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2010 CALENDAR YEAR HATCHERY STEELHEAD REPORT:

IPC and LSRCP Monitoring and Evaluation Programs for the State of Idaho

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IDFG Report Number 11-12
April 2011

2010 Calendar Year Hatchery Steelhead Report: IPC and LSRCP Monitoring and Evaluation Programs for the State of Idaho

January 1, 2010—December 31, 2010

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LSRCP Agreement #: 14110-A-J008

IDFG Report Number 11-12
April 2011

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INTRODUCTION

This report summarizes the various components of hatchery steelhead monitoring and evaluation (M&E) activities associated with the Idaho Power Company (IPC) and Lower Snake River Compensation Plan (LSRCP) mitigation programs, which occurred in Idaho during the 2010 calendar year. Information is provided for steelhead from four rearing hatcheries and six broodstock collection sources operated by Idaho Fish and Game (IDFG) and the US Fish and Wildlife Service (USFWS).

Because this report summarizes information for a calendar year, data from multiple brood years are included. Brood year specific reports are produced annually by monitoring and evaluation staff and are available as IDFG reports at the following address: https://researchidfg.idaho.gov/Fisheries%20Research%20Reports/Forms/Show%20All%20Reports.aspx. Because of the five-year life cycle of steelhead and to allow for downriver harvest to be reported, the most recent brood year report available is current year minus seven.

Steelhead Broodstock Collection Facilities

The IPC and LSRCP mitigation programs utilize steelhead eggs collected from four hatchery weirs and two satellite facilities (Table 1, Figure 1, and Figure 2). It is important to note that none of the steelhead rearing hatcheries discussed in this report (see below) collect broodstock, but receive eggs and/or fry from off-site sources. Eggs collected from each broodstock source are managed as a unique stock within the hatchery programs, regardless of where smolts are released. In most cases, these egg collection operations are managed as segregated programs; one exception is the integrated program in the East Fork Salmon River (EFNAT).

Table 1. Broodstock collection facilities that provide steelhead eggs to the LSRCP and IPC mitigation hatcheries in Idaho.

Broodstock Collection Facilities	Stock Abbreviation	Mitigation Program
Dworshak National Fish Hatchery[1]	DWORB	USACOE
Oxbow Fish Hatchery	OXA	IPC
Pahsimeroi Fish Hatchery	PAHA	IPC
Sawtooth Fish Hatchery	SAWA	LSRCP
East Fork Satellite Facility[2]	EFNAT	LSRCP
Squaw Creek Temporary Weir[2]	USALB	LSRCP

[1] Dworshak National Fish Hatchery operates a steelhead mitigation program funded by the U.S. Army Corps of Engineers (USACOE) that is not included in this report.
[2] Satellite facilities operated by the Sawtooth Fish Hatchery.

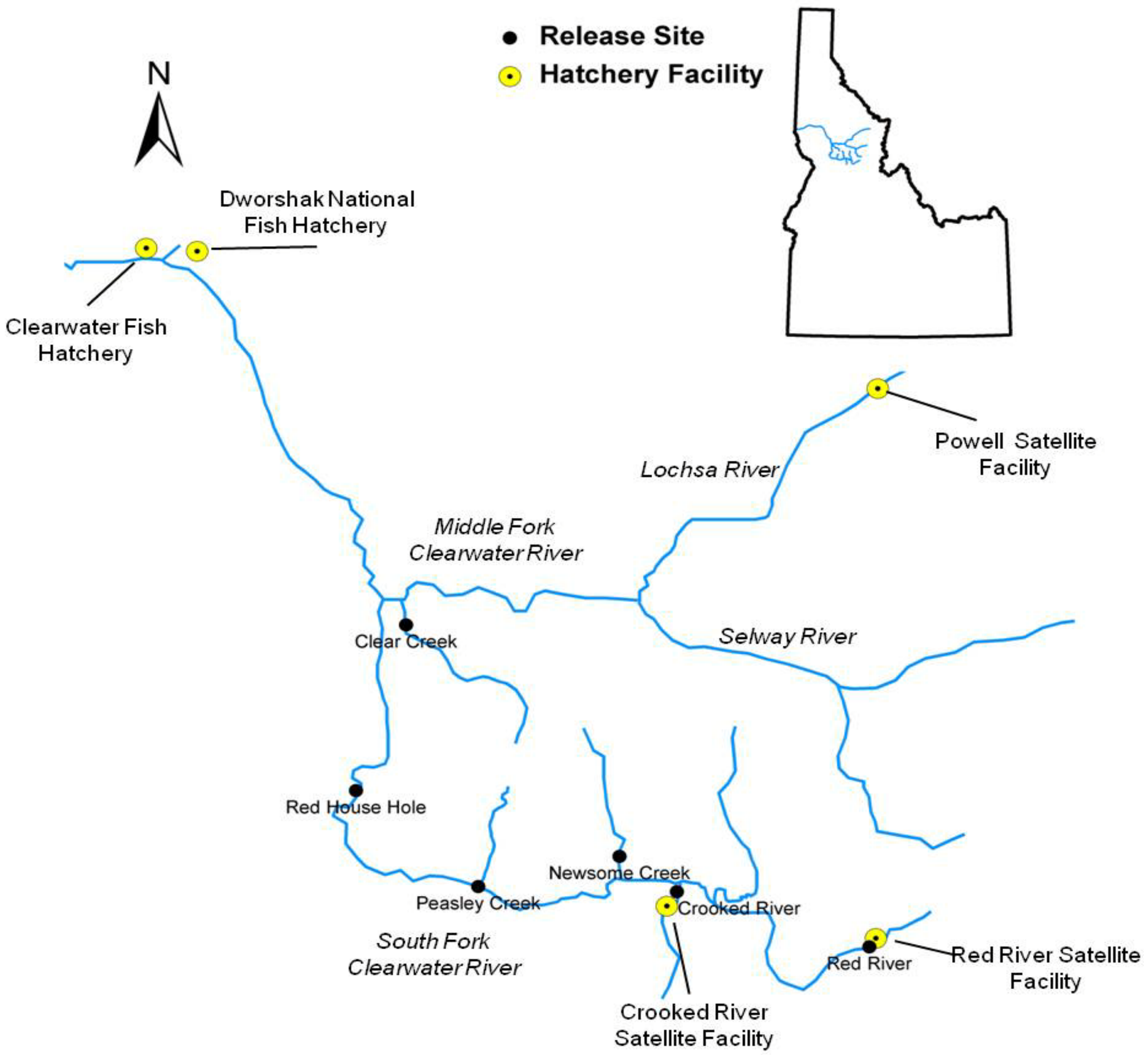

Figure 1. The location of steelhead release sites and hatchery facilities in the Clearwater River Basin associated with the LSRCP mitigation program.

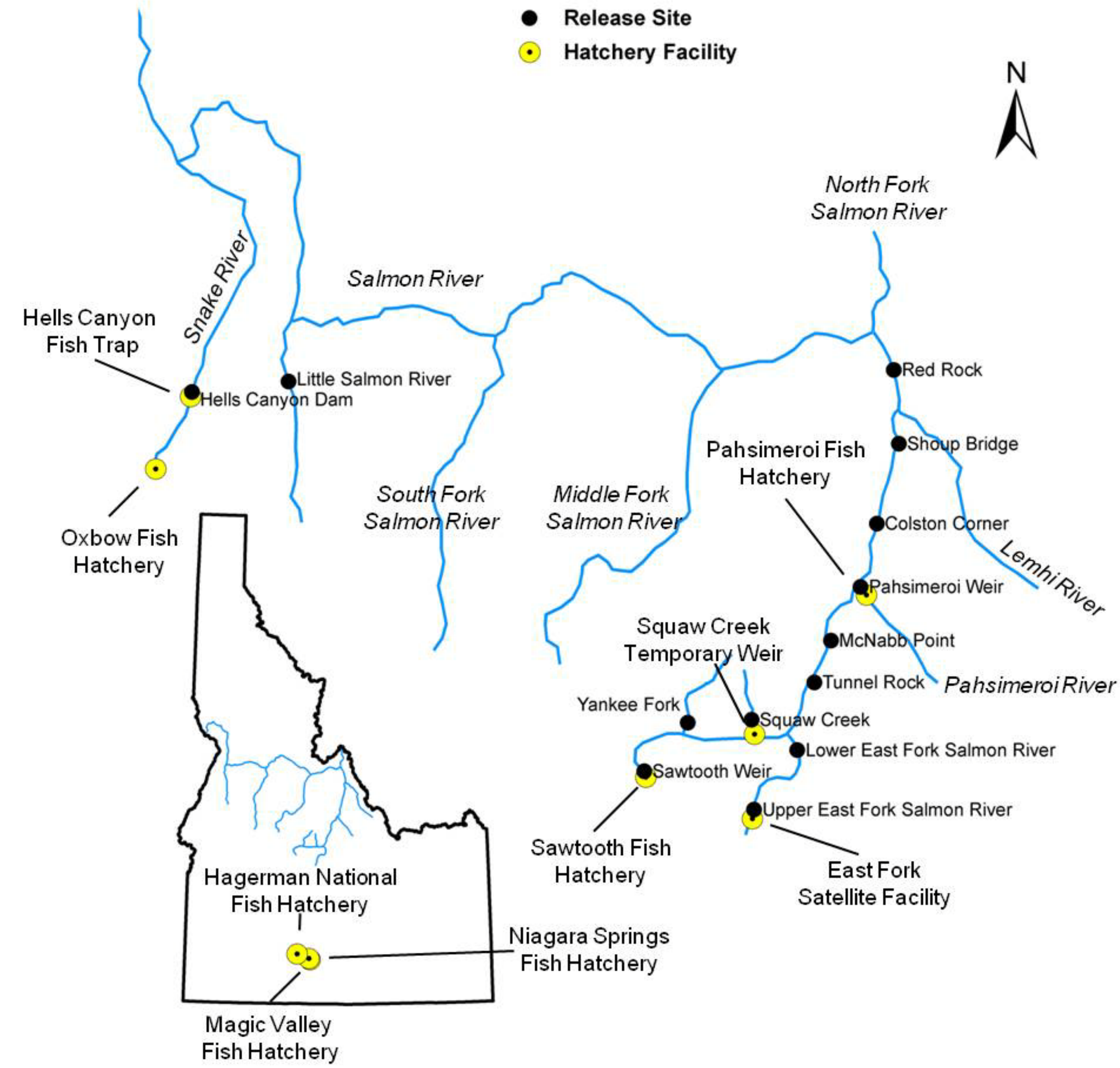

Figure 2. The location of steelhead release sites and hatchery facilities in the Salmon and Snake river basins associated with the LSRCP and IPC mitigation programs.

IPC Rearing Facilities

Niagara Springs Fish Hatchery (Niagara Springs) is located on the Snake River near Wendell, Idaho. Unlike other facilities, which receive only eyed eggs, Niagara Springs receives eyed eggs and fry from two stocks (OXA and PAHA). Steelhead produced at Niagara Springs are released in the Snake and Salmon rivers (Figure 2). The smolt production goal for Niagara Springs is 400,000 pounds of smolts annually, which equates to approximately 1,800,000 yearling smolts at 4.5 fish per pound.

LSRCP Rearing Facilities

Clearwater Fish Hatchery (Clearwater) is located at the confluence of the North Fork Clearwater River near Ahsahka, Idaho and is the only LSRCP steelhead rearing facility located in current day anadromous waters. Clearwater receives green eggs from one stock (DWORB) and rears them to yearling smolts for release into the South Fork Clearwater River (Figure 1). In 2010, an angler broodstock collection program was initiated in the South Fork Clearwater River near Peasley Creek to develop a locally adapted broodstock for the area (see "Development of Locally Adapted Broodstocks for Steelhead Programs in Idaho" in Research section). The annual mitigation goal for this facility is to return 14,000 adult steelhead to the project area above Lower Granite Dam. Clearwater annually releases 843,000 smolts to achieve this goal. Clearwater's annual production goal was originally 1,750,000 smolts; however, production was reduced to 843,000 smolts to provide more rearing space for the Chinook salmon program at that facility. Despite these changes, the adult return goal remains the same. In addition to its primary mitigation function, Clearwater also receives green DWORB eggs that are incubated to the eyed egg stage before being transferred to Magic Valley Fish Hatchery for final rearing and release into the Salmon River. Transferring DWORB eggs to Magic Valley will be phased out in the future as USALB, a B-run stock locally adapted to the Upper Salmon River, production increases.

Hagerman National Fish Hatchery (Hagerman National) is located along the Snake River in southern Idaho near the town of Hagerman, Idaho. Hagerman National receives eyed eggs from two stocks (SAWA and EFNAT), which are reared to yearling smolts and released in the upper Salmon River (Figure 2). In brood year 2009, Hagerman began rearing EFNAT smolts, which were released in 2010. Prior to this, EFNAT smolts were reared at Magic Valley. The annual mitigation goal for this facility is to return 13,600 adult steelhead to the project area above Lower Granite Dam. Hagerman National's annual production goal was originally 1,700,000 smolts; however, production has been reduced to 1,460,000 smolts in recent years due to limited water availability. Hagerman National's production capacity was again reduced in brood year 2010 to 1,360,000 smolts due to continued reductions in flow from the springs that provide water for the hatchery.

Magic Valley Fish Hatchery (Magic Valley) is located along the Snake River near Filer, Idaho. Magic Valley receives eyed eggs from four stocks (DWORB, PAHA, SAWA, and USALB), which are reared to yearling smolts. In brood year 2009, Magic Valley assumed responsibility for rearing all LSRCP funded DWORB and PAHA production released into the Salmon River in 2010. Prior to this a portion of these stocks were reared at Hagerman National. This change was prompted by recommendations from the USFWS Hatchery Review Team (HRT) and the Bonneville Power Administration-sponsored Hatchery Scientific Review Group (HSRG). The annual mitigation goal for this facility is to return 11,600 adult steelhead to the project area above Lower Granite Dam. Magic Valley's annual production goal was originally

1,749,000 smolts; however, production has been reduced to 1,600,000 in recent years due to limited water availability.

JUVENILE PRODUCTION AND RELEASES

Marking

All marks and tags that were applied to steelhead released in 2010 are outlined in Table 2. All marks and tags were applied by the Pacific States Marine Fisheries Commission (PSMFC) marking crew. For more information and a complete overview of the fish marking program, see "Idaho Anadromous Fish Marking Program." This report will be available through IDFG.

During calendar year 2010, various mark and loading plans were cooperatively developed to outline tagging and marking procedures in upcoming years. In May of 2010, a mark plan was developed that outlined preliminary mark and tag numbers for Brood Year 2011 steelhead. In November of 2010, both a Passive Integrated Transponder (PIT) Tag loading plan for Brood Year 2010 and a mark/Coded Wire Tag (CWT) loading plan for Brood Year 2011 were developed by M&E staff with input from hatchery staff and marking personnel. Loading plans are designed to indicate where specific groups of marks and tags should be applied at each individual hatchery taking into account family units, rearing containers, and any specific treatments of fish. Plans are developed in an effort to maximize tag representation while at the same time maintaining a manageable tagging and rearing scheme.

Under current operations, steelhead typically can receive an adipose fin clip (Ad clip) mark and two types of tags (CWT and PIT). The purpose and uses of those marks and tags are outlined below.

Adipose Fin Clips

The presence or absence of an Ad clip is used as the sole designator of hatchery or natural origin in Idaho sport fisheries and is also one of the primary indicators of origin at hatchery traps. Some non-Ad clipped hatchery fish are released to meet other management objectives. However, for adults that have intact adipose fins, fin erosion is used as an indicator to distinguish hatchery-and natural-origin fish when they return.

Coded Wire Tags

CWTs are an important tool for monitoring and evaluating steelhead post release, and are used to generate stock- and brood year-specific harvest and stray estimates outside of Idaho. These tags are also used to generate stock and age composition of mixed stock fisheries within the state of Idaho and provide a known age component at hatchery traps to use in assigning an age composition to the entire hatchery return at each trap.

Passive Integrated Transponder Tags

PIT tags serve multiple purposes and like CWTs are an important tool for monitoring and evaluating steelhead. PIT tags allow us to generate estimates of juvenile survival to Lower Granite Dam and juvenile run timing through the Snake and Columbia river hydropower system. In adult returns, PIT tags provide stock and age-specific estimates of return numbers to various dams, adult return timing through the hydropower system, adult conversions between dams, and rates of fallback/reascension and after-hours passage at the dams. All of these parameters are outlined in this report.

PIT-tagged steelhead go through the sort-by-code process where groups are assigned as 70% run-at-large (treated similarly to the untagged population) and 30% return-to-river (treated independently of the untagged population and automatically returned to the river, if detected). The 70% run-at-large component is used to generate adult return estimates because it represents the untagged population. The 30% return-to-river component is mainly used as a part of the ongoing Comparative Survival Study (CSS) (Comparative Survival Study Oversight Committee and Fish Passage Center 2007); however, they are also incorporated into juvenile survival estimates.

Release Information

From March through May 2010, yearling steelhead smolts were released at locations in the Clearwater, Salmon, and Snake rivers (Figure 1 and Figure 2). A total of 5,656,363 (1,789,795 IPC, 3,866,568 LSRCP) yearling smolts were released (Table 2). Release information was submitted to the Regional Mark Information System (RMIS) in August 2010.

Table 2. Summary of hatchery steelhead released in 2010.

Hatchery	Release Site	Stock	Total Release	AD	AD/ CWT	NONE	CWT	PIT Tag[1]
Clearwater	Clear Creek	DWORB	144,934	144,934				4,079
	Crooked River	DWORB	86,743			86,743		2,392
	Newsome Creek	DWORB	107,312			107,312		2,755
	Peasley Creek	DWORB	176,194	129,192	47,002			4,968
	Red River	DWORB	153,644			153,644		4,171
	Red House Hole	DWORB	186,133	114,554	71,579			5,237
	Clearwater Total		**854,960**	**388,680**	**118,581**	**347,699**		**23,602**
Hagerman National	Upper East Fork Salmon River	EFNAT	120,918			3,951	116,967	6,686[2]
	Sawtooth Weir	SAWA	797,057	718,976	78,081			12,775[2]
	Tunnel Rock	SAWA	66,418	47,300	19,118			928[2]
	Yankee Fork	SAWA	209,362	126,088	83,274			3,675[2]
	Yankee Fork	SAWA	218,078			218,078		3,525[2]
	Hagerman Total		**1,411,833**	**892,364**	**180,473**	**222,027**	**116,969**	**27,589**
Magic Valley	Colston Corner	PAHA	153,793	96,854	56,939			2,590
	Lower East Fork Salmon River	DWORB	306,949	246,829	60,120			5,576
	Little Salmon	DWORB	279,671	166,912	112,759			5,563
		PAHA	182,902	164,402	18,500			3,385
	McNabb Point	SAWA	117,883	60,731	57,152			2,097
	Pahsimeroi Weir	USALB	95,023			2,851	92,172	7,172
	Red Rock	PAHA	124,373	48,250	76,123			2,082
	Shoup Bridge	PAHA	61,562	42,570	18,992			989
	Squaw Creek	DWORB	277,619	217,561	60,058			3,285
	Magic Valley Total		**1,599,775**	**1,044,109**	**460,643**	**2,851**	**92,172**	**32,739**
Niagara Springs	Hells Canyon Dam	OXA	529,667	442,293	87,374			8,256
	Little Salmon	OXA	281,599	251,354	30,245			4,287
		PAHA	145,622	116,930	28,692			2,687
	Pahsimeroi Weir	PAHA	832,907	746,353	86,554			12,897
	Niagara Springs Total		**1,789,795**	**1,556,930**	**232,865**			**28,127**
	Grand Total		**5,656,363**	**3,882,083**	**992,562**	**572,577**	**209,141**	**112,057**

[1] PIT tag release numbers are not in addition to other mark tag combinations but are included in those groups.
[2] PIT tag release numbers have been corrected using fish pump array, see Research section.

Outmigration Survival and Environmental Conditions

Juvenile survival rates of PIT-tagged steelhead are estimated using the PitPro program (Westhagen and Skalski 2009) developed in the School of Aquatic and Fishery Sciences at the University of Washington. This program generates a point estimate and a standard error that is used to generate 95% confidence intervals. The program uses the Cormack-Jolly-Seber model (Cormack 1964; Jolly 1965; Seber 1965) for single release and multiple recapture events, which accounts for differences in collection efficiency at the mainstem Snake and Columbia river dams.

In general, juvenile survival was similar to previous years. Table 3 provides the juvenile survival estimates to Lower Granite Dam for the 2010 smolt releases. Table 4 shows a comparison of 2010 to the previous five years' survival estimates for each release group.

In an effort to provide managers with more information about juvenile outmigration conditions, M&E staff added environmental conditions to figures depicting smolt release timing and arrival timing at Lower Granite Dam for 2010. This information was distributed in-season to all hatchery managers. Appendices A-G provide juvenile release timing information and environmental conditions in the upstream migration corridor. Appendices H-N summarize arrival timing at Lower Granite Dam as well as spill and outflow that coincided with the migration period.

Table 3. Juvenile steelhead survival estimates and arrival timing to Lower Granite Dam in 2010.

Hatchery	Release Group	Stock	PIT Tagged Fish Released	Release Date	Size at Release (ffp)	Median Passage Date	80% Arrival Window (# Days)	% Survival (95% CI)
Clearwater	Clear Creek	DWORB	4,079	4/20-4/21	4.5	4/28	4/24 - 5/11 (17)	90.9 (80.7- 101.1)
	Crooked River	DWORB	2,392	4/14-4/15	4.5	5/18	4/30 - 5/30 (30)	72.2 (61.5 - 82.9)
	Newsome Creek	DWORB	2,755	4/15-4/16	4.5	5/2	4/24 - 5/24 (30)	78.8 (68.8 - 88.8)
	Peasley Creek	DWORB	4,968	4/19-4/21	4.5	5/2	4/26 - 5/19 (23)	89.0 (80.7 - 97.3)
	Red House Hole	DWORB	5,237	4/19-4/20	4.5	4/27	4/24 - 5/10 (16)	86.9 (79.0 - 94.8)
	Red River	DWORB	4,171	4/12-4/14	4.5	5/7	4/24 - 5/24 (30)	74.6 (66.1 -83.1)
Hagerman National	Upper East Fork Salmon River	EFNAT	6,804	5/3-5/4	4.3	5/24	5/19 - 6/7 (19)	70.9 (63.9 - 77.9)
	Sawtooth Weir	SAWA	12,936	4/13-4/30	4.3	5/7	4/27 - 5/27(30)	76.6 (70.6 - 782.6)
	Tunnel Rock	SAWA	934	4/12	4.6	4/23	4/29 - 5/24 (25)	67.6 (53.1 - 82.1)
	Yankee Fork	SAWA	7,258	5/5-5/12	4.6	6/5	5/21 - 6/17 (27)	72.0 (67.6 - 76.4)
Magic Valley	Colston Corner	PAHA	2,590	4/7-4/9	4.8	5/1	4/24 - 5/24 (30)	84.3 (73.8 - 94.8)
	Little Salmon River	DWORB	5,563	5/13-5/15	5.2	5/20	4/26 - 6/3 (38)	88.2 (81.4 - 95.3)
		PAHA	3,385	4/9-4/13	4.8	5/2	4/23 - 5/23 (30)	99.1 (88.3 - 109.9)
	Lower East Fork Salmon River	DWORB	5,576	4/16-4/21	5.0	5/21	5/2 - 6/2 (31)	72.9 (65.1 - 80.7)
	McNabb Point	SAWA	2,097	4/27-4/28	4.6	5/19	5/5 - 5/26 (21)	90.6 (73.3 - 107.9)
	Pahsimeroi Weir	USALB	7,172	4/28-4/29	4.6	5/21	5/12 - 5/27 (15)	84.3 (73.8 - 94.8)
	Red Rock	PAHA	2,082	4/5-4/7	4.7	4/29	4/24 - 5/23 (29)	77.9 (66.2 - 89.6)
	Shoup Bridge	PAHA	989	4/6	4.9	4/29	4/24 - 5/21 (27)	78.9 (59.0 - 98.8)
	Squaw Creek	DWORB	3,285	4/21-4/27	4.9	5/23	5/10 - 6/4 (25)	68.8 (59.2 - 78.4)
Niagara Springs	Hells Canyon Dam	OXA	8,256	3/23-3/29	4.7	5/27	5/6 - 6/5 (30)	93.4 (86.2 - 100.6)
	Little Salmon River	OXA	4,287	4/6	4.6	5/16	4/24 - 6/3 (40)	88.7 (79.7 - 97.7)
		PAHA	2,687	4/9	3.8	5/3	4/23 - 5/23 (30)	98.9 (85.0 - 112.8)
	Pahsimeroi Weir	PAHA	12,897	4/16-4/26	3.9	5/14	4/29 - 5/24 (20)	94.6 (86.8 - 102.4)

Table 4. Estimated percent survival of juvenile hatchery steelhead to Lower Granite Dam from migration years 2005 through 2010.

Hatchery	Release Site	Stock	2005[1]	2006[1]	2007[1]	2008	2009	2010	Average (05-09)
Clearwater	Clear Creek	DWORB						90.9	
	Crooked River	DWORB	85.2	74.9	81.5	64.1	58.4	72.2	72.8
	Newsome Creek	DWORB						78.8	
	Peasley Creek	DWORB					88.3	89.0	88.3
	Red House Hole	DWORB	88.1	84.8	86.5	82.4	92.9	86.9	87.0
	Red River	DWORB	80.3		73.9	59.5	71.6	74.6	71.3
Hagerman National	Upper E. F. Salmon River	EFNAT[2]				78.2	71.8	70.9	75.0
	Sawtooth Weir	SAWA	76.9	78.6	61.3	86.2	83.7	76.6	77.3
	Tunnel Rock	SAWA				78.4	85.2	67.6	81.8
	Yankee Fork	SAWA	69.6	69.7	56.3	83.3	73.3	72.0	70.4
Magic Valley	Lower E. F. Salmon River	DWORB			94.2	76.6	81.5	72.9	84.1
	Little Salmon River	DWORB	81.3	72.6	82.6	85.3	80.9	88.2	80.5
		PAHA[3]	80.9	40.7	91.8	93.8	90.8	99.1	79.6
	Pahsimeroi Weir	USALB[4]			69.9	78.7	73.5	84.3	74.0
	Colston Corner	PAHA	79.6	92.8	80.6	85.0	81.8	84.3	84.0
	McNabb Point	SAWA	71.3	86.3	79.9	79.8	84.9	90.6	82.4
	Red Rock	PAHA		80.8	92.0	81.5	81.2	77.9	83.9
	Shoup Bridge	PAHA				81.6	85.8	78.9	83.7
	Squaw Creek	DWORB	62.0	71.2	69.5	70.7	75.2	68.8	69.7
Niagara Springs	Hells Canyon Dam	OXA	73.6	75.3	76.6	85.4	88.1	93.4	79.8
	Little Salmon River	OXA	66.0	3.7	90.2	92.7	90.4	88.7	68.6
		PAHA	82.2	46.1	105.6	84.8	94.1	98.9	82.6
	Pahsimeroi Weir	PAHA	76.9	79.9	137.1	83.7	88.8	94.6	93.3

1 Prior to 2008 (2009 for Niagara Springs), PIT tag sample sizes were small, resulting in spurious point estimates.
2 Prior to release year 2010, EFNAT smolts were reared at Magic Valley Fish Hatchery.
3 Prior to release year 2010, the PAHA smolts released into the Little Salmon River were reared at Hagerman National.
4 Prior to release year 2010, the USALB smolts were released at Squaw Pond or Squaw Creek.

ADULT RETURNS

Adult hatchery steelhead from brood years 2007, 2006, and 2005 returned to Idaho during the 2009-2010 run as one-, two-, and three-ocean adults, respectively. This section accounts for adult hatchery steelhead returning to Bonneville Dam, Lower Granite Dam, and back to hatchery traps in Idaho.

Returns to Bonneville and Lower Granite Dams

The one-ocean component of the 2009/2010 steelhead run (brood year 2007) was the first age class to be PIT tagged in sufficient quantities to allow for relatively accurate adult return estimates for LSRCP releases. Adult return estimates cannot be made for Niagara Springs (IPC mitigation program) because PIT tagging rates were not increased until brood year 2008 for this facility. The Sawtooth Weir release from Hagerman National is corrected post-season using tagged to untagged ratios obtained from in-ladder PIT tag arrays at the release site (see "Estimating a Correction Factor for PIT Tag Expansions in Steelhead Returning to Sawtooth Fish Hatchery Trap" in Research section). The remaining return estimates that are not corrected post-season are likely an underestimate of actual returns due to decreased PIT tagged to untagged ratios between release and return. Adult return estimates were generated for steelhead at Bonneville Dam from 3 March through 11 November 2009 and Lower Granite Dam from 27 April 2009 through 30 March 2010. It is important to note, these date ranges may extend beyond dates identified for other management purposes, such as dates used by the US v. OR Technical Advisory Committee. Table 5 summarizes the expanded adult return estimates for each rearing hatchery by stock; these estimates were corrected for detection efficiency, which was high for all dams (>99%).

Table 5. Summary of expanded one-ocean (brood year 2007) hatchery steelhead PIT tag return estimates for the 2009/2010 run. Estimates are corrected for detection efficiency.

		Adult Return Estimate			
Hatchery	**Stock**	**Bonneville**	**McNary**	**Ice Harbor**	**Lower Granite**
Clearwater	DWORB	1,080	700	682	632
	Clearwater Total	**1,080**	**700**	**682**	**632**
Hagerman	DWORB	573	438	377	315
National	PAHA	11,556	9,763	9,159	8,829
	SAWA[1]	57,848	43,849	42,721	40,360
	Hagerman Total	**69,977**	**54,049**	**52,257**	**49,504**
Magic Valley	DWORB	886	700	674	565
	EFNAT	1,109	836	831	829
	PAHA	20,894	17,464	16,449	15,866
	SAWA	14,669	12,407	11,407	11,220
	USALB	199	144	129	143
	Magic Valley Total	**37,757**	**31,551**	**29,490**	**28,623**
	Grand Total	**108,813**	**86,301**	**82,428**	**78,759**

[1] Adult return estimate for SAWAs returning from the Sawtooth Weir release were adjusted based on adult return rates at rack, see "Estimating a Correction Factor for PIT Tag Expansions in Steelhead Returning to Sawtooth Fish Hatchery Trap" in research section.

Conversion Rates Between Dams

Using one-ocean returning PIT-tagged steelhead, conversion percentages were calculated for each stock. For the purposes of this report, interdam conversion represents all loss between dams (harvest, strays, mortality).

Table 6 summarizes the conversion rates of one-ocean steelhead from Bonneville Dam to McNary Dam and Lower Granite Dam. EFNAT, PAHA, and SAWA steelhead (A-run type stocks) had similar conversion patterns between dams, whereas the conversion rates of DWORB and USALB steelhead (B-run type stocks) appears to be more variable, particularly between Bonneville Dam and McNary Dam. It is important to note that the conversion estimates apply only to the one-ocean component of the B-run steelhead return and that the conversion rates for two-ocean B-run fish may be lower due to their larger size, which makes them more susceptible to harvest by recreational and tribal fisheries. Furthermore, sample sizes of one-ocean fish from B-run type stocks are small due to the relatively low number of one-ocean adults (< 20% of a brood); therefore, there is likely more error associated with conversion rate estimates for one-ocean fish from B-run type stocks.

Table 6. Conversion percentages of one-ocean (Brood Year 2007) PIT-tagged hatchery steelhead through the Columbia and Snake river hydropower system during the 2009/2010 run. Estimates are corrected for detection efficiency. DWORB adults are grouped into the basin in which they were released.

Stock	Bonneville to McNary	Bonneville to Lower Granite
DWORB (Clearwater)	64.9	58.5
DWORB (Salmon)	78.0	60.3
EFNAT	75.4	74.8
PAHA	83.9	76.1
SAWA	77.6	71.1
USALB	72.3	71.7

Run Timing

Run timing curves for one-ocean fish were generated at Bonneville Dam, Lower Granite Dam, and hatchery traps by graphing the cumulative percentage of return vs. return date. For returns to Bonneville and Lower Granite dams, PIT tag detections were used to generate stock specific timing curves for adult hatchery-origin fish. The run timing difference between A-run and B-run type stocks is clearly visible at Bonneville Dam in Figure 3; B-run stocks (DWORB and USALB) arrive later than A-run stocks (EFNAT, PAHA, and SAWA). This difference in run timing becomes less pronounced at Lower Granite Dam; however, B-run stocks do arrive slightly later than A-run stocks (Figure 4).

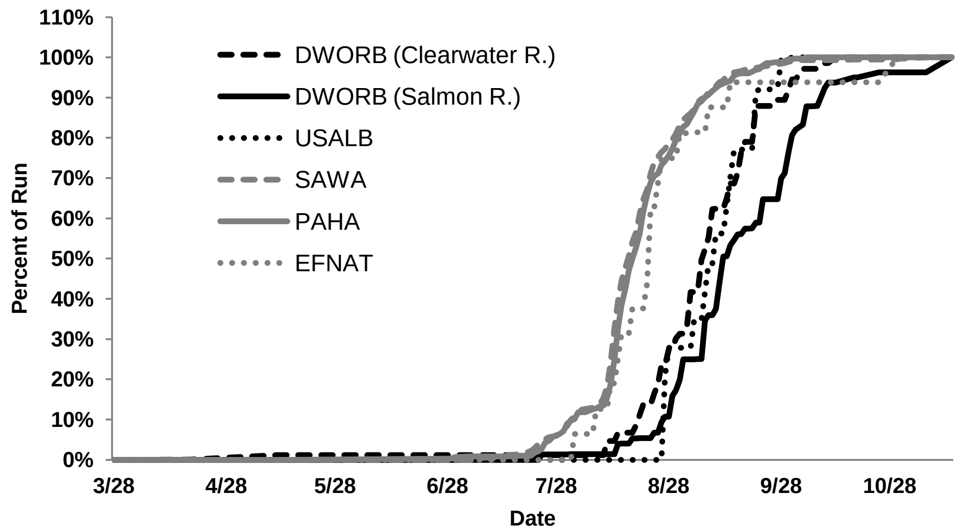

Figure 3. Run timing of one-ocean (brood year 2007) hatchery steelhead at Bonneville Dam based on PIT tag detections during the 2009/2010 run. DWORB adults are grouped into the basin in which they are released.

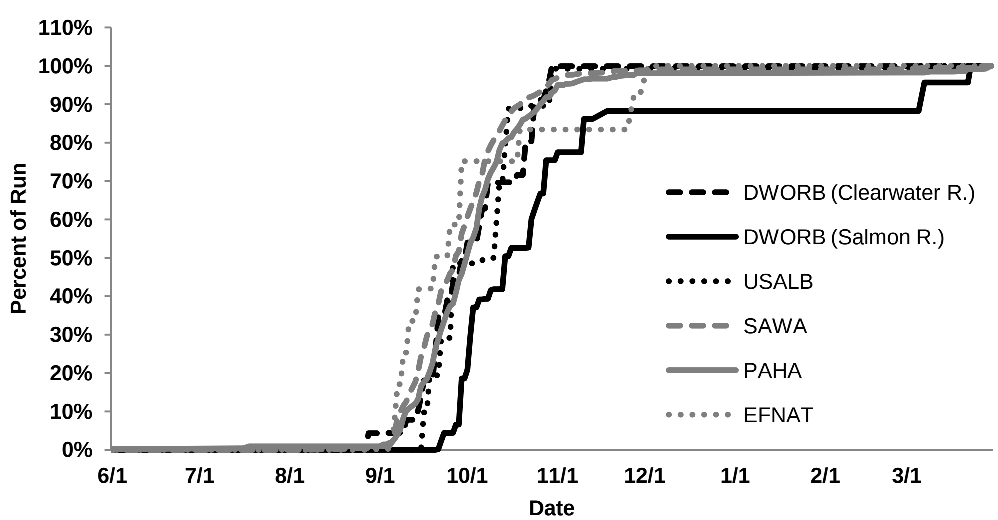

Figure 4. Run timing of one-ocean (brood year 2007) hatchery steelhead at Lower Granite Dam based on PIT tag detections during the 2009/2010 run. DWORB adults are grouped into the basin in which they are released.

For returns to hatchery traps, daily trapping numbers were used to summarize the run timing for hatchery- and natural-origin fish. Arrival timing at Crooked River, Powell, and Red River satellite facilities, as well as the Squaw Creek temporary weir, was not included due to the low number of adults returning. Figures 5 and 6 summarize the run timing of steelhead returning to hatchery traps in the upper Salmon River, which is similar to previous years for all traps (IDFG unpublished data).

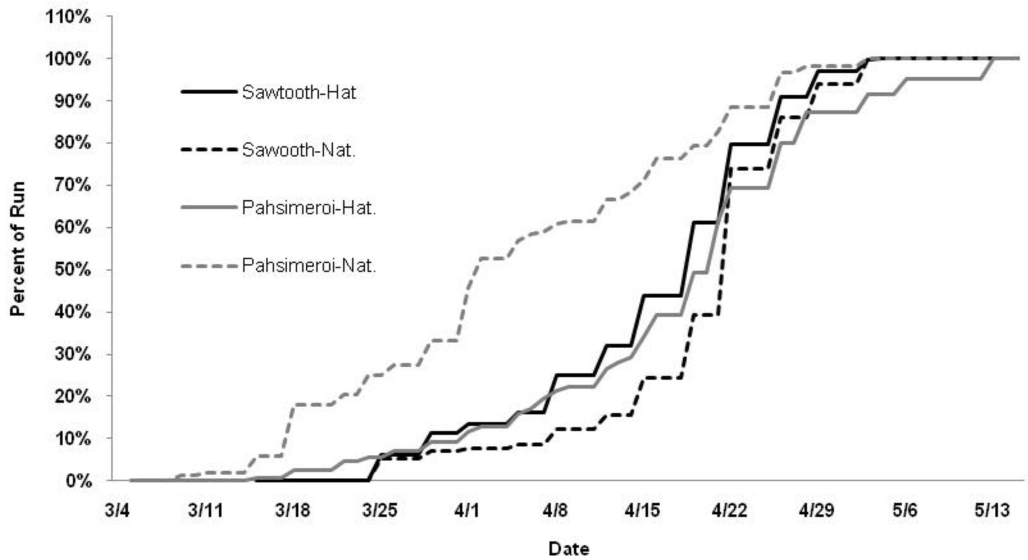

Figure 5. Run timing of adult hatchery and natural steelhead returning to the Pahsimeroi and Sawtooth traps, two major broodstock collection facilities, in 2010.

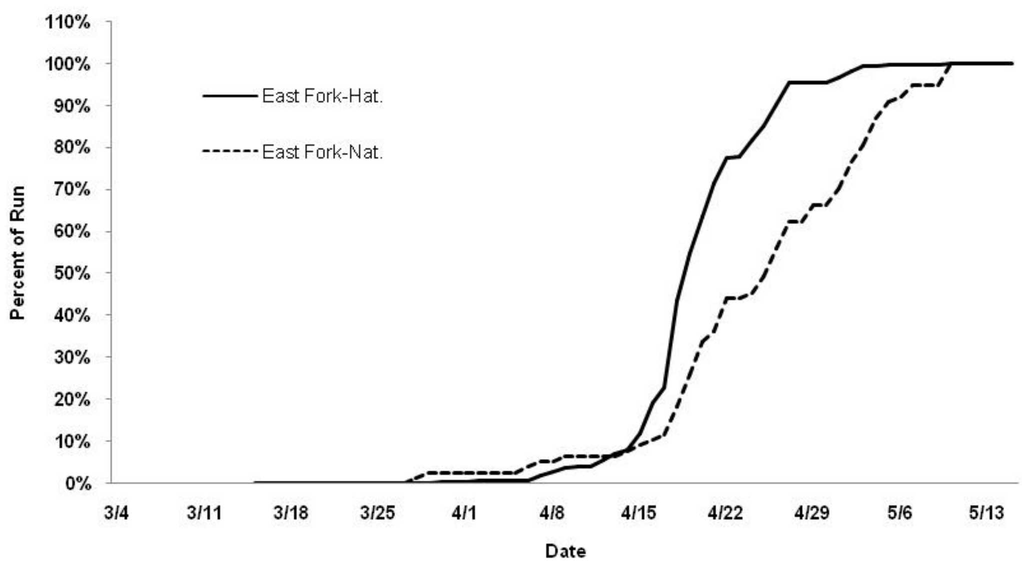

Figure 6. Run timing of adult hatchery and natural steelhead returning to the East Fork Satellite Facility, the broodstock collection source for the integrated East Fork Natural Program, in 2010.

Hatchery Trap Returns

Steelhead that escaped fisheries were collected at hatchery weirs and traps where they were enumerated and processed. We estimated the age composition of adults returning to individual hatchery facilities by one of three methods, depending on the availability of known age information (CWTs) recovered from returning adults. In cases where enough known age information is available, the statistical computer program *R* (R Development Core Team 2010) was used with the *mixdist* library package (Macdonald 2010) to estimate the proportion of each age group that was used to calculate the size of each age class. *Rmix*, as it is called, was designed to estimate the parameters of a mixture distribution with overlapping components, such as the overlapping length distributions associated with adult steelhead returns composed of multiple age classes, and applies the maximum likelihood estimation method to a population based on a known-age subsample. If known age information was lacking, then age composition was estimated using the NORMSEP feature in the FAO-ICLARM Stock Assessment Tools (FiSAT) II software (Gayanilo et al. 2005). This method also applies the maximum likelihood concept and provides an estimated proportion of fish for each age class that is used to calculate the size of each age class. In some cases where neither program could be used because of few returning adults, an age was assigned after reviewing length frequencies. A summary of adults trapped by age is shown in Table 7.

Table 7. Age composition and average fork length (cm) of adult steelhead returning to hatchery traps in 2010.

		Males				Females				
		One-ocean		Two-ocean		One-ocean		Two-ocean		
Rack	Origin	Num.	Avg. Len.	Num.	Avg. Len.	Num.	Avg. Len.	Num.	Avg. Len.	Total Return[1]
Crooked	H	15	68.5	19	80.7	-	-	1	76	35
River	N	8	65.8	24	83	-	-	6	80.3	38
Powell	N	1	65	-	-	-	-	-	-	1
Red River	N	1	66	1	88	-	-	-	-	1
East Fork	H	376	60.9	5	71.9	116	60.2	21	66.8	518
	N	35	60.8	1	84	12	59.7	13	73	61
Pahsimeroi	H	6,485	60.1	202	69.3	7,735	58.6	1,010	67	15,432
	N	79	58.9	10	81.8	47	58.5	21	69.6	157
Sawtooth	H	3,427	61.1	118	72.5	2,272	59.7	788	68	6,605
	N	51	61.6	8	73.5	32	59.6	24	67.8	115
Squaw	H	3	63.5	12	80	-	-	19	75.5	34
Creek	N	5	59.8	-	-	3	58	3	68.6	11
Hells Canyon	H	2,652	63.5	268	69.5	2,247	58.9	544	67.5	5,711

[1] Although a small percentage of steelhead reside in the ocean for three years, none were observed at hatchery racks in 2010.

CWT Processing and Data Submission

The CWT laboratory is up-to-date in extracting and processing steelhead CWT recovery information for submittal to RMIS. The CWT laboratory processed all 2,243 steelhead snouts collected in 2010. Pursuant to RMIS guidelines, steelhead recovery information from the 2009/2010 steelhead run was submitted to RMIS in January 2011.

Table 8. Summary of CWT recovered in Idaho from steelhead in 2010 by recovery type.

Recovery Type	Number
Creel	1,109
Hatchery Trap	1,134
Total	**2,243**

RESEARCH

Evaluating the Ability to Recover Shed PIT Tags in Hatchery Raceways

With PIT tagging rates increasing in recent years to estimate adult hatchery steelhead returns, the need to accurately report PIT tag release numbers has been elevated. In the past, the number of PIT tags recovered in rearing vessels (sheds or mortalities) was subtracted from the number of fish initially tagged to determine the number of PIT-tagged fish released. This approach seemed reasonable but was dependent on the efficiency of recovering PIT tags, particularly shed tags. In 2010, two evaluations were conducted to determine how effective hatchery crews are at recovering shed tags.

In a blind test, PIT tags were seeded in raceways at Hagerman National to evaluate how effective magnetic “sweepers” were at recovering shed PIT tags in 2010. Twenty-five PIT tags were placed at the bottom of four raceways (100 tags total) without the knowledge of hatchery staff. After two days, staff used magnetic “sweepers” to try to manually recover shed PIT tags as part of their regularly scheduled duties. None of the seeded PIT tags were recovered. The staff were then informed of the test and diligently tried to find the seeded PIT tags with no success. Weeks later, at least 30% of the planted PIT tags were detected in the fish pump array (see below) and/or at the dams in the Snake and Columbia river hydropower system, indicating a substantial number of planted tags had been ingested. This is a minimum estimate, as not every raceway was scanned with the fish pump array, and detection efficiencies of juvenile steelhead in the Snake and Columbia river hydropower system are low. Other potential explanations for the inability to recover the seeded PIT tags in the raceways include the magnets not being powerful enough to attract tags, as well as some tags passing through the raceway prior to recovery efforts. While plausible, these explanations would likely account for few PIT tags because the same magnetic sweepers have collected shed tags from raceways in the past and the low water velocity, as well as the short period between seeding and recovery, make it unlikely that tags exited the raceway prior to recovery attempts. Therefore, the consumption of PIT tags likely accounts for the majority of unrecovered seeded tags.

A similar evaluation was done at Niagara Springs to assess a passive technique of recovering shed PIT tags within a raceway using stationary magnets. Due to the size of the raceways, the use of a magnetic “sweeper” is not practical and has not been employed as a method of PIT tag recovery at Niagara Springs. As an alternative to actively sweeping the raceways for tags, two magnetic strips were placed in each of two separate raceways prior to PIT tagging in January and left in place until release in March and April. The two magnetic strips were placed five and 15 feet from the tail screens in the two raceways in an effort to collect shed tags as they moved through the raceways. The magnetic strips spanned the full width of the raceways and were heavy enough to remain in place throughout the evaluation. The magnetic strips were removed and inspected daily by the hatchery crew and any tags found on the magnets were reported. Before installation, the magnetic strips were tested to ensure that they were powerful enough to attract a PIT tag. One month after installation, no PIT tags were recovered from the magnets. At that time it was decided to “seed” the raceways with 25 PIT tags each, without knowledge of the hatchery staff. In the two months following the PIT tag “seeding,” only four out of the 50 PIT tags were ever recovered. It is important to note that all of the tags recovered on the magnets were “seeded” in the two raceways and that none of the roughly 9,000 tags implanted in fish in the two raceways were recovered. The results of this evaluation are unclear but several possible explanations exist. These explanations include: 1) the magnets may not have been powerful enough to hold PIT tags for long periods of time, 2) the velocity in the raceways suspended tags in the water column and did not allow PIT tags to move along the bottom of the raceways, or 3) in light of the aforementioned study, fish may be ingesting the tags and therefore the tags are unrecoverable. Though the last explanation seems to be the most plausible given the results from the Hagerman National study, unlike that study, none of the seeded PIT tags were detected at any of the lower Snake or Columbia river dams.

Evaluation Of An Alternative Method To Estimate The Number of PIT Tagged Fish Released

A fish pump PIT tag array with multiple antennas was tested to determine if it was a viable option to more accurately report PIT-tagged fish release numbers at Hagerman National. The array was comprised of four FS2001F-ISO PIT tag readers, each having a round 11-inch pass-through antenna. Antennas were arranged on the intake line of the fish pump and spaced approximately one meter apart to minimize interference. These readers were connected to a laptop computer that recorded detections from each antenna.

All steelhead from 13 of the 21 raceways that contained PIT-tagged fish passed through the fish pump PIT tag array as they were loaded onto transport trucks. Detection efficiency of the array was estimated for each raceway using PIT tag detections at the dams in the Snake and Columbia river hydropower system. Overall, the detection efficiency of the array was high and averaged 91.7%; however, raceways with high PIT tag densities generally had lower efficiencies (Table 9). These detection efficiencies were then used to adjust the estimated number of PIT tags released from each raceway. The adjusted release numbers accounted for 98.6% of the tags known to be in the raceways (number originally tagged minus mortalities and sheds). It is interesting to note the tags unaccounted for by the array represent 1.4% of the tags in the raceways, which is similar to the 1.3% shed rate observed in a controlled experiment at Hagerman National (Hagerman National Hatchery Evaluation Team 2010). However, the fate of the unaccounted tags is uncertain. If tags were shed and subsequently consumed, they should have been detected by the array. Other more plausible explanations include tags were shed and exited the raceways, as well as error associated with our methods used to adjust release numbers based on detections at the dams.

The results of the fish pump array were very encouraging in that the array detected a high proportion of tags that exited the raceway and will be continued in 2011. However, there still remains the question of what the impact of ingested PIT tags will have on PIT tag release numbers used to estimate adult returns.

Adult return estimates should not be substantially affected by ingested PIT tags because the occurrence of shed tags, which are consumed by other fish, is very low. Given the PIT tag shed rate of 1.3% observed at Hagerman National in a controlled experiment, if all shed tags were ingested by fish it would have a negligible effect on the expansion rate used to estimate adult returns. For example, the Sawtooth Weir release group from brood year 2009 had an expansion rate of 88.7 untagged fish per run-at-large PIT-tagged fish, based on detection in the fish pump PIT tag array. If a PIT tag shed rate of 1.3% was applied and all PIT tags were assumed to have been ingested, the expansion rate would increase to 89.9. The difference between these values is negligible and would be accounted for in the error bounds of the adult return estimate.

Table 9. Summary of results for the fish pump PIT tag array used at Hagerman National in 2010. Array efficiency was estimated using detections at the dams in the Snake and Columbia river hydropower system.

Raceway	Total Fish In Raceway	# Fish PIT Tagged[1]	Array Detections	Array Efficiency (%)	Adjusted Release Numbers	Unaccounted Tags
41	24,356	1,171	1,152	99.3	1,160	11
44	24,793	1,182	1,105	98.0	1,127	55
47	19,789	1,167	1,064	92.7	1,148	19
50	21,634	1,132	1,070	98.1	1,091	41
53	22,002	1,207	1,126	96.7	1,164	43
59	22,825	1,146	1,076	93.9	1,146	0
65	20,001	1,158	1,048	94.1	1,114	44
82	21,402	1,116	1,030	89.9	1,146	-30
85	21,110	1,208	1,045	87.7	1,191	17
92	21,162	1,224	1,062	91.4	1,162	62
96	21,167	923	872	92.2	946	-23
99	17,889	2,139	1,792	87.2	2,055	84
101	15,288	2,296	1,700	71.3	2,384	-88

[1] Number of tagged fish minus recovered mortalities and shed tags.

<u>Development of Locally Adapted Broodstocks for Steelhead Programs in Idaho</u>

Upper Salmon B-run Program

Since 2002, large two-ocean steelhead of DWORB ancestry have been collected at a temporary weir at Squaw Creek in an effort to develop a locally adapted B-run stock for the Upper Salmon River. The progeny of these adults (USALB) were then released in Squaw Creek along with additional DWORB smolts. These stocks were differentially tagged (CWT) to evaluate stock performance. In 2009, these results were reviewed and it was determined that the USALB stock had greater performance (adult survival) than the DWORB smolts released at the same location (IDFG unpublished data). Based on those results, managers have decided to make substantial changes to the Upper Salmon B-run program in an effort to increase adult collection and ultimately USALB smolt production. The goal is to phase out DWORB smolt releases in the Salmon River and replace them with locally adapted USALB smolts. Phasing out DWORB releases in the Salmon River in favor of a locally adapted USALB stock was also recommended by the HRT and HSRG.

Some changes to the Upper Salmon B-run program were implemented in the spring of 2010 to increase the number of adults collected for broodstock in the future. These changes included releasing USALB smolts at Pahsimeroi Fish Hatchery's permanent weir, which unlike the temporary weir at Squaw Creek, could collect broodstock throughout the run. USALB smolts were also released with intact adipose fins and CWTs to eliminate harvest in selective fisheries and differentially mark these fish from other adult steelhead returning to the Pahsimeroi Trap. These changes are expected to substantially increase adult collection, which was a major limitation to the program while it was based at Squaw Creek. Staff from IDFG, IPC, and LSRCP are currently working to ensure that the necessary infrastructure upgrades are in place at Pahsimeroi Fish Hatchery when the two-ocean adults from this release return in 2013. These upgrades will allow the USALB and PAHA stocks to be segregated during holding and will also provide more incubation capacity for the USALB program. Additionally, a management plan will be developed in 2011 that will include a history of the program, as well as evaluation parameters and a smolt distribution strategy to phase out DWORB releases in the upper Salmon River. Broodstock collection activities for the Upper Salmon B-run program will continue at Squaw Creek until 2013, after which the site may continue to be used as secondary broodstock collection site to collect genetically unrelated adults for broodstock.

In 2010, USALB broodstock were collected using a temporary weir in Squaw Creek and from anglers who voluntarily contributed broodstock from 29 March through 3 May. A total of 34 (18 from the weir and 16 from anglers) adult steelhead were collected during this period and transported to the East Fork Satellite Facility. Nineteen females and 15 males were spawned at the East Fork Satellite Facility to produce a total of 97,068 eyed eggs. These eggs were incubated at Pahsimeroi Fish Hatchery prior to being shipped to Magic Valley Fish Hatchery for rearing. These eggs should yield approximately 80,000 smolts for release in 2011 at the Pahsimeroi Fish Hatchery. See the 2010 Upper Salmon B-run Program Summary for more detailed information related to smolt releases and broodstock collection as well as the changes implemented in the Upper Salmon B-run Program in 2010 (Stiefel 2010).

South Fork Clearwater River Program

The HRT and HSRG recommended phasing out the practice of releasing DWORB smolts in the South Fork Clearwater River in favor of a locally adapted hatchery stock. Although hatchery fish had been released for years at Red River and Crooked River satellite facilities, very few hatchery adult steelhead returned to these sites, likely the result of fallout due to a migration barrier near Golden, Idaho and possibly due to straying. To overcome the lack of an adequate broodstock collection site, a volunteer angler contribution program was initiated in 2010 that allowed anglers to contribute fish to be used as broodstock. The goal was to collect 50 males and 50 females to produce approximately 70,000 smolts. The broodstock goal was intentionally set high to ensure an adequate number of smolts would be produced in case a substantial number of eggs had to be culled because the females spawned to produce these eggs tested positive as carriers of Infectious Hematopoietic Necrosis (IHN).

Staff from Clearwater and IDFG's Lewiston Regional Office assisted by sport anglers collected 51 females and 34 males from 2 March through 18 March 2010. These fish were temporarily held in fish tubes before being transported to Dworshak National Fish Hatchery for spawning. Forty-six females were spawned. Because there was an unequal sex ratio some males were spawned multiple times to ensure the eggs from all females were fertilized. Low incidence of IHN and high fecundity and eye-up rates far exceeded expectations, resulting in the production of 250,000 eyed eggs. These locally adapted smolts were marked and tagged to compare their performance with that of DWORB releases in the South Fork Clearwater River, as well as to provide a differential mark so that these fish could be targeted as broodstock in the future.

Estimating a Correction Factor for PIT Tag Expansions in Steelhead Returning to Sawtooth Fish Hatchery Trap

Recent research has shown that PIT-tagged adult Chinook salmon return at lower rates than non-PIT-tagged fish due to tag loss and differential survival (Knudsen et al. 2009); however, tag loss and differential survival has not been studied in steelhead. In an effort to determine the accuracy at which PIT tags estimated adult returns, we installed an in-ladder PIT tag array with multiple antennas at the Sawtooth Hatchery fish trap in 2010. The system, coupled with regular hand scanning of fish removed from the trap and a one-ocean return estimate from CWT recoveries, enabled researchers to obtain antenna efficiencies and in turn, estimate the proportion of one-ocean steelhead at the trap that were PIT tagged. This proportion provided a corrected PIT tag expansion rate that was used to correct return estimates to Lower Granite Dam.

Overall, PIT tag return estimates for this particular group were accurate and accounted for 95.6%. Table 10 summarizes the corrected expansions for the Sawtooth Weir release group and Table 11 shows the corrected estimates at Lower Granite Dam.

Table 10. Corrected expansion rate for the Sawtooth Weir steelhead release group derived from the in-ladder PIT tag array at the Sawtooth trap.

Juvenile Expansion Rate	Run At Large PIT Tags at Trap Array	Return to River PIT Tags at Trap Array	Estimated Expanded Return	Actual Return	Corrected Expansion Rate
108.6	50	19	5,449	5,699	113.6*

* Adjusted for array efficiency

Table 11. Corrected PIT tag expansion rate and adult return estimate at Lower Granite Dam for one-ocean steelhead returning from the Sawtooth Weir release group during the 2009-2010 run.

Run At Large PIT Tags at Lower Granite Dam	Return to River PIT Tags at Lower Granite Dam	Corrected Expansion Rate	Original Estimate from Juvenile PIT Tag Rate	Estimated Number from Corrected Expansions
296	112	113.6	32,257	33,737

Currently, one-ocean steelhead that returned to the Sawtooth trap in 2010 is the only release group for which a corrected expansion rate was generated. This correction factor was not applied to other release groups because there may be significant variation between release groups, as observed in Chinook salmon (Cassinelli and Rosenberger 2011). In the future, we will be able to evaluate multiple age classes returning to the Sawtooth Trap. Unlike spring/summer Chinook salmon releases in Idaho, generating a corrected expansion rate for each steelhead release group is not possible using the methods described above because a substantial number of returning adult steelhead are released “offsite” and therefore do not return to a weir where they can be detected.

Fallback / Reascension Rates and After-Hours Passage at Lower Granite Dam

With a substantial number of one-ocean PIT-tagged steelhead returning in 2010, we were able to evaluate levels of fallback resulting in reascension as well as after-counting-hours passage rates at Lower Granite Dam. Fallback resulting in reascension was assessed by looking at PIT tag coil reads within the Lower Granite Dam adult fish ladder. A fish was determined to have fallen back and reascended when it had more than one distinct PIT tag tracking event from the bottom to the top of the adult ladder. Counting hours at Lower Granite Dam occur for 16 hours per day from 0400 hours to 2000 hours. A fish was considered to have passed after hours if it was detected in the lower set of PIT tag antennas outside of this 16 hour period. The level at which these two actions occur is of interest because fallback that results in reascension of an adult ladder results in some fish being counted more than once in dam window counts (overestimate), while fish passing after counting hours results in some fish not being counted at all (underestimate). In 2010, the level that each of these behaviors occurred was monitored and is summarized by rearing facility and stock (Tables 12 and 13).

Although the net difference between fallback and reascension estimates for these fish suggest the window counts would underestimate escapement, the limitations of PIT tags prevent an accurate correction factor (Boggs et al. 2004). PIT tags require subsequent detections downriver of LGD to estimate fallback without reascension; a component needed to correct dam counts. Because of the paucity of PIT tag arrays downriver of LGD and the infinite number of ways PIT-tagged fish can leave or be removed from this area, fallout without reascension cannot be estimated with any reasonable degree of confidence.

Table 12. Detections of one-ocean PIT tagged steelhead during the 2009/2010 run and reascension rates at Lower Granite Dam.

Hatchery	Stock	PIT Detections	Fallback / Reascension	Percent
Clearwater	DWORB	20	1	5.0
Hagerman	DWORB	23	0	0.0
National	PAHA	253	5	2.0
	SAWA	471	8	1.7
Magic Valley	DWORB	10	0	0.0
	EF Nat.	18	1	5.6
	PAHA	200	2	1.0
	SAWA	166	3	1.8
	USALB	14	0	0.0
	Total	**1,199**	**21**	**1.7**

Table 13. Detections of one-ocean PIT tagged steelhead during the 2009/2010 run and after-hours passage when window counts are not performed at Lower Granite Dam.

Hatchery	Stock	PIT Detections	After-Hours Passage	Percent
Clearwater	DWORB	20	1	5.0
Hagerman	DWORB	23	3	13.0
National	PAHA	253	13	5.1
	SAWA	471	24	5.1
Magic Valley	DWORB	10	1	10
	EF Nat.	18	0	0
	PAHA	200	11	5.5
	SAWA	166	9	5.4
	USALB	14	1	7.1
	Total	**1,199**	**63**	**5.4**

CWT Shed Rates

CWT retention checks are conducted annually at Hagerman National, Magic Valley, and Niagara Springs fish hatcheries to correct CWT release numbers for shed tags. These checks typically occur just prior to release, up to seven months post tagging, and can only be done in raceways where 100% of the fish are tagged with CWTs. In 2009, the mark crew initiated three-week post tagging retention checks to evaluate tagging quality. The results of these efforts were compared with the prerelease checks and an intermediate check, to determine if earlier checks would provide the same results as the prerelease checks. If so, the three-week check would satisfy reporting requirements and allow for retention checks in raceways that are not 100% CWT. Checks performed in partial raceways would be accomplished by segregating a subsample of fish that were 100% CWT for three weeks (a logistically feasible period of time) and then released back into the raceway from which they came.

Retention checks were conducted on brood year 2009 steelhead at three and seven weeks post tagging as well as prerelease (approximately seven months post tagging). A v-board CWT detector was used to evaluate CWT retention for 300 fish in raceways or raceway sections that were completely CWT tagged at Hagerman National, Magic Valley, and Niagara Springs fish hatcheries. To test whether there was a difference in retention between time periods, a two-stage cluster sampling for proportions analysis was done (Scheaffer et al. 1996). The results indicate there was little to no difference in CWT retention between the time periods (Table 14). This evaluation is being continued in brood year 2010 to examine annual variation. Final checks for brood year 2010 will be conducted in March 2011. If the results are consistent, retention checks could be completed as soon as three weeks post tagging. This short time period would allow for retention checks in raceways that are not 100% CWT by having a subsample of CWT fish segregated for three weeks. Furthermore, because there are very few rearing containers that are 100% CWT in Chinook salmon facilities across the state, (making a similar evaluation impossible) this evaluation may also serve as a surrogate for these fish as well.

Table 14. CWT retention estimates and 95% confidence intervals (CI) for the three time periods sampled from brood year 2009 hatchery steelhead.

		Three Week		**Seven Week**		**Prerelease**	
Hatchery	**Raceway**	**Retention**	**CI (+/-)**	**Retention**	**CI (+/-)**	**Retention**	**CI (+/-)**
Hagerman National	12	98.6	.38	98.1	.44	97.4	.52
Magic Valley	9	98.3	.49	98.0	.53	98.1	.52
Niagara Springs	8	99.1	.38	98.5	.49	97.4	.64

ACKNOWLEDGMENTS

We would like to thank the many folks who contributed to the material in this report. Firstly, thanks to the hatchery managers and their staffs for all their efforts to collect data and adapt to ever-changing requests. Thanks to the PSMFC marking crew for their efforts in marking and tagging fish and to PSMFC employees Carlos Camacho and Forrest Bohlen for their help in compiling and analyzing data. Thanks to Nathan Wiese (USFWS) who operated and contributed to the evaluation of the fish pump PIT tag array. Thanks to Sam Sharr for providing draft feedback. Thanks to Paul Abbott, John Cassinelli, and Brian Leth for providing draft edits and feedback on the content of this report.

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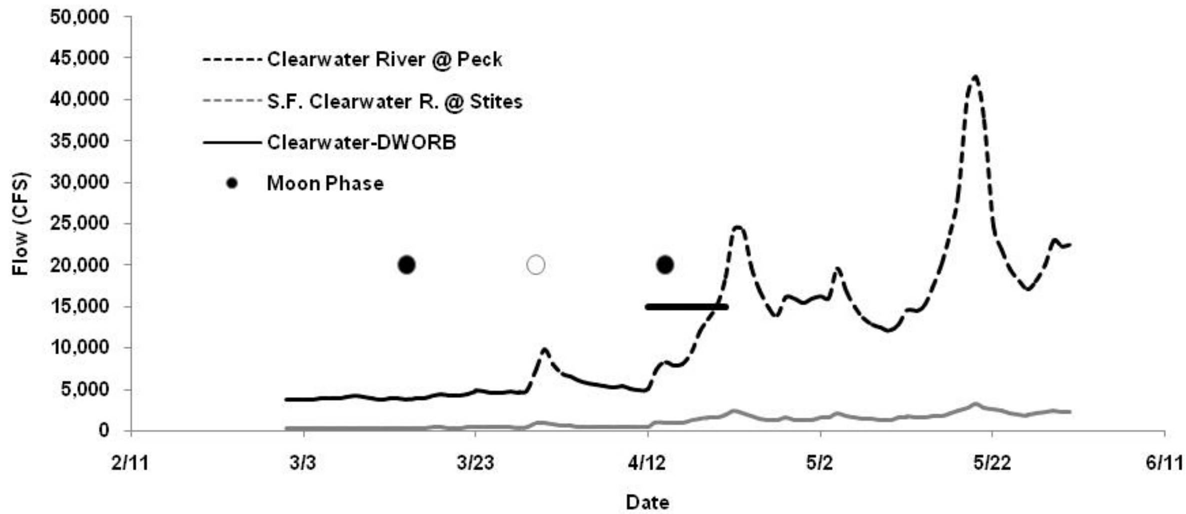
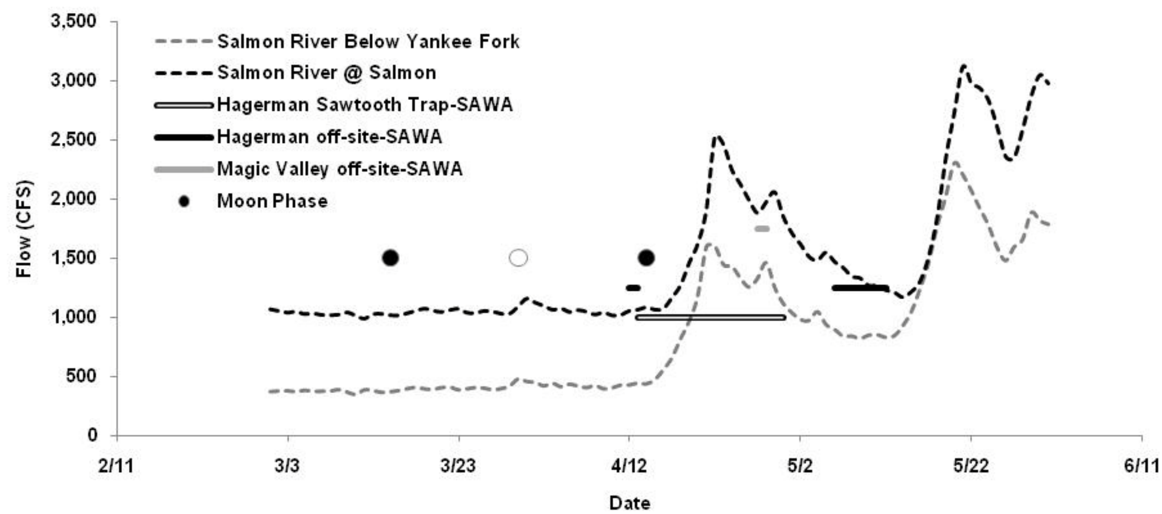
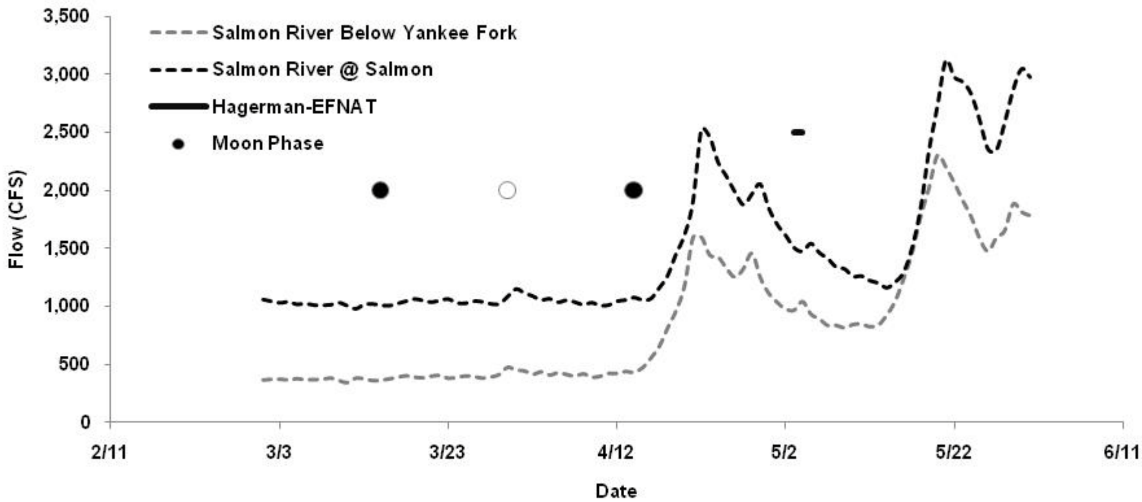
APPENDICES



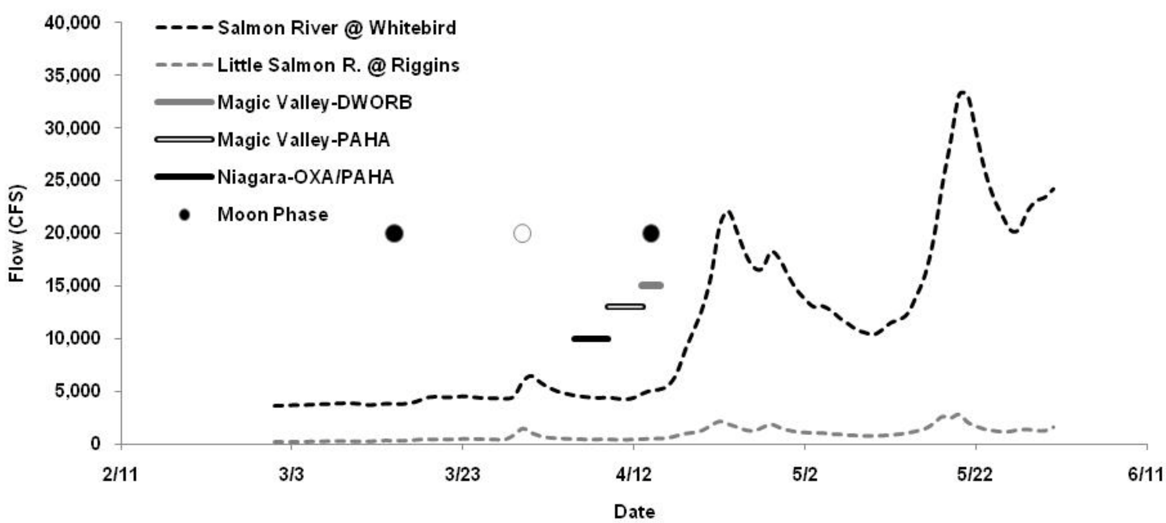
Appendix A. Release timing for DWORB steelhead smolts released into the Clearwater River basin from Clearwater Fish Hatchery in 2010 vs. moon phase and flow.



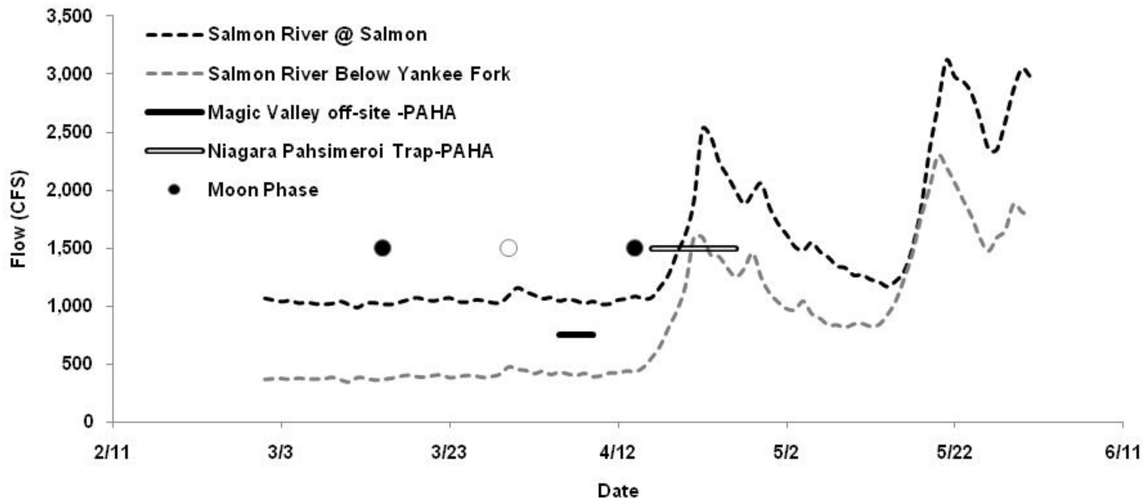
Appendix B. Release timing for SAWA steelhead smolts released from Hagerman National and Magic Valley fish hatcheries into the upper Salmon River in 2010 vs. moon phase and flow.



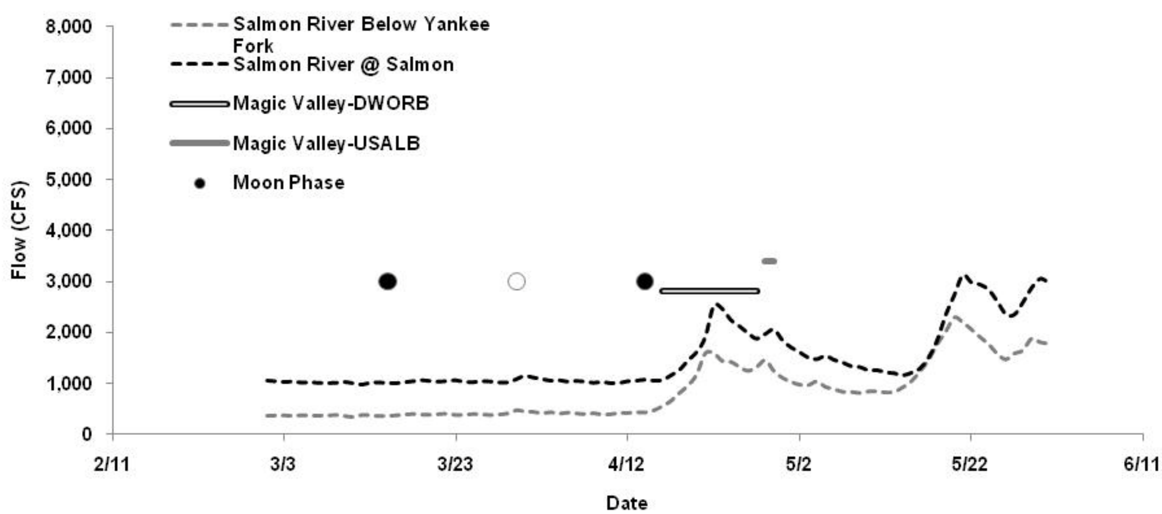
Appendix C. Release timing for EFNAT steelhead smolts released into the East Fork Salmon River from Hagerman National Fish Hatchery in 2010 vs. moon phase and flow.



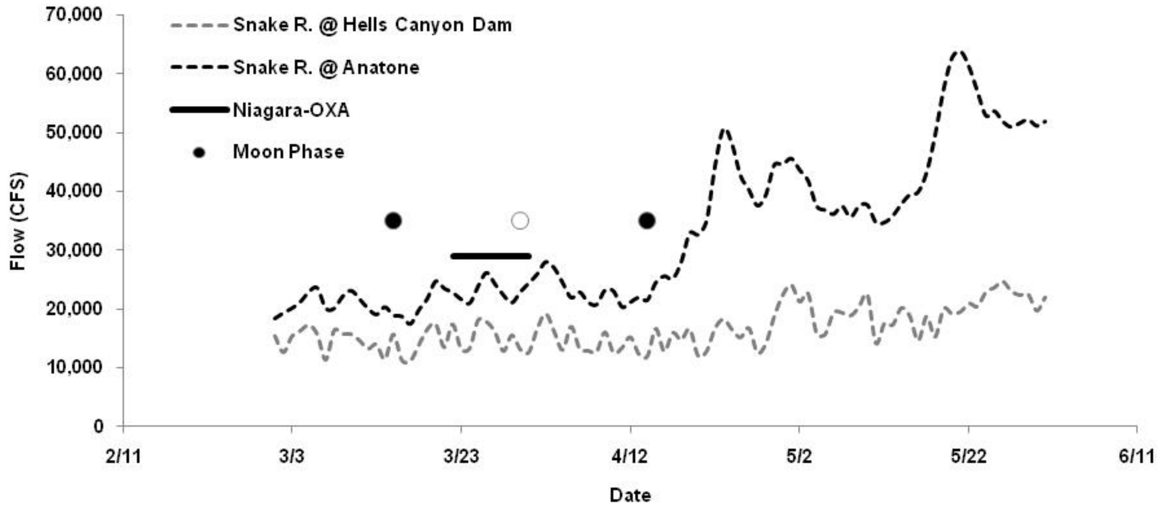
Appendix D. Release timing for steelhead smolts released into the Little Salmon River from Magic Valley and Niagara Springs fish hatcheries in 2010 vs. moon phase and flow.



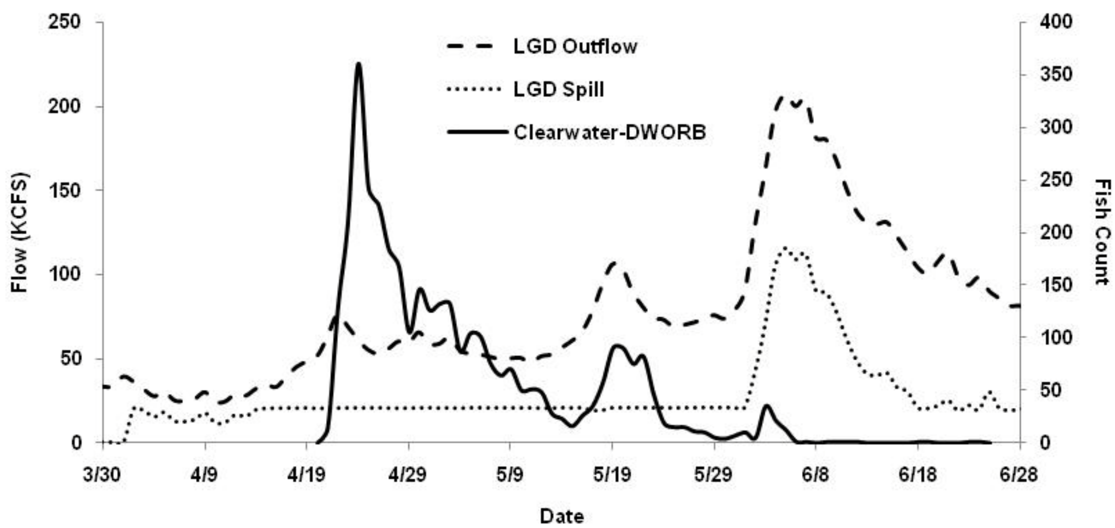
Appendix E. Release timing for PAHA steelhead smolts released from Magic Valley and Niagara Springs fish hatcheries into the upper Salmon River in 2010 vs. moon phase and flow.



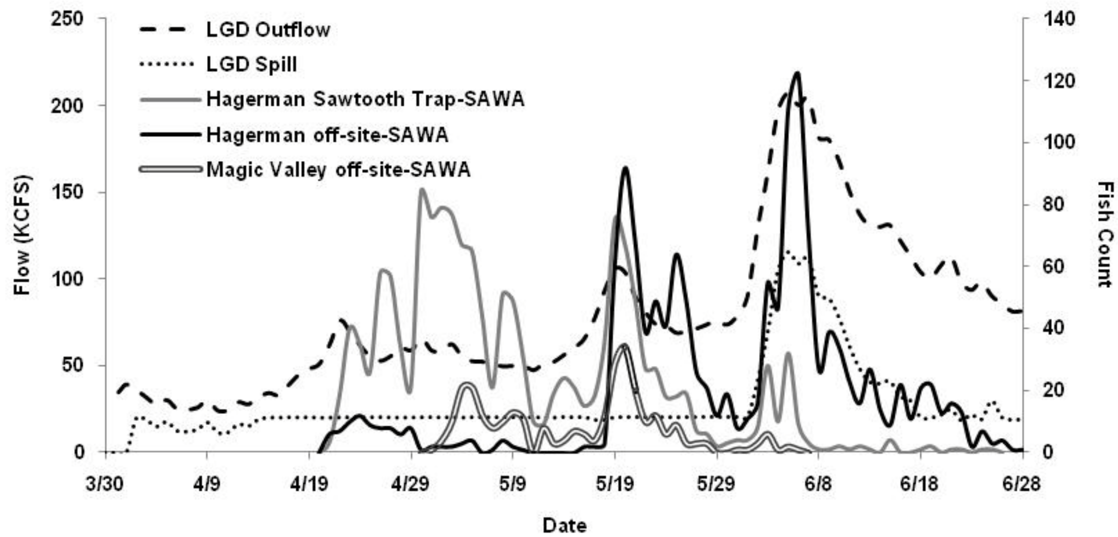
Appendix F. Release timing for DWORB and USALB steelhead smolts released from Magic Valley Fish Hatchery into the upper Salmon River in 2010 vs. moon phase and flow.



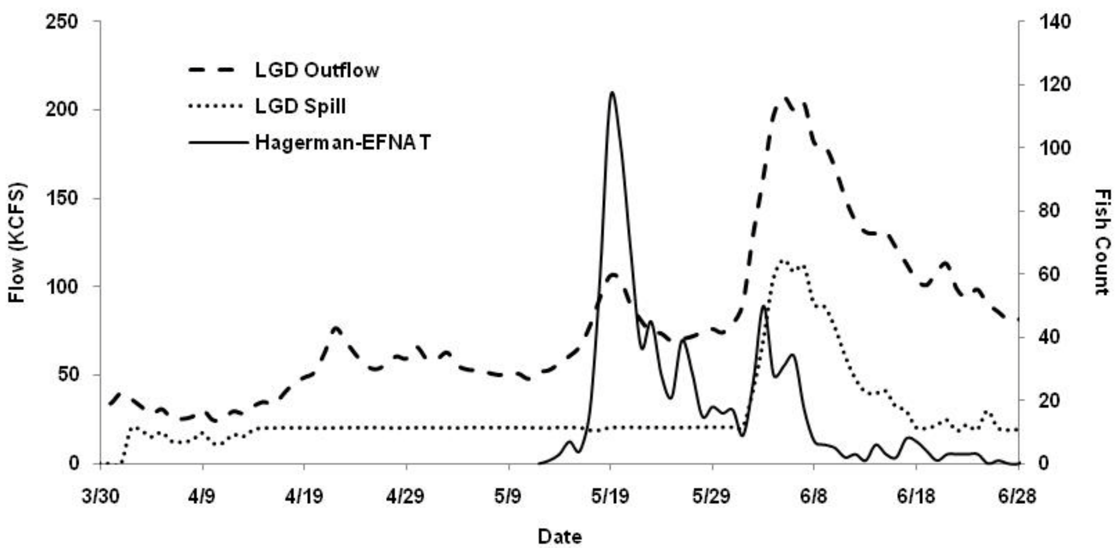
Appendix G. Release timing for OXA steelhead smolts released from Niagara Springs Fish Hatchery into the Snake River in 2010 vs. moon phase and flow.



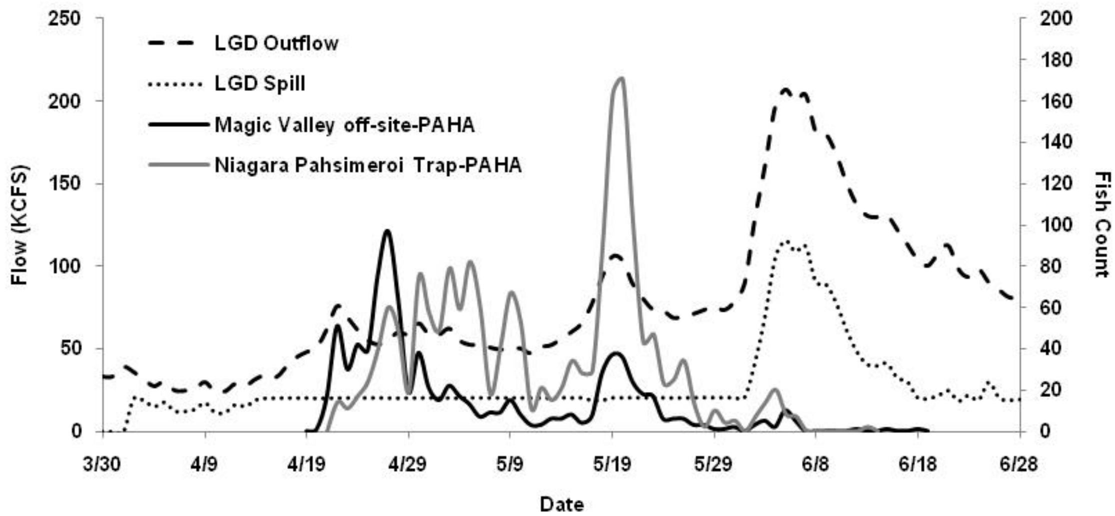
Appendix H. Smolt arrival timing at Lower Granite Dam (LGD) for DWORB steelhead released from Clearwater Fish Hatchery in 2010 vs. outflow and spill.



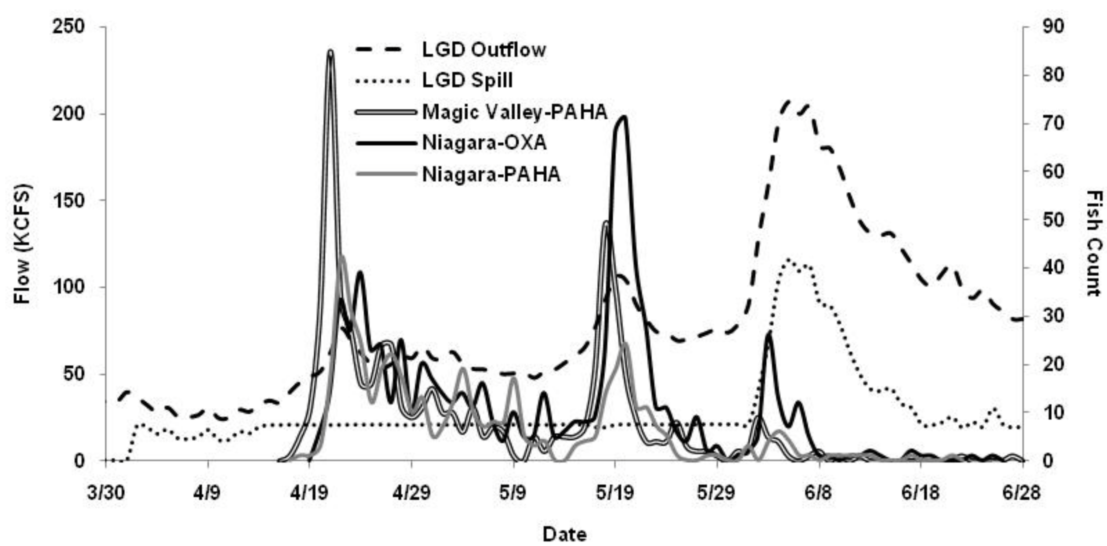
Appendix I. Smolt arrival timing at Lower Granite Dam (LGD) for SAWA steelhead smolts released from Hagerman National and Magic Valley fish hatcheries in 2010 vs. outflow and spill.



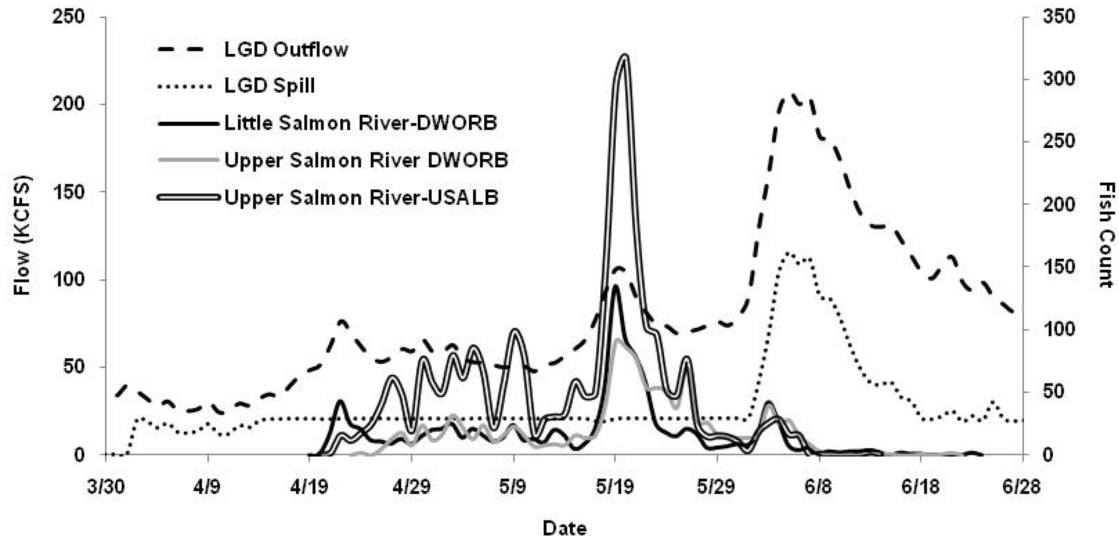
Appendix J. Smolt migration timing at Lower Granite Dam (LGD) for EFNAT steelhead released from Hagerman National Fish Hatchery in 2010 vs. outflow and spill.



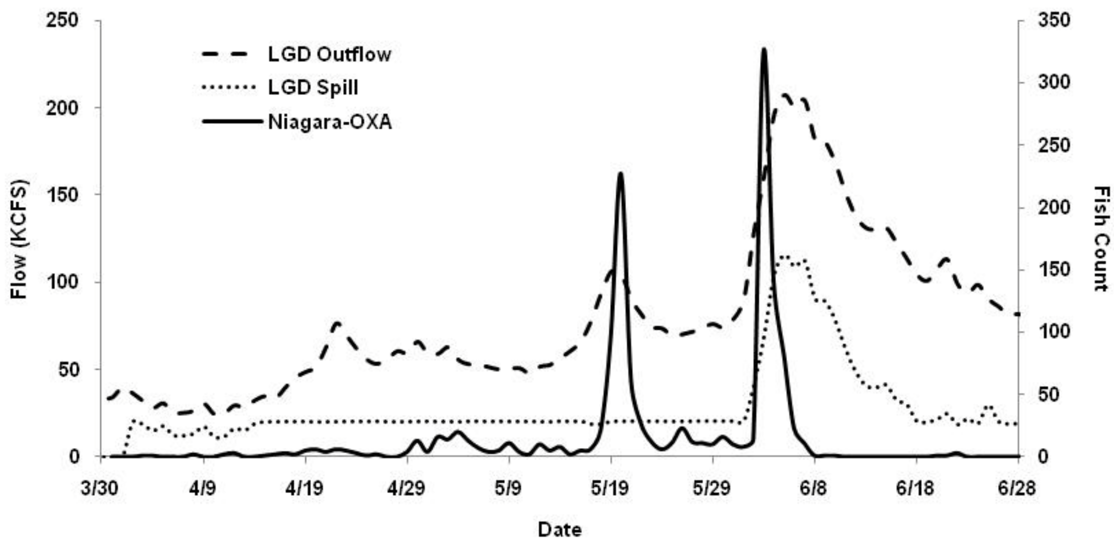
Appendix K. Smolt arrival timing at Lower Granite Dam (LGD) vs. outflow and spill for PAHA steelhead released from Magic Valley and Niagara Springs fish hatcheries in 2010.



Appendix L. Smolt arrival timing at Lower Granite Dam (LGD) for PAHA and OXA steelhead released from Magic Valley and Niagara Springs fish hatcheries into the Little Salmon River in 2010 vs. outflow and spill.



Appendix M. Smolt arrival timing at Lower Granite Dam (LGD) for DWORB and USALB steelhead released from Magic Valley Fish Hatchery into the upper Salmon River in 2010 vs. outflow and spill.



Appendix N. Smolt arrival timing at Lower Granite Dam (LGD) for OXA steelhead released from Niagara Springs Fish Hatchery at Hells Canyon Dam in 2010 vs. outflow and spill.

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