveys (ID:192)
https://www.monitoringmethods.org/Protocol/Details/192
OBMEP - Adult Abundance - Adult Weir and Video Array (ID:6)
https://www.monitoringmethods.org/Protocol/Details/6
Estimate the abundance and origin of Upper Columbia steelhead (2010-034-00) v1.0 (ID:235)
https://www.monitoringmethods.org/Protocol/Details/235

The Okanogan River flows from the northern headwaters near Vernon, BC to the confluence with the Columbia River near Brewster, WA (Figure 1). Counts of summer steelhead spawning downstream of anadromous fish migration barriers in the mainstem and all accessible tributaries of the Okanogan and Similkameen River drainages were conducted within the United States (Arterburn et al. 2007, 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.

Summer steelhead were enumerated in all remaining spawning habitats following the OBMEP redd survey protocol. 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 redd survey reaches are listed in Table 1. The Okanogan River was divided into seven survey reaches and the Similkameen River was surveyed as two reaches. Survey reaches were determined by access points along the river and directly related to the EDT reach layer, used in habitat monitoring. Discharge data, air and water temperature, and local knowledge of fish movements collected from previous years were used 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' catarafts. Small tributaries were surveyed on foot, walking in an upstream direction.

Geographic position of redds were collected with a Trimble GeoXT™ 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.

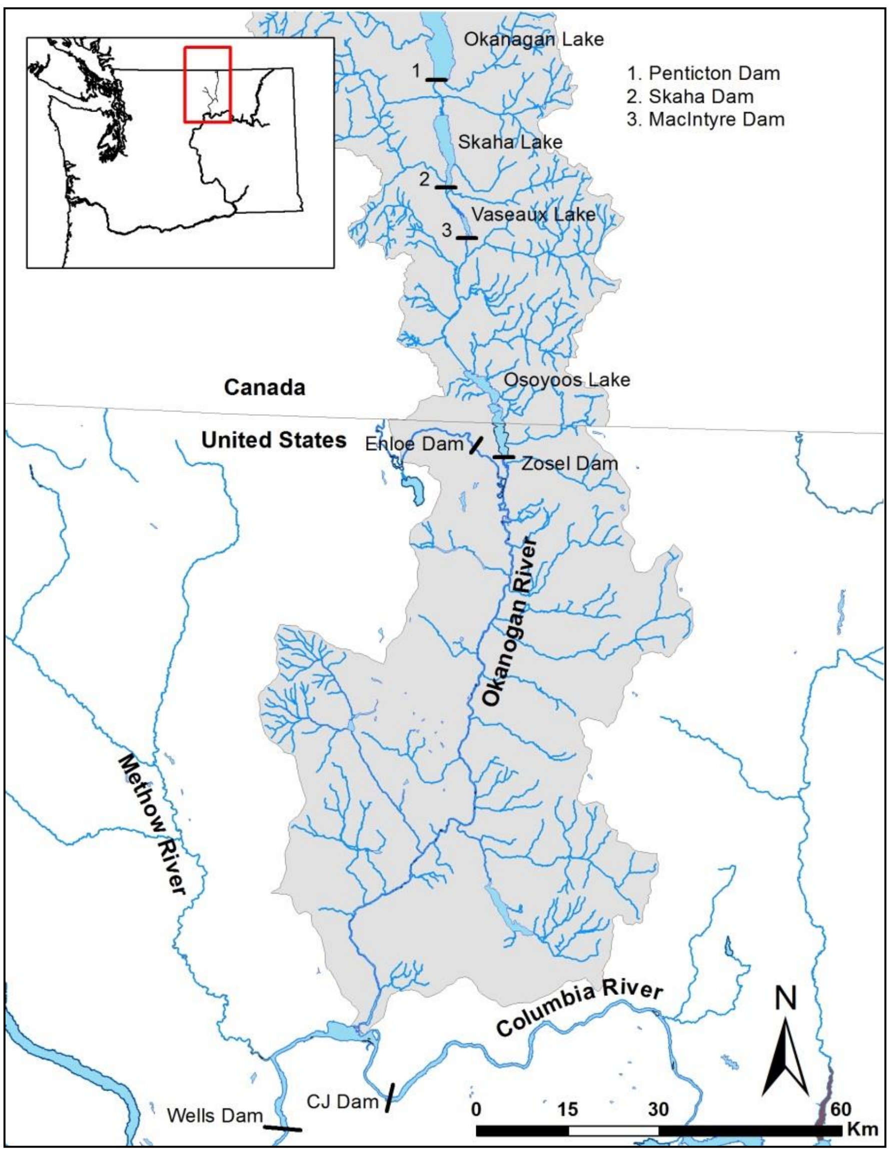


Figure 1. Study area, the Okanogan River subbasin in north-central Washington State and southern British Columbia.

Table 1. Okanogan subbasin redd survey reaches.

Redd Survey Reach	Location and Description	Reach Length (km)
Okanogan River 1	Okanogan River at Loup Loup Creek (26.7) to Salmon Creek (41.4)	14.7
Okanogan River 2	Okanogan River at Salmon Creek (41.4) to the office (52.3)	10.9
Okanogan River 3	Okanogan River at the office (52.3) to Riverside (66.1)	13.8
Okanogan River 4	Okanogan River at Riverside (66.1) to Janis Bridge (84.6)	18.5
Okanogan River 5	Okanogan River at Janis Bridge (84.6) to Tonasket Park (91.4)	6.8
Okanogan River 6	Ok. R. at Horseshoe Lake (112.4) to confluence with Sim. R. (119.5)	7.1
Okanogan River 7	Okanogan River at Sim. confluence (119.5) to Zosel Dam (127.0)	7.5
Similkameen River 1	Similkameen/Okanogan Confluence (0) to sewer plant (6.6)	6.6
Similkameen River 2	Similkameen from sewer plant (6.6) Enloe Dam (14.6)	8.0
Loup Loup Cr	Loup Loup Creek/Ok. R. confluence to Loup Loup Creek diversion (2.3)	2.3
Salmon Cr	Salmon Creek/Okanogan River confluence (0) to OID diversion (7.2)	7.2
Omak Cr	Omak Creek/Ok. R. Confluence (0) to Omak Creek trap site (1.5)	1.5
Wanacut Cr	Wanacut Creek/Okanogan River confluence (0) to the falls (2.5)	2.5
Johnson Cr	Johnson Cr./Ok. R. conf. (0) to PIT tag array above Hwy 97 (0.5)	0.5
Tunk Cr	Tunk Creek/Okanogan River confluence (0) to the falls (1)	1.0
Aeneas Cr	Aeneas Creek/Okanogan River confluence (0) to the barrier (0.4)	0.4
Bonaparte Cr	Bonaparte Creek/Ok. River confluence (0) to Bonaparte Falls (1.6)	1.6
Antoine Cr	Antoine Creek/Okanogan River confluence (0) to video weir (1.3)	1.3
Wildhorse Spring Cr	Wild Horse Spring Creek/Okanogan River Confluence to barrier (1.1)	1.1
Tonasket Cr	Tonasket Creek/Okanogan River confluence (0) to Tonasket Falls (3.5)	3.5
Ninemile Cr	Ninemile Creek from Lake Osoyoos (0) to PIT tag array (0.7)	0.7
Foster Cr	Foster Creek/Columbia River confluence (0) to barrier (1.7)	1.7

Sex Ratio and Number of Fish Per Redd

OBMEP employed the method currently used by Washington Department of Fish and Wildlife in the Upper Columbia Basin to extrapolate escapement estimates from redd counts using the sex ratio fish collected randomly over the run at Wells Dam (Andrew Murdoch, WDFW, pers. comm.). A sample of 584 summer steelhead, including 218 males (185 hatchery, 33 wild) and 366 females (327 hatchery, 39 wild), were sexed at Wells Dam during the 2012 upstream migration by WDFW personnel (Charles Frady, WDFW, pers. comm.). Adjusted proportionally for the run, the WDFW calculated a sex ratio of 0.603 males per female or 1.603 fish per redd (FPR). This value was used to expand redd counts on the mainstem Okanogan River into steelhead spawning estimates. All calculations using sex ratio multipliers assume that each female will produce only one redd.

Percent-Wild

The WDFW estimated that the proportion of wild fish bound for the Okanogan River was 168 out of a total of 1,890 steelhead, or 8.9% (Charles Frady, WDFW, pers. comm.). This value was based on ad-present steelhead counts, PIT tags, coded wire tags, scale analysis, harvest, broodstock collection, radio telemetry data, and stray rates estimated at Wells Dam. The wild percentage was applied to all mainstem Okanogan River reaches to estimate the number of wild steelhead that spawned in mainstem habitats.

PIT Tag Expansion Estimates

Permanent and temporary PIT tag arrays were operated near the mouth of all tributaries to the Okanogan River known to contain steelhead spawning, throughout the spring of 2013. 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 13.4%, were tagged and released above Priest Rapids Dam (Ben Truscott, WDFW, pers. comm.). 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 in the Okanogan subbasin, the escapement estimate would be 22 hatchery and 15 wild steelhead, calculated from the mark-rate at Priest Rapids. This method assumes pre-spawn mortality is negligible. Based on the relatively few numbers of detections at many locations, particularly at smaller tributaries, escapement estimates derived from PIT tag detections may be 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 (such as out-migrating juveniles, adults returning to Bonneville Dam, Wells Dam, among others); however, marking at those locations were not consistent across the run. Therefore, any extrapolations from PIT tag detections to an escapement estimate were derived only from the Priest Rapids release group. Detections from fish tagged at other locations may be mentioned anecdotally in this report.

Results

Steelhead Spawning Estimates: Okanogan and Similkameen River Mainstem

Redd surveys were largely unsuccessful at documenting the spawning activity of steelhead in the Okanogan River mainstem reaches in the spring of 2013. Due to an early onset of runoff in the Okanogan and Similkameen Rivers, only one preliminary survey could be completed on most mainstem reaches. Although a number of redds were documented in Okanogan River Reach 7 and Similkameen River Reach 2 (Table 2), it is unknown what proportion of the population they represented. Flows remained high through the end of July, when spawning had long since concluded and steelhead redds were indistinguishable.

Although redd surveys were unable to capture the complete spawning activity of summer steelhead, an estimate of mainstem spawning for 2013 was determined as follows. Assuming that the ratio of mainstem spawning remained comparable to previous years' surveys, spawner estimates for 2013 were calculated by combining data from previous years' redd distributions and Wells Dam count estimates generated by WDFW. The average proportion of spawning that occurred in each reach (from 2005-2011) was multiplied by the WDFW total spawning estimate for the Okanogan Basin in 2013. The estimated number of summer steelhead spawning in mainstem reaches is provided in Table 3.

Table 2. Redd survey and steelhead spawning estimates for mainstem reaches, 2013. Observed redds were multiplied by the WDFW fish per redd value (1.603) for a total steelhead estimate. The total steelhead estimate was multiplied by the proportion of ad-present steelhead (0.089) to calculate a mainstem wild steelhead estimate.

Redd Survey Reach	A. GPS'd Steelhead Redds	B. Total Steelhead Estimate (B=A*1.603)	C. Wild Steelhead Estimate (C=B*.089)	D. Hatchery Steelhead Estimate (D=B-C)	Complete Redd Counts?
Okanogan River 1	0	0	0	0	No
Okanogan River 2	0	0	0	0	No
Okanogan River 3	0	0	0	0	No
Okanogan River 4	0	0	0	0	No
Okanogan River 5	0	0	0	0	No
Okanogan River 6	0	0	0	0	No
Okanogan River 7	68	109	10	99	No
Similkameen River 1	0	0	0	0	No
Similkameen River 2	5	8	1	7	No
Mainstem Total	73	117	11	106	

Table 3. Modeled estimate of mainstem steelhead spawning, 2013. The WDFW Okanogan population estimate (1,890) was multiplied by the average proportion from previous spawning years in each reach. The total estimate was multiplied by the proportion of ad-present steelhead (0.089) to calculate a mainstem wild steelhead estimate.

Mainstem Survey Reach	A. Avg. Proportion of Spawning by Reach (2005-2011)	B. 2013 Total Estimate (B=A*1,890)	C. 2013 Wild Steelhead (C=B*.089)	D. 2013 Hatchery Steelhead (D=B-C)
Okanogan River 1	0.009	17	2	15
Okanogan River 2	0.033	63	6	57
Okanogan River 3	0.007	13	1	12
Okanogan River 4	0.028	53	5	48
Okanogan River 5	0.045	84	7	77
Okanogan River 6	0.012	22	2	20
Okanogan River 7	0.289	546	49	497
Similkameen River 1	0.098	184	16	168
Similkameen River 2	0.074	139	12	127
Mainstem Total	0.595	1,121	100	1,021

Steelhead Spawning Estimates: Tributaries to the Okanogan River

Tributary surveys were more successful at documenting locations of spawning steelhead when compared to the mainstem in 2013. Redd 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 unable to be surveyed when water visibility remained poor. Steelhead redd surveys within tributary habitats occurred from March 18 through June 7. The upstream extent of each survey was limited by either a natural fish passage barrier or access to private land. Above-normal precipitation and discharge in 2013 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. Results from redd surveys on tributaries to the Okanogan River are presented in Table 4.

PIT tag interrogation sites were installed and operated on 12 tributaries to the Okanogan River in 2013. Detections of steelhead marked and released at Priest Rapids Dam (PRD) were expanded by a tag rate of 0.1339 for wild steelhead and 0.1343 for hatchery steelhead, as described in the methods section. The number of tags detected at discrete locations and the expanded summer steelhead spawning estimates are presented in Table 5. Although redd surveys were not able to capture complete spawning activity of summer steelhead on multiple streams, due to poor water visibility, PIT tag antennas were in place to produce an estimate of spawning abundance. In the following paragraphs, we provide a summary of spawning estimates for steelhead in tributaries to the Okanogan River, given both methods.

Loup Loup Creek
Two redds were documented in Loup Loup Creek on May 14, but poor visibility prevented redd surveys from occurring during the primary spawning time period, from early-April through mid-May. PIT tag detections at site LLC suggested that a total of 74 steelhead likely spawned in Loup Loup creek, including 22 wild and 52 hatchery steelhead.

Salmon Creek
A total of 17 redds were documented from the confluence of Salmon Creek with the Okanogan River to the upstream irrigation diversion. These redds were expanded by 1.603 FPR for a total estimate of 28 spawning steelhead. At the diversion, an underwater video monitoring site captured a total of 98 upstream migrants (26 adipose fin-present and 72 hatchery steelhead). The combined estimate from downstream redd surveys and video counts above the diversion was 126 steelhead. The PIT tag array (SA1) documented 14 PRD PIT tags of hatchery origin, which was expanded to 104 hatchery steelhead. No wild PRD tags were detected at this site. Because 26 adipose fin-intact steelhead were documented passing at the video site, a combined estimate of 104 hatchery and 26 wild steelhead, from the PIT expansion and video monitoring, represented the best estimate for Salmon Creek in 2013.

Omak Creek
No redd surveys occurred on Omak Creek, from the confluence with the Okanogan River to the adult weir trap due to turbid water and high flows. Although the weir (operated by the Colville Tribes's Broodstock Acclimation Program, funded by Grant County PUD) was down for a period of time, an estimated 35 wild and 264 hatchery steelhead were estimated to have passed that point, based upon weir captures, tag detections, and marked and unmarked kelts recovered (Wesley Tibbits, CCT, unpublished data). At the PIT tag array (OMK), an estimated 37 wild and 238 hatchery spawned in Omak Creek, which were derived from PRD tag detections. Although the two estimates are comparable, the weir estimate was selected due to counting of actual fish in hand and to maintain agency consistency between the two monitoring operations.

Wanacut Creek
Wanacut Creek was successfully surveyed across the 2013 spring spawning period. A total of 5 redds were documented for a total estimate of 8 steelhead, 7 hatchery and 1 wild. No PRD tags were detected at the PIT tag antenna and the subsequent PIT tag derived estimate was zero steelhead. However, one hatchery steelhead not from the PRD mark-release group was detected in Wanacut Creek. Because 5 redds were found and there

was an additional hatchery PIT tagged steelhead detected in the creek, it was estimated that 8 steelhead likely spawned in this Wanacut Creek.

Table 4. Redd survey and steelhead spawning estimates for tributary reaches, 2013. Observed redds were multiplied by the WDFW fish per redd value (1.603) for a total steelhead estimate. The total steelhead estimate was multiplied by the proportion of ad-present steelhead (0.089) to calculate a wild steelhead estimate.

Redd Survey Reach	A. GPS'd Steelhead Redds	B. Total Steelhead Estimate (B=A*1.603)	C. Wild Steelhead Estimate (C=B*.089)	D. Hatchery Steelhead Estimate (D=B-C)	Complete Redd Counts?
Loup Loup Cr	2	3	0	3	No
Salmon Cr, below PIT tag array	1	2	0	2	No
Salmon Cr, above array/below diversion	16	26	2	24	No
Omak Cr	0	0	0	0	No
Wanacut Cr	5	8	1	7	Yes
Johnson Cr	11	18	2	16	Yes
Tunk Cr	3	5	0	5	No
Aeneas Cr	0	0	0	0	Yes
Bonaparte Cr	0	0	0	0	No
Antoine Cr	0	0	0	0	No
Wildhorse Spring Cr	43	69	6	63	Yes
Tonasket Cr	8	13	1	12	No
Ninemile Cr	1	2	0	2	No
Tributary Total	90	146	12	134	

Table 5. PIT tag expansion estimates at detection sites in the Okanogan subbasin, 2013. PIT tag detections in tributaries were divided by the proportion of wild (0.1339) or hatchery (0.1343) steelhead observed in the PRD mark group.

Creek (Interrogation Site)	A. PRD Wild PIT Tags	B. PRD Hatchery PIT Tags	C. Expanded Wild (C=A/0.1339)	D. Expanded Hatchery (D=B/0.1343)	E. Expanded Total (E=C+D)
Loup Loup Cr (LLC)	3	7	22	52	74
Salmon Cr (SA1)	0	14	0	104	104
Omak Cr (OMK)	5	32	37	238	275
Wanacut Cr (WAN)	0	0	0	0	0
Johnson Cr (JOH)	0	3	0	22	22
Tunk Cr (TNK)	0	2	0	15	15
Aeneas Cr (AEN)	0	0	0	0	0
Bonaparte Cr (BPC)	3	8	22	60	82
Antoine Cr (ANT)	0	0	0	0	0
Wildhorse Spring Cr (WHS)	2	6	15	45	60
Tonasket Cr (TON)	1	8	7	60	67
Ninemile Cr (NMC)	1	3	7	22	29
Total	15	83	110	618	728

Johnson Creek

Redd surveys occurred in Johnson Creek throughout the spring of 2013, due to clear water conditions and relatively stable water flows. Eleven redds were documented, representing 18 total steelhead, 16 hatchery and two wild. Three PIT tags from the PRD mark-release group were detected in Johnson Creek, which were expanded to 22 hatchery steelhead. Although a total of 5 PIT tags were detected near the mouth of Johnson Creek, only one tag was detected upstream of the rock weir structure above Hwy 97, suggesting that it may pose a significant barrier to adult passage. On April 18, six adult steelhead were observed in Johnson Creek, attempting to jump into the Hwy 97 culvert; none were visually observed above this point.

Tunk Creek

In Tunk Creek, one early redd survey was conducted in late March and subsequently, elevated flows prevented surveys from occurring from April through May. No redds were observed. Detections from the PIT tag antenna (TNK) suggested that 15 hatchery and no wild steelhead spawned in Tunk Creek.

Aeneas Creek

Water conditions remained favorable in Aeneas Creek throughout the spring of 2013 and zero redds were found. Additionally, no tags were detected, suggesting that Aeneas Creek was not utilized for spawning during the spring of 2013. This was consistent across previous years' surveys.

Bonaparte Creek

Only one survey was conducted on Bonaparte Creek, in late March, before water conditions became unfavorable through May. No redds were found in Bonaparte Creek in 2013. PIT tag detections suggested that Bonaparte Creek was used for spawning by a large number of steelhead, even given its relatively short extent from the mouth to the upstream natural barrier (approximately 1.6 km). A total of 82 steelhead, 60 hatchery and 22 wild, were estimated to have spawned in Bonaparte Creek, based on expanded PRD PIT tag detections.

Antoine Creek

Zero redds were documented in Antoine Creek in 2013, although water conditions remained turbid during the month of April. Additionally, no adult steelhead were observed on an underwater video monitoring system. No PRD PIT tag detections occurred in 2013, however, one hatchery steelhead, not from the PRD mark-release group, was detected in Antoine Creek. It is possible that turbid water conditions precluded video observation during a short timeframe and passed undetected. Nonetheless, very few steelhead have utilized Antoine Creek for spawning in 2013 and in previous years. A barrier upstream of the video and PIT tag monitoring site was removed after the 2013 spawning period, which potentially opened 11 km of upstream habitat in Antoine Creek.

Wildhorse Spring Creek

In 2013, Wildhorse Spring Creek was surveyed successfully through the spring spawning period. A total of 43 redds were documented, leading to a total estimate of 69 steelhead, which were divided into 63 hatchery and 6 wild. Two wild and six hatchery PRD tagged steelhead were detected on Wildhorse Spring Creek, rendering 15 wild and 45 hatchery steelhead, for a total estimate of 60 spawning steelhead. Due to the fact that this small system largely dries up annually by early summer, the redd count estimate of 6 wild steelhead, rather than 15, is likely a more realistic value.

Tonasket Creek

Eight redds were observed in Tonasket Creek in May of 2013, although poor water visibility limited surveys prior to that date, during March and April. An unknown number of redds may have been missed during that timeframe. One wild and 8 hatchery PIT tagged steelhead were detected on Tonasket Creek from the PRD mark-release group. These detections led to an estimate of 7 wild and 60 hatchery steelhead, for a total of 67 spawning adults. The PIT tag derived estimate likely captured a more accurate value, when compared to the incomplete redd survey count.

Ninemile Creek

One redd was found in the lower reaches on Ninemile Creek before high flows occurred in April, which precluded further redd surveys and forced removal of an underwater video weir. One wild and three hatchery PRD PIT tagged steelhead were detected on the PIT tag array (NMC), which was operable throughout the season. This provided a total estimate of 29 steelhead, 7 wild and 22 hatchery. The upstream extent of spawning in Ninemile Creek is currently unknown.

Zosel Dam and Upstream Locations

At Zosel Dam, both video monitoring and PIT tag antennas documented steelhead passage through the fishways in 2013. At high flows, spillways were opened and fish bypassed the fishways, passing upstream undetected. Underwater video captured the passage of 240 steelhead (151 hatchery, 89 ad-present) through May, at which time, the spillgates were opened. During that same timeframe, 27 hatchery and 4 wild PRD PIT tag mark-released steelhead passed in the fishways, for an estimate of 231 steelhead (201 hatchery and 30 wild). Both methods rendered similar total counts, albeit each likely underestimated the total count due to the spillways opening in May. The PIT tag counts likely better represented the adipose fin-intact hatchery steelhead count, so that method likely generated a more accurate count to date.

Zosel Dam is located immediately above Okanogan River Reach 7, the largest spawning area in the Okanogan subbasin, and the downstream end of Osoyoos Lake. Above this point are Tonasket and Ninemile Creek in the Washington State portion of the subbasin, which both have PIT tag detection capability. In the upriver British Columbia portion of the subbasin are the mainstem Okanagan (detection site OKC at VDS3, just upstream from Lake Osoyoos), Inkaneep Creek (no adult monitoring in 2013), and very small perennial streams. Three wild steelhead from the PRD mark-release group were detected at OKC, which represented approximately 22 wild steelhead. Two additional hatchery steelhead and one wild, not from the PRD mark-release group, were also detected at this location. From all upstream monitoring sites (Tonasket, Ninemile, OKC), approximately 120 steelhead were accounted for from Zosel Dam counts. The remainder leaves approximately 110 steelhead unaccounted for. These fish may have entered Inkaneep Creek, past OKC undetected, been caught in the Osoyoos Lake recreational fishery, or may have fallen back over Zosel Dam to downstream locations. The fall back rate at Zosel Dam is currently unknown, but may be relatively large, due to heavily utilized spawning habitat available in Okanogan Reach 7 immediately downstream and the inundated Lake Osoyoos directly upstream.

In the Canadian portion, above Lake Osoyoos (upstream of OKC at VDS3), steelhead have access up to the dam at the outlet of Okanagan Lake at Penticton, British Columbia. Between Lake Osoyoos and Okanagan Lake are thirteen Vertical Drop Structures, as well as, two more lakes (Skaha Lake and Vaseux Lake), both with outlet dams. The outlet dam at Vaseux Lake (McIntyre Dam) was the upstream barrier for anadromous salmonids up until 2009 and the outlet dam at Skaha Lake was still undergoing improvements for fish passage in 2013. The majority of the Canadian portion of the mainstem Okanagan River is characterized as being straightened and channelized. The main tributaries to the mainstem Okanagan River include Shingle Creek, Ellis Creek, McLean Creek, Shuttleworth Creek, Vaseux Creek and a number of small perennial streams. In 2013, no adult steelhead monitoring was performed through OBMEP above the OKC site at VDS3.

Foster Creek (located outside the Okanogan subbasin)

Although Foster Creek is not located within the Okanogan subbasin, OBMEP installed a PIT tag antenna and conducted redd surveys in 2013 to further describe the spatial extent of Upper Columbia River steelhead. Foster Creek was successfully surveyed across the entire 2013 spawning period, due to clear water and stable flows. A total of 19 steelhead redds were observed for an estimated total of 30 steelhead, divided into 3 wild and 27 hatchery. The PIT tag antenna detected 2 wild and 3 hatchery PIT tagged steelhead from the PRD mark-release group, which led to an estimated 15 wild and 22 hatchery steelhead, or a total of 37. Because no juveniles were observed during adult surveys, we reverted to the more conservative estimate of 3 wild and 27 hatchery steelhead. Either method considered, a comparable total number of steelhead entered and spawned in Foster Creek in 2013.

Okanogan Subbasin Steelhead Spawning Distribution and Trends

A summary of the estimated adult steelhead population in the Okanogan subbasin, distributed by mainstem survey reach and individual tributaries, is presented in Table 6. Table 7 and Table 8 contain a summary of total and wild steelhead spawning estimates, as determined by WDFW and OBMEP from 2005 through 2013.

Table 6. Estimated number of total and wild spawning steelhead for each sub-watershed or assessment unit in 2013. The total Okanogan River population is presented with subtotals for tributary and mainstem habitat types in Washington State. The estimates are based on combinations of PIT tag detections, video counts, and observed redds.

Distribution of Steelhead Spawning in the Okanogan Basin, 2013

Category	Description/location	Estimated Total # Spawners	Estimated Total # Wild
WA Mainstem	Okanogan River 1	17	2
WA Mainstem	Okanogan River 2	63	6
WA Mainstem	Okanogan River 3	13	1
WA Mainstem	Okanogan River 4	53	5
WA Mainstem	Okanogan River 5	84	7
WA Mainstem	Okanogan River 6	22	2
WA Mainstem	Okanogan River 7	546	49
WA Mainstem	Similkameen River 1	184	16
WA Mainstem	Similkameen River 2	139	12
WA Tributary	Loup Loup Creek	74	22
WA Tributary	Salmon Creek	130	26
WA Tributary	Omak Creek	299	35
WA Tributary	Wanacut Creek	8	1
WA Tributary	Johnson Creek	18	2
WA Tributary	Tunk Creek	15	0
WA Tributary	Aeneas Creek	0	0
WA Tributary	Bonaparte Creek	82	22
WA Tributary	Antoine Creek	1	0
WA Tributary	Wild Horse Spring Creek	69	6
Zosel Dam	**Observed Passing Zosel Dam**	231	30
WA Tributary	Tonasket Creek	67	7
WA Tributary	Ninemile Creek	29	7
Subtotals	**Adult escapement into WA mainstem**	**1,121**	**100**
Subtotals	**Adult escapement into WA tributaries**	**792**	**128**

Subtotals	**Adult escapement into BC**	**24**	**22**
Grand total		**1,937**	**250**

Table 7. Total escapement of summer steelhead for the Okanogan River, 2005 - 2013, 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]	
2013	1,890		1,937[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 8. Natural origin summer steelhead estimates for the Okanogan River, 2005 - 2013.

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]	
2013	168		250[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.

Discussion

Okanogan Subbasin Adult Steelhead Trends

In the United States, summer steelhead are currently listed as "threatened" under the Endangered Species Act in the Upper Columbia River ESU (NMFS 2009). OBMEP monitored adult Viable Salmonid Population (VSP) abundance attributes (McElhany et al. 2000) within the subbasin for Okanogan River summer steelhead. Adult monitoring was conducted through redd surveys, underwater video counts, and Passive Integrated Transponder (PIT) tag expansion estimates. Detailed percent-wild information has been provided annually and every attempt has been made to ensure that these estimates are as accurate as stated 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 currently undefined.

A summary of spawning estimates in the Okanogan subbasin from 2005 through 2013, for both hatchery and wild Steelhead is presented in Figure 2. Estimates were compared with recovery goals outlined by the Upper Columbia Spring Chinook and Steelhead Recovery Plan (UCSRB 2007). The Upper Columbia Spring Chinook and Steelhead Recovery Plan stated 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).

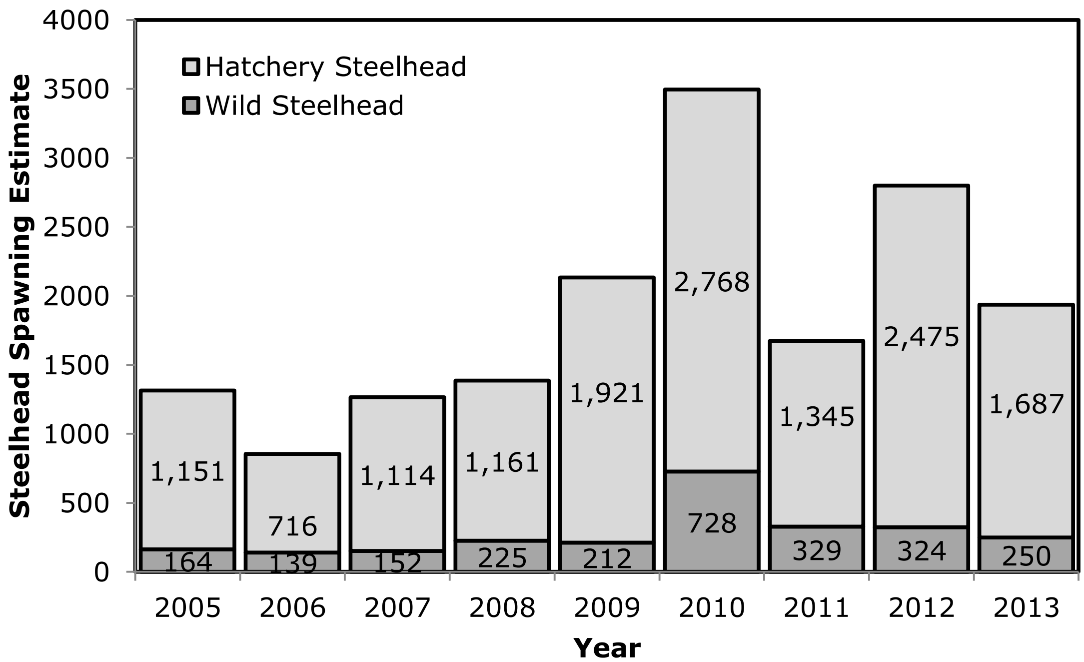


Figure 2. Spawning estimates for the Okanogan subbasin from 2005 through 2013, as determined by OBMEP.

Results from steelhead adult enumeration efforts indicate that the number of spawning steelhead in the Okanogan River subbasin, both hatchery and naturally produced, continued to increase since OBMEP began collecting data in 2005. The slope of the 2005 through 2013 trend line suggests that the number of total steelhead spawning in the Okanogan subbasin increased at an average rate of 187 fish per year (Figure 3) and the number of naturally produced spawners increased at an average rate of 29 fish per year (Figure 4). 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 the Similkameen River, Omak Creek, and Salmon Creek.

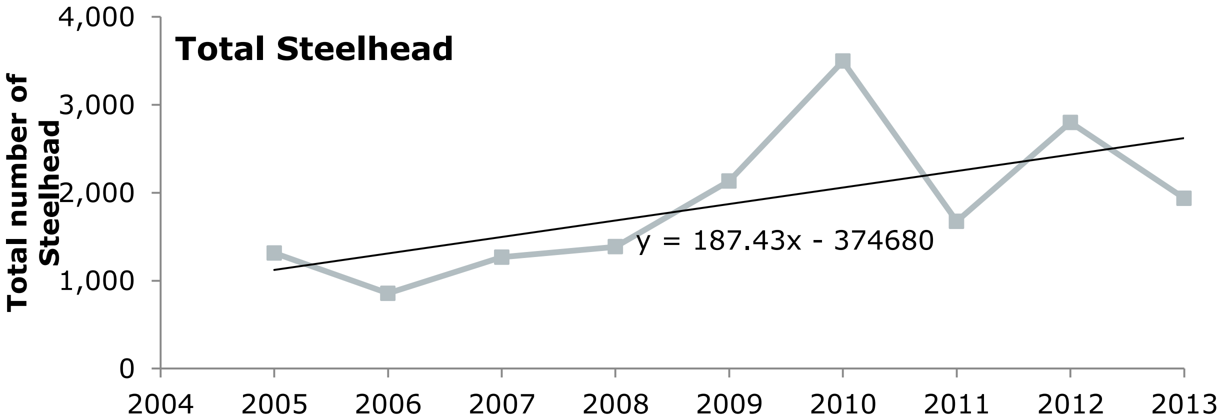


Figure 3. Trend in the estimated total number of summer steelhead spawning in the Okanogan River subbasin, 2005 - 2013.

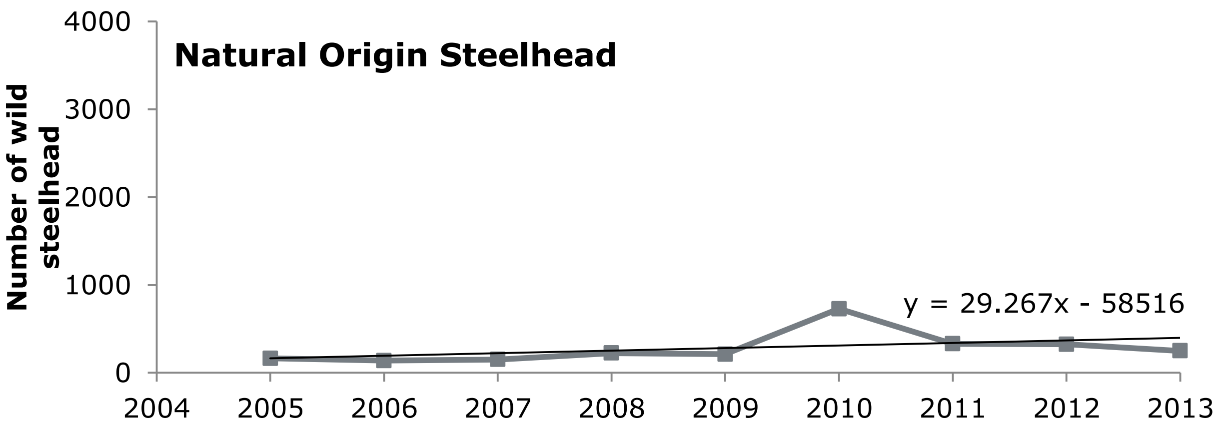


Figure 4. Trend in the estimated number of natural origin summer steelhead spawning in the Okanogan River subbasin, 2005 - 2013.

Large variations in estimates exist in many reaches from year to year, but often, 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 (e.g. Loup Loup Creek escapement of 0, 0, and 125 for 2008, 2009, and 2010, respectively). 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 subbasin.

Annual variations of environmental factors can profoundly impact redd distributions in small tributaries to the Okanogan River. Changes in summer steelhead spawning 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 in relation to run timing of steelhead, and 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 (Figure 5). Habitat alterations at the mouths of key spawning tributaries may improve access, provided that sufficient discharge is available.

In 2010, 2011, and 2012, water availability in the Okanogan subbasin was above normal and subsequently, a larger proportion of steelhead spawned in tributaries than documented in previous years. Approximately 41% and 43% of steelhead were estimated to have spawned in tributaries to the Okanogan in 2010 and 2011, respectively. Because mainstem values were largely calculated and not directly counted for 2007, 2012, and 2013, no certain conclusions can be drawn for those survey years. Summer steelhead that spawn in tributary habitats of the Okanogan subbasin are more likely to find suitable environmental conditions and rearing habitats than those spawning in mainstem habitats. Therefore, the Fish and Wildlife Program should consider continuing restoration projects that address adequate flow in tributaries to the Okanogan River and providing access to additional kilometers of tributary streams.

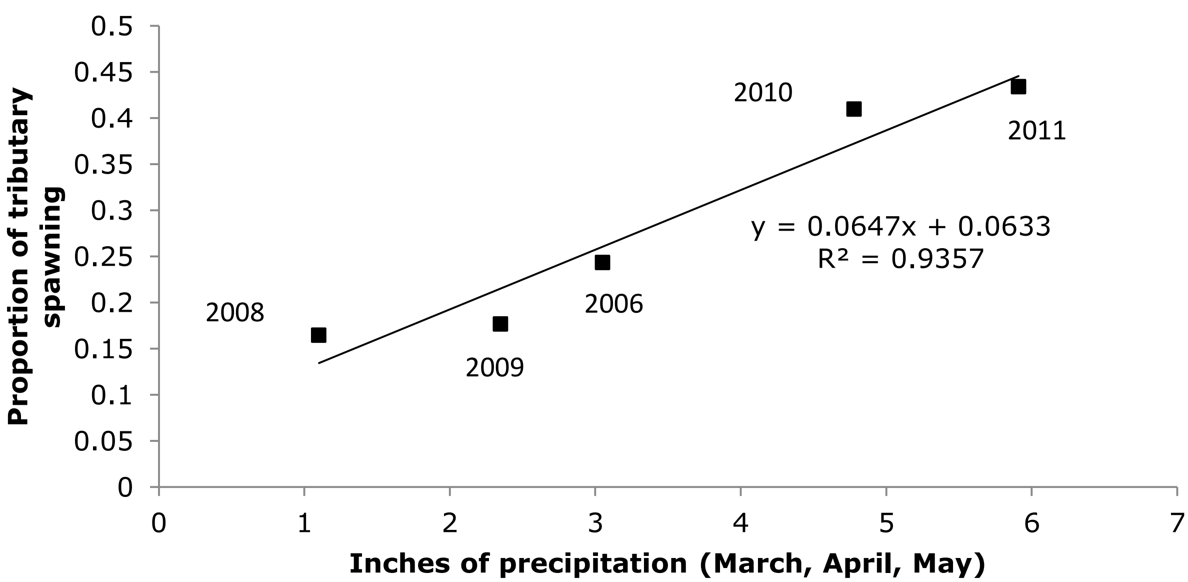


Figure 5. Correlation between precipitation occurring during March, April, and May and the proportion of summer steelhead spawning in tributaries to the Okanogan River in Washington State.

Comparison of PRD PIT Tag Expansion and 'On-the-Ground' Survey Estimates

Summer steelhead redd surveys, underwater video, and weir counts can provide a reasonable depiction of spawning distribution and an estimate of escapement on years when spring runoff occurs post-steelhead spawning. However, using these methods to determine distribution and abundance of spawning on years with early runoff is less objective. Since OBMEP began collecting steelhead spawning data in 2005, the importance of not relying solely on redd surveys for abundance estimates has become evident. Implementation of an Upper Columbia Basin-wide PIT tag interrogation systems (Project # 2010-034-00), coupled with the representative marking of returning adults at Priest Rapids Dam, allowed managers an additional means to estimate abundance on years with poor water visibility, to validate redd survey efficiency, and describe spatial distribution and upstream extent of spawning where previously unknown.

In 2013, steelhead spawning estimates could not be determined for many tributaries through the use of redd surveys alone, including Loup Loup, Tunk, Bonaparte, Antoine, Tonasket, and Ninemile Creeks. In these systems, an estimate would not have been able to be produced, if not for PIT tag detection and expansion to a total estimate. It is useful to compare the traditional methods that OBMEP has used to calculate spawning estimates (defined as: expanding redd counts by FPR values, using underwater video counts, and weir traps) to PRD PIT tag expansion estimations. In the example below, PRD PIT tag expansion estimates were compared in systems where redd counts, video, and/or weir traps (referred to here-on as 'on-the-ground' estimates) were successful at monitoring adult steelhead. Any locations where on-the-ground estimates were unachievable were omitted in this analysis, and it is useful to note that PIT tag expansion was feasible in systems where redd surveys could not occur.

The total count of steelhead using on-the-ground estimates were compared to the PRD PIT tag expansion estimate (Table 9) and further analyzed by hatchery and wild steelhead (Table 10). Steelhead estimates were compared by linear regression analysis (Figure 6). Preliminary results from data from 2013 suggest that both methods provide highly correlated estimates for total steelhead ($p < 0.001$, Figure 6a.) and for hatchery steelhead ($p < 0.001$, Figure 6b.). The independent estimates of wild steelhead were noticeably less correlated ($p = 0.130$, Figure 6c.).

Multiple factors may lend clues to discrepancies between the two methods for wild steelhead. For on-the-ground counts, estimates were loosely determined from an applied general percent-wild rate, calculated from expanding observed redds to fish, and further dividing the calculated total fish to wild and hatchery. Video counts used the observation of an adipose fin alone to differentiate between wild from hatchery steelhead. This assumption may be over estimating the number of wild steelhead, due to a number of hatchery steelhead only being marked with a coded wire tag and not a fin clip. Although great efforts are made to differentiate hatchery from wild steelhead when PIT tagging occurred at PRD, relatively few detections of PIT tagged wild steelhead in small watersheds had a significant influence on the total estimate for wild steelhead, based on PIT tag detections alone. It is interesting to note that in one case, Omak Creek, both estimates produced a similar estimate of 35 and 37 wild steelhead (Table 10). This is likely due to the operation of a weir trap and a larger number of wild PIT tagged steelhead detected (Table 5) when compared with smaller sites.

From these initial analyses, we felt confident expanding PIT tag expansion estimates, for total and hatchery steelhead, to creeks where redd surveys and underwater video observations failed to document the spawning activity. However, determining the number of wild steelhead in small discrete watersheds continued to be a challenging task for both methods. Prospective solutions to aid monitoring programs in better defining an accurate estimate of spawning wild steelhead in the Okanogan subbasin include: 1) mark all hatchery steelhead with a visual mark, 2) increase the percent of tagged wild steelhead at PRD, 3) determine the feasibility of using the number of PIT tags detected at Wells Dam, and the total passage count, to determine the tag rate passing above that facility for use in expansion estimates, and 4) potentially implement a similar representative PIT tagging program at Wells Dam during the adult migration period. Continuing these adult steelhead monitoring efforts will allow managers to more accurately describe the spatial extent of steelhead spawning in the Okanogan River subbasin and define spawning estimates when redd surveys cannot be conducted.

Table 9. Comparison of 'On-the-Ground' and PIT Tag Expansion total estimates from 2013.

Location	'On-the-Ground' Total Steelhead	PRD PIT Tag Expansion Total Steelhead
Salmon Creek	126	104
Omak Creek	299	276
Wanacut Creek	8	0
Johnson Creek	18	22
Wildhorse Spring Creek	69	60
Zosel Dam	240	231
Foster Creek	30	37

Table 10. Comparison of 'On-the-Ground' and PIT Tag Expansion hatchery and wild steelhead estimates from 2013.

	'On-the-Ground'		PRD PIT Tag Expansion	
Location	Hatchery Steelhead	*Wild Steelhead*	Hatchery Steelhead	*Wild Steelhead*
Salmon Creek	98	*28*	104	*0*
Omak Creek	264	*35*	238	*37*
Wanacut Creek	7	*1*	0	*0*
Johnson Creek	16	*2*	22	*0*

Wildhorse Spring Creek	63	*6*	45	*15*
Zosel Dam	151	*89*	201	*30*
Foster Creek	27	*3*	22	*15*

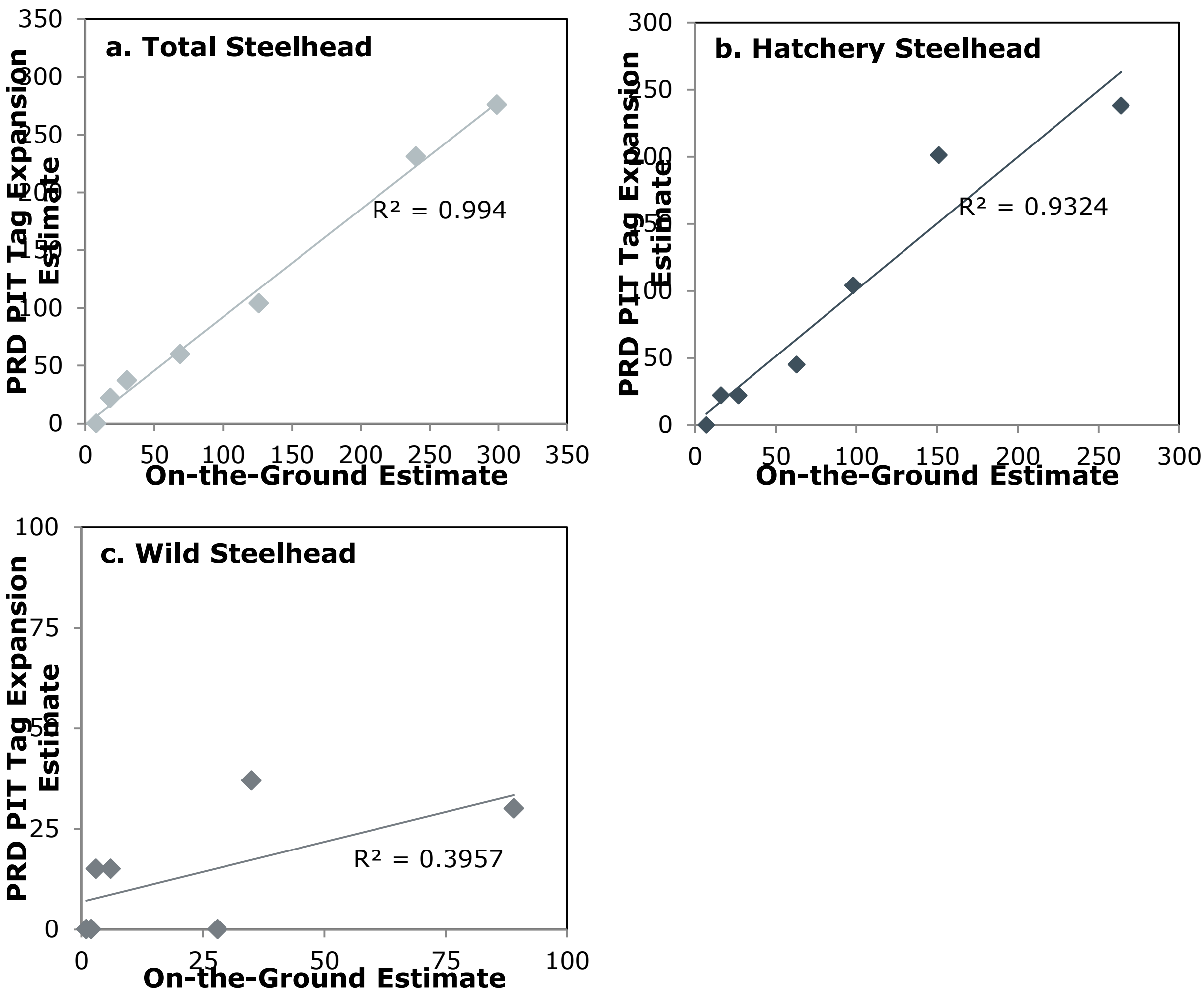


Figure 6. Linear regression analysis of PRD PIT tag expansion and 'On-the-Ground' spawning estimates, for a. total steelhead, b. hatchery steelhead, and c. wild steelhead.

References

Arterburn, J.E., K. Kistler and R. Dasher 2005. 2005 Okanogan Basin Steelhead Spawning Ground Surveys. 2005 Report for Bonneville Power Administration project #200302200. Colville Confederated Tribes Fish and Wildlife Department. Nespelem, WA. *http://www.colvilletribes.com/media/files/Final%202005%20steelhead%20spawning.pdf*

Arterburn, J.E., K. Kistler and C. Fisher 2007. Anadromous Fish Passage Barriers in the Okanogan Basin. Report# CCT/AF-2007-1 for the Colville Tribes. Colville Confederated Tribes Fish and Wildlife Department. Nespelem, WA. *http://colville.whydevelop.com/media/files/Barriers%20to%20anadromous%20fish%20in%20the%20Okanogan%20River.pdf*

Hillman, T. W. 2004. Monitoring strategy for the Upper Columbia Basin. Prepared for: Upper Columbia Regional Technical Team, Upper Columbia Salmon Recovery Board, Wenatchee, Washington.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionary significant unite. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

Murdoch, A. R., T. L. Miller, B. L. Truscott, C. Snow, C. Frady, K. Ryding, J. E. Arterburn, and D. Hathaway. 2011. Upper Columbia Spring Chinook Salmon and Seelhead Juvenile and Adult Abundance, Productivity, and Spatial Structure Monitoring. BPA Project # 2010-034-00. Washington Department of Fish and Wildlife, Olympia, WA.

NMFS (National Marine Fisheries Service). 2009. Listing Endangered and Threatened Species: Change in Status for the Upper Columbia River Steelhead Distinct Population Segment. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register, Volume 74, No. 162, pages 42605-42606. 50 CFR Part 223 Docket No. 0907291194–91213–01. RIN 0648–XQ71.

UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia Spring Chinook and Summer Steelhead Recovery Plan. *http://www.ucsrb.com/UCSRP%20Final%209-13-2007.pdf*

Walsh, M. and K. Long. 2006. Survey of barriers to anadromous fish migration in the Canadian Okanagan subbasin. Prepared by the Okanagan Nation Alliance Fisheries Department, Westbank, BC.