2012 Annual Report

Steelhead Broodstock Acclimation and Monitoring (BAM) Program in the Okanogan Basin, Annual Report 2012

Report covers performance under GPUD Contract No. 430-3559
1/1/2012 – 12/31/2013

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I. Executive Summary by Chapter

Chapter 1

The 2012 spawning steelhead were comprised primarily of 2-salt hatchery fish with a mean fecundity of 5,500 eggs and no significant difference in fecundity between wild and hatchery steelhead was detected between fish of the same salt-age. Low numbers of broodstock captured from Omak Creek in 2012 resulted in below average numbers of smolts for release in 2013. Egg to smolt survival exceeded hatchery goals for Omak Creek wild by wild locally-adapted steelhead. Releases of wild-by-wild progeny from 2011 in Omak Creek did not meet levels identified in the CCT juvenile stocking plan for 2012. Overall juvenile release numbers were within 10% of release goals for the Okanogan Basin. The most recent brood years of steelhead exhibited hatchery replacement rates great enough to replace parent broods (i.e., > 1). Number of smolt-to-adult-returns (SAR) was below 0.5 % based on one year of return data. A larger return of 2-salt fish is expected in 2014 from this brood year.

Chapter 2

A total of 40 females were collected at the weir and 9 redds counted below the weir provide an estimated 49 redds in Omak Creek for 2012. Trap efficiency was low due to high water for most of the month of May. Based on efficiency trials from a RST we estimated 6,519 (± 3,956, 95% CI) of natural origin smolts were produced in Omak Creek for 2012. Dividing the number of estimated smolts by the total number of redds produced in Omak Creek we calculated 133 smolts per redd. A high and low estimate at the 95 % confidence interval conclude a range of 213 to 52 smolts per redd. Average fork length of natural and hatchery juvenile salmonids captured at the Omak RST were 128 mm and 188 mm, respectively. Condition factors (K) measured for natural (N=3,882) and hatchery (N=808) steelhead at the RST in Omak Creek were 1.071 and 0.868, respectively.

Chapter 3

Redd surveys identified 9 redds below the Omak Creek weir trap. Using an experimental escapement model those redds were expanded to 30 hatchery and five wild steelhead from FPR and percent wild values derived at the weir (Miller et al., 2012). Based on combined redd surveys and weir counts, the escapement estimate was 193 adult steelhead for Omak Creek in 2012. Using a determined NRR of 13.3 % from weir collections we estimated 25 natural origin fish to spawn in Omak Creek. A total of 191 steelhead were calculated to have returned to Salmon Creek based on redd surveys, PITS and video monitoring. Video monitoring provided an estimate of 20 % of the run to be of natural origin for Salmon Creek. Expanded for the entire drainage we calculated 38 of the 191 fish to be of natural origin. Harvest counts based on WDFW creel surveys including Columbia River (Rocky Reach to Chief Joseph Dam), Okanogan River and the Similkameen River was 1,772 steelhead.

II. Acknowledgements

We would like to thank Grant County PUD (GCPUD) for funding the Okanogan locally-adapted summer steelhead project. Edits to this report from Brian Miller and Jennifer Miller. The Okanogan Basin Monitoring and Evaluation Program (OBMEP) for contributing information regarding adult spawner estimates. Field data collectors Rhonda Dasher, Oliver Pakootas, Rocky Timentwa, Oly Zacherle, and Byron Samiam. Collaboration efforts with the WDFW Charlie Snow, Charles Frady and Alex Repp and many thanks to those spawning and rearing our fish at the Wells Fish Hatchery Facility.

III. General 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). Several reasons for this decline include overharvest, habitat degradation/alteration, hydro-system mortality and past hatchery practices.

Okanogan steelhead population continues to be at high risk of extinction based on current abundance, productivity, spatial distribution and diversity. The NOAA Fisheries 2008 FCRPS Supplemental Comprehensive Analysis (SCA) identified the Okanogan River steelhead population at high risk for extinction. Natural origin returns (NOR) is currently 104 steelhead, compared to the recovery abundance target of 1,000. The SCA describes the Okanogan population to be high risk relative to productivity (NOAA 2008) based on an average Hatchery Return Rate (HRR) or recruit/spawner value of 0.06 for brood years 1980-1999. Furthermore, the SCA identifies genetic diversity and spatial distribution as high risk, due to large hatchery influence of non-local stock (Wells stock) and spawner escapement limited to only Omak and Salmon Creeks (NOAA 2008).

Salmon and steelhead fishing has historically been an important use of the Okanogan River by the members of the Colville Confederated Tribes (CCT). Unfortunately, spawning and rearing habitat for summer steelhead is now limited in the Okanogan River Basin within the state of Washington, primarily due to irrigation diversions or water withdrawals from tributaries. 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 recovery efforts for summer steelhead within the Okanogan River basin. In 1992 personnel of the CCT-Fish and Wildlife Department surveyed and described the physical condition of in-stream habitat in Omak Creek from the confluence of the Okanogan River upstream 12.2 miles. 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

Grant County PUD provides funding to develop hatchery programs coupled with comprehensive monitoring and evaluation (M&E) plans that are intended to provide the information necessary for adaptive management. To be consistent with other monitoring and evaluation (M&E) activities a comprehensive plan including a monitoring and evaluation (M&E) program was developed. In coordination with project planning and implementation the Colville Tribe, under contract with GCPUD, provided the M&E strategy for the Okanogan locally-adapted summer steelhead program. Consultation with the hatchery sub-committee of the Priest Rapids Coordinating Committee (PRCC HSC 2009) helped develop this plan for the Okanogan basin. The guiding principles for the development of the M&E plans were developed from the Hatchery Scientific Review Group recommendations (HSRG 2009) and current M&E plans in the Methow and Wenatchee basins (Pearsons and Langshaw, 2009).

Background

The Public Utility District No. 2 of Grant County funds hatchery programs intended by the Joint Fishery Parties (JFP) to supplement natural populations of summer steelhead, and to produce summer steelhead for harvest augmentation. These hatchery programs collect, rear, and release salmonids under the PRCC Salmon and Settlement Agreement and in accordance with protocols governing 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.

In 2002, the Colville Tribe, with support from NOAA Fisheries and funding from the Pacific Coast Salmon Recovery Fund, initiated a locally-adapted pilot broodstock program in Omak Creek, a tributary to the Okanogan River Basin. Initial objectives were to determine if non-local hatchery steelhead released into the Okanogan River Basin would have an impact on the local population. Future objectives included increasing juvenile to adult survival due to development of a locally-adapted summer steelhead in Omak Creek.

Beginning in 2007, Grant County Public Utility District (GCPUD), through the Priest Rapids Project Settlement Agreement process, began providing the operation and maintenance funding for implementation of a locally-adapted steelhead production program at Cassimer Bar Fish Hatchery (CBFH). Past production targets at CBFH were 20,000 yearling steelhead smolts for release in the Okanogan River Basin. In conjunction with the CBFH, the Wells (WDFW) Hatchery Genetic Management Plan (HGMP) fulfills the remaining GCPUD Hatchery Program mitigation requirement of 100,000 (±10%) smolts. The program was permitted under ESA through Section 10(a)(1)(A)(Permit 1412). In 2010, the CBFH was closed due to program failures, including low smolt to adult return rates and it was decided that the entire 100,000 GCPUD Hatchery Program component for the Okanogan Basin would be moved to Wells Fish Hatchery.

Components of the current Scope of Work funded by GCPUD include: 1) annual broodstock collection of up to 16 adults from Omak Creek; 2) transfer of broodstock from Omak Creek to Wells Fish Hatchery; 3) conduct spawning and egg incubation at Wells Fish Hatchery; 4) rear summer steelhead to approximately 18-20 fish per lb. by release date; 5) annually tag up to 20,000 juvenile steelhead; 6) release of approximately 20,000 yearling steelhead smolts in the Okanogan River Basin; 7) maintain Wells Fish Hatchery and provide fish health treatments as prescribed by state fish pathologist; 8) evaluate survival of out-migrating steelhead smolts released from Omak Creek; 9) estimate juvenile abundance in Omak Creek and up to three additional tributaries and 10) provide monthly and annual reports of the program.

Summarized data and recommendations included in this annual report for the period of January 1, 2012 - December 31, 2012 includes: 1) Adult broodstock collection and spawning for Omak Creek; 2) Relative success of hatchery and natural reared locally-adapted returning adults; 3) Redd abundance and adult estimates for Omak and Salmon creeks; 4) Rotary screw trap juvenile survival and production estimates; 5) Juvenile short-term acclimation and survival estimates.

IV. Study Area

The Okanogan River headwaters begin in British Columbia (B.C.) and flows into the United States near the town of Orville, WA, where it then continues south and meets the Columbia River near the town of Brewster, WA. (Figure 1). The majority of the landscape consists of rugged hillsides and rolling shrub steppe. This arid environment often provides limited overhead cover and one of the major reasons for warm (>25^{0}C) summer water temperatures in the Okanogan River. Steelhead appear to have a better probability of survival in small tributaries, where thermal refuge can be found, but often these inlets are blocked by insufficient water, geographic obstructions, and man-made diversions. Progress is ongoing in the areas of habitat improvements and landowner agreements to provide more cover and water in these sensitive areas in the Okanogan Basin.

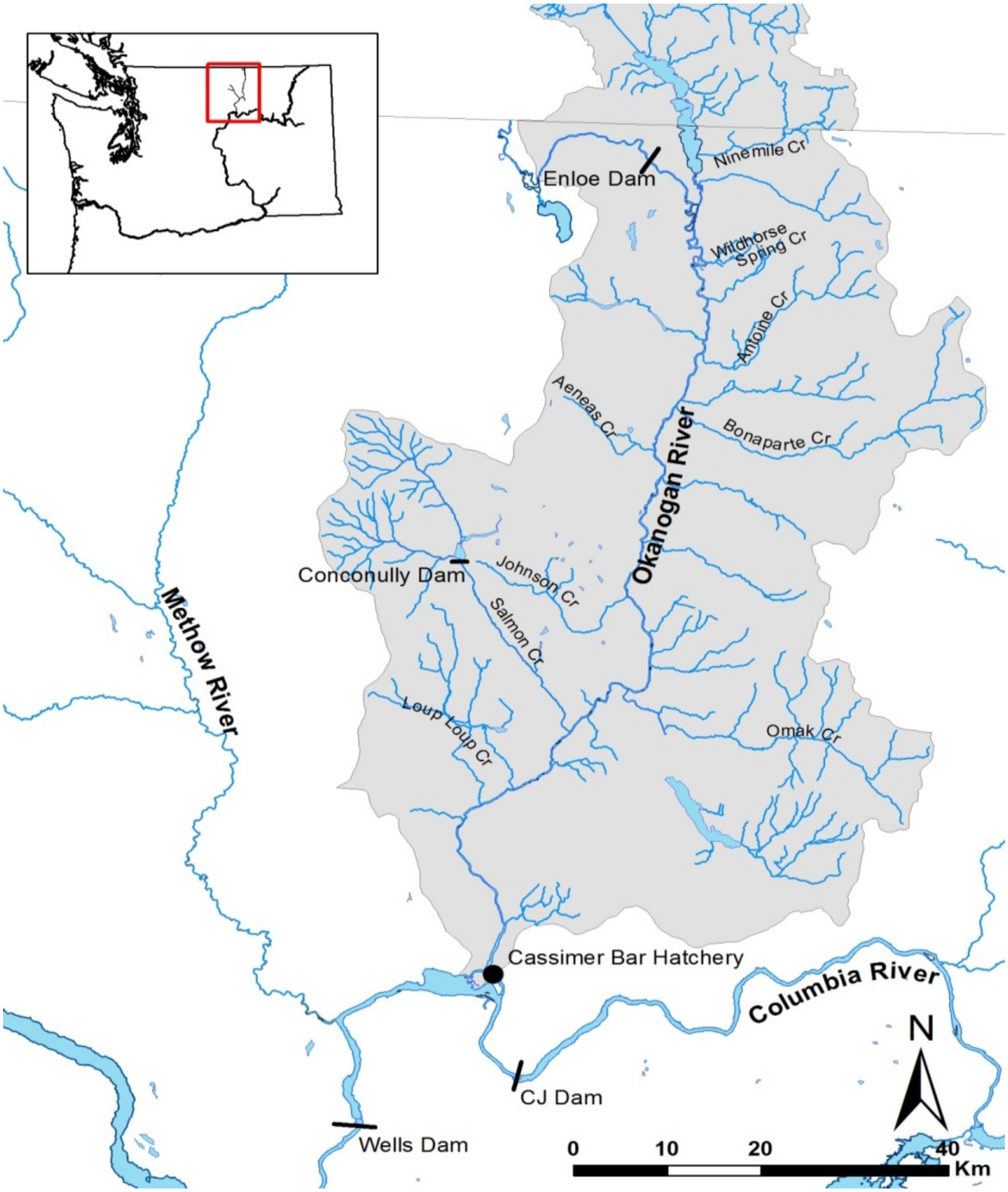


Figure 1: Okanogan basin and its connection to Canada and the Columbia River through the United States.

V. Chapter 1. Hatchery Brood Report

Introduction

A hatchery program has been funded by GCPUD to mitigate for the mortality associated with mortality associated with the construction and operation of the Priest Rapids and Wanapum hydroelectric projects. Hatchery mitigation has been a cornerstone for hydroelectric mitigation for decades. The number of broodstock required for the Okanogan summer steelhead program was derived from biological assumptions related to the sex ratio, broodstock survival, fecundity, and juvenile survival within the hatchery. The ratio of the number of returning hatchery fish from a particular brood year to the number of broodstock collected for that brood is referred to as the Hatchery Replacement Rate (HRR). This chapter addresses hatchery activities related to the 2012 brood Okanogan summer steelhead program. Specifically for HRR, number of fish released and size of fish released for the following objectives and associated hypothesis statements.

Objective 3: Determine if population structure and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

- H0: Age at Maturity Hatchery = Age at Maturity Naturally produced
- H0: Size (length) at Maturity Hatchery Age X and Gender Y = Size (length) at Maturity Naturally produced Age X and Gender Y

Objective 4: Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate) is greater than the natural adult-to-adult survival (i.e., natural replacement rate) and equal to or greater than the program specific expected value (BAMP 1998).

- H0: HRR Year X < NRR Year X
- H0: HRR < BAMP value (expected)

Objective 6: Determine if hatchery fish were released at the programmed size and number.

- H0: Hatchery fish Size at release = Programmed Size at release
- H0: Hatchery fish Number released = Programmed Number released

Methods

Broodstock Collection and Spawning

Steelhead broodstock were collected in accordance with protocols designed to ensure a desired genetic composition (i.e., hatchery and wild) were collected to satisfy specific program release goals. A gravity-style weir located at river kilometer 2.1 on Omak Creek was used to collect adult summer steelhead for the locally-adapted Okanogan summer steelhead program. 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 which discourage fish from backing out of the trap. Collection occurred once every morning and during peak flows, a second visit occurred in the afternoon to clear debris from the trap and check for additional fish captures.

Adult steelhead return to the Okanogan River Basin in late winter and early spring and are affected by river flow and water temperature. Because these environmental conditions were variable between years and within a particular stream, a systematic broodstock collection is not possible; therefore, broodstock collection is "opportunistic" and dependent upon in-season assessment of return abundance and composition. Initially, broodstock collection targeted natural origin steelhead and collected one of every three natural origin steelhead captured in Omak Creek. As the return progressed, abundance and origin composition was assessed and the ratio of natural origin steelhead was adjusted accordingly to only collect 33 percent of the total wild run. Should the abundance of natural origin steelhead be low, where the full broodstock collection of 16 adults is not attainable, broodstock collection targets shift to F1 generation hatchery fish returning from the locally-adapted steelhead program (i.e., adipose present/adipose CWT) and finally to adipose-clipped steelhead if necessary to achieve the target collection of 16 brood fish.

At time of collection, CCT staff recorded the date of collection, marks/tags, presumed origin, sex, maturation state (i.e., how close to spawning) and individually PIT tags each fish collected. These data were recorded on a data sheet and provided to WDFW and left at Wells FH each day as fish were delivered to Wells FH.

Transport/Holding

Adult steelhead collected from Omak Creek were transported to Wells FH daily as collected. Collection and transport occurred Sunday-Saturday, with delivery at Wells FH between 8:00 am and 7 pm. Adults were held in a covered vinyl raceway (raceway #12).

Spawning

Wells FH staff checked all fish and spawned them as needed, at a minimum of once a week. Wells FH staff, at time of spawning examined fish for marks and 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. If sufficient males were available on the spawning day, factorial spawning was conducted. Female eggs are equally divided and fertilized with two separate males and incubated separately until virology results were available. Factorial spawned females can be recombined as a single female, pending a negative virology result for all fish involved in an individual factorial cross. Females were kill-spawned and 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 the locally-adapted steelhead was kept separate from the remainder of the steelhead at Wells FH.

Juvenile Rearing and Release

An agreement with the WDFW and Wells FH (Wells project No. 2149 and Section 10 (a)(1)(A) permit number 1395) states that all spawning, rearing and transporting of locally-adapted summer steelhead smolts to the Okanogan basin shall be managed by Wells Hatchery. Up to 100,000 (±10%) smolts are produced at Wells FH for GCPUDmitigation requirements. The program rears locally-adapted Okanogan fish and Okanogan basin safety-net fish. A description of the rearing facilities at Wells FH can be found in the Integrated Hatchery Operations Team (IHOT) (1995) manual. The marking scheme for this program varies depending on study purpose. All Wells stock fish released into the Okanogan Basin received an external mark (i.e., adipose fin-clip).

Locally-adapted summer steelhead smolts reared at Wells fish hatchery were transported to the St. Mary's acclimation pond on Omak Creek. Acclimated fish at St. Mary's acclimation pond below Mission Falls, a natural falls, considered a barrier to anadromous fish were volitionally released. A diet used to maintain fitness, but not growth, was implemented in order to encourage outmigration. We fed fish a fitness diet over a three-week period, from May 7 to May 28, to allow ample acclimation time. Any remaining fish were removed, transported and released in the lower Okanogan River and assumed part of the local harvest group.

Juvenile Hatchery/Natural Survival

The survival of juveniles in the hatchery is monitored under the Wells HGMP Plan. Survival rates were calculated based on the complete inventory of the population at tagging and any mortality that occurred prior to or after tagging was complete, depending on the specific stage of development. PIT tagged natural steelhead captured at the Rotary Screw Trap (RST) in Omak Creek were used to determine out-of-basin survival.

Number of Juvenile Fish Released

A 100% inventory of fish on station was achieved because all juvenile fish received either an internal and/or external tag or mark during rearing. The actual number of juvenile fish released was calculated by subtracting any mortality that occurred during holding from the total number of marked fish.

Size of Juvenile Fish Released

Target release sizes specified in the M&E Plan were derived from weight at release (fish per pound) goals outlined in the Wells HCP. Corresponding length at release targets were derived from 5-years of pre-release length and weight sample data for each stock. The size of juvenile fish released was estimated from fish randomly sampled immediately prior to release. Fork length was measured to the nearest millimeter and weight was measured to the nearest 0.1 gram.

Hatchery/Natural Replacement Rate

Hatchery and natural replacement rates were calculated by dividing the number of PIT tagged returning adults detected at Wells Dam. Natural origin fish on average have a two year fresh water life cycle and therefore total number of wild returns in 2012 were divided by a two year return hypothesis (2010 and 2011) to provide a natural adult to adult survival estimate. Estimates are based on total escapement numbers collected at Wells and a proportion of those (13.5%) assumed destined for the Okanogan River (Miller et al., 2013). These estimates are then validated through actual numbers collected at the adult weir and expanded PIT tag data for Omak Creek.

Results

Broodstock Collection and Spawning

Locally-adapted summer steelhead collected from Omak Creek were used as part of the locally-adapted summer steelhead program for the Okanogan basin. In 2012, we captured a total of 171 adult summer steelhead in the Omak Creek weir (Table 1), of which 48 were natural origin and 123 were of hatchery origin. Of the hatchery fish collected at the weir, 73.9 % were male (N=91) and 26.1 % female (N=32) (Table 1). Similarly 33 of the 48 natural origin fish collected at the weir were male compared to 15 female (Table 1). A total of nine natural origin broodstock were collected from this pool of fish for broodstock. Four females and five males were spawned by a factorial cross to enhance genetic variation. Virology tests were taken on all broodstock to test for diseases and any abnormalities.

Table 1. Summary of broodstock collected in the Okanogan basin between the years 2003-2012 for the locally adapted summer steelhead program. Origin by year and drainage with total number trapped and broodstock collected for spawn. HM = Hatchery Male, HF = Hatchery Female, WM = Wild Male, WF = Wild Female, H:W = Hatchery:Wild.

Drainage	Year	HM	HF	WM	WF	Total Trapped	Total Brood	Broodstock Ratio H:W
Omak Cr.								
	2003	3	2	1	2	8	4	1:3
	2004	63	33	8	2	106	16	8:8
	2005	83	62	0	3	148	15	12:3
	2006	21	76	2	6	105	11	8:3
	2007	39	37	15	5	96	12	7:5
	2008	39	15	15	9	78	8	1:7
	2009	22	9	12	4	47	8	2:6
	2010	25	16	111	54	206	16	2:14
	2011	5	3	20	28	36	11	0:11
	2012	91	32	33	15	171	9	4:5
Bonaparte Cr.								
	2006	10	0	2	0	12	0	0
	2007	140	0	23	0	163	0	0
	2008	13	0	13	0	16	4	0:4
	2009	14	7	6	3	30	8	3:5
	2010	45	0	32	0	77	1	1:0
	2011	1	0	2	2	5	3	0:3
	2012	0	0	0	0	0	0	0

The majority of natural steelhead returned to Omak Creek as a 2-salt fish. Size-at-maturity for natural steelhead ranged from 330 mm to 840 mm (N=9). Average age-at-maturity for natural steelhead was 3.5 years (N=9) and fish greater than 720 mm was assumed a 3-salt fish based on scale analysis. Mean fork length was 565 mm for natural steelhead measured at the Omak weir. Egg fecundity from broodstock taken at Omak Creek averaged 5,500 eggs per female.

Juvenile Hatchery/Natural Survival

The Wells steelhead Fry-Smolt survival was estimated to be 91.5 percent, far above current standards for fry to smolt survival (Table 2). This may be due to the lower densities of fish being reared and less chance of disease and increased fitness due to less competition then those reared in higher densities. Survival in the unfertilized egg-to-eyed egg and ponding-to-release categories were higher than expected (Table 2). Overall, the wild by wild locally-adapted summer steelhead met survival standards at release (Table 3). Survival of most recent broods of Wells steelhead for the Twisp and Methow stock has been below survival standards for these categories (WDFW, 2011).

Table 2: Okanogan Basin locally-adapted steelhead hatchery egg-take, fecundity and life stage survival between the years of 2004-2012.

Year	Number Females	Total Green	Eggs-Female	Total Eyed	Grn-Eyed Survival	Total Fry	Fry-Smolt Survival	Total Smolt
2004	8	31,414	3,927	24,260	77.2	21,500	88.6	13,232
2005	9	32,038	3,560	25,206	78.7	21,452	85.1	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	9,639

Table 3. Count, mortality and cumulative post ponding survival for broodyear 2012 Okanogan basin locally-adapted summer steelhead from July 2012 to April 2013. (July to March data provided by Wells Fish Hatchery, WDFW).

Site	Month	Inventory	Morts	% Survival
Wells	June	NA	NA	NA
Fish	July	10,015	322	96.9
Hatchery	August	9,802	213	94.8
	September	9,750	52	94.3
	October	9,700	50	93.8
	November	9,680	20	93.5
	December	9,665	15	93.4
	January	9,654	11	93.4
	February	9,639	15	93.2
	March	9,200	439	89.0
Omak Acclimation	April	9,079	121	87.8

Juvenile Rearing and Release

A total of 9,203 juvenile fish reared at Wells Fish Hatchery, from 2012 locally-adapted adult steelhead, were delivered on 27-March, 2013. Locally-adapted summer steelhead acclimated at St. Mary's Mission pond were held on a mix of both well and Omak Creek water. Average fork length at release for the locally adapted steelhead was 179 mm with a CV of 16.99 (Table 4). A volitional release strategy was initiated on 23-April, 2013.

Table 4. Average weight (g), length (mm) and coefficient of variation of broodyear 2012 summer steelhead reared at Wells Fish Hatchery from June 2012 to April 2013 (August to March data provided by Wells Fish Hatchery, WDFW).

Month	Length (mm)	Weight (g)	CV Length
June	NA	NA	NA

July	NA	NA	NA
August	42.0	0.79	NA
September	65.0	3.34	15.81
October	85.0	7.96	14.18
November	112.0	15.65	13.47
December	140.0	30.24	11.12
January	155.0	41.24	13.43
February	170.0	54.65	9.51
March	187.0	NA	9.50
April	179.0	56.41	16.99

Total number of fish released in Omak Creek has increased from 20,000 to 40,000 starting in 2010 (Table 5). Similarly in Salmon Creek stocking efforts increased directly resulting in fewer fish being stocked in the mainstem Okanogan.

Table 5. Total number of smolts released in the Okanogan basin by tributary for 2003-2012.

	Smolt Release							
Brood year	**Omak Cr.**	**Salmon Cr.**	**Nine-mile Cr.**	**Antoine Cr.**	**Tunk Cr.**	**Similkameen R.**	**Okanogan R.**	**Total**
2003	3,450	-	-	-	-	50,860	65,920	120,230
2004	13,442	-	-	-	-	57,750	12,000	83,192
2005	19,862	-	-	-	-	68,940	-	88,802
2006	19,772	7,447	-	-	-	146,862	-	174,081
2007	19,914	13,120	5,152	2,856	4,993	106,317	16,403	168,755
2008	13,601	-	1,904	-	-	79,286	14,200	108,991
2009	23,618	25,657	-	-	-	51,868	-	101,143
2010	32,333	40,000	-	-	-	61,090	-	133,423
2011	41,285	50,000	-	-	-	73,623	3,960	168,868
2012	43,226	50,000	-	-	-	10,080	-	103,306
Total	**196,647**	**186,224**	**7,056**	**2,856**	**4,993**	**706,676**	**112,483**	**1,250,791**

Numbers of smolts released in 2012 was consistent with the management plan for stocking locally-adapted fish in Omak Creek (HGMP, *in review*). Detection of juvenile fish at Rocky Reach dam on the Columbia River has greatly improved with the addition of Rocky Reach Juvenile (RRJ) fish passage detection site. Survival estimates were determined based on the number of fish detected passing the RRJ PTIS. An assumption was made that all fish released and survived to RRJ migrated through the PTIS and not over the spillways at the dam. Based on PIT tags over the last three years Omak Creek locally-adapted fish are between 10 and 20 percent survival to Rocky Reach dam (Table 6).

Table 6. Total number of PIT tags detected outside of Omak Creek. Percent survival to Rocky Reach (RRJ) Dam and out of basin survival.

Brood Year	Smolts Released	PIT Tagged	Detected @RRJ	Detected All Dams	Percent RRJ	Percent All Dams	Percent PIT
2005	19,862	19,862	0	1,593	0.00	9.10	100
2006	19,772	19,772	0	NA	0.00	0.00	100
2007	19,914	6,753	0	1,307	0.00	7.25	33.91
2008	15,505	13,665	0	45	0.00	0.65	88.01
2009	23,801	14,482	17	447	0.00	3.75	60.84
2010	32,346	19,898	4,519	5,120	22.71	25.73	61.52
2011	41,250	16,887	2,004	2,948	11.87	17.46	40.94
2012	43,226	17,390	2,309	2,741	13.28	15.76	40.23

Average fork length for smolts released between 2004 and 2008 was 158 mm (Table 7). Average fork length for smolts released after 2008 was 196 mm (Table 7). The number of adults returned (SAR) to Wells Fish Hatchery increased after 2009 (Table 7). Based on a one year return in 2012, smolt to adult returns (SAR) were 0.39% of the total number of smolts released in 2011 (Table 7). Since 2010, hatchery return rates have exceeded the expected >1 replacement rate (Table 7) identified in the HGMP (HGMP, 2013 *in review*). A natural return rate for 2012 based on a two year (2010 and 2011) return was estimated at 5.6% (Miller et al., 2013).

Table 7. Average fork length at release compared to Smolt to Adult Returns (SAR) and Hatchery Return Rate (HRR) of Omak Creek locally-adapted steelhead back to Wells Dam for 2004 - 2012. Passive Integrated Transponder (PIT) detections were not corrected for tag loss, residuals or stray rate. *2011 based on two years of adult returns and 2012 based on only one year of adult returns.

Rearing Facility	Release Year (RY)	Smolts Released	PIT smolts released	Average Fork Length at Release	SAR (.%)	HRR
Cassimer Bar Hatchery	2004	NA	13,232	137	0.17	5.5
	2005	19,862	19,862	160	0.04	0.4
	2006	19,772	19,772	153	0.00	0.0
	2007	19,914	6,753	160	0.22	1.4
	2008	15,505	13,665	184	0.00	0.0
	2009	23,801	14,482	190	0.06	1.0
	2010	32,346	19,898	208	0.56	14.0
Wells Fish Hatchery	2011*	41,250	16,887	191	0.73	7.8
	2012*	43,226	17,390	187	0.39	6.1

Coded Wire Tag (CWT) recovery at Wells was estimated to be 0.06 percent of the total number of CWT tagged fish from 2009 and 2010 brood years (Table 8). Tag rate increased to a 100% CWT from previous years (Table 8). Even though CWT tag rates increased from previous years total number of those recovered did not increase at the Omak weir (Table 8). Coded wire tags are used to determine origin of adult broodstock at both the Wells Fish Hatchery and for the BAM program at the Omak adult weir.

Table 8. Total number of CWT tags deployed since 2009 and number of adults with CWT to Wells Fish Hatchery and Omak Creek.

Brood Year	Smolts Released	CWT Tagged	Tag Rate CWT	CWT Adults Wells Hatchery	.% Recovered	CWT Adults Omak Creek
2009	23,801	15,430	0.65	447	0.04	2
2010	32,346	23,618	0.73	5,120	0.29	106
2011	41,250	32,346	0.78	2,948	0.11	74
2012	43,226	43,226	1.00	2,741	0.06	56

Discussion

Hatchery return rate (6.1%) was similar to the natural return rate (5.6%) for Omak Creek in 2012 based on one year of data. A larger proportion of males then females for both hatchery and wild fish returned to Omak Creek. The replacement rate for hatchery fish has increased since 2009 and was greater than the expected value for 2012. A high percentage of Cassimer Bar Hatchery fish comprised the majority of the hatchery fish in Omak Creek. However, extrapolating the number of adult steelhead observed at Wells Dam to the entire Okanogan Basin and then estimating what portion of those fish are bound for Omak Creek involves making a lot of assumptions and the resulting estimate may not be precise. Collection of natural origin fish at the weir and detection of previously PIT tagged fish in Omak Creek help validate some of our assumptions and contribute to a better estimate.

Brood year 2012 fish released in 2013 was within range of the acceptable size at release for a one year hatchery reared summer steelhead smolt. Number of smolts (N = 9,070) released in Omak Creek was below the program goal of 20,000 wild-by-wild hatchery reared summer steelhead. Only eleven of the sixteen total fish needed for broodstock in Omak Creek were collected in 2011. Fish capture at the Omak Creek weir has become increasingly difficult due to sediment build up on the trap. A revised design to this trap capable of removing sediment and debris and increased buoyancy to elevate the trap is needed to effectively collect broodstock and manage hatchery fish on the spawning grounds into the future. Plans to deploy a box trap in Wild horse Spring Creek and collect adult broodstock to be used for 2014 broodyear.

Population structure and effective population size are changing in natural spawning populations as a result of the hatchery program. Additionally, the hatchery programs have caused changes in phenotypic characteristics of natural populations based on observations. To define the extent of these changes, a genetic study has been proposed to define the natural composition stock of those spawned in Omak Creek (CRTFC, 2007). Broods determined to be from returning adults will provide the potential F1 progeny; however, reproductive success, hatchery influence on the spawning grounds and ocean survival or productivity can greatly reduce final outcomes. To determine successful reproduction from returning adults, their progeny will need to be recaptured and identified at the rotary screw trap. This would then provide a complete history of origin of Omak Creek steelhead production for each brood year.

In 2013 a 3-D micro-digital fish scale camera and scope was purchased by the CCT to analyze scales taken from wild adult broodstock in Omak Creek. Scales are currently being analyzed to confirm origin (hatchery vs. wild), and determine age at maturity, size at age, average number of ocean years and average size at return. These findings will be reported in the 2013 annual report and on-going monthly reports as data are analyzed.

Recommendations

Broodstock collection in 2012 increased from 2011 due to run-size and weir trap improvements. Capture efficiency can be directly related to weir trap avoidance by returning adults. In 2011, we found a greater number of fish return as kelts than spawners indicating poor upstream trap efficiency. In 2011, improvements to reduce trap avoidance (2011 Annual Report) were made and found to be highly effective. Numbers of adult steelhead in Omak Creek was relatively high for 2012 but due to a selection process geared towards natural origin stock few fish were collected for broodstock. This limited our total numbers of fish and in the process only allowed nine of the 16 total to be collected from Omak Creek. A more conservative approach will be taken in future years to ensure local broodstock and provide gametes of local stock rather than Wells hatchery stock.

Improvements to the weir are needed to provide better trap efficiency during high water events. This may involve a structural change to the overall design of this trap to allow debris removal upon demand. Often this trap is inundated by woody debris and silt and sand that will weigh the floating picket fence down allowing fish to pass. A design that enables debris to pass freely and or on demand as needed would help increase the number of locally adapted broodstock collected from Omak Creek.

VI. Chapter 2. Smolt Monitoring

Introduction

Estimates of natural production by steelhead, coupled with characteristics of the spawning population (i.e., abundance and composition), should provide some of the data necessary to assess the efficacy of hatchery supplementation programs. Limited information exists on smolt production in the Okanogan Basin because of highly variable environmental conditions, small sample sizes, and difficulties getting sufficient recapture to produce meaningful estimates. Estimates of smolt production for the entire Omak Creek were not calculated because monitoring was intermittent or occurred for only short periods of time due to low water conditions. The primary objective to operating a Rotary Screw Trap in Omak Creek was to estimate juvenile production of steelhead and to estimate stage-specific survival rates. These objectives were incorporated into the Districts Monitoring and Evaluation plan (GCPUD M&E Plan 2008).

Objective 7: Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of smolts per redd) of supplemented streams when compared to non-supplemented streams.

Hypotheses:

- H0: Δ smolts/redd $_{\text{Supplemented population}} \geq \Delta$ smolts/redd $_{\text{Non-supplemented population}}$

Given variability in abundance of adult salmonid populations in the Upper Columbia River Basin, monitoring juvenile production (e.g., smolts/redd) should provide a direct assessment of the efficacy of hatchery fish in rebuilding natural populations. Monitoring the freshwater production of both supplemented and non-supplemented populations may provide an early indication of the reproductive success of hatchery fish on the spawning grounds. Smolt monitoring programs are currently ongoing for Omak Creek and estimates are being made from these efforts. Improvements in PIT tag monitoring and evaluation have been made in recent years that has allowed for the use of these technologies in the assessment of smolt production. Increased tagging in all natal and potential natural rearing streams (i.e., Salmon Creek) in conjunction with redd surveys can be used to determine the number of smolts per redd. In this chapter, we focus on the number of smolts produced from Omak Creek using a Rotary Screw Trap and PIT tag interrogation systems. Currently resources do not allow for smolt production estimates in non-supplemented streams.

Methods

Downstream juvenile steelhead migrants were collected using a five foot rotary screw trap in Omak Creek. We started to trap on 3, April 2012 and trapped 24 hours a day five days a week or until flows allowed, ending 29, June 2012. Fish collected were handled and sampled following standard operating procedures as described in the ISEMP field protocols for operation of a rotary screw trap in the upper Columbia basin (protocol available at www.Monitoringmethods.org). Age breaks were determined by fork length using a length frequency histogram. We used this model to predict life stage for fry (<45mm), parr (45>90), parr-smolt (90>120mm (transitional)) and smolts (>120mm). Condition factors were calculated for both hatchery and natural origin fish captured at the RST in Omak Creek. We determined these factors using a K-formula ($W/L^3 \times 10^5$).

Mark/recapture efficiency trials were conducted throughout the season with a minimum of 30 individual fish of a given target species over a three day period. Mark groups can be comprised of hatchery fish or fish that have been previously captured in the trap. However, if using hatchery fish, one must assume their probability of capture is the same as for naturally reared fish.

A valid estimate requires the following assumptions to be true concerning the trap efficiency trials:

1) All marked fish passed the trap or were recaptured during time period *i*.
2) The probability of capturing a marked or unmarked fish is equal.
3) All marked fish recaptured were identified.
4) Marks were not lost between the time of release and recapture.

Production estimates were calculated using estimated daily trap efficiency derived from a R-script written regression formula using trap efficiency (dependent variable) and discharge (independent variable) (Appendix A).

Trap efficiency was calculated using the following formula: Trap efficiency = $E_i = R_i / M_i$
Where E_i is the trap efficiency during time period i; M_i is the number of marked fish released during time period i; and R_i is the number of marked fish recaptured during time period i. The number of fish captured was expanded by the estimated daily trap efficiency (e) to estimate the daily number of fish migrating past the trap (N_i).

Estimation of abundance:

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;

Discharge levels are measured from a staff gauge located at rkm 8.2 in Omak creek below Mission falls. Washington State Department of Ecology (DOE) has developed a discharge rating table for Omak Creek at valid periods throughout the year. Determination of a given flow can be determined by reading the staff gauge and referencing the rating table for the corresponding discharge. An annual visit to this site for calibration purposes is made by the United States Geological Survey (USGS). Data are compiled and uploaded to a DOE web site (*https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=49C100*). A new real time USGS discharge gauge will be installed at this site in the fall of 2013.

Results

Number of smolts and production estimate using a RST

In 2012, we captured a total of 3,838 *O. mykiss* at various life stages of wild parr, parr-smolt (transitional) and smolt at the RST in Omak Creek. We estimated that a total of 6,519 (± 3,956, 95% CI) *O. mykiss* from the 2010-2011 spawning activities emigrated from Omak Creek including 1,093 parr and 5,200 wild smolts. Estimates were based on 0.64 trap efficiency during peak steelhead migration (May). Efficiency trials and production estimates were based on flows; therefore more efficiency trials for the entire range of flows in Omak Creek are needed to produce more precise estimates.

Size at emigration

We used a model based on a length weight relationship to predict size at emigration for natural origin steelhead from Omak Creek (Figure 2). Compared to actively migrating natural origin fish hatchery fish released from St. Maries Acclimation pond were on average larger in weight and fork length (Figure 3). Natural steelhead were found to migrate early in their life stage (parr) and presumably smolt to the ocean. Differences in life history between natural origin fish may be due to pressure from hatchery released fish to migrate prior to smolting. Average fork length for wild steelhead was 128 mm for the month of May (Figure 4). Hatchery reared 2011 brood year summer steelhead were on average 188 mm at release (Figure 5). Hatchery reared fish captured in the RST on Omak Creek were on average 51 mm larger then wild juvenile summer steelhead. Condition factors (K) measured for natural (N=3,882) and hatchery (N=808) steelhead at the RST in Omak Creek was 1.071 and 0.868, respectively. A <1.0 fitness factor for hatchery steelhead may have been due to a reduction in feeding during acclimation.

Figure 2: A length-weight regression of wild juvenile steelhead collected from the Omak Creek RST.

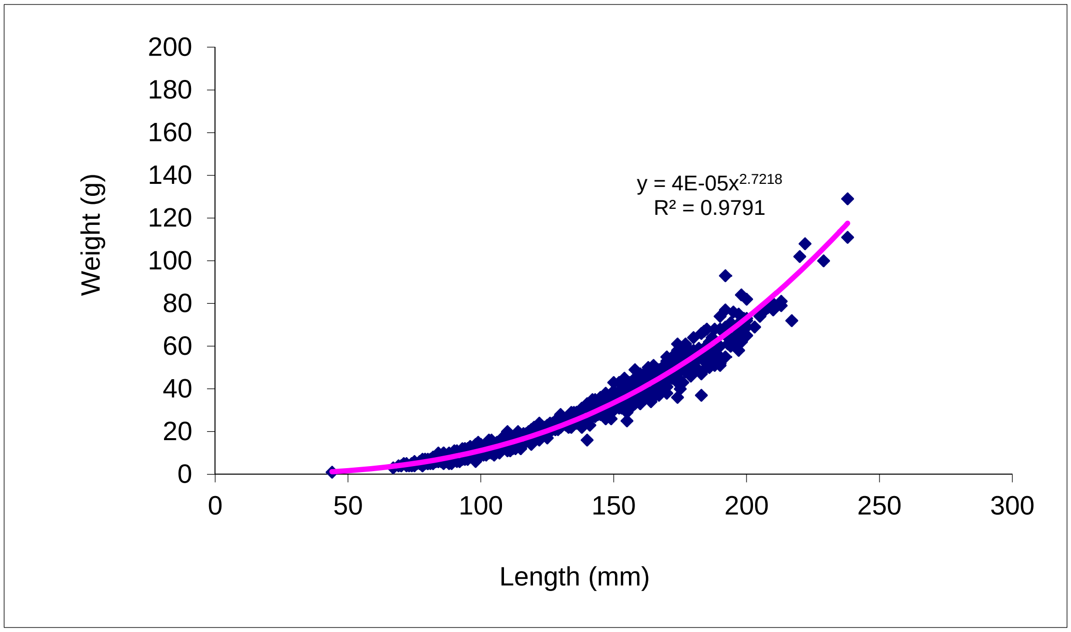
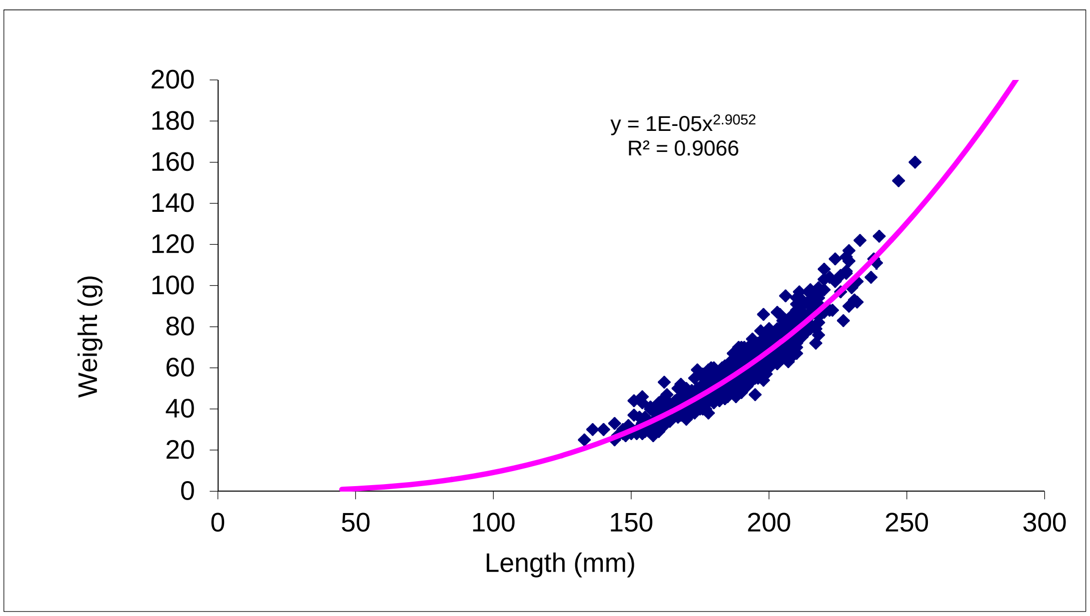


Figure 3: A length-weight regression of hatchery juvenile steelhead collected from the Omak Creek RST.



Age at emigration

Based on a length frequency relationship for wild juveniles we determined age at migration for wild summer steelhead to be age 2 (transitional) and age 3 (smolt) from Omak Creek (Figure 4). Due to low numbers (N=7), we could not provide a statistically valid age 0 comparison for steelhead fry. Fry captured in the RST ranged from 28 to 45 mm in length and assumed age 0 in their first year of growth. April length frequency data indicates similar age at migration to May length frequency data. During the month of June however length frequency data for wild steelhead showed more transitional size fish migrated then smolts from Omak Creek (Figure 6).

Figure 4: Wild juvenile steelhead captured at the rotary screw trap in Omak Creek length – frequency graph for the month of May 2012.

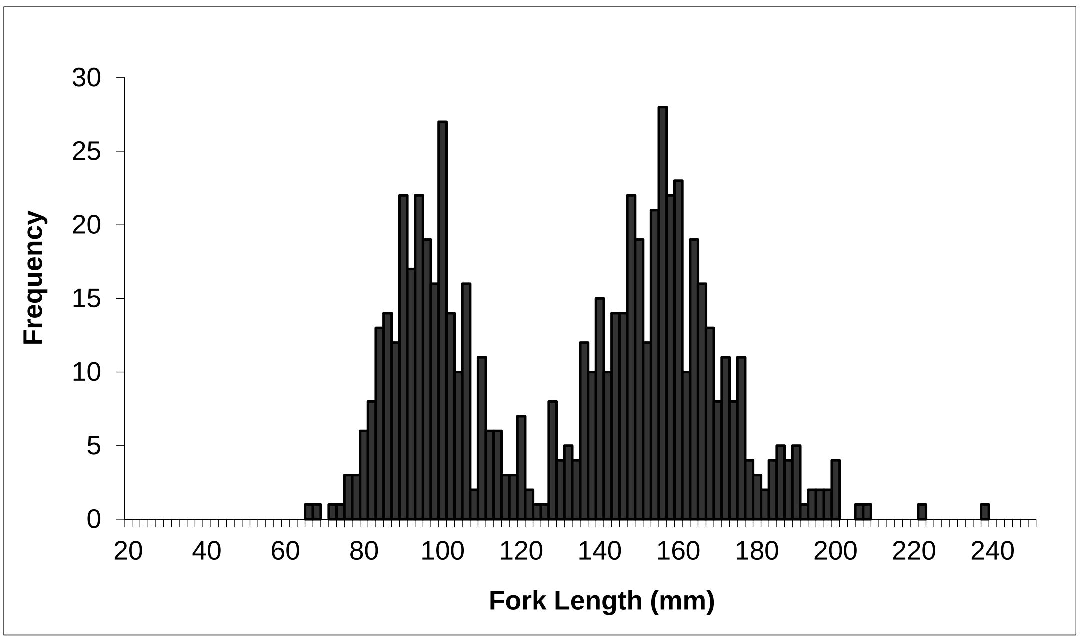


Figure 5: Hatchery steelhead length-frequency collected from the RST on Omak Creek for the month of May 2012.

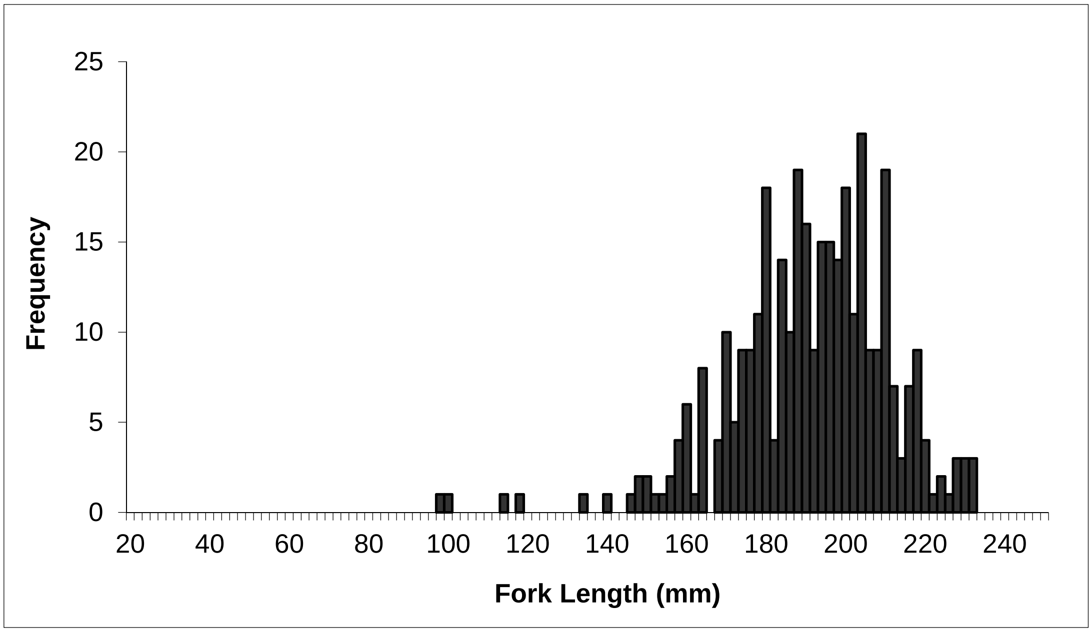
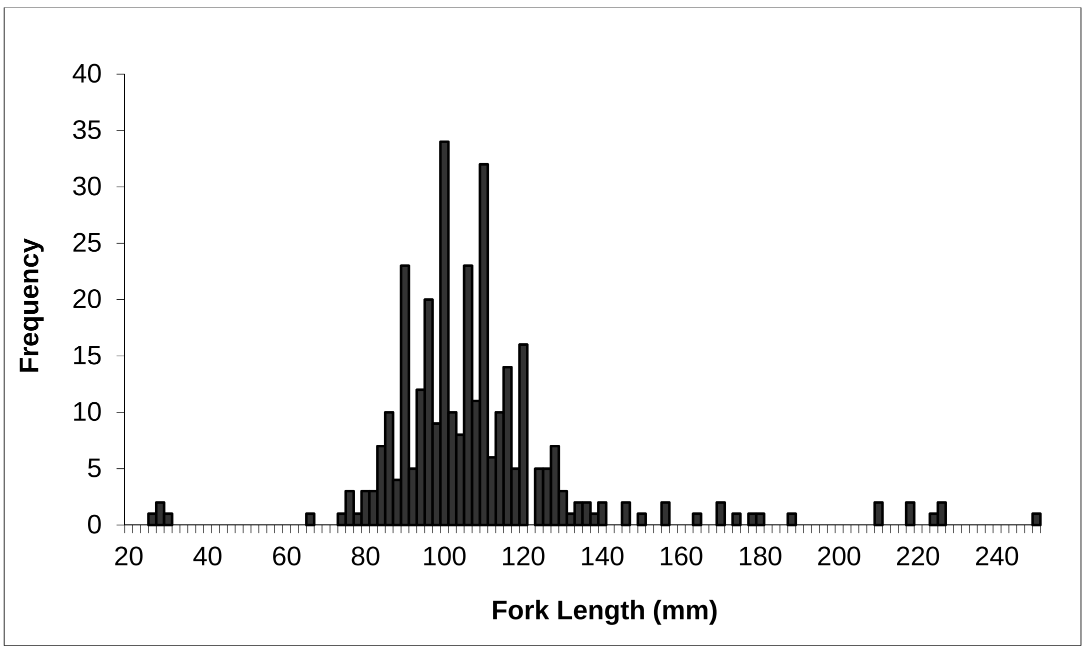


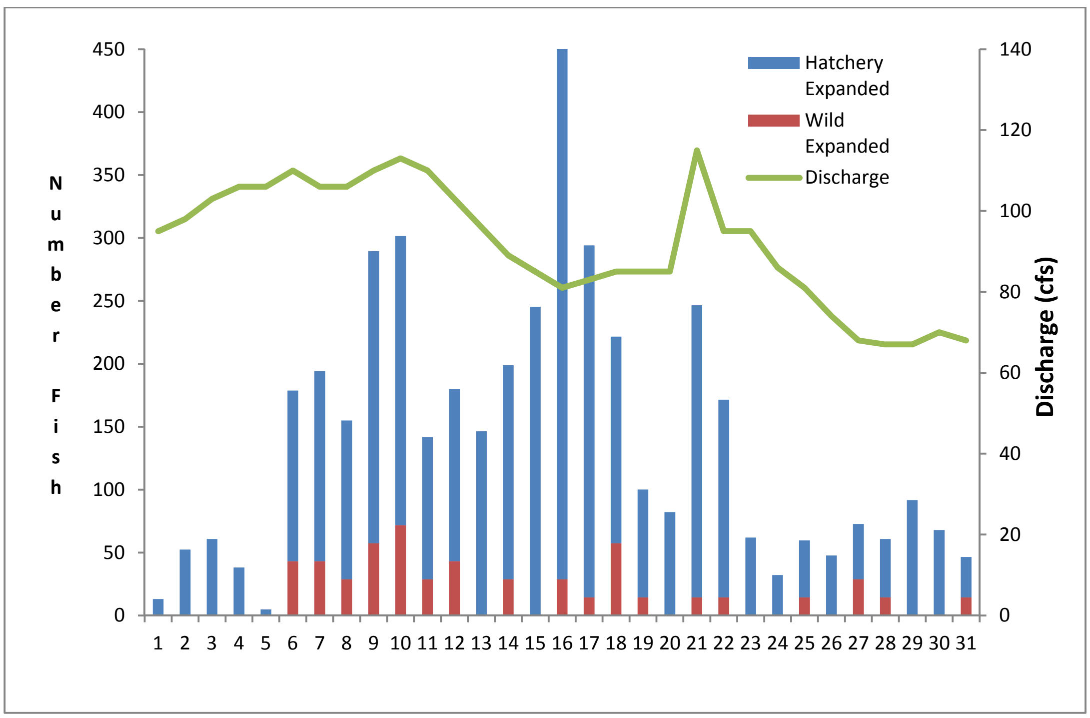
Figure 6: Wild steelhead length-frequency collected from the RST on Omak Creek for the month of June 2012.



Smolt emigration timing

Wild juvenile smolt migration timing was measured by PIT tag detection at the Omak Creek PTIS (Figure 7). A total of 1,852 wild steelhead were captured during the month of May which represented 48% of the total summer steelhead collected in Omak Creek at the RST. The majority of these wild steelhead were parr and transitional size fish. Discharge measured in Omak Creek peaked on 21 May at 365 cubic feet per second (cfs). Based on PIT tagged hatchery steelhead average travel time to RRJ was 16 days. The minimum number of days recorded to RRJ was 4 days and the maximum number of days was 250 days.

Figure 7: Juvenile emigration model based on discharge for the month of May. Total hatchery and estimated wild detections are expanded from the determined efficiency of the Omak (OMK) PTIS.



Smolt Survival to Rocky Reach Dam (RRJ)

Hatchery juvenile survival was estimated using PIT tagged smolts released in the Okanogan basin. Only 40% of the total 43,226 steelhead stocked in 2012 received a PIT tag. In 2012, 13.28 % of these PIT tagged fish were detected at Rocky Reach Dam (Table 9). Rocky Reach is

80-90 percent efficient at detecting PIT tags through the PTIS. Using this expansion percentage (0.85) this suggests 2,645 PIT tagged fished survived to Rocky Reach Dam. Using this same survival estimate and percent detection efficiency at RRJ expanded over the entire mitigation requirement of 100,000 fish we estimate that 15,272 smolt survived to Rocky Reach Dam. This estimate does not include those PIT tagged fish going over spillways or through the turbines. Using a 0.5 % return rate suggests 76.4 adult steelhead would return from this brood year.

Table 9. Total number of PIT tags detected outside of Okanogan basin. Percent survival to Rocky Reach (RRJ) Dam and out of basin survival.

Brood Year	Smolts Released	PIT Tagged	Detected @RRJ	Detected All Dams	Percent RRJ	Percent All Dams	Percent PIT
2005	19,862	19,862	0	1,593	0.00	9.10	100
2006	19,772	19,772	0	NA	0.00	0.00	100
2007	19,914	6,753	0	1,307	0.00	7.25	33.91
2008	15,505	13,665	0	45	0.00	0.65	88.01
2009	23,801	14,482	17	447	0.00	3.75	60.84
2010	32,346	19,898	4,519	5,120	22.71	25.73	61.52
2011	41,250	16,887	2,004	2,948	11.87	17.46	40.94
2012	43,226	17,390	2,309	2,741	13.28	15.76	40.23

Discussion

To provide the District with direct measurements and meet their requirements from the M&E plan, we have combined data from a smolt production estimate using a rotary screw trap and expanded redd density estimates for Omak Creek.

Smolts per redd were estimated using both an expanded number of redds found in Omak Creek (Miller et al. 2012) and the estimated number of smolts produced using a RST and production model (Appendix B). Redd surveys combined with identified 9 redds below the Omak Creek weir trap. Those redds were expanded to 30 hatchery and five wild steelhead from fish per redd (FPR) and percent wild values derived at the weir. Using an estimated 6,519 (± 3,956, 95% CI) smolts produced in Omak Creek we calculated 133 (± 80, 95% CI) smolts per redd for 2012. A high and low estimate at the 95 % confidence interval conclude a range of 213 to 52 smolts per redd. To determine whether we can accept or reject the given hypothesis a non-supplemented stream would need to be studied.

Average fork length of natural and hatchery juvenile salmonids captured at the Omak RST were 128 mm and 188 mm, respectively. Condition factors (K) measured for natural (N=3,882) and hatchery (N=808) steelhead at the RST in Omak Creek were 1.071 and 0.868, respectively. Although this is not a parameter among the hypothesis given we feel size at migration and the conditions of those fish emigrating are tools we can use to measure the success or demise of those fish downstream.

Recommendations

To determine if the number of naturally spawning and naturally produced adults of the target population are changed relative to a non-supplemented population (i.e., reference stream) one must sample a non-supplemented stream. Currently the Colville Tribes are under contract to only sample supplemented streams (Omak and Salmon Creeks). Differences in carrying capacities of supplemented and non-supplemented streams can be confounded with basin wide stocking efforts and the ability of hatchery fish to utilize non-supplemented streams (i.e., Loup-Loup Creek). To avoid the conclusion that the supplementation program has no effect on natural spawners corrections need to be made to the monitoring and analysis with the Districts support.

Smolt production estimates often are problematic given the constraints of the equipment used and environmental conditions during spring run-off. Working closely with WDFW on predicting best estimates using an R-script based production model is on-going and improvements are being made to this model. Collection data needs to be consistent with 2012 efforts which provided 7 days a week, 24 hrs a day fish collection and efficiency trials. Gaps in the model need to be filled at both high and low flows. Consistency in operation of an RST for efficiency trials on Omak Creek will continue..

Production estimates using a PTIS is new and on-going for the CCT F&W program. In cooperation with OBMEP PIT tags will be deployed in natural origin fish in 2013. An estimate based on a tag rate and detection efficiency of the Omak PTIS can be used to determine production. These values will prove invaluable during those periods when the RST is not in operation due to low flow. Similar effort should be concurrent with Salmon Creek. In 2013, efforts to PIT tag natural origin steelhead will be a goal of this program. Efforts to stock PIT tagged hatchery reared steelhead needs to take place in 2013-2015 to assess the effect of hatchery fish on natural origin fish and provide a more accurate HOR estimate for Salmon Creek.

Efforts to provide better PIT detection in Salmon Creek will also be a goal of the CCT BAM Project moving forward.

VII. Chapter 3: Harvest and Steelhead Spawning Ground Surveys

Introduction

In 2009, in-stream antenna arrays were installed in all tributaries to the Okanogan River within the United States to assess the distribution and migration timing of adult hatchery and wild steelhead. Spawn timing and redd distribution data for summer steelhead was collected during spawning ground surveys (Miller et al. 2013). Selecting index reaches where similar proportions of hatchery and naturally produced fish are expected to spawn can be used to evaluate spawn timing. All spawning information necessary for evaluating differences between hatchery and naturally produced steelhead was collected during spawning ground surveys (e.g. presence or absence of an adipose clip).

Objective 2: Determine if the run timing, spawn timing, and spawning distribution of both the natural and hatchery components of the target population are similar.

Hypotheses:

- H0: Migration timing $_{\text{Hatchery}}$ = Migration timing $_{\text{Naturally produced}}$

- H0: Spawn timing $_{\text{Hatchery}}$ = Spawn timing $_{\text{Naturally produced}}$

- H0: Redd distribution $_{\text{Hatchery}}$ = Redd distribution $_{\text{Naturally produced}}$

In order for the natural population to remain stable or to increase, the Natural Replacement Rate (NRR), or the ratio of NORs to the parent spawning population, must be at a level where parents are being replaced by their offspring as spawners in the next generation. It is possible to affect an increase in natural origin spawners through supplementation with a stable or decreasing NRR. However, if the NRR is below replacement (NRR<1.0), termination of the supplementation program will result in a declining natural population should that state of NRR persist.

Objective 1: Determine if programs have increased the number of naturally spawning and naturally produced adults of the target population relative to a non-supplemented population (i.e., reference stream or condition) and the changes in the natural replacement rate (NRR) of the supplemented population are similar to that of the non-supplemented population.

Hypotheses:

- H0: Number of HOR1 $_{\text{Supplemented population}}$ ≥ Expected value per BAMP

- H0: Δ NOR2 $_{\text{Supplemented population}}$ ≥ Δ NOR $_{\text{Non-supplemented population}}$

- H0: Δ NRR $_{\text{Supplemented population}}$ ≥ Δ NRR $_{\text{Non-supplemented population}}$

Steelhead counts over Wells Dam and harvest estimates in the Okanogan have occurred since 2001 (Table 8).. Levels of escapement for anadromous steelhead may change annually due to environmental conditions, ocean conditions, and harvest. Harvest is considered those fish removed from the total run by removal at dams for broodstock collection, recreational hook and line and commercial fishing. Estimates provided here are only from those fish that escaped to Wells Dam and specific tributaries in the Okanogan Basin.

Objective 8: Determine if harvest opportunities have been provided using hatchery returning adults where appropriate.

Hypotheses:

- H0: Harvest rate ≤ Maximum level to meet program goals

Methods

As part of Broodstock, Acclimation and Monitoring (BAM) scope of work, redd surveys were conducted in Salmon and Omak Creeks. Preliminary methods for implementing redd surveys were developed in 2005 (Arterburn et al. 2004) and these methods were later revised in 2007 (Arterburn et al. 2007c). Adult weir traps, PIT tag arrays, and redd counts were used to expand redd data beyond their locations in Omak Creek (Miller et al. 2013). Total number of adult spawners in Salmon Creek was enumerated using redd counts by foot, PTIS, and underwater video equipment (Miller et al. 2013).

Harvest counts provided by the WDFW are for ad-clipped hatchery only. Incidental take of natural origin fish from catch and release is not included in these estimates. Harvest in the

1 Hatchery Origin Recruits

2 Natural Origin Recruits

Columbia River above Wells Dam includes fish from multiple locations, not just the Okanogan. Columbia River estimates include Rocky Reach Dam to Chief Joseph Dam.

Results

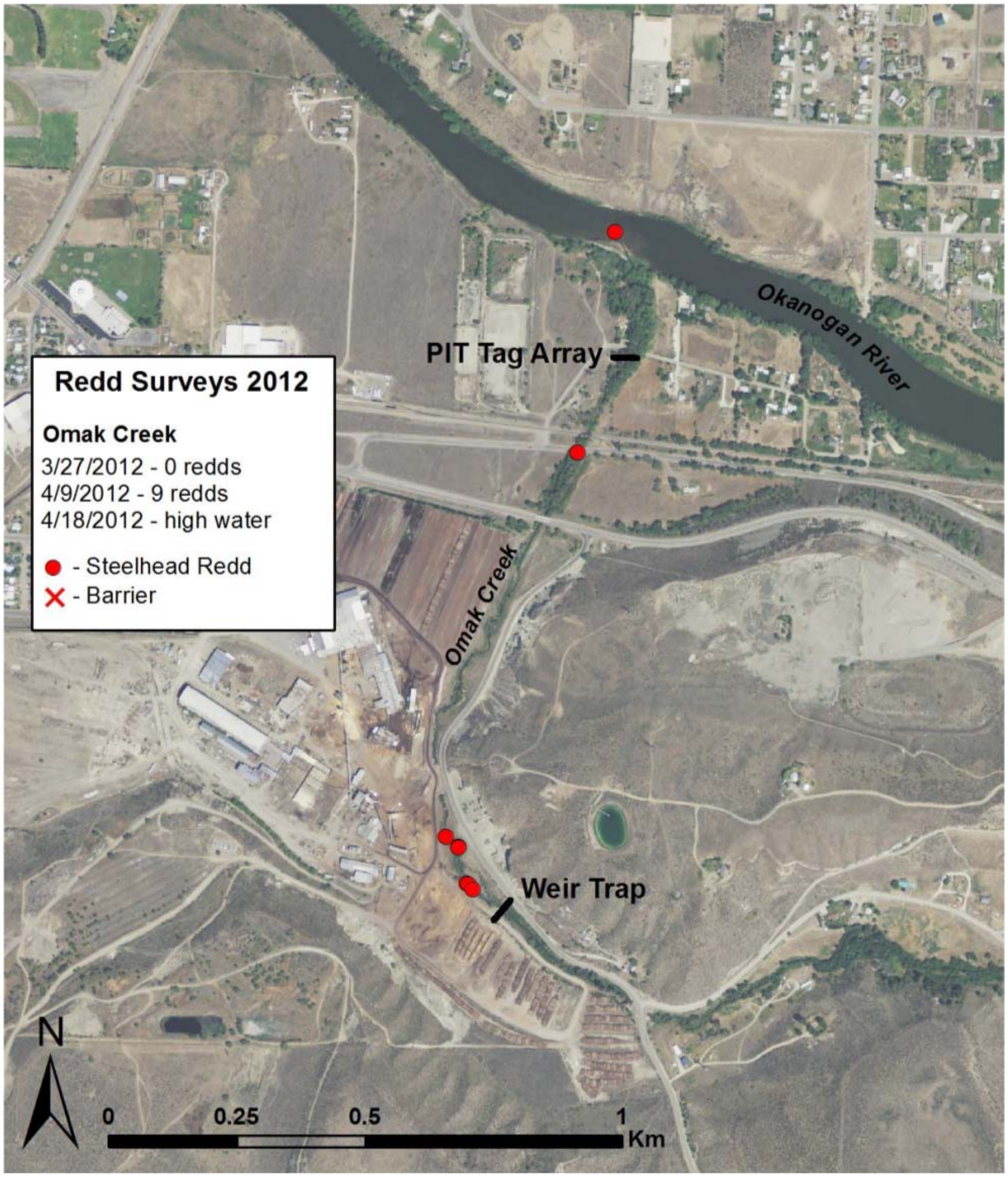
Omak Creek adult abundance estimates

Redd surveys identified 9 redds below the Omak Creek weir trap (Figure 8). Those redds were expanded to 30 hatchery and five wild steelhead from fish per redd (FPR) and percent wild values derived at the weir. Based on combined redd surveys and weir counts, the escapement estimate was 26 adult wild steelhead for Omak Creek in 2012.

In 2012, a total of 158 unique steelhead were captured at the Omak Creek weir. A 13.3% wild NRR was calculated from the 21 wild and 137 hatchery steelhead handled and released upstream of the trap (Miller et al. 2013). Forty female and 117 male steelhead were sexed, rendering a sex ratio of 2.93 M:F (3.93 FPR) for Omak Creek. The weir was compromised due to high flows from April 21 through May 6 and an unknown number of steelhead may have passed during that timeframe.

A permanent PIT tag array was located on Omak Creek, just upstream from the confluence with the Okanogan River, but below the adult weir trap, and it remained functional for the entire spring. A total of 41 steelhead from the Priest Rapids Dam release group were detected, resulting in an estimate of 313 summer steelhead returning to Omak Creek (Miller et al. 2013). It is still being determined whether the CCT will use a combination of redd surveys and data from the weir or solely data from PIT tagged returning adult steelhead to estimate escapement for Omak Creek.

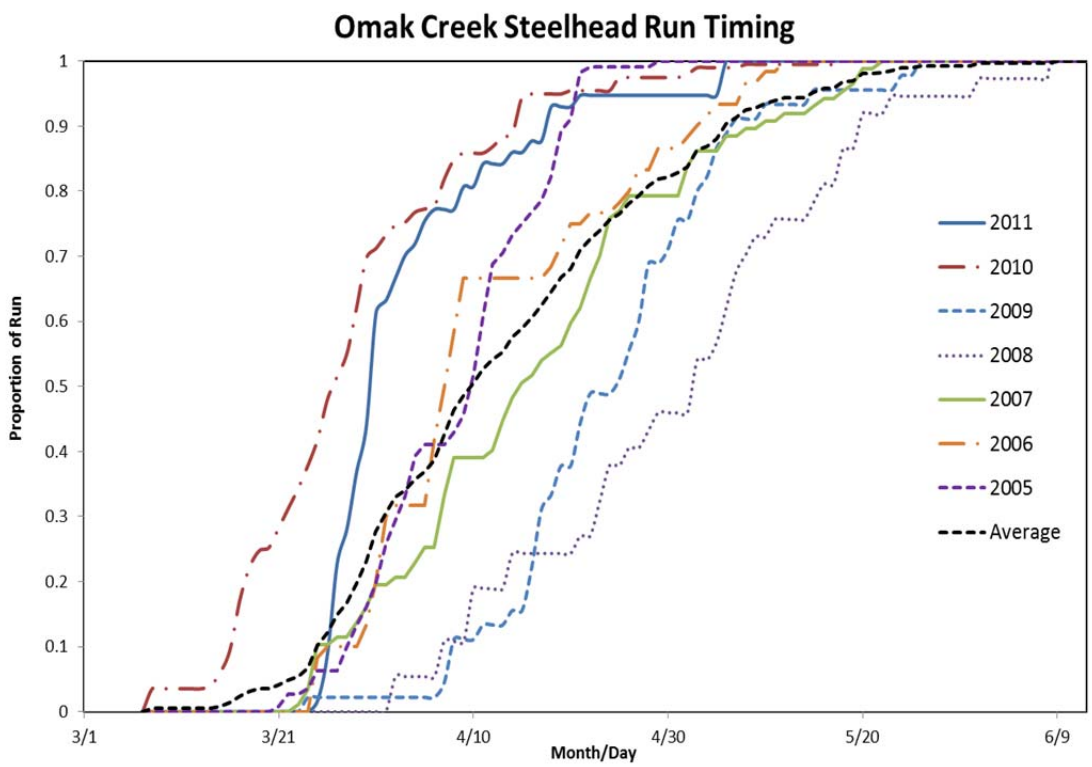
Figure 8: Map of summer steelhead redds observed below the Omak Creek Adult trap in 2012.



Migration and Spawn Timing

Complete run timing at the Omak Creek weir was not determined due to unknown capture rates at the weir in 2012. Steelhead run timing in Omak Creek from 2005-2009 is presented in Figure 8 for reference. In 2012, the first adult steelhead was detected at the PTIS in Omak Creek on 20 March and the last kelt to be captured was on 24 June at the Omak weir. This suggests migration to occur in Omak Creek in early March and run through June.

Figure 9: Run times for summer steelhead in Omak Creek 2005-2009.



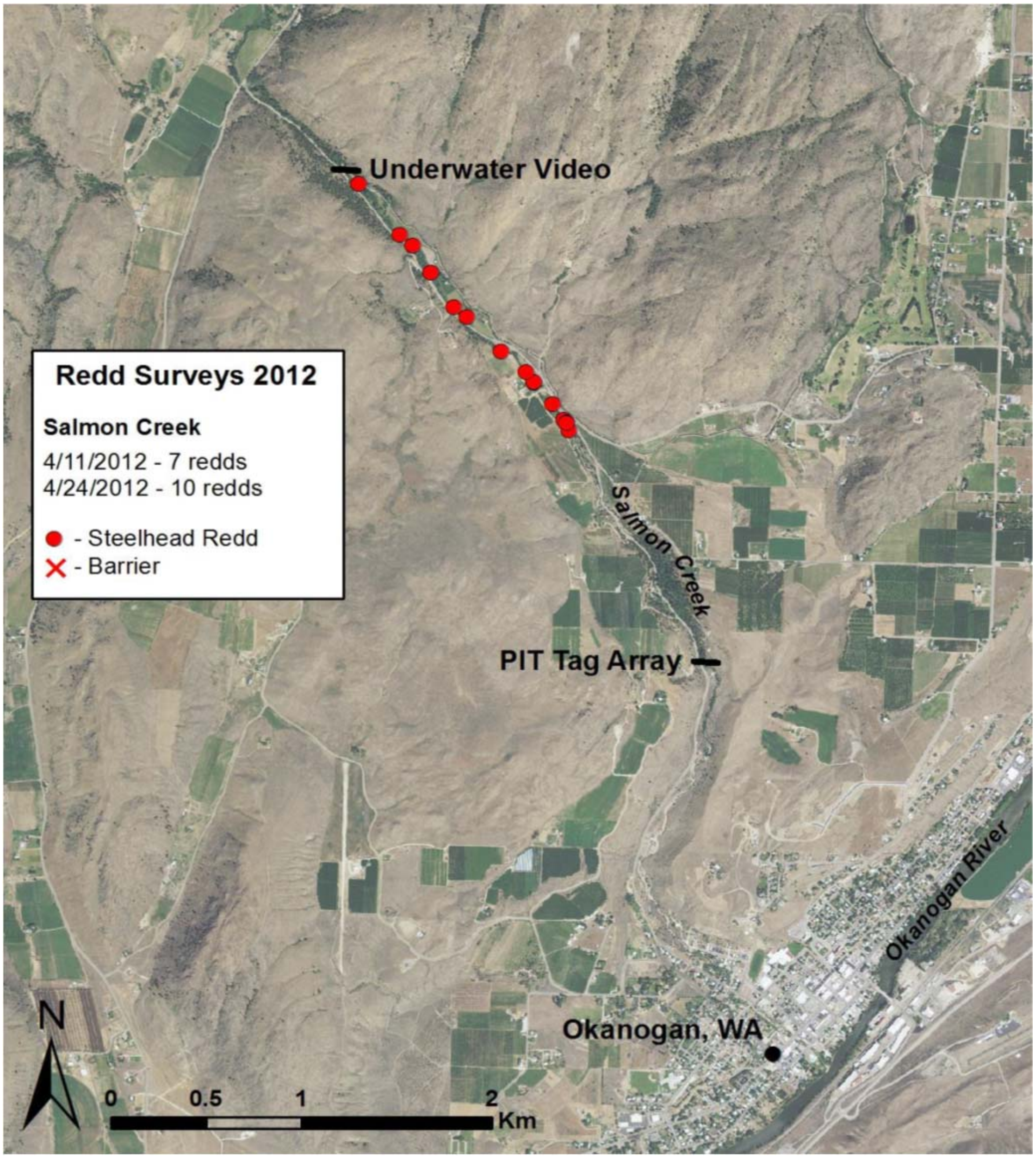
Salmon Creek adult abundance estimates

Salmon Creek was surveyed for redds on 11 April, 2012 and 24 April, 2012. Surveys could not be conducted after this date due to sustained high water through July. A total of 17 steelhead redds were documented in the lower 7.2 km of Salmon Creek (Figure 10). A 20.0% ad-present rate (observed rate from video counts) was applied to redd counts downstream of the diversion (Miller et al. 2013). Based on an expanded 2.06 fish per redd those redds would then be expected to have 30 hatchery and five ad-present presumed natural origin

A total of 68 hatchery and 17 adipose present adult steelhead were observed passing upstream through the video system. An additional nine fish were observed passing upstream with no video confirmation of an adipose intact or not (Miller et al. 2013). Two of the nine unknown origin fish were estimated to have been wild, based on the 20.0% observed wild rate. The combined estimate of 161 spawners from redd surveys and video observations should be considered a minimum escapement estimate, due to high water and incomplete surveys in 2012 (Miller et al. 2013).

Two wild, 30 hatchery, and one unknown origin steelhead were detected at the PIT tag array on Salmon Creek above the city of Okanogan. The calculated escapement estimate from Priest Rapids Dam release group (25) was 191 total steelhead.

Figure 10: Map of summer steelhead redds observed below the Salmon Creek diversion in 2012.



Migration and Spawn Timing

Migration timing is assumed to be similar to that of Omak Creek. Steelhead run timing in Omak Creek from 2005-2011 is presented in Figure 8 for reference. Redd surveys identified 17 redds above the PIT tag array on Salmon Creek and below the video camera. Two surveys were conducted on 11 April, 2012 and 24 April, 2012 prior to high flows. Based on 2004-current redd data (Miller et al. 2013) spawning in Salmon Creek is similar to Omak Creek (Figure 8).

Harvest Counts

Adult steelhead counts at Wells Dam and harvest in the Columbia River above Wells Dam and the Okanogan River have occurred since 2004 (Table 10). Harvest counts based on WDFW creel surveys including Columbia River (Rocky Reach to Chief Joseph Dam), Okanogan River and the Similkameen River was 1,772 steelhead of 9,778 total or 18% of the total run. Steelhead counts at Wells Dam for 2012 was below the three year mean. A similar trend was observed in the Columbia River, Okanogan River and Similkameen River (Table 10). Data collection from creel surveys in general can be considered low and therefore often managers will expand this data based on an estimate of the total number of steelhead counted over Wells Dam (WDFW, personal communication).

Table 10. Recent 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).

			WDFW Steelhead Harvest[1]		
Year	Wells Dam Total Count	CCT Steelhead Harvest[2]	Columbia River Upstream of Wells Dam[2]	Okanogan River	Similkameen River
2001-2002		269			
2002-2003	9,475	234			
2003-2004	9,963	45		304	54
2004-2005[3]	9,317	279	389	229	280
2005-2006[3]	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

Discussion

Trap and dam counts provide the basis for determining the natal origin of summer steelhead in the Okanogan River basin. In 2012, WDFW estimated the number of wild summer steelhead that passed Wells Dam at 261 or 9 % of the total escapement. Wells Dam values were based upon fish counts, PIT tags, coded wire tags, scale analysis, harvest, broodstock collection, and stray rates estimated for Wells Hatchery (Miller et al. 2013). Based on combined redd surveys and weir counts, the wild escapement estimate was 26 adult steelhead for Omak Creek in 2012.

Complete run timing at the Omak Creek weir was not determined due to unknown capture rates in 2012. Steelhead run timing in Omak Creek from 2005-2009 is presented in Figure 8 for reference. In 2012, the first adult steelhead was detected at the PTIS in Omak Creek on 20 March, 2012 and the last kelt to be captured was on 24 June, 2012 at the Omak weir. This suggests migration timing to occur in Omak Creek in early March and run through June.

Because this is a reintroduction program focused on conservation there are no program goals for harvest. The district's ability to meet mitigation requirements is fulfilled under the Wells HGMP program of 100,000 smolts to be produced for the Okanogan basin. In most years approximately 80,000 of the 100,000 smolts are ad-clipped and considered part of the harvest program. Harvest counts based on WDFW creel surveys including Columbia River (Rocky Reach to Chief Joseph Dam), Okanogan River and the Similkameen River was 1,772 steelhead of 9,778 total or 18% of the total run for 2012.

Recommendations

Although redd surveys are a combined effort shared between the BAM program and OBMEP much of this data is compiled and reported by OBMEP. These reports and findings can be found at *http://www.colvilletribes.com/obmep_publications.php* . Efforts to improve best estimates using redd counts, PIT tag detections and video counts are being made. Recent efforts using a tag rate from Priest Rapids Dam, provided by WDFW, is being used to compare and validate production estimates for the Okanogan Basin.

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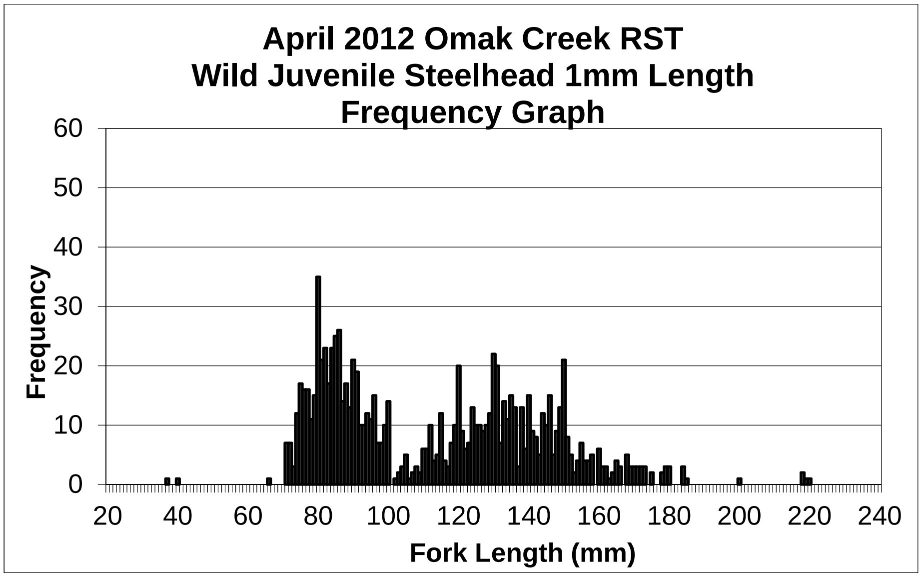
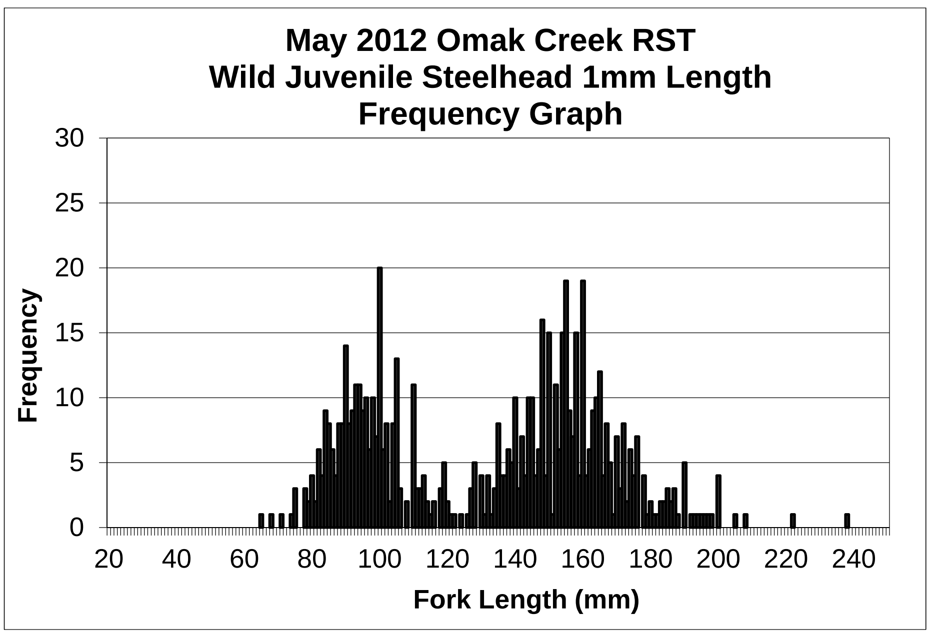
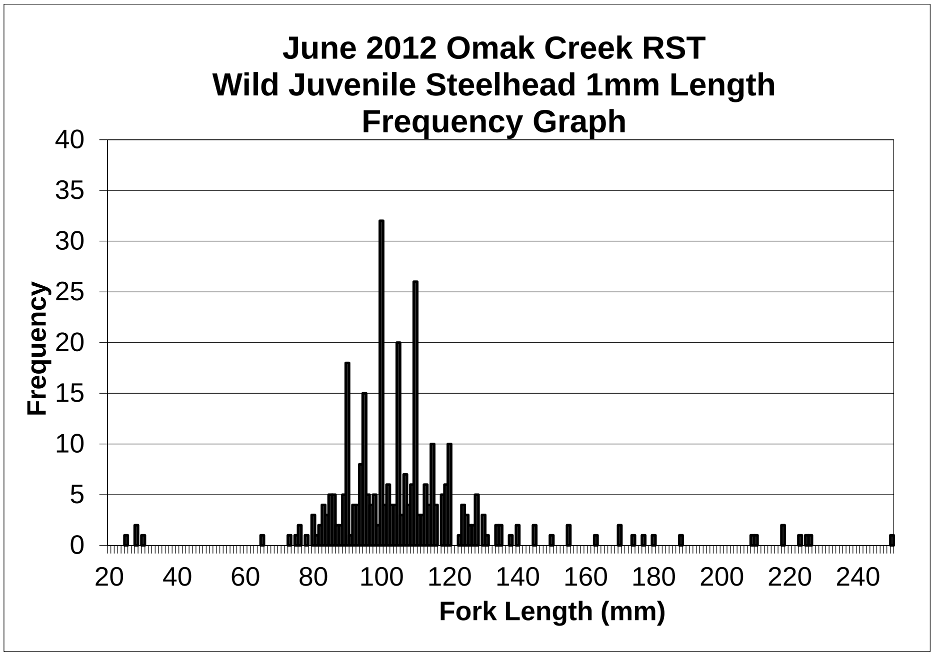
IX. Appendix A: Length frequency graphs for wild steelhead captured in the Omak Creek Rotary Screw Trap by month.






June 2012 Omak Creek RST
Wild Juvenile Steelhead 1mm Length
Frequency Graph
Frequency
0
5
10
15
20
25
30
35
40
20
40
60
80
100
120
140
160
180
200
220
240
Fork Length (mm)

X. Appendix B: Smolt Estimator Standard Measurement Methods Washington Department of Fish and Wildlife (WDFW) protocols in development of a Rotary Screw Trap (RST) smolt abundance estimator

Introduction

A recent review of the smolt monitoring program in the Wenatchee basin suggested changes in the calculations for estimating abundance and its associated variance. Calculation of daily and season smolt abundance changed only slightly. Major changes were made to the variance estimator making the calculations more complex. The following describes an Excel spreadsheet used for the calculation of the point estimate, variance, and standard error of seasonal smolt abundances that are based on regression relationships.

Efficiency estimates using regression

Worksheet: **Smolts – Regression Efficiency**

Estimation of abundance

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,

$$\hat{N}_i = \frac{C_i}{\hat{e}_i}, \qquad (1)$$

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

$$\arcsin\left(\sqrt{e_k^{obs}}\right) = \beta_0 + \beta_1 flow_k + \varepsilon, \qquad (2)$$

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.

In Equation 2, the observed trap efficiency, e_k^{obs}, is calculated as follows,

$$e_k^{obs} = \frac{r_k + 1}{m}. \tag{3}$$

Estimated variance of seasonal migration

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,

$$Var\left(\sum_{i=1}^{n} \hat{N}_i\right) = \underbrace{\sum_i Var\left(\frac{(C_i+1)}{\hat{e}_i}\right)}_{Part\ A} + \underbrace{\sum_i \sum_j Cov\left(\frac{(C_i+1)}{\hat{e}_i}, \frac{(C_j+1)}{\hat{e}_j}\right)}_{Part\ B}. \tag{4}$$

Part A of equation 4 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 $\hat{Var}(b_0 + b_1 flow_i) = M\hat{S}E\left(1 + \frac{1}{n} + \frac{(flow_i - \overline{flow})^2}{(n-1)s_{flow}^2}\right)$, 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.

Calculations in Excel

Calculating daily migration, seasonal migration, and the associated variance is mostly done automatically, once the information is input by the user.

Input Area

At the top of the spreadsheet is the area where all estimates of the trap efficiency model information is provided. Estimates are obtained from regression model output. Typical regression model summary in Excel looks like

SUMMARY OUTPUT				
Regression Statistics				
Multiple R	0.944191			
R Square	0.89149664			
Adjusted R Square	0.88732344			
Standard Error*	0.00591464	*This is the mean squared error SE. It gets squared		
Observations	28			
ANOVA				
	df	*SS*	*MS*	*F*
Regression	1	0.00747319	0.007473	213.6239
Residual	26	0.000909556	3.5E-05	
Total	27	0.008382747		
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.1850	0.0056	33.2362	0.0000
X Variable 1	-1.0241E-05	7.0068E-07	-14.6159	0.0000

The parameter estimates that go directly into the table are shaded in green. The inputs that are squared first, then go into the table are in orange.

The first row of the input table refers to the trap efficiency model being used. This is required so that calculations match to the correct values.

Model Inputs (parameter estimates)					
Model:		***Model:***		***Model:***	
Parameter	**Estimates**	**Parameter**	**Estimates**	**Parameter**	**Estimates**
Intercept	Intercept	**Intercept**		**Intercept**	
Var(Int)	Standard Error ^2	**Var(Int)**		**Var(Int)**	
Slope	X Variable 1	**Slope**		**Slope**	
Var(Slope)	Standard Error ^2	**Var(Slope)**		**Var(Slope)**	
MSE		**MSE**		**MSE**	
n (from regression)		**n (from regression)**		**n (from regression)**	
Mean Flow (regression)		**Mean Flow (regression)**		**Mean Flow (regression)**	
Sxx (regression)		**Sxx (regression)**		**Sxx (regression)**	

Intercept, Var(Int), Slope, and Var(Slope) are from the area of the output with Coefficient values. The MSE, mean squared error of the regression, can either be taken directly off the ANOVA table, or as the square of the Standard Error in the Regression Statistics table. The number of observations, *n*, is obtained from the Regression Statistics. The term Mean Flow the average of all flows used in the regression model, $\overline{flow}$, calculated as,\

$$\overline{flow} = \frac{\sum_{k=1}^{n} flow_k}{n}$$

Sxx refers to the sum of squares of the flow values used in the regression. It is calculated as,

$$Sxx = \sum_{k=1}^{n} \left(flow_k - \overline{flow} \right)^2 .$$

Other inputs are the date, trap efficiency model used, catch, and flow for the date. It is important that the "**Model"** field in the daily estimate area match the "***Model:"*** field in the Input area.

Daily estimates area: Inputs

Day Number	Date	**Model**	**Catch**	**Flow**

		(Estimator)		
1	21-Apr-10	Flood Position	153.00	5037
2	22-Apr-10	Flood Position	137.00	**6607**

Trap efficiency and daily abundances are calculated automatically from information provided in the Input area, and daily Catch and Flow information. Daily estimates are currently set to estimate up to 3 different models.

It is important that each model is grouped, i.e., a section for Model 1, then Model 2, etc.

Daily Abundance calculations

y - from the regresson	Efficiency (e_i)	**Daily Abundance - N_i**
0.137207682	0.018708105	8178.273335
0.122074959	0.014828416	9239.017541

Variance – Part A

Part A variance calculations are also done automatically from regression inputs, and daily catch and flow.

For Variance Calculations: Part A					
N_i - squared	Var(C_i)	(Flow - AveFlow)^2	(1-e_i)	Var(e_i)	**Total A**
66884154.74	0.00641367 3	7547348.3	0.981291895	0.00728904 4	916494.6033
85359445.12	0.00719103 3	1385902.8 8	0.985171584	0.00920405 8	1399475.9

Variance – Part B

Part B of the variance equation is much more complex. The part is calculated from a matrix of all pairwise covariances for a single model. The inputs for Part B are taken directly from the columns in the Daily Information section. Again, it is important that estimates obtained from the same model are grouped together. For the columns going down, copy and paste the appropriate information from the Daily information section into each area. For input rows going across the top, do copy the columns, the do "Paste Special > Transpose" for the top rows. Make sure that the information of each day number is the same in the columns as the rows, i.e., Day 1 with Day 1. The covariance of Part B is calculated as the sum of all cells for a particular model

Variance calculations: Covariance (Part B). Model dependent estimates, currently set up for 2 models.				Regression Model	Flood	Flood
				N_i - estimated	8231.7261	9306.46
				Flow	5037	**6607**
				(1-e_i)	0.98129189	0.985172
Regression Model	N_i - estimated	Flow	(1-e_i)	Day Number	1	2
Flood	8231.7261	5037	0.981291895	1	0.00E+00	1.34E+04
Flood	9306.45562	**6607**	0.985171584	2	1.34E+04	0.00E+00
Flood	22888.0569	**6208**	0.984227582	3	3.22E+04	4.04E+04

Results

Seasonal estimates by model, in total, and the associated variance and covariances are calculated in the Results area. Some fields in this section are calculated by hand and sums of other columns or entire areas. To obtain seasonal abundance estimates for a particulate model, sum all the Daily Abundances for that model in the appropriate field in the results areas. Same for the Part A variances. The Part B variance will actually be the sum of all values in the covariance matrix (array) that correspond to a particular model. This is why it is important to group models together.

Other results such as total seasonal abundance, total variance, upper and lower 95% and 90% confidence interval values, and the percent standard error are done automatically.

Results						
Abundance		**Variance**			**Standard Error**	**161,036**
Model 1	5,406,538	Model 1	Part A	15,979,850,577	***Lower 95% CI***	5,608,864
Model 2	517,957		Part B (Covariance)	7,756,650,207	***Upper 95% CI***	6,240,126
Model 3		Model 2	Part A	2,165,610,256	***Lower 90% CI***	5,659,590
Total	**5,924,495**		Part B (Covariance)	30,574,129	***Upper 90% CI***	6,189,400
		Model 3	Part A		***PSE***	2.72%
			Part B (Covariance)			
		Total	Part A	18,145,460,832		
			Part B (Covariance)	7,787,224,335		
		Total Variance		**25,932,685,168**		

Estimates when efficiency estimated using pooling by stratum

Worksheet: **Smolt – Pooled Efficiency**

In cases when there is no significant flow-efficiency relationship, i.e., low correlation, then a pooled, or average trap efficiency will suffice for the stratum. The estimator is calculated as follows,

$$\hat{\bar{e}} = \frac{\sum_{j=1}^{k} r_j}{\sum_{j=1}^{k} m_j}$$

where $\hat{\bar{e}}$ = the average or pooled trap efficiency for the stratum;

m_j = the number of smolts marked and released in efficiency trial *j* for the stratum;

r_j = the number of smolts recaptured out of m_j marked fish in efficiency trial *j*.

Abundance for a trapping period is estimated as,

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

and total stratum abundance is,

$$N^{pooled} = \sum_i \hat{N}_i^{pooled}.$$

The variance of season abundance takes into account the variability in catch numbers that are a result of binomial sampling (Part A), the pooled variance of trap efficiency, $\hat{\bar{e}}$ (Part B), and the covariance in daily estimates that arises from using a common estimate of efficiency across all trapping days (Part C),

$$V\hat{a}r\left(\sum_{i=1}^{n} \hat{N}_i^{pooled}\right) = \underbrace{\left(\sum_i \frac{\hat{N}_i\left(1-\hat{\bar{e}}\right)}{\hat{\bar{e}}}\right)}_{PartA} + \underbrace{\frac{Var\left(\hat{\bar{e}}\right)}{\hat{\bar{e}}^2}\sum_i \hat{N}_i^2}_{PartB} + \underbrace{\frac{Var\left(\hat{\bar{e}}\right)}{\hat{\bar{e}}^2}\sum_i\sum_j \hat{N}_i\hat{N}_j}_{PartC}.$$

The Part B and Part C terms are combined in the calculation as a new Part B

$$V\hat{a}r\left(\sum_{i=1}^{n} \hat{N}_i^{pooled}\right) = \underbrace{\left(\sum_i \frac{\hat{N}_i\left(1-\hat{\bar{e}}\right)}{\hat{\bar{e}}}\right)}_{PartA} + \underbrace{\frac{Var\left(\hat{\bar{e}}\right)}{\hat{\bar{e}}^2}\left[\sum_i \hat{N}_i^2 + \sum_i\sum_j \hat{N}_i\hat{N}_j\right]}_{PartB}.$$

The variance of $\hat{\bar{e}}$ is calculated as,

$$V\hat{a}r\left(\hat{\bar{e}}\right) = V\hat{a}r\left(\frac{\sum_{k=1}^{n} r_k}{\sum_{k=1}^{n} m_k}\right) = \frac{\sum_{k=1}^{n}\left(r_k - \hat{\bar{e}}_k m_k\right)^2}{\bar{m}^2 n(n-1)}$$

where $\overline{m}$ is the average release size across all efficiency trial, $\frac{\sum_{k=1}^{n} m_k}{n}$.

Calculations in Excel

This worksheet can be copied for each stratum. That is, it is a stratum specific worksheet. All results and calculations only apply to one stratum.

Estimating efficiency:

The section used to estimate efficiency is to the right. Because there will only be one stratum per worksheet, there will only be one efficiency estimate.

Data for each efficiency trial is entered into the appropriate column. The **Efficiency Estiamte** is calculated as the sum of **Recapture** divided by the sum of **Release Size** (number of fish released per efficiency trial). **Efficiency Estiamte** the stratum specific or pooled efficiency, $\hat{\hat{e}}$.

			Data for pooled efficiency calcluation			
Stratum (i)	**Efficiency Estiamte**		**Stratum (i)**	**Trial Number (j)**	**Release Size (m_ij)**	**Recapture (r_ij)**
	#DIV/0!		1	1		

Daily abundance

Estimates of daily abundance are calculated daily catch (or trapping period) divided by the stratum efficiency (pooled efficiency). Enter the stratum number, the day number for the stratum and the catch for that day. **Daily Abundance** should be calculated automatically. If not, it is just **Catch/ Efficiency estimate** (or just drag the first row down). The **Efficiency estimate** should also be the same in each row.

Stratum Number	**Day in Stratum**	**Efficiency estimate**	**Catch**	**Daily Abundance**

Total stratum abundance

Is calculated as the sum of **Daily Abundance** in the appropriate cells in **Stratum Totals.**

Sum Abundance	

Variance calculations

Part A

Part A of the variance is a function of .**Daily Abundance** and **Efficiency estimate** , summed across all days. For each day, part A of the variance is calculated in the appropriate cell, $\frac{\hat{N}_i\left(1-\hat{\bar{e}}\right)}{\hat{\bar{e}}}$.

For Part A Varinace
Part A - daily

Part A for the season is the sum of the values in this column; these cells are in the **Stratum Totals**

Part A variance	***Sum of values in For Part A Varinace***

Variance of efficiency

The variance of the pooled (stratum) efficiency is,

$$V\hat{a}r\left(\hat{\bar{e}}\right)=\frac{\sum_{k=1}^{n}\left(r_k-\hat{\bar{e}}_k m_k\right)^2}{\bar{m}^2 n(n-1)}.$$

And is calculated from efficiency trial data. The part of the worksheet "**For Var(e)"** calculates the trail-specific $\left(r_k-\hat{\bar{e}}_k m_k\right)^2$ term. Copy down the first row.

For Var(e)
(rij - ei*mij)^2
#DIV/0!

The total variance is calculated using from the sum of the **(rij - ei*mij)^2** column, the average release size across all trials, and the number of trial conducted. The following cells in the "**Stratum Totals"** area contain these data.

Number of efficiency trials (k)	Number of trials
Average Release size (mij_ave)	Calculated as "Average(N12 to end)"
Sum ((rij - ei*mij)^2)	Calculated as "Sum(Q12: end)"
Var (efficiency)	#DIV/0!

The variance of efficiency, **Var (efficiency),** is calculated automatically.

Part B – variance

Part B of the variance is calculated from the array. It is the sum of all terms in the array, $\left[\sum_i \hat{N}_i^2 + \sum_i \sum_j \hat{N}_i \hat{N}_j\right]$ time the variance of efficiency divide by efficiency- squared,

$$\underbrace{\frac{Var(\hat{\hat{e}})}{\hat{\hat{e}}^2}\left[\sum_i \hat{N}_i^2 + \sum_i \sum_j \hat{N}_i \hat{N}_j\right]}_{PartB}.$$

Inputs for the array are just daily abundance estimates and can be copied from column F. Cells in the array are calculated automatically. Fill in for all days in stratum.

	Columns	
	Stratum	
Rows:	**Daily Abundance**	**Copy from column F**

Stratum	Daily Abundance	Day in stratum	1	2	3
		1	0	0	0
	Copy from column F	**2**	0	0	0
		3	0	0	0

The **Sum of Array** cell is hand calculated by summing across all cells in the array. **Part B Variance** is calculated automatically.

Sum of Array	0
Part B Variance	#DIV/0!

The variance and standard error in the results section are also calculated automatically.

XI.

Appendix C (HSRG, 2009)

Hatchery Scientific Review Group

Review and Recommendations

Okanogan Summer Steelhead Population and
Related Hatchery Programs

Okanogan River Summer Steelhead

Okanogan River summer steelhead are considered part of the Upper Columbia River Steelhead DPS. This DPS includes all naturally-spawned anadromous steelhead populations below natural and man-made impassable barriers in the Columbia River Basin between the Yakima River and the U.S.-Canada border. Since June 2007, the DPS has been classified as endangered under the ESA. The Okanogan River population is considered an "Intermediate" population by the Interior Columbia Technical Review Team (ICTRT). An "Intermediate" steelhead population is one that must have a minimum abundance of 1,000 spawners and a S/S ratio of 1.2 to be viable.

There are no estimates of historical summer steelhead abundance in the Okanogan River subbasin. They were thought to have spawned in the mainstem Okanogan River as well as in Salmon and Omak creeks, and possibly the Similkameen River. Summer steelhead were also distributed throughout streams in the Canadian portion of the subbasin (UCSRB 2007).

Current Conditions

The UCSRB (2007) describes the life history status of Okanogan summer steelhead as follows:

Adults return to the Columbia River in the late summer and early fall. Unlike spring Chinook, most steelhead do not move upstream quickly to tributary spawning streams. A portion of the returning run overwinters in the mainstem reservoirs, passing over the Upper Columbia River dams in April and May of the following year. Spawning occurs in late spring of the calendar year following entry into the river. Currently, and for the past 20+ years, most steelhead spawning in the wild are hatchery fish. The effectiveness of hatchery fish spawning in the wild compared to naturally produced spawners is unknown at this time and may be a major factor in reducing steelhead productivity.

Juvenile steelhead rear from 1 to 3 years in freshwater and then adults spend 1 to 2 years in the ocean before returning to the Columbia River. Adult fecundity averages from 5,300 to 6,000 eggs per female.

Between 1967 and 2002, adult escapement to the Okanogan River ranged from 1 to 156 fish. The running 12-year geometric mean ranged from 11 to 64 adults over this same time period. At the time of listing, the 12-year geometric mean for adult abundance and productivity was 53 and 0.09, respectively. In 2005, the Colville Tribes reported over 300 steelhead redds in the U.S. portion of the subbasin. The majority of the adults are of hatchery origin. Dam counts over Zosel Dam indicate that wild fish escapement into Canada is less than 150 fish.

Steelhead currently spawn in Omak Creek, Similkameen River, mainstem Okanogan River, Salmon Creek and streams in the Canadian portion of the subbasin (UCSRB 2007). Habitat and hatchery actions are being implemented to increase spawning levels in Salmon Creek and Omak Creek.

2.1 Current Population Status and Goals

This section describes the current population, status, and goals for the natural population.

.. ESA Status: Endangered

.. Population Description: A mixed stock of hatchery and natural production; however, the run is dominated by hatchery-origin fish. The Okanogan River population is considered an “Intermediate” population by the ICTRT, which by definition must have a minimum abundance of 1,000 spawners and a S/S ratio of 1.2 to be viable. The HSRG has classified this population as Primary.

.. Recovery Goal for Abundance: 1,000 adults

.. Productivity Improvement Expectation: The Upper Columbia River recovery plan sets a 12-year geometric mean abundance and productivity target at 500 and 1.2 (S/S), respectively.

.. Habitat Productivity and Capacity: Productivity: 1.65; Capacity: 168

2.2 Current Hatchery Programs Affecting this Population

The primary hatchery programs most likely to affect the Okanogan summer-run steelhead population are discussed below:

1. Okanogan Similkameen Rivers (Wells Stock) Summer Steelhead. According to the HGMP, this is an integrated conservation and harvest program that may release 130,000 smolts (6 fpp) to three sites in the Okanogan River subbasin (mainstem Okanogan, Similkameen River, and Omak Creek). Fish are generally scatter-planted in the subbasin starting in April. In some years, fish have been acclimated in the Similkameen Chinook rearing pond. All juveniles released into the subbasin are adipose fin-clipped

2. Adults for the program are collected from the run at large at Wells Dam, not from the Okanogan River. Egg incubation and juvenile rearing occurs at the Wells Hatchery. The program has a R/S value of 20.

3. Cassimer Bar Steelhead: Approximately 20,000 juvenile summer steelhead are released into Omak Creek at 10-15 fpp. Fish are either acclimated in Omak Creek prior to release or are scatter-planted within the watershed. All incubation and rearing activities occurs at the Cassimer Bar Hatchery. Broodstock is collected at a weir on Omak Creek. The program has a R/S value of 20; however, this value is based on data collected for the Wells summer steelhead program. Adult returns are insufficient to develop a R/S value for the Cassimer Bar program due to the short time the program has been in operation (2004).

In the future, the Colville Tribe proposes to increase Cassimer Bar steelhead production to between 80,000 and 200,000 smolts, depending on the success of habitat restoration efforts in the subbasin. The Colville Tribe is also proposing to eliminate the Wells Hatchery program that releases 100,000 to 140,000 summer steelhead to the Okanogan River each year.

Initially, 80,000 smolts and a yet to be defined number of parr, will be released as part of an integrated conservation program for the subbasin. Also, an adult reconditioning program will be used to increase steelhead production. Broodstock will be collected at weirs located in key streams in the subbasin. The Cassimer Bar Hatchery will be upgraded to accommodate all hatchery operations.

In addition to the above-described programs, the WDFW summer steelhead program releasing fish in the Methow River also collects natural broodstock from the run-at-large passing Wells Dam.

Estimated number of hatchery strays affecting this population:

• Hatchery strays from integrated in-basin programs: 117 fish

• Hatchery strays from in-basin segregated and out-of-basin hatchery programs: 1,085 fish

HSRG Review

The HSRG has developed guidelines for minimal conditions that must be met for each type of program as a function of the biological significance of the natural populations they affect. For populations of the highest biological significance, referred to as Primary, the proportion of effective hatchery-origin spawners (pHOS) should be less than 5% of the naturally spawning population, unless the hatchery population is integrated with the natural population. For integrated populations, the proportion of natural-origin adults in the broodstock should exceed pHOS by at least a factor of two, corresponding to a proportionate natural influence (PNI) value of 0.67 or greater. For Contributing populations, the corresponding guidelines are: pHOS less than 10% or PNI greater than 0.5. It is important to note that these represent minimal conditions, not targets. For example, the potential for fitness loss when effective pHOS is 5% is significantly greater than it would be at 3%. For Stabilizing populations, we assume the current pHOS or PNI would be maintained.

The HSRG analyzed the current condition and a range of hatchery management options for this population, including the effect of removing all hatchery influence, and arrived at one or more proposed solutions intended to address the manager's goals consistent with the HSRG guidelines for Primary, Contributing, and Stabilizing populations. The solution included in the cumulative analysis is the last option described in the Observations and Recommendation box below.

In order to highlight the importance of the environmental context, two habitat scenarios were considered: current conditions and a hypothetical 10% habitat quality improvement.

See HSRG Observations and Recommendations in the box below for more information.

3.1 Effect on Population of Removing Hatchery

The No Hatchery scenario is intended to look at the potential of the natural population absent all hatchery effects with projected improved fish passage survival in the Snake and Columbia mainstem (FCRPS Biological Opinion May 5, 2008).

Our analysis estimated that Adjusted Productivity (with harvest and fitness factor effects from AHA) would increase from 0.7 to 1.8. Average abundance of natural-origin spawners (NOS) would decrease from approximately 76 fish to approximately 65 fish. The harvest contribution of the natural and hatchery populations would go from approximately 635 fish to approximately 9 fish.

3.2 HSRG Observations/Recommendations

In the Observation and Recommendation box below we describe elements of the current situation (Observations) that were important to evaluate the natural population and where applicable, the hatchery program(s) affecting that population. We also describe a solution (Recommendations) that appeared to be consistent with managers' goals; however, this is not the only solution. In some cases more than one solution is described.

Summary results of this analysis are presented in Table 1. The adjusted productivity values reported for each alternative incorporates all factors affecting productivity (i.e., habitat quality, hatchery fitness effects, and harvest rates).

Observations

The Managers have stated their goals for this program as; "Supporting the recovery of ESA listed species by increasing the abundance of natural adult populations, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity." (Goal statement adopted by Habitat Conservation Plan Committee, Hatchery Sub-Committee). To achieve this end the managers have identified a current mitigation goal of 130,000 smolts for release within the basin. Managers have identified Okanogan summer steelhead as an important population. For the purposes of this analysis, the HSRG assumed this population should be considered a Primary population. The Upper Columbia River Steelhead ESU is listed as endangered. The Okanogan population is one of four that are essential to the survival and recovery of this ESU.

This population cannot meet the standards for a Primary or Contributing population designation due to limited habitat capacity and productivity. Given the existing habitat productivity and capacity levels, it does not appear that Okanogan summer steelhead can be a self-sustaining population at this time. An integrated program to meet standards for a Contributing or Primary population is not possible under current habitat conditions.

Current steelhead management does not allow for differentiation of populations above Wells Dam. Broodstock for both the Methow and Okanogan River hatchery programs are currently collected at

Wells Dam with subsequent smolt releases occurring in both basins. Broodstock are currently collected at Wells Dam and are comprised of up to 33% natural-origin adults. Juveniles

are reared at Wells Hatchery and a proportion of the progeny of this aggregate broodstock is released into the Methow and a portion into the Okanogan. About 130,000 steelhead smolts are released into the Okanogan which are typically the result of hatchery by hatchery matings.
Hatchery-origin adults comprise approximately 90% of the spawning population. Currently there is no capability within the Okanogan subbasin to collect broodstock and manage adult composition on the spawning grounds other than at Omak Creek.

In addition to the Wells Hatchery program, there is a small integrated program (25,000 smolt release) using local broodstock from Omak Creek and a kelt reconditioning project at Cassimer Bar Hatchery. The Colville Tribes have plans to expand the integrated program to a total release of 200,000 smolts.

We understand that a number of habitat projects are being implemented that may allow this population to become self-sustaining.

Adult trapping in Omak Creek indicates that out-of-basin strays make up a high proportion of the natural spawning population.

Recommendations

The HSRG suggests that managers consider the ecological effect of outplants on this population. While outplants may not be having a detectable long-term genetic effect resulting from direct interbreeding with the natural population, the HSRG is concerned about the ecological effects of outplanted steelhead. They may be affecting overall survival and productivity of natural-origin steelhead considering Kostow's data for summer steelhead (Kostow 2003, 2004, 2005).
Consequently, the HSRG recommends that outplanting of hatchery steelhead be discontinued (or at least minimized) wherever facilities are not available to recapture returning adults that escape harvest.

All fish should be adipose fin-clipped unless they are being released to initiate new local broodstock or to achieve needed demographic benefits.

The HSRG recommends that the Okanogan population be managed using a phased transition approach, as described below. Hatchery facilities should be developed to provide within-basin full-term rearing to meet both conservation and fishery objectives. If this is not possible, long-term acclimation and adult recapture facilities should be developed within the subbasin. Control of out-of-basin hatchery steelhead also may be required.

Phase 1: Use adult returns from the existing Wells smolt release program and adults from the Colville's Omak Creek facility to develop a locally adapted hatchery population for release into the Okanogan subbasin. Reconditioned kelts also could be included in this broodstock.
Implement broodstock spawning protocols to maximize effective population size (factorial matings). As the locally adapted Okanogan hatchery population increases, phase out the Wells Hatchery releases. Collection of natural-origin adults at Wells Dam should be terminated and replaced with natural-origin fish collected from the Okanogan subbasin.

Phase 2: As benefits from planned habitat improvements occur, introduce steelhead from the locally adapted hatchery population into these habitats.

Phase 3: As habitat capacity and productivity increases and as the number of naturally-produced steelhead also increases, natural-origin adults should be incorporated into the hatchery broodstock in ever-increasing proportions to achieve a PNI greater than 0.67. Once the natural population abundance increases, more of the hatchery production could be used to provide harvest.