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LOWER SNAKE RIVER
COMPENSATION PLAN
Hatchery Program

2016 CALENDAR YEAR HATCHERY STEELHEAD REPORT:

IPC AND LSRCP MONITORING AND EVALUATION PROGRAMS FOR THE STATE OF IDAHO

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IDFG Report Number 18-21

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

January 1, 2016—December 31, 2016

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Boise, ID 83709

LSRCP Agreement # F16AC00027

IDFG Report Number 18-21
December 2018

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INTRODUCTION

This report summarizes hatchery steelhead monitoring and evaluation (M&E) activities associated with the Lower Snake River Compensation Plan (LSRCP) and Idaho Power (IPC) mitigation programs, which occurred in Idaho during the 2016 calendar year. Information is provided for steelhead from six broodstock collection sources and four rearing hatcheries operated by the IDFG and the USFWS.

The LSRCP steelhead hatchery mitigation program was established to provide in-kind and in-place mitigation for lost harvest opportunity resulting from the construction and operation of the four lower Snake River hydroelectric dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams). The Idaho component of the mitigation program calls for the operation of broodstock collection and rearing facilities operated by the Idaho Department of Fish and Game (IDFG) and the U.S. Fish and Wildlife Service (USFWS) under the auspices of the LSRCP. It is anticipated that the summer steelhead hatchery smolt release programs operated in Idaho will return 117,780 (71% of the total) adult steelhead towards the total LSRCP mitigation goal of 165,300 adult steelhead downstream of Lower Granite Dam (Corps of Engineers 1975 [COE]). The remaining 29% of the adult return are from Oregon and Washington releases.

The IPC maintains a hatchery steelhead mitigation program as part of the Hells Canyon Settlement Agreement (HCSA) of 1980 resulting from the construction and operation of the Hells Canyon Complex (Brownlee, Oxbow, and Hells Canyon dams). Mitigation goals established through the HCSA specify an annual smolt production target of 400,000 pounds to be reared at the Niagara Springs Fish Hatchery, which equates to approximately 1,800,000 yearling smolts at 4.5 fish per pound.

As 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: https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/Forms/AllItems.aspx.

Steelhead Broodstock Collection Facilities

Steelhead eggs are collected from females trapped at four hatchery weirs and one satellite facility (Table 1, Figures 1 and 2). The South Fork Clearwater River (SFCR) stock is collected by volunteer anglers who donate their catch from the South Fork Clearwater River to the SFCR program. With the exception of the Clearwater Fish Hatchery, which initiated an angler broodstock collection program in 2010, none of the other steelhead rearing hatcheries discussed in this report collect broodstock. Eggs are transferred to rearing facilities that do not collect their own broodstock (Table 1). Broodstock are 100% hatchery origin (known as a “segregated program”) except for the integrated supplementation program in the East Fork Salmon River (EFNAT), which has a goal of 100% natural origin broodstock.

Hatchery steelhead broodstocks used in Idaho hatcheries include both A-index and B-index run types. The run designations are based on fish length and migration timing and were originally established by fisheries managers in the Columbia River for in-season fisheries management. The stocks classified as A-index types predominately spend one year in the ocean while stocks classified as B-index types spend predominantly two years in the ocean before returning as adults.

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

Broodstock Collection Facility	Hatchery Abbreviation	Stock Abbreviation (Run Type)	Mitigation Program
Dworshak National Fish Hatchery[1]	DNFH	DWOR (B-index)	COE
South Fork Clearwater River[2]	CLFH	SFCR (B-index)	LSRCP
Oxbow Fish Hatchery	OXFH	OX (A-index)	IPC
Pahsimeroi Fish Hatchery	PFH	PAH (A-index)	IPC
		USAL (B-index)	LSRCP
Sawtooth Fish Hatchery	SFH	SAW (A-index)	LSRCP
East Fork Salmon River Satellite Facility[3]	EFSF	EFNAT (A-index)	LSRCP

1. Dworshak National Fish Hatchery operates a steelhead mitigation program funded by the U.S. Army Corps of Engineers (COE) that is not included in this report.
2. Broodstock is currently collected in the South Fork Clearwater River by angling.
3. Operated by Sawtooth Fish Hatchery.

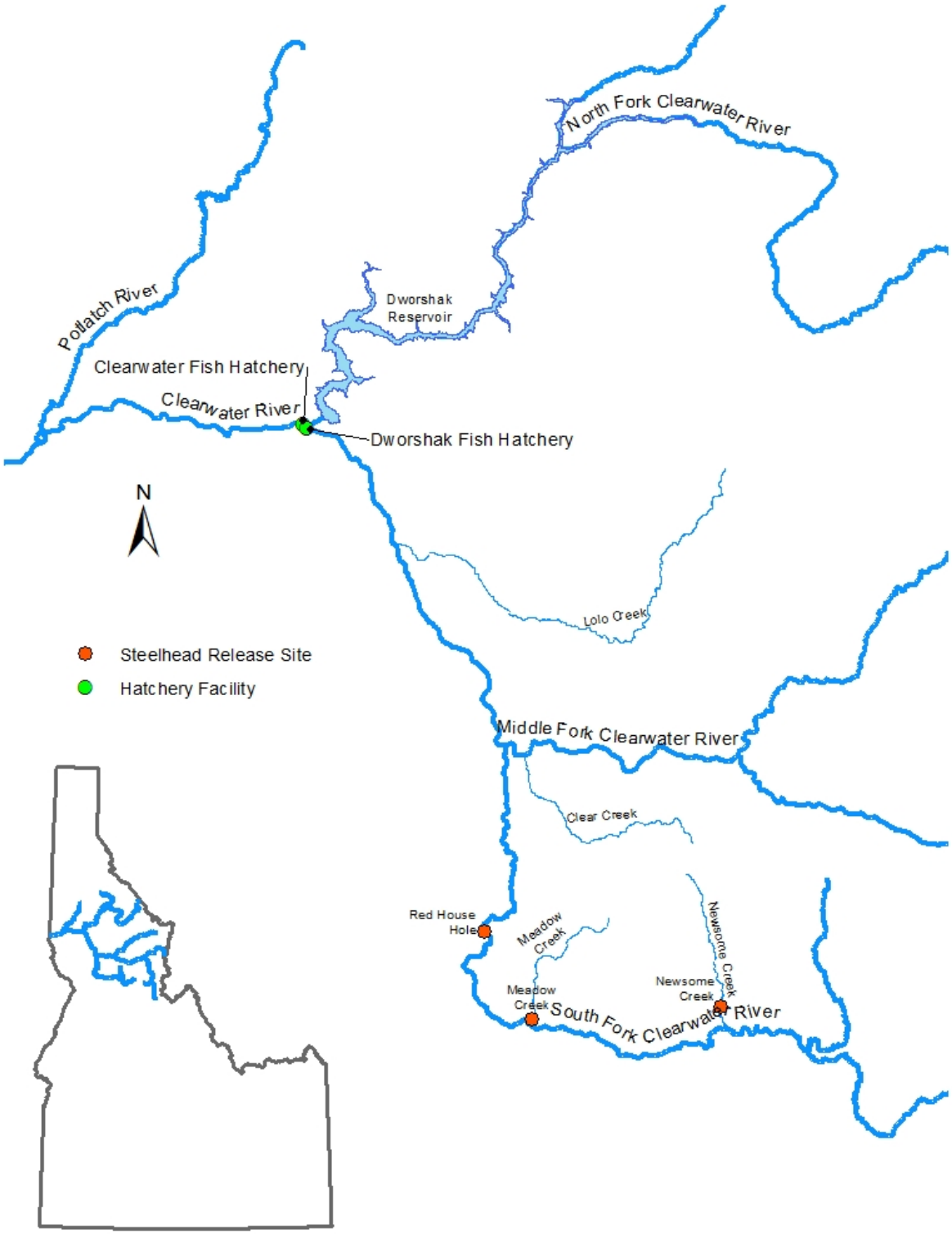

Figure 1. Location of steelhead release sites and hatchery facilities in the Clearwater River basin associated with the LSRCP mitigation program.

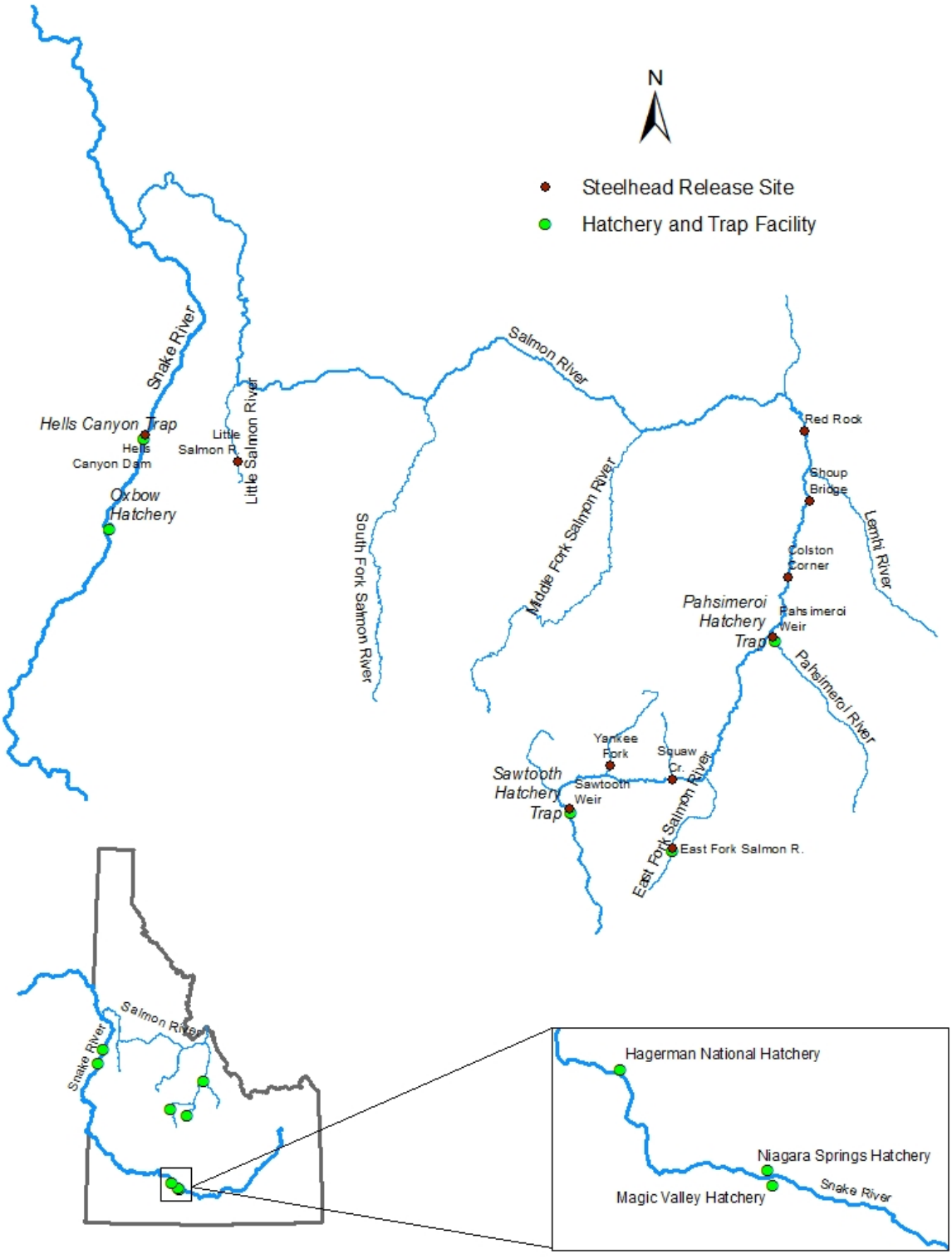

Figure 2. Location of steelhead release sites and hatchery facilities in the Salmon and Snake river basins associated with the LSRCP and IPC mitigation programs.

IPC Rearing Facility and Release Goals

Niagara Springs Fish Hatchery (Niagara Springs) is located on the Snake River near Wendell, Idaho. Niagara Springs receives eyed eggs from Pahsimeroi Fish Hatchery (PAH stock) and from Oxbow Fish Hatchery (OX stock). 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 (Figure 2, Table 2).

LSRCP Rearing Facility and Release Goals

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 within Idaho (Figure 1). The annual mitigation goal for this facility is to produce 42,000 adult steelhead. Clearwater annually releases 843,000 smolts to achieve this goal (Table 2). Clearwater's annual production target was originally 1,750,000 smolts; however, production was reduced to 843,000 smolts due to limited water availability and to provide more rearing space for the Chinook Salmon program at that facility. Despite these changes, the adult return goal remains the same. Clearwater historically received DWOR stock green eggs from Dworshak National Fish Hatchery (Dworshak) and reared them to yearling smolts for release into the South Fork Clearwater River. However, in 2010, a program was initiated to develop a hatchery stock (SFCR) that is locally adapted to the South Fork Clearwater River by utilizing broodstock collected by anglers as a temporary measure until an adult collection facility can be constructed in the South Fork Clearwater River (see the Localized Broodstock Development section of this report). Although the primary goal is to utilize only SFCR broodstock for all smolt releases into the South Fork Clearwater River, DWOR stock progeny will continue to be used if there is a deficit of SFCR broodstock. In addition to its primary mitigation function, Clearwater also receives green DWOR eggs that are incubated to the eyed egg stage before being transferred to Magic Valley Fish Hatchery (Magic Valley) for final rearing and release into the Salmon River as part of the Upper Salmon River stock (USAL) program (a B-index stock locally adapted to the upper Salmon River). The USAL program is the continuation of efforts that were initiated with the transfer of DWOR broodstock in 1974 to establish a B-index stock in the upper Salmon River basin. Although the first priority is to eventually utilize only USAL broodstock for smolt releases into the Salmon River, DWOR eggs will continue to be used to backfill shortages as needed.

Hagerman National Fish Hatchery (Hagerman) is located along the Snake River in southern Idaho near the town of Hagerman, Idaho (Figure 2). The annual mitigation goal for this facility is to return 40,800 adult steelhead. Hagerman's annual production target was originally 1,700,000 smolts; however, production was incrementally reduced to 1,470,000 smolts as a result of continued reductions in flow from the springs that provide water for the hatchery (Table 2). In an effort to mitigate for these losses to production, Hagerman implemented a pilot study to evaluate the effectiveness of a partial reuse aquaculture system (PRAS). The goal is to rear an additional 90,000 fish in three circular tanks that partially (75%) reuse water. This system was put into operation in 2014, increasing production at the facility to 1,560,000 smolts. A more detailed description of the PRAS and the study design to evaluate the performance of fish reared in it is presented in the "Evaluation of Steelhead Reared in a Reuse Aquaculture System at Hagerman National Fish Hatchery" section below. Hagerman receives eyed eggs from two stocks (SAW and EFNAT), which are reared to yearling smolts and released in the upper Salmon River (Table 2). The rearing of EFNAT smolts at Hagerman began in brood year 2009. Prior to this, EFNAT smolts were reared at Magic Valley Fish Hatchery.

Magic Valley Hatchery is located along the Snake River near Filer, Idaho. The annual mitigation goal for this facility is to return 34,800 adult steelhead (Table 2). Magic Valley's annual production target was originally 1,749,000 smolts; however, production has been incrementally reduced to 1,550,000 smolts as a result of continued reductions in flow from the springs that provide water for the hatchery. Magic Valley receives eyed eggs from three stocks (DWOR, PAH, and USAL), which are reared to yearling smolts. Magic Valley is responsible for rearing all LSRCP-funded DWOR, USAL, and PAH production released into the Salmon River.

Table 2. Migration year 2016 steelhead smolt release goals for IPC and LSRCP facilities and adult return mitigation goals for LSRCP facilities.

Rearing Facility	Mitigation Program	Stock	Smolt Release Goal	Adult Return Mitigation Goal
Clearwater	LSRCP	SFCR	843,000	42,000
Clearwater Production Total			**843,000**	
Hagerman	LSRCP	SAW	1,500,000	40,800
		EFNAT	60,000	
Hagerman Production Total			**1,560,000**	
Magic Valley	LSRCP	PAH	465,000	34,800
		DWOR/USAL	1,085,000	
Magic Valley Production Total			**1,550,000**	
Niagara Springs	IPC[1]	OX	800,000	
		PAH	1,000,000	
Niagara Springs Production Total			**1,800,000**	

[1] Idaho Power Company's (IPC) mitigation agreement is to release 400,000 lbs. of smolts at about 4.5 fish/lb., which equates to 1,800,000 smolts. There is no adult return mitigation agreement for IPC.

JUVENILE PRODUCTION AND RELEASES

Marking

The IDFG contracts with Pacific States Marine Fisheries Commission (PSMFC) for the marking and tagging of juvenile steelhead (Friedrich 2016). A complete overview of the anadromous fish marking and tagging program is annually reported and available through the IDFG website: https://collaboration.idfg.idaho.gov/FisheriesTechnicalReports/Forms/AllItems.aspx

Passive integrated transponder (PIT), coded wire tagging (CWT), and marking plans are developed in November and December of the year prior to the brood year. M&E staff collaboratively developed and finalized mark and loading plans with hatchery and marking personnel in June and July of 2015. Loading plans for PIT tags were finalized in the fall of 2015. 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 (hereafter referred to as ad-clipped) mark and two types of tags (CWT and/or PIT). In addition, all hatchery-origin steelhead are parentage-based tagged (PBT) through genetic analysis of tissue samples collected from every fish used as broodstock. The purpose and uses of those marks and tags are outlined below.

Adipose Fin Clips

The presence or absence of an adipose fin is used as the sole designator of a harvestable hatchery-origin fish in mark selective fisheries and is also one of the primary indicators of origin at hatchery traps. Some adipose fin-intact (hereafter referred to as ad-intact) hatchery smolts are released to meet other management objectives but can generally be identified as hatchery origin by secondary characteristics (fin erosion or CWT).

Coded Wire Tags

Smolts released in 2013 (brood year 2012) are the last groups that were tagged with CWTs for the purpose of estimating stock composition in fisheries. Age and stock composition of the harvest and returns to the hatchery weir are now based on analysis of PBT data. Currently, CWTs are used only to identify Ad-intact hatchery steelhead for broodstock and weir management purposes or in special instances such as evaluations of treatment and control groups.

Parentage-Based Tags

All broodstock spawned at Idaho hatcheries since 2008 have had a tissue sample collected to maintain the PBT genetic baseline (Steele et al. 2013). These genetic samples are used to identify juvenile fish produced from each parental cross that is recorded within the genetics baseline database. At any point in the offspring's life cycle, a tissue sample can be collected, and through the genetic baseline can be assigned back to its hatchery, stock, cohort, and release site. PBT is beneficial because fish are 100% marked and sampling to detect the mark is non-lethal. PBT can be used to generate stock and age compositions of fisheries, on spawning grounds, and at hatchery traps. Tissue samples are collected at the adult trap at Lower Granite Dam (LGD), which allows stock-, age-, and release-site-specific adult return estimates to be generated for the entire hatchery-origin return to LGD using PBT.

Passive Integrated Transponder Tags

Passive integrated transponder (PIT) tags serve multiple purposes and like PBT are an important tool for monitoring and evaluating hatchery steelhead programs. PIT tags are used to generate estimates of juvenile survival to LGD and juvenile run timing through the Snake and Columbia river hydropower systems. As fish return as adults, PIT tags provide in-season stock- and age-specific abundance estimates and arrival timing, as well as conversion rates between dams. All of these parameters are outlined in this report.

All PIT tags implanted in hatchery steelhead go through the separation-by-code process prior to juvenile outmigration. The separation-by-code process enables managers to predetermine how a PIT-tagged fish will be treated if detected in one of the juvenile bypass systems at a Snake River or Columbia River dam. As part of ongoing research for the Comparative Survival Study (CSS), the majority of PIT tags (about 70%) are assigned to the 'monitor mode' group for the separation-by-code process, and the remaining 30% are assigned to the 'default mode' group (http://www.fpc.org/). When detected at the dam, monitor mode fish

will either be transported downriver on a barge or truck, or returned back to the river based on what the current protocol is at that particular dam for the untagged population. Tagged fish assigned to the default mode group are treated independently of the untagged population and are automatically returned to the river. Because the monitor mode component represents the untagged population, they are the only tags that are expanded by the juvenile tagging rate to generate the adult return estimates outlined above.

Juvenile Release Information

From March through May 2016, 5,832,693 (1,875,711 IPC; 3,956,982 LSRCP) brood year 2015 yearling steelhead smolts were released at locations in the Clearwater, Salmon, and Snake river basins (Figures 1 and 2; Table 3). Clearwater exceeded their smolt release goal by 66,237 fish, which is 7.8% above their goal. Hagerman was 38,875 (2.5%) and Magic Valley was 23,380 (1.5%) short of their release goals. Niagara Springs exceeded their smolt release goal by 75,711 fish, which is 4.2% above their goal.

Table 3. Summary of brood year 2015 hatchery steelhead released in 2016 from IPC and LSRCP facilities.

Hatchery	Release Site	Stock	Total Release	Ad-Clip Only	Ad-Clip/ CWT	CWT Only	No Mark	PIT Tag[1]	PBT Tag Rate[2]
Clearwater	Newsome Creek	SFCR	123,816	0	0	0	123,816	5,980	1.00
	Meadow Creek	SFCR	351,345	351,345	0	0	0	6,178	0.89
	Meadow Creek	SFCR	202,010	0	0	159,705	42,305	4,483	0.90
	Red House	SFCR	232,066	232,066	0	0	0	4,795	0.96
	Clearwater Totals		**909,237**	**583,411**	**0**	**159,705**	**166,121**	**21,436**	
Hagerman	Up. EF Salmon R.	EFNAT	80,213	0	0	77,872	2,341	8,401	1.00
	McNabb Pt.	SAW	123,785	123,785	0	0	0	0	1.00
	Sawtooth Weir	SAW	1,317,127	1,136,952	180,175	0	0	25,778	0.94
	Hagerman Totals		**1,521,125**	**1,260,737**	**180,175**	**77,872**	**2,341**	**34,179**	
Magic Valley	Little Salmon-Stinky Springs	DWOR	49,130	49,130	0	0	0	593	0.73
	Pahsimeroi	DWOR	93,600	0	0	91,728	1,872	4,183	0.86
	Squaw Creek	DWOR	124,830	124,830	0	0	0	1,891	0.80
	Yankee Fork 3rd bridge	DWOR	71,030	71,030	0	0	0	1,693	0.90
	Yankee Fork Ponds	DWOR	160,500	0	0	0	160,500	5,685	0.80
	Little Salmon-Stinky Springs	PAH	204,020	204,020	0	0	0	2,195	0.81
	Colston Corner	PAH	111,200	111,200	0	0	0	1,894	0.87
	Red Rock	PAH	94,000	94,000	0	0	0	1,898	0.87
	Shoup Bridge	PAH	94,310	94,310	0	0	0	1,899	0.87
	Little Salmon-Stinky Springs	USAL	157,700	157,700	0	0	0	1,597	0.64
	Pahsimeroi	USAL	155,000	0	0	152,393	2,607	7,187	0.79
	Yankee Fork 3rd bridge	USAL	155,330	155,330	0	0	0	3,928	0.78
	Yankee Fork Ponds	USAL	55,970	0	0	0	55,970	0	0.64
	Magic Valley Totals		**1,526,620**	**1,061,550**	**0**	**244,121**	**220,949**	**34,643**	
Niagara Springs	Little Salmon-Stinky Springs	OX	268,857	268,857	0	0	0	2,789	0.93
	Hells Canyon	OX	569,357	569,357	0	0	0	8,572	0.99
	Little Salmon-Stinky Springs	PAH	200,992	200,992	0	0	0	2,295	0.98
	Pahsimeroi	PAH	836,505	836,505	0	0	0	8,973	0.98
	Niagara Springs Totals		**1,875,711**	**1,875,711**	**0**	**0**	**0**	**22,629**	
	Grand Totals		**5,832,693**	**4,781,409**	**180,175**	**481,698**	**389,411**	**112,887**	

[1] PIT tag release numbers are not in addition to other mark tag combinations but are included in those groups.
[2] PBT tag rate is the proportion of released smolts whose parental genotypes are in the broodstock database and can be tracked to the juvenile release site.

Out-migration Survival and Environmental Conditions

Juvenile survival rates of PIT-tagged steelhead to LGD are estimated using the PitPro software program (Westhagen and Skalski 2009) developed in the School of Aquatic and Fishery Sciences at the University of Washington. PitPro is designed to translate PIT tagging and interrogation data into usable capture histories for SURPH (SURvival under Proportional Hazards), which is a program developed to analyze data from release-recapture studies of animal populations (Lady et al. 2013). Output files generated by PitPro produce a point estimate of survival and a standard error that is used to generate 95% confidence intervals for a SURPH2 data program output. The program uses the Cormack-Jolly-Seber model (Cormack 1964; Jolly 1965; Seber 1965) for single release and multiple recapture events, which is adjusted for differences in collection efficiency at Lower Granite Dam. An intuitive derivation of the release-recapture parameters used in the survival estimate adjusted for detection probability is provided by Lady et al. (2013):

$$\widehat{S_1} = \left(\frac{m_1}{R}\right)\left(\frac{1}{\hat{P}_1}\right)$$

where $\hat{S}$ is the estimate of survival to LGD, $m_1$is the number of detections at event 1 (LGD), R is the number of PIT tags initially released, and $\hat{P}_1$ represents the probability of detection. The probability of detection is the ratio of tags detected at LGD which are also detected at any of the six mainstem downriver detection sites to those detected only at any one of the downriver detection sites, which include Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, and Bonneville dams. In the event that the probability of detection is lower than the unadjusted estimate of survival, the adjusted estimate of survival will exceed 100%. All adjusted survival rates are hereafter referred as "survival rates."

Juvenile survival rate estimates to LGD for all release groups ranged from 48.8-98.6% in 2016 (Table 4). The low survival rate of 48.8% were smolts reared in the PRAS rearing tanks at Hagerman that were PIT tagged and tracked separately for the purpose of comparing performance with fish reared in conventional raceways at the same hatchery (see "Hagerman PRAS Description and Evaluation" section below for more details). Juvenile survival estimates of the various release groups to LGD were compared with previous years' estimates (Table 5). The weighted average survival of all groups combined in 2016 was 80.9%, as compared to 79.7% for all groups combined from migration years 2008-2015.

Appendix A provides juvenile release timing information and environmental conditions in the upstream migration corridor. Appendix B summarizes arrival timing at LGD as well as spill and outflow that coincided with the migration period.

Table 4. Estimated survival rates from release to LGD of brood year 2015 steelhead released from IPC and LSRCP hatchery facilities in 2016. All release groups were ad-clipped unless otherwise noted.

Hatchery	Release Group	Stock	Pit Tags Released	Release Date	50% Passage Date	80% Arrival Window	% Survival rate (95% CI)
Clearwater	Meadow Cr.	SFCR	6,178	4/25/2016	4/15	4/6 - 4/28	82.6 (79.6-85.6)
	Meadow Cr. AD-Intact	SFCR	4,483	4/30/2016	4/16	4/6 - 4/28	85.7 (82.1-89.3)
	Newsome Cr.	SFCR	5,980	4/4/2016	4/19	4/11 - 5/10	79.5 (76.7-82.3)
	Red House Hole	SFCR	4,795	4/6/2016	4/12	4/11 - 4/25	84.3 (81.1-87.5)
Hagerman	E. Fork Salmon AD-Intact	EFNAT	8,401	4/28/2016	5/10	5/7 - 5/23	63.6 (59.8-67.4)
	Sawtooth Weir	SAW	8,305	4/6/2016	4/27	4/20 - 5/9	73.1 (70.9-75.3)
	Sawtooth PRAS-treatment	SAW	8,761	4/4/2016	4/17	4/13 - 5/4	48.8 (46.8-50.8)
	Sawtooth PRAS-control	SAW	8,712	4/4/2016	4/20	4/14 - 5/6	71.1 (69.4-72.8)
Magic Valley	Salmon R. @ Colston	PAH	1,894	4/13/2016	4/26	4/22 - 5/9	81.9 (76.6-87.2)
	Little Salmon R. @ Stinky Springs	DWOR	593	4/18/2016	4/27	4/23 - 5/18	98.3 (88.7-107.9)
	Little Salmon R. @ Stinky Springs	USAL	1,597	4/19/2016	4/26	4/24 - 5/10	90.9 (86.8-95.0)
	Little Salmon R. @ Stinky Springs	PAH	2,195	4/14/2016	4/25	4/21 - 5/10	98.6 (93.9-103.3)
	Pahsimeroi R. AD-Intact	DWOR	4,183	4/25/2016	5/7	5/2 - 5/16	88.7 (82.1-95.3)
	Pahsimeroi R. AD-Intact	USAL	7,187	4/26/2016	5/7	5/3 - 5/16	94.2 (89.3-99.1)
	Salmon R. @ Red Rock	PAH	1,898	4/11/2016	4/26	4/17 - 5/9	85.6 (81.5-89.7)
	Salmon R. @ Shoup Bridge	PAH	1,899	4/12/2016	4/26	4/19 - 5/8	82.0 (77.6-86.4)
	Squaw Cr.	DWOR	1,891	4/22/2016	5/7	5/1 - 5/15	89.3 (80.5-98.1)
	Yankee Fork R.	DWOR	1,693	4/29/2016	5/11	5/9 - 5/21	74.3 (67.5-81.1)
	Yankee Fork Pond AD-Intact	DWOR	5,685	5/2/2016	5/12	5/11 - 5/25	72.1 (68.5-75.7)
	Yankee Fork R.	USAL	3,928	4/28/2016	5/10	5/8 - 5/19	64.8 (60.1-69.5)
Niagara Springs	Hells Canyon Dam	OX	8,572	3/21/2016	4/28	4/5 - 5/24	75.5 (73.0-78.0)
	Little Salmon R. @ Stinky Springs	PAH	2,295	4/26/2016	5/5	5/2 - 5/15	98.2 (91.0-105.4)
	Little Salmon R. @ Stinky Springs	OX	2,789	4/28/2016	5/12	5/9 - 5/23	90.5 (85.3-95.7)
	Pahsimeroi R.	PAH	8,973	4/5/2016	4/28	4/19 -5/11	84.5 (82.5-86.5)

Table 5. Annual and eight-year estimated survival (percent) from release to LGD for steelhead smolts released from IPC and LSRCP hatcheries, by stock and migration year.

		Migration Year									
Rearing Hatchery	**Stock**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2008-2015 Average**
Clearwater	DWOR	69.5	83.1	83.3	80.3	74.0	62.8	85.6	80.5	-	77.4
	SFCR				80.4	81.5	65.4	86.0	72.9	83.3	78.2
Clearwater Average		69.5	83.1	83.3	80.3	76.7	63.6	85.7	77.6	83.3	77.5
Hagerman	EFNAT	78.2	71.8	70.9	79.9	81.2	62.6	66.8	61.6	63.6	70.7
	SAW	85.5	80.8	74.6	79.9	72.3	80.4	79.5	72.4	71.2	78.2
Hagerman Average		85.5	80.8	74.3	79.9	73.5	78.3	78.9	72.0	70.8	77.9
Magic Valley	DWOR	76.4	78.9	76.5	72.0	77.2	63.4	77.9	64.1	82.4	73.3
	PAH	79.6	81.7	86.6	78.4	85.5	91.7	89.8	87.4	89.4	85.1
	SAW	85.0	76.9	90.6	87.1	80.6				-	84.1
	USAL[1]	78.7	73.5	84.3	89.3	76.4	80.1	78.6	81.0	83.3	80.2
Magic Valley Average		81.6	79.7	81.2	76.4	80.1	73.7	82.0	81.5	85.1	79.5
Niagara Springs	OX	87.9	88.9	91.8	72.8	71.8	53.9	75.0	83.5	80.3	78.2
	PAH	83.8	89.7	95.2	76.4	74.9	69.0	96.7	90.6	87.2	84.5
Niagara Springs Average		85.7	89.3	93.6	75.3	73.5	66.9	89.9	87.6	84.1	82.7
Weighted Average		**81.0**	**83.8**	**83.7**	**77.5**	**75.7**	**70.9**	**84.5**	**80.3**	**80.9**	**79.7**

[1] Prior to migration year 2010, the USAL smolts were released at Squaw Pond or Squaw Creek.

ADULT RETURNS

This section accounts for adult hatchery steelhead returning to Bonneville Dam (Bonneville), LGD, and back to hatchery traps in Idaho. The majority of adult hatchery steelhead returning to Idaho during the 2015-16 run were progeny from brood years 2013 (one-ocean) and 2012 (two-ocean). There were also small numbers of progeny from brood years 2011 and older in the analysis of adult returns described below.

Returns to Bonneville Dam and Lower Granite Dam

Estimates of the stock and cohort (brood year) composition of returning adult steelhead in spawn year 2016 were made with PIT tag detections at Bonneville and LGD and with PBT analysis at LGD. For the purposes of this report, spawn year 2016 encompasses adult return data to Bonneville and LGD between July 1, 2015 and June 30, 2016.

Estimated Escapement of Hatchery Steelhead at Bonneville Dam and Lower Granite Dam Based on PIT Tag Detections

Detections of PIT tags from hatchery origin steelhead at Bonneville and LGD fish ladders were expanded by dividing each unique PIT detection by the juvenile tagging rate. Expanded detections were summed across the migration period to estimate the escapement, by stock and cohort, of steelhead released from fish hatcheries in Idaho. Detections at Bonneville were also adjusted by dividing the expanded PIT detection by the detection efficiency of the PIT tag array located in the Bonneville fish ladder. Detection efficiency at Bonneville is defined as the percent of tagged fish detected upstream of Bonneville Dam that were also detected at Bonneville. The detection efficiency at Bonneville for the 2015-16 adult migration year was 97.9%. The detection efficiency for LGD is defined as the percent of tagged fish detected upstream of LGD that were also detected at LGD. Detection efficiency at LGD was 100%. Tables 6 and 7 summarize the estimated adult returns for each rearing hatchery by stock and cohort at Bonneville and LGD. During the 2015-16 steelhead run an estimated 65,743 adult steelhead from Clearwater, Hagerman, Magic Valley, and Niagara Springs fish hatcheries returned to Bonneville. An estimated 48,378 of these fish crossed LGD for a 74% conversion rate.

Table 6. Summary of expanded PIT tag estimates for one-, two-, and three-ocean (Brood Years 2013, 2012, and 2011) steelhead passing upstream of Bonneville Dam by hatchery and stock. Estimates are adjusted based on a 97.9% tag detection efficiency at Bonneville Dam.

Hatchery	Stock	One-Ocean	Two-Ocean	Three-Ocean	Total
Clearwater	DWOR	1,536	2,508	-	**4,045**
	SFCR	303	1,089	-	**1,391**
Clearwater Total		**1,839**	**3,597**	**-**	**5,436**
Hagerman	SAW	15,134	4,195	0	**19,328**
	EFNAT	535	538	-	**1,073**
Hagerman Total		**15,669**	**4,733**	**0**	**20,401**
Magic Valley	DWOR	70	1,866	80	**2,016**
	PAH	4,900	2,188	-	**7,088**
	USAL	2,982	544	39	**3,565**
Magic Valley Total		**7,952**	**4,597**	**120**	**12,669**
Niagara Springs	OX	3,381	1,470	94	**4,945**
	PAH	14,620	7,672	-	**22,292**
Niagara Springs Total		**18,001**	**9,141**	**94**	**27,237**
Idaho Total		**43,461**	**22,068**	**214**	**65,743**

Table 7. Summary of expanded PIT tag estimates for one-, two-, and three-ocean (Brood Years 2013, 2012, and 2011) hatchery steelhead passing upstream of Lower Granite Dam by hatchery and stock.

Hatchery	Stock	Brood Year 2013	Brood Year 2012	Brood Year 2011	Total
Clearwater	DWOR	1,127	2,098	0	**3,225**
	SFCR	296	1,009	0	**1,305**
Clearwater Total		**1,423**	**3,107**	**0**	**4,530**
Hagerman	SAW[1]	11,576	3,102	0	**14,678**
	EFNAT	342	412	0	**754**
Hagerman Total		**11,917**	**3,514**	**0**	**15,431**
Magic Valley	DWOR	51	1,341	0	**1,392**
	PAH	3,674	1,339	0	**5,013**
	USAL	2,175	511	19	**2,705**
Magic Valley Total		**5,900**	**3,191**	**19**	**9,110**
Niagara Springs	OX	1,851	988	92	**2,931**
	PAH	10,353	6,023	0	**16,376**
Niagara Springs Total		**12,204**	**7,011**	**92**	**19,307**
Idaho Total		**31,445**	**16,823**	**111**	**48,378**

Estimated Escapement of Hatchery Steelhead at Lower Granite Dam Based on Window Counts and PBT Analysis

Estimating Window Counts of Steelhead

The US Army Corps of Engineers (COE) estimates daily steelhead passage at LGD by enumerating fish that pass a counting window located in the adult fish ladder. During the months of April through October observers count fish passing the window 50 minutes of each hour between 0400 and 2000 (COE 2015). Window counts are expanded by dividing the count by 0.833 (50 out of 60 minutes counted). During the months of November and December, fish are enumerated by reviewing videotape that was recorded continuously during the hours of 0600-1600 daily (COE 2015). The fish ladder was dewatered for annual maintenance in January and February of 2016 then reopened and put back into service in March of 2016 (COE 2016). Fish were enumerated by reviewing continuous videotape recordings made daily between the hours of 0600-1600 PST during the month of March then visually enumerated at the counting window between the hours of 0400 and 2000 PST from April through June. Window counts are aggregated ad-clipped and ad-intact groups based on the presence or absence of an adipose fin when they are observed. The ad-clipped group consists of hatchery fish, and the ad-intact group is composed of natural origin and ad-intact hatchery fish. It is important to note that the COE window counts do not account for fish that pass the window outside of counting hours, those that pass through the navigation lock, or for those that fall back downstream over LGD without subsequent reascension. The aggregated total estimated escapement of adult steelhead for the period July 1, 2015 through June 30, 2016 was 136,150 fish (Camacho et al. 2017). The majority (>70%) of steelhead crossed LGD between September and October.

Decomposing Window Counts into Natural and Hatchery Origin

Decomposing the window count of adult steelhead passing LGD into natural and hatchery origin groups is based on information obtained from fish sampled at the LGD adult trap. The adult trap is located in the fish ladder upstream from the fish counting window and is used to examine fish for marks and tags and to collect tissue samples for genetic analysis. Fish are collected by operating a trap gate that diverts fish migrating up the fish ladder into a collection chamber according to a predetermined sample rate. The sample rate determines how long the trap gate remains open during four intervals each hour, and the trap is operated 24 hours per day under normal operation. Data and biological samples are collected from steelhead that are captured in the trap according to established protocols. Data is collected at the LGD trap for numerous projects assessing returns of both natural origin and hatchery summer steelhead and other anadromous salmonids. Due to overlapping run timing distributions, a trapping rate is agreed upon to meet objectives for all projects and may change during the trapping season. The sample rate established for assessing returns of natural origin (ad-intact) steelhead exceeds that needed for assessing hatchery (ad-clipped) returns. Therefore, a subsample rate is established for ad-clipped hatchery steelhead. If the trapping rate changes during the season, the subsample rate for ad-clipped steelhead is adjusted to maintain a consistent sample rate across the run.

Trapping and sampling operations at LGD were temporarily suspended for the period July 1-12, 2015 to reduce handling stress on fish due to water temperatures in the ladder reaching 21°C (70°F). Emergency supplemental protocols were implemented between July 13 and August 31 allowing trapping to resume under provisions that included pumping cool water into the top of the ladder, restricting trapping hours to between 0700 and 1100 PDT, and allowing for a maximum of 100 Chinook Salmon/steelhead (combined total) to be trapped and handled on a daily basis. The trap was operated under these protocols Monday through Friday most weeks during this time period. Trapping operations shifted to seven days per week beginning on September 1, 2015.

Because ad-intact steelhead include both hatchery and naturally produced steelhead it is necessary to decompose the ad-intact steelhead into hatchery and natural groups. Protocols at the trap are intended to determine origin of ad-intact steelhead by checking for the presence of CWT and visually scanning the fish for dorsal or ventral fin erosion (Camacho et al. 2017). Genetic samples are collected and processed from all ad-intact steelhead and compared to the hatchery genetic PBT baseline. The final analysis between the inspection of fish at the trap and the results of the PBT analysis indicate that 709 of the 5,044 samples collected from ad-intact steelhead were of hatchery origin. The final adjusted escapement of hatchery steelhead at LGD was estimated using the Salmonid Composition Bootstrap Intervals (SCOBI) script in the R computer program environment, which produces a point-estimate and associated 90% confidence intervals (Ackerman et al. In Prep; R Development Core Team 2008; Steinhorst et al. 2017). In addition to COE window count data, one of the input files required to run the SCOBI analysis is the results of PBT analysis of all of the samples collected from ad-intact fish put into time-series strata. The goal is to include 100 to 200 samples in each time stratum that are at least one week long. The final results of the analysis provide escapement estimates of ad-clipped and ad-intact fish of hatchery origin within each time stratum (Table 8). Estimated passage of adult steelhead for the period July 1, 2015 through June 30, 2016 included 96,761 ad-clipped and 39,389 ad-intact fish (Camacho et al. 2017). The ad-intact estimate was made up of 5,453 ad-intact hatchery fish and 33,936 natural origin fish.

Decomposing Hatchery Steelhead into Hatchery of Origin, Stock, and Cohort

During the period between July 1, 2015 and June 30, 2016, tissue samples were systematically collected from 1,773 ad-clipped hatchery steelhead and 709 ad-intact hatchery steelhead. Because ad-clipped and ad-intact steelhead were sampled at different rates, we analyzed the composition of the ad-clipped and ad-intact hatchery return separately. The hatchery escapement estimate was decomposed into hatchery of origin, stock, and cohort using the Salmonid Composition Bootstrap Intervals (SCOBI) script in the R computer program environment described above. The program script resamples (bootstraps) with replacement from the original PBT assignment data set. The sample size for each iteration was equal to the number of samples in the dataset. Stock frequencies for each stock/cohort in each iteration were expanded by the inverse of the PBT tag rate to estimate the true number of samples representing the stock/cohort group. Finally, the expanded stock assignments were then divided by the number of samples in the original dataset to estimate stock proportions. We performed 5,000 iterations and the 90% confidence intervals were then generated by removing $\alpha/2$ proportions from the extremes of the 5,000 ordered stock proportions. The adult steelhead run was divided into eleven temporal strata to account for changes in the trapping rate and run characteristics through time (Table 8).

Decomposition of Ad-clipped Hatchery Steelhead

The sample rate of the total ad-clipped escapement estimate of 96,761 fish was 1.8% (Table 8). Sample rates between the 11 time strata varied from 1.6% to 2.0%, resulting in the initial collection of 1,773 samples. Of these, 1,682 successfully genotyped and assigned to 32 release groups and 78 successfully genotyped but failed to assign to a release group, resulting in the use of 1,760 samples for the SCOBI analysis. Thirteen samples failed to genotype and were not included in the analysis. The SCOBI analysis used tag rates of each stock/cohort to expand the true frequency of trapped fish assigned to specific release groups, thereby reducing the total number of fish that did not assign to a release group. After accounting for the PBT tag rates of the 32 release groups, the total number of samples that assigned to a release group increased to 1,717 while the number of unassigned samples decreased to 43 (Appendix C1). Unassigned samples are most likely the result of broodstock not being sampled, lost samples, or out-of-basin strays from broodstock not in the PBT baseline.

The largest number (~59%) of ad-clipped steelhead arriving at LGD this run year was age-3 (one-ocean) fish released as smolts in 2014 (Table 9). Releases from Niagara Springs made up 23% of the combined return. Clearwater River basin releases from Dworshak and from Clearwater made up 18% of the return. Releases from Hagerman made up 19% of the return and releases from Magic Valley made up 8% of the return. Releases from Oregon made up 18% of the return and include Little Sheep Creek of the Imnaha River (LSCR) and Wallowa River of the Grande Ronde (WALL) stocks. Releases from Washington made up 11% of the return and included Cottonwood Creek of the Grande Ronde River (CGRW), Lyon's Ferry Fish Hatchery (LYON) and Tucannon River (TUCA) stocks. Three percent did not assign to a release group.

Decomposition of Ad-intact Hatchery Steelhead

Of the 5,047 samples taken from ad-intact steelhead at LGD, 709 were from fish of hatchery origin, identified by the presence of a CWT, eroded fins, or by genetically assigning to the hatchery baseline. The resulting sample rate for the entire run of ad-intact fish of hatchery origin was 13.0% (Table 8). Of the 709 samples analyzed, 682 samples assigned to 34 hatchery/stock/cohort groups (Appendix C2). Most of the ad-intact hatchery origin steelhead returning to LGD are DWOR, SFCR, and USAL stock fish returning after two years in the ocean (brood year 2012) (Table 10). The small number of ad-intact returns that assigned to PAH stock from Magic Valley, SAW stock from Hagerman, and all returns from Niagara Springs are probably misclips since those are ad-clipped releases.

Table 8. Sampling strategy for the selection of bio-samples collected at Lower Granite Dam for age and stock composition analysis of the hatchery origin adult steelhead escapement at the dam.

			Hatchery Origin Ad-Clipped			Hatchery Origin Ad-Intact		
Strata Start	**Strata End**	**Trap Closures (# Days)**	**Escapement Estimate**	**Sample Size**	**Sample Rate (%)**	**Escapement Estimate**	**Sample Size**	**Sample Rate (%)**
7/1/2015	8/30/2015	31	1,542	24	1.6	42	5	11.9
8/31/2015	9/13/2015	0	6,117	101	1.7	155	18	11.6
9/14/2015	9/20/2015	0	11,847	207	1.7	311	37	11.9
9/21/2015	9/27/2015	0	20,453	360	1.8	578	69	11.9
9/28/2015	10/4/2015	0	16,896	328	1.9	734	100	13.6
10/5/2015	10/11/2015	0	12,031	229	1.9	858	112	13.1
10/12/2015	10/18/2015	0	9,105	176	1.9	751	101	13.4
10/19/2015	10/25/2015	0	6,903	130	1.9	636	82	12.9
10/26/2015	11/1/2015	0	4,082	84	2.0	405	58	14.3
11/2/2015	12/31/2015	39	5,514	88	1.6	480	52	10.8
1/1/2016	3/3/2016	62			Ladder Closed			
3/7/2016	6/30/2016	0	2,271	46	2.0	503	75	14.9
Totals:			**96,761**	**1,773**	**1.8**	**5,453**	**709**	**13.0**

Table 9. Summary of escapement estimates of ad-clipped hatchery steelhead returning to LGD during the 2015-16 run, based on PBT analysis of tissue samples. The range in parenthesis represents the 90% confidence interval of the estimate.

Hatchery	Stock	Brood Year 2013	Brood Year 2012	Brood Year 2011	Brood Year 2010	Total
Dworshak	DWOR	2,660 (2,072 to 3,288)	10,640 (9,482 to 11,827)	211 (51 to 391)		**13,511**
	Total	**2,660**	**10,640**	**211**		**13,511**
Clearwater	DWOR	919 (568 to 1,316)	2,369 (1,799 to 2,963)	106 (2 to 259)		**3,394**
	SFCR	109 (2 to 263)	816 (486 to 1,185)	67 (1 to 173)		**992**
	Total	**1,028**	**3,185**	**173**		**4,386**
Hagerman	EFNAT	111 (2 to 254)				**111**
	SAW	14,665 (13,308 to 16,050)	3,164 (2,525 to 3,844)			**17,829**
	Total	**14,776**	**3,164**			**17,940**
Magic Valley	DWOR		1,177 (771 to 1,595)			**1,177**
	PAH	4,064 (3,316 to 4,856)	1,436 (989 to 1,915)			**5,500**
	USAL	1,380 (934 to 1,850)				**1,380**
	Total	**5,444**	**2,613**			**8,057**
Niagara Springs	OX	2,622 (2,020 to 3,263)	1,327 (898 to 1,780)	62 (1 to 172)		**4,011**
	PAH	13,571 (12,282 to 14,909)	4,588 (3,795 to 5,403)		51 (1 to 148)	**18,210**
	Total	**16,193**	**5,915**	**62**	**51**	**22,221**
Lyon's Ferry WA	CGRW	7,363 (6,420 to 8,364)	2,377 (1,789 to 2,974)	58 (1 to 171)		**9,798**
	LYON		584 (295 to 894)			**584**
	TUCA	114 (0 to 255)				**114**
	Total	**7,477**	**2,961**	**58**		**10,496**
Irrigon OR	LSCR	1,944 (1,428 to 2,485)	972 (612 to 1,370)			**2,916**
	WALL	7,763 (6,735 to 8,828)	7,013 (6,059 to 7,995)	52 (1 to 155)		**14,828**
	Total	**9,707**	**7,985**	**52**		**17,744**
Unassigned						**2,406**
Total		**57,285**	**36,463**	**556**	**51**	**96,761**

Table 10. Summary of escapement estimates of ad-intact hatchery steelhead returning to LGD during the 2015-16 run, based on PBT analysis of tissue samples. The range in parenthesis represents the 90% confidence interval.

Hatchery	Stock	Brood Year 2013	Brood Year 2012	Brood Year 2011	Brood Year 2009	Total
Clearwater	DWOR	404 (313 to 500)	769 (647 to 900)			**1,173**
	SFCR	201 (138 to 269)	547 (441 to 652)	10 (1 to 27)		**758**
	Total	**605**	**1316**	**10**		**1,931**
Dworshak	DWOR	171 (111 to 235)	799 (675 to 931)	20 (3 to 41)		**990**
	Total	171	799	20		**990**
Hagerman	EFNA	257 (189 to 334)	415 (323 to 512)	16 (2 to 38)		**688**
	SAW	64 (29 to 103)	16 (2 to 37)			**80**
	Total	**321**	**431**	**16**		**768**
Magic Valley	DWOR	44 (15 to 76)	204 (141 to 271)	9 (1 to 26)		**257**
	PAH		9 (1 to 25)			**9**
	USAL	223 (159 to 295)	621 (510 to 742)	15 (2 to 35)		**859**
	Total	**267**	**834**	**24**		**1,125**
Niagara Springs	OX		7 (1 to 22)			**7**
	PAH	8 (1 to 23)	16 (2 to 37)			**24**
	Total	**8**	**23**			**31**
Sho-Ban Egg Box	PAH		16 (2 to 36)	10 (1 to 26)	7 (0 to 22)	**33**
	Total		**16**	**10**	**7**	**33**
Lyon's Ferry WA	CGRW	54 (23 to 90)	8 (1 to 23)			**62**
	TOUW	76 (39 to 118)	9 (1 to 26)	7 (1 to 22)		**92**
	TUCW	231 (163 to 303)	111 (65 to 163)			**342**
	Total	**361**	**128**	**7**		**496**
Irrigon OR	WALL		16 (2 to 38)			**16**
	Total		**16**			**16**
Unassigned						**63**
Total		**1,733**	**3,563**	**87**	**7**	**5,453**

Comparison of Lower Granite Dam Escapement Estimates Based on PIT Tag Detections and PBT Analysis

The two methods of using PIT tag expansions and PBT analysis for estimating stock and cohort composition of the adult escapement over LGD are independent of each other and are expected to differ slightly. Estimates derived from PIT tag detections provided in Table 7 were broken down into ad-clipped and ad-intact groups for comparison against estimates derived from PBT analysis (Figures 3 and 4). Only release groups that assigned to Idaho releases were used in this comparison. There were fish from 36 separate ad-clipped and ad-intact release groups that assigned to the PBT base-line database, 30 of which were also represented by PIT detections at LGD. In most instances (72%), the escapement based on PBT analysis were greater than the estimates created by the expanded sum of PIT tags detected from each release group at LGD. Estimates from PIT tag detections were less than the lower confidence interval (α = 90%) of the PBT estimates in 28% of the release group comparisons. Estimates from PIT tag detections were significantly greater than PBT estimates in 11% of the comparisons. In the previous years' analysis, estimates from PIT tag detections were less than estimates from the PBT analysis in 76% of the release groups compared (Warren et al. 2017). Both methods of estimating the stock composition of escapement have potential for bias. For estimates based on PIT tag detections, shedding of tags after release will underestimate the population of the release group, and differential mortality between tagged and untagged fish within the same release group will change the tag rate. Camacho et al. (2017) lists potential sources of bias in the development of escapement estimates based on window counts and analysis of PBT sample data, including unaccounted for fallback and reascension of fish counted at the ladder.

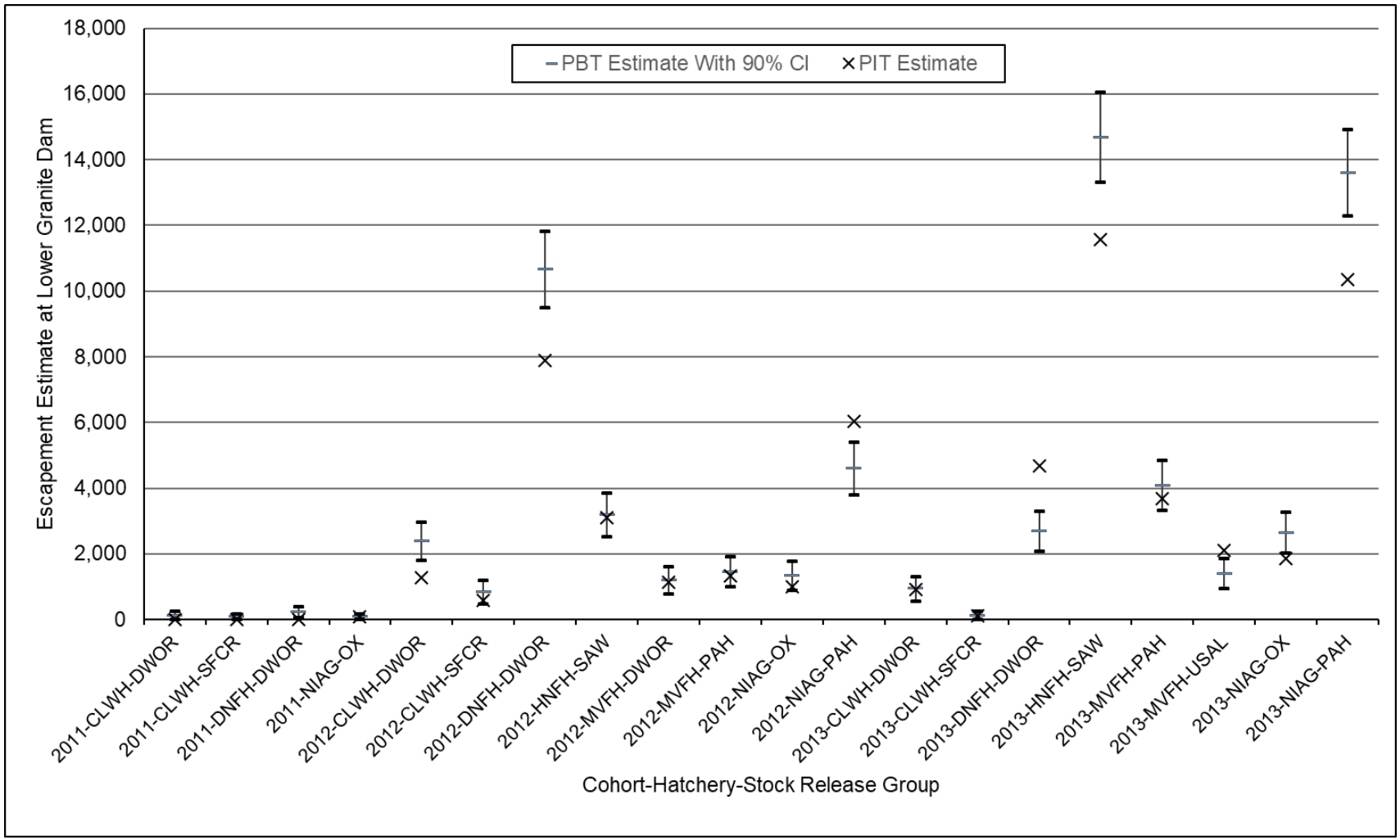

Figure 3. Hatchery steelhead escapement to Lower Granite Dam with estimates derived from PBT analysis (with 90% C.I.) of samples from ad-clipped fish and PIT tag expansions of ad-clipped release groups.

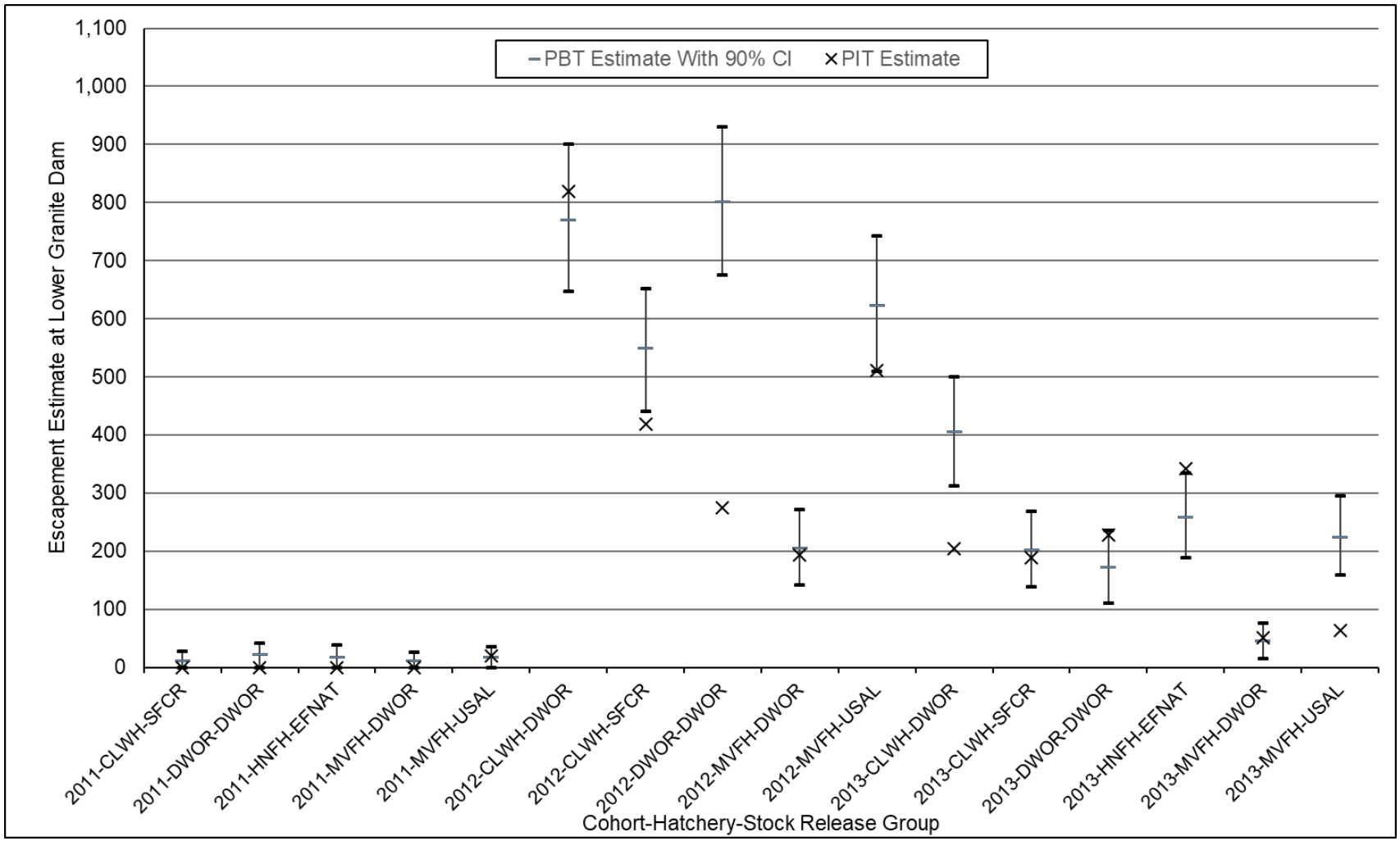

Figure 4. Hatchery steelhead escapement to Lower Granite Dam with estimates derived from PBT analysis (with 90% C.I.) of samples from ad-intact fish and PIT tag expansions of ad-intact release groups.

Conversion Rates Between Dams

Conversion rates from Bonneville to McNary dam and from Bonneville to LGD were based on detections of PIT-tagged adult hatchery steelhead. Tables 11 and 12 provide the number of tags detected, which are grouped by stock, release basin, and brood year for two cohorts. For the purposes of this report, PIT tag detections include only tags in the monitor mode sort-by-code category and conversion rates represent all losses between dams, including harvest, strays, and mortalities. Conversion rates from Bonneville to McNary dam ranged from 74% to 100% for one-ocean age fish (brood year 2013) and 75% to 96% for two-ocean age fish (brood year 2012). Conversion rates from Bonneville to LGD ranged from 56% to 100% for brood year 2013 fish and from 69% to 96% for brood year 2012 fish.

Table 11. Total number of PIT-tagged adult hatchery steelhead detected at Bonneville and McNary dams and the conversion rate during the 2015-16 run.

River Basin	Brood Year 2013			Brood Year 2012		
Stock	**Bonneville**	**McNary**	**Conversion**	**Bonneville**	**McNary**	**Conversion**
Clearwater River						
DWOR	53	48	91%	145	124	86%
SFCR	9	9	100%	20	19	95%
Salmon River						
DWOR	4	4	100%	31	25	81%
EFNAT	54	45	83%	23	19	83%
PAH	159	130	82%	97	75	77%
SAW	64	51	80%	53	44	83%
USAL	28	23	82%	25	24	96%
Snake River						
OX	34	25	74%	16	12	75%
PAH				8	7	88%

Table 12. Total number of PIT tagged adult hatchery steelhead detected at Bonneville and Lower Granite dams and the conversion rate during the 2015-16 run.

River Basin	Brood Year 2013			Brood Year 2012		
Stock	**Bonneville**	**LGD**	**Conversion**	**Bonneville**	**LGD**	**Conversion**
Clearwater River						
DWOR	53	45	85%	145	120	83%
SFCR	9	9	100%	20	19	95%
Salmon River						
DWOR	4	3	75%	31	22	71%
EFNAT	54	35	65%	23	18	78%
PAH	159	117	74%	97	73	75%
SAW	64	50	78%	53	40	75%
USAL	28	20	71%	25	24	96%
Snake River						
OX	34	19	56%	16	11	69%
PAH				8	7	88%

Run Timing

Stock specific run timing curves were generated for steelhead passage at Bonneville Dam and LGD by graphing the cumulative percentage of the return by date based on PIT tag detections in the adult ladders. The run timing difference between A-index and B-index stocks is clearly visible at Bonneville in Figure 5; B-index stocks (DWOR, SFCR and USAL) arrived approximately one month later than A-index stocks (EFNAT, OX, PAH, and SAW). Run timing differences were less pronounced at LGD, where upriver migration was likely influenced by in-river conditions including water temperatures (Figure 6).

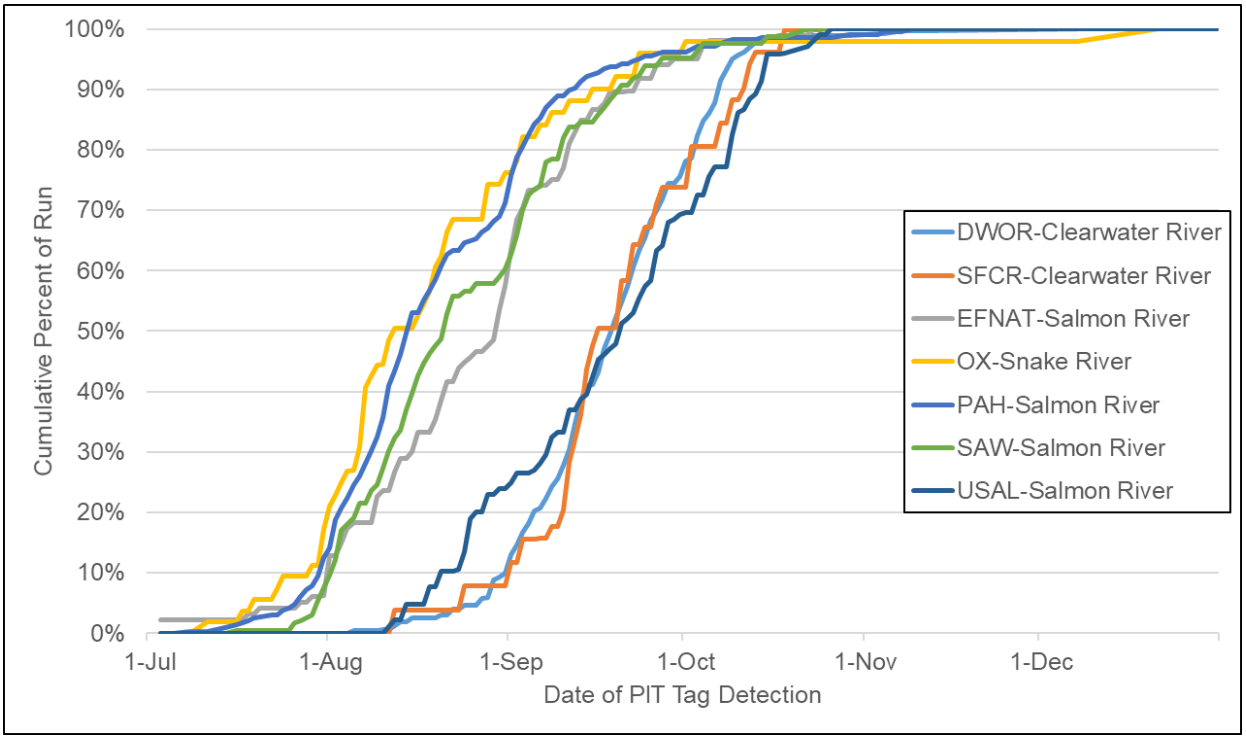

Figure 5. Run timing of hatchery steelhead at Bonneville based on PIT tag detections during the 2015-2016 run.

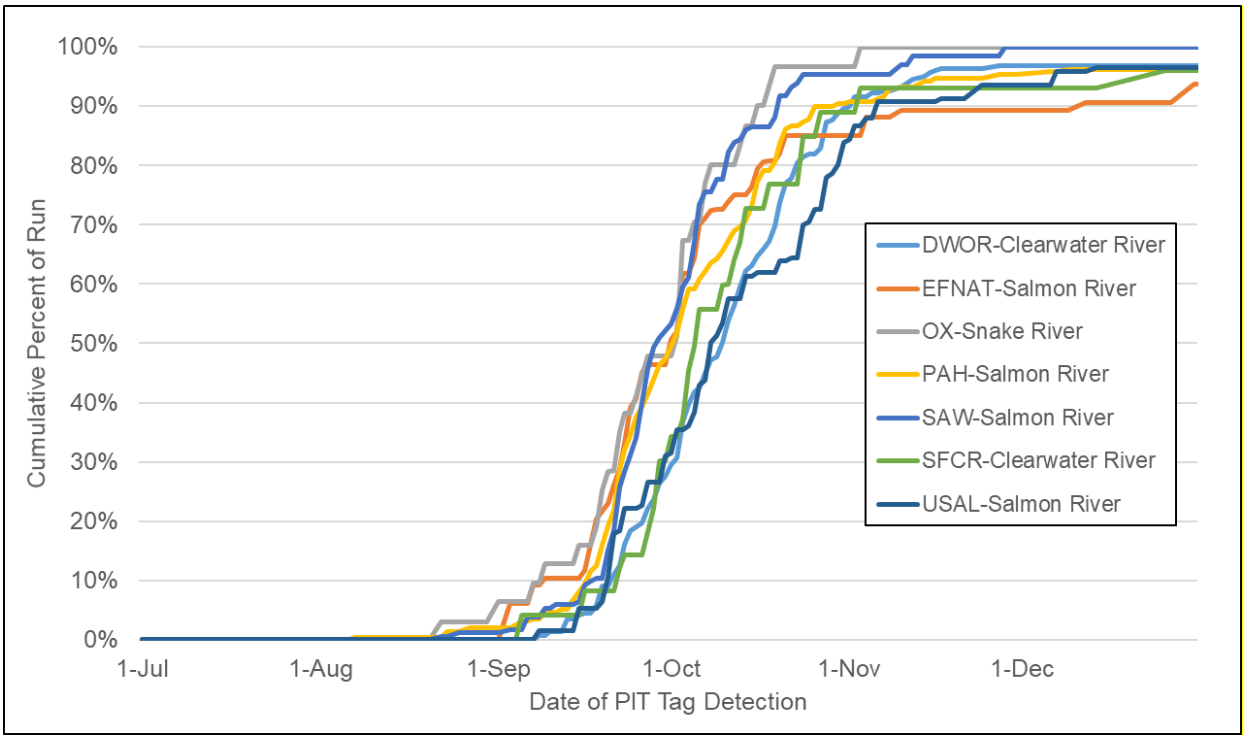

Figure 6. Run timing of hatchery steelhead at Lower Granite Dam based on PIT tag detections during the 2015-2016 run.

Idaho Recreational Fisheries

Harvest surveys (mail and telephone) were conducted at the end of each of the fall and spring seasons to estimate statewide harvest (SWH) and angler effort in steelhead fisheries. Results of the SWH survey indicated that anglers harvested 19,987 hatchery steelhead during the fall season of 2015 and 18,406 hatchery steelhead during the spring season of 2016 in Idaho. This information was summarized for each river section (Figure 7) and season combination (stratum) (Table 15). For the purposes of this analysis, several adjacent river sections were combined into stratum. Composition of the catch to the hatchery of origin, stock, and smolt release site level from each stratum was based on the results of angler surveys conducted by roving creel survey personnel who gathered fin tissue samples throughout the fishing season from anglers' catch for PBT analysis. No creel surveys were conducted in Hells Canyon Reservoir (River Stratum 27) or the Boise River (River Stratum 28) because steelhead caught in those strata were fish transplanted from the Hells Canyon trap. The goal was to use a sample size of 186 tissue samples per stratum for analysis. In stratum where samples collected were greater than 186, a random subsample was selected. Assignment of samples to the Hatchery-Stock-Release group was based on genetically matching samples to the PBT baseline. Frequencies of Hatchery-Stock-Release groups were divided by their PBT tagging rates to account for untagged fish to estimate the true number of fish within the mixture of samples. The expanded stock assignments were then divided by the number of samples in each strata to estimate Hatchery-Stock-Release group proportions. These proportions were applied to the SWH estimate of each strata to acquire Hatchery-Stock-Release group composition.

A total of 844 PBT samples were used for the Hatchery-Stock-Release group composition analysis of angler harvest from seven strata for the fall fishing season (Appendix C1). No angler surveys to collect PBT samples were conducted in the South Fork Clearwater River (River Stratum 07), or upper Salmon River (River Stratum 18-19) during the fall of 2015, where angler effort is generally known to be low, resulting in a total harvest estimate for the fall season (Table 14) less than the sum of the statewide harvest estimate in Table 13. The strata with the largest amount of harvest in the fall fishery was river section 03-04 (Table 13), which was composed of stocks from every rearing hatchery in Idaho as well as stocks from Oregon and Washington (Table 14). The presence of a mixed stock in the lower Clearwater River fall harvest is a result of Salmon and Snake river fish seeking temporary thermal refuge early in their migration. Stocks from Oregon and Washington that were harvested in the fall fishery include Little Sheep Creek (LSCW) from the Imnaha and Wallowa River (WALW) reared at Irrigon Fish Hatchery in Oregon, and Cottonwood-Grande Ronde (CGRW), Lyon's Ferry (LYFW), and Tucannon River (TUCW) stocks reared at Lyon's Ferry Hatchery in Washington.

There were 1,072 PBT samples from nine strata used in the analysis of the stock composition for the spring 2016 fishing season (Appendix C2). Results of the PBT analysis of spring harvest samples indicated that the harvest of most stocks was within or near the stratum from which they were released as smolts (Table 15).

Fall and spring fishery data were combined to estimate the Hatchery-Stock age component of the total harvest (Table 16). The majority of the harvest (62%) was comprised of age-3 progeny from brood year 2013 stock and the majority of the age-4 harvest (59%) were from DWOR and SFCR stocks. There were no age-4 ad-clipped USAL stock fish available for harvest in the spawn year 2016 fishery. Approximately 326 age-5 progeny from brood year 2011 stock were harvested.

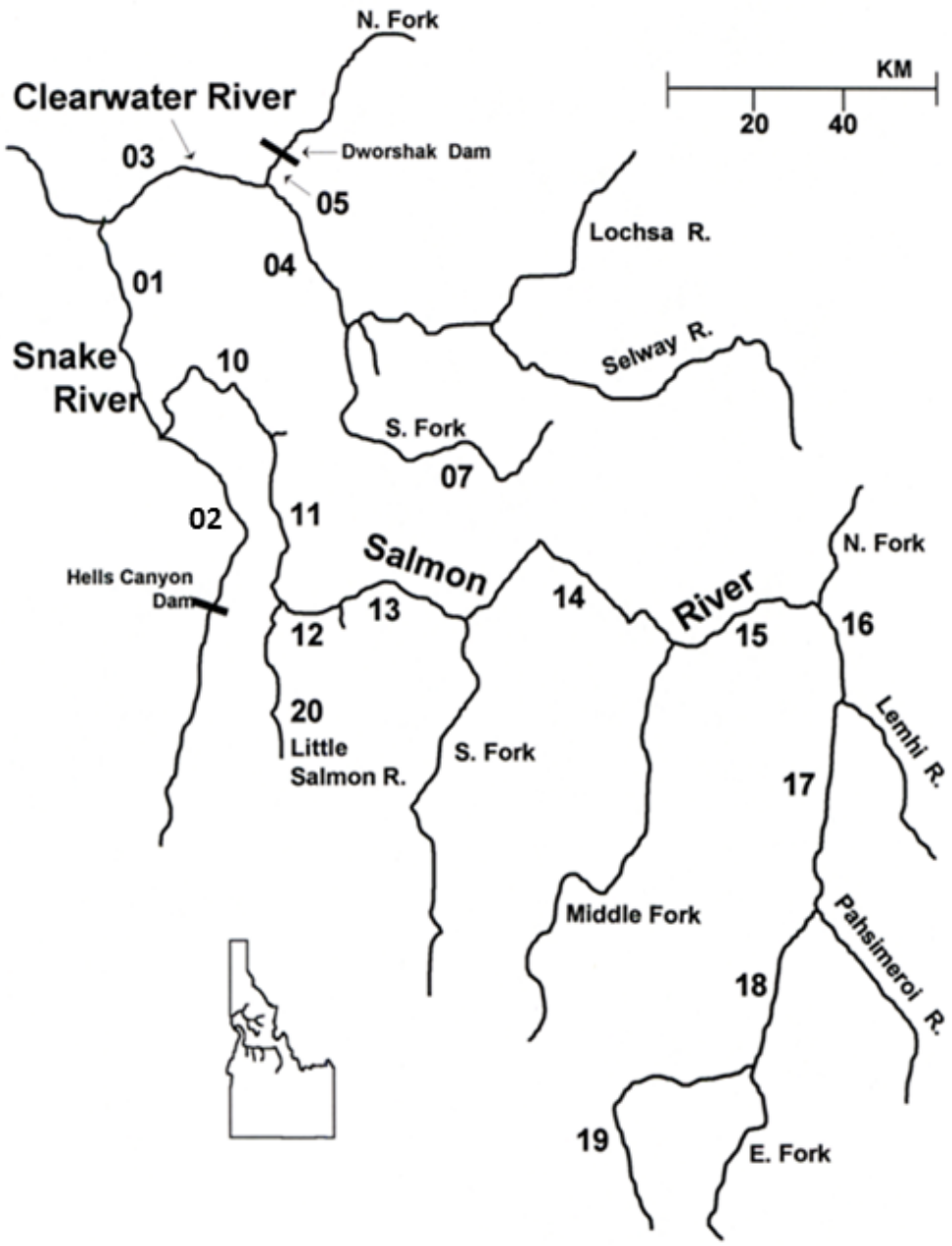

Figure 7. Idaho Department of Fish and Game river section designations where hatchery steelhead are available for harvest. Major tributaries or dams indicated on the map are used as section boundaries.

Table 13. Adult steelhead harvest estimated from statewide angler survey after the close of the 2015-16 fishing season.

Location Stratum	Location Code (River Section)	Location Description	Fall Effort (Angler Days)	Spring Effort (Angler Days)	Fall Harvest	Spring Harvest	Total Harvest
01	01	Snake R.; State Line to Salmon R.	11,856	2,120	2,868	582	3,450
02	02	Snake R.; Salmon R. to Hells Canyon Dam	2,344	1,025	1,082	598	1,680
03-04	03	Clearwater R.; Mouth to N.Fk.	28,747	9,087	5,295	1,564	6,859
	04	Clearwater R.; N. Fk. to S. Fk.	7,167	5,313	857	1,088	1,945
05	05	N. Fk. Clearwater R.	4,849	3,612	898	819	1,717
07	07	S. Fk. Clearwater R.	3,543	6,781	153	1,147	1,300
10-12	10	Salmon R.; Mouth to Whitebird Cr.	2,584	816	244	180	424
	11	Salmon R.; Whitebird Cr. To Little Salmon R.	7,033	4,148	1,632	860	2,492
	12	Salmon R.; Little Salmon R. to Vinegar Cr.	5,195	2,237	969	540	1,509
13-17	13	Salmon R.; Vinegar Cr. To S. Fk. Salmon R.	1,332	652	163	205	368
	14	Salmon R.; S. Fk. Salmon R. to Middle Fk. Salmon R.	2,904	3,286	419	344	763
	15	Salmon R.; Middle Fk. Salmon R. to N. Fk. Salmon R.	11,696	6,338	2,990	2,382	5,372
	16	Salmon R.; N. Fk. Salmon R. to Lemhi R.	5,755	2,913	949	803	1,752
	17	Salmon R.; Lemhi R. to Pahsimeroi R.	3,863	8,062	387	2,152	2,539
18-19	18	Salmon R.; Pahsimeroi R. to E. Fk. Salmon R.	1,918	3,822	62	1,343	1,405
	19	Salmon R.; E. Fk. Salmon to Sawtooth	1,172	5,989	51	1,515	1,566
20	20	Little Salmon R.	2,931	3,985	560	2,161	2,721
27	27	Hells Canyon Reservoir [1]	1,039	746	163	123	286
28	28	Boise River [1]	3,197	862	245		245
		Statewide Total:	**109,125**	**71,794**	**19,987**	**18,406**	**38,393**

[1] Recreational fishery created by transplanting adult steelhead from Hells Canyon Dam trap facility.

Table 14. Hatchery-Stock-Release group composition of the estimated harvest of adult steelhead by river strata during the fall of 2015 fishing season.

Hatchery	Stock	Smolt Release Site	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	Salmon Sect. 10-12	Salmon Sect. 13-17	Little Salmon Sect. 20	Total Harvest
Dworshak	DWOR	N Fk Clearwater	0	0	1,331	501	0	0	0	1,832
		N Fk Clearwater/ Clear Cr	20	0	934	148	0	0	0	1,102
		N Fk Clearwater/ Red House Hole	20	0	1,332	210	0	0	0	1,562
		N Fk Clearwater/ S Fk Clearwater	0	0	39	0	0	0	0	39
		Redhouse Hole	0	0	217	23	0	0	0	240
		Unknown	0	0	75	16	0	0	0	91
Dworshak Total			**40**	**0**	**3,928**	**898**	**0**	**0**	**0**	**4,865**
Clearwater	DWOR	Meadow Cr	0	0	643	0	0	0	0	643
		Red House Hole	0	0	192	0	0	0	0	192
		Red House Hole\ Meadow Cr	19	0	38	0	0	0	0	57
	SFCR	Meadow Cr	0	0	37	0	0	0	0	37
Clearwater Total			**19**	**0**	**910**	**0**	**0**	**0**	**0**	**929**
Hagerman	SAW	McNabb Point	58	0	0	0	0	194	0	252
		Sawtooth	323	8	222	0	170	2,386	0	3,109
		Yankee Fk	0	0	37	0	51	27	0	115
Hagerman Total			**381**	**8**	**259**	**0**	**221**	**2,607**	**0**	**3,476**

Table 14. Continued

Hatchery	Stock	Smolt Release Site	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	Salmon Sect. 10-12	Salmon Sect. 13-17	Little Salmon Sect. 20	Total Harvest
Magic Valley	DWOR	Little Salmon	39	8	0	0	139	0	0	186
		Pahsimeroi/ Squaw Cr	19	0	0	0	68	54	0	141
		Yankee Fk	0	0	0	0	86	82	0	168
	PAH	Colston Corner	0	0	0	0	0	81	0	81
		Little Salmon	122	0	42	0	438	92	256	950
		Red Rock	0	0	0	0	51	27	0	78
		Shoup Bridge	0	0	37	0	17	108	0	162
	USAL	Little Salmon	76	0	0	0	136	27	0	239
		Squaw Cr	0	0	0	0	17	27	0	44
		Yankee Fk	39	0	38	0	17	82	0	175
Magic Valley Total			**295**	**8**	**117**	**0**	**969**	**580**	**256**	**2,225**
Niagara Springs	OX	Hells Canyon	156	898	151	0	0	0	48	1,253
		Little Salmon	0	0	0	0	18	0	0	18
	PAH	Hells Canyon	70	45	0	0	0	0	0	115
		Little Salmon	432	0	80	0	1,192	237	256	2,197
		Little Salmon/ Pahsimeroi	19	0	0	0	34	27	0	80
		Pahsimeroi	121	0	170	0	235	1,405	0	1,931
		Pahsimeroi/ Hells Canyon	19	0	0	0	17	27	0	64
Niagara Springs Total			**817**	**943**	**401**	**0**	**1,496**	**1,696**	**304**	**5,657**
Irrigon	LSCW	Imnaha	342	100	0	0	37	0	0	479
	WALW	Grande Ronde	368	0	421	0	70	0	0	859
Irrigon Total			**710**	**100**	**421**	**0**	**107**	**0**	**0**	**1,338**
Lyon's Ferry	CGRW	Grande Ronde	399	0	37	0	51	27	0	514
	LYFW	Lower Snake	95	0	37	0	0	0	0	132
	TUCW	Tucannon	0	0	42	0	0	0	0	42
Lyon's Ferry Total			**494**	**0**	**116**	**0**	**51**	**27**	**0**	**688**

Table 14. Continued

Hatchery	Stock	Smolt Release Site	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	Salmon Sect. 10-12	Salmon Sect. 13-17	Little Salmon Sect. 20	Total Harvest
Failed to Assign			112	23	0	0	0	0	0	134
Grand Total[1]			**2,868**	**1,082**	**6,152**	**898**	**2,845**	**4,908**	**560**	**19,313**

[1] The sum of the grand totals in Table 14 is less than the sum of the total harvest in Table 13 because strata from which no PBT samples were collected are not included in the seasonal analyses.

Table 15. Hatchery-Stock-Release group composition of the estimated harvest of adult steelhead by river strata during the spring of 2016 fishing season.

Hatchery	Stock	Smolt Release Site	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	S. Fk. Clearwater Sect. 07	Salmon Sect. 10-12	Salmon Sect. 13-17	Salmon Sect. 18-19	Little Salmon Sect. 20	Total Harvest
Dworshak	DWOR	Clear Cr	0	0	179	0	44	0	0	0	0	222
		Clear Cr/Red House Hole	0	0	0	43	17	0	0	0	0	60
		N Fk Clearwater	0	0	865	285	43	0	0	0	0	1,193
		N Fk Clearwater/ Clear Cr	0	0	505	180	17	0	0	0	0	702
		N Fk Clearwater/ Red House Hole	0	0	538	297	321	0	0	0	0	1,157
		Redhouse Hole	0	0	39	0	48	0	0	0	0	87
		Unk	0	0	68	0	17	0	0	0	0	84
Dworshak Total			**0**	**0**	**2,194**	**805**	**507**	**0**	**0**	**0**	**0**	**3,506**
Clearwater	DWOR	Meadow Cr	0	0	249	0	267	0	0	0	0	516
		Newsome Cr	0	0	0	0	18	0	0	0	0	18
		Red House Hole	0	0	168	14	272	0	0	0	0	454
		Red House Hole/ Meadow Cr	0	0	14	0	0	0	0	0	0	14
	SFCR	Meadow Cr	0	0	27	0	83	0	0	0	0	110
Clearwater Total			**0**	**0**	**458**	**14**	**640**	**0**	**0**	**0**	**0**	**1,112**
Hagerman	SAW	McNabb Point	19	0	0	0	0	10	198	65	0	292
		Sawtooth	0	0	0	0	0	178	2,146	2,573	0	4,897
		Yankee Fk	0	0	0	0	0	0	0	111	0	111
Hagerman Total			**19**	**0**	**0**	**0**	**0**	**188**	**2,344**	**2,749**	**0**	**5,300**

Table 15. (Continued)

Hatchery	Stock	Smolt Release Site	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	S. Fk. Clearwater Sect. 07	Salmon Sect. 10-12	Salmon Sect. 13-17	Salmon Sect. 18-19	Little Salmon Sect. 20	Total Harvest
Magic Valley	USAL	Little Salmon	0	7	0	0	0	79	0	0	97	183
		Squaw Cr	19	0	0	0	0	10	32	16	0	76
		Yankee Fk	0	0	0	0	0	40	195	16	12	263
	DWOR	Little Salmon	0	14	0	0	0	50	0	0	74	139
		Little Salmon/ Squaw Cr/ Yankee Fk	0	0	0	0	0	0	33	16	0	49
		Pahsimeroi/ Squaw Cr	19	0	0	0	0	30	96	16	0	160
		Yankee Fk	0	0	0	0	0	0	65	16	0	81
	PAH	Colston Corner	0	0	0	0	0	10	129	16	0	154
		Little Salmon	0	0	0	0	0	98	0	0	466	563
		Red Rock	0	0	0	0	0	0	96	0	0	96
		Shoup Bridge	0	0	0	0	0	40	193	0	0	233
Magic Valley Total			**38**	**21**	**0**	**0**	**0**	**357**	**839**	**96**	**649**	**2,000**
Niagara Springs	PAH	Hells Canyon	0	84	0	0	0	0	0	0	15	99
		Little Salmon	65	24	0	0	0	662	110	0	1,436	2,297
		Little Salmon/ Pahsimeroi	0	0	0	0	0	10	32	0	61	103
		Pahsimeroi	60	0	0	0	0	321	2,168	0	0	2,549
		Pahsimeroi/ Hells Canyon	0	0	0	0	0	10	393	0	0	403
	OX	Hells Canyon	77	192	0	0	0	0	0	0	0	269
Niagara Springs Total			**202**	**300**	**0**	**0**	**0**	**1,003**	**2,703**	**0**	**1,512**	**5,720**

Table 15. (Continued)

Hatchery	Stock	Smolt Release Site	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	S. Fk. Clearwater Sect. 07	Salmon Sect. 10-12	Salmon Sect. 13-17	Salmon Sect. 18-19	Little Salmon Sect. 20	Total Harvest
Irrigon	LSCW	Imnaha	60	116	0	0	0	12	0	0	0	188
	WALW	Grande Ronde	116	50	0	0	0	20	0	0	0	186
Irrigon Total			**176**	**166**	**0**	**0**	**0**	**32**	**0**	**0**	**0**	**374**
Lyon's Ferry	CGRW	Grande Ronde	94	28	0	0	0	0	0	0	0	122
Lyon's Ferry Total			**94**	**28**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**122**
Failed to Assign			53	83	0	0	0	0	0	13	0	149
Grand Total[1]			**582**	**598**	**2,652**	**819**	**1,147**	**1,580**	**5,886**	**2,858**	**2,161**	**18,283**

[1] The sum of the grand totals in Table 15 is less than the sum of the total harvest in Table 13 because strata from which no PBT samples were collected are not included in the seasonal analyses.

Table 16. Total estimated harvest of adult steelhead by rearing hatchery, stock, and cohort during the fall of 2015 and the spring of 2016 sport fishery.

Hatchery	Stock	Brood Year 2013	Brood Year 2012	Brood Year 2011	Total
Dworshak	DWOR	2,559	5,640	175	8,374
Dworshak Total		**2,559**	**5,640**	**175**	**8,374**
Clearwater	DWOR	536	1,162	71	1,769
	SFCR		272		272
Clearwater Total		**536**	**1,434**	**71**	**2,041**
Hagerman	SAW	7,380	1,394		8,774
Hagerman Total		**7,380**	**1,394**		**8,774**
Magic Valley	DWOR		923		923
	USAL	981			981
	PAH	636	370		1,007
Magic Valley Total		**1,617**	**1,293**		**2,910**
Niagara Springs	OX	879	577	67	1,523
	PAH	8,860	2,285	13	11,158
Niagara Springs Total		**9,738**	**2,862**	**79**	**12,681**
Irrigon OR	LSCR	427	243		670
	WALL	628	420		1,049
Irrigon OR Total		**1,055**	**663**		**1,718**
Lyon's Ferry WA	CGRW	437	201		638
	LYON		133		133
	TUCA	42			42
Lyon's Ferry WA Total		**478**	**334**		**812**
Failed to Assign					286
Grand Total[1]		**23,364**	**13,620**	**326**	**37,596**

[1] The sum of the grand totals in Table 16 is less than the sum of the total harvest in Table 13 because strata from which no PBT samples were collected are not included in the seasonal analyses.

Hatchery Trap Returns

Daily trapping numbers were used to summarize the run timing for hatchery and natural origin fish collected in hatchery traps. Arrival timing at Hells Canyon Dam was not included, as the trap was operated intermittently (primarily in the fall) and would not show representative run timing. South Fork Clearwater River broodstock were collected by an angler contribution program and were, therefore, also not represented. Figures 8 and 9 summarize the run timing of steelhead that returned to hatchery traps in the upper Salmon River in 2016.

Table 17 summarizes the age composition, origin, average fork lengths, and the total number of adult steelhead trapped at each of the four trapping facilities operated by IDFG. The proportion of fish in each age group was estimated from the statistical computer program *R* (R Development Core Team 2010) with the *mixdist* library package (Macdonald 2010). The *mixdist* program, called *Rmix*, is used 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. The subsample of known age and fork length data used as input parameters for the program was acquired by genotyping the broodstock and assigning samples to the PBT baseline. If known age information was not available through PBT analysis, then age composition was estimated using 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 was used to estimate the number of fish in each age class. In some cases where neither program could be used because of few returning adults, an age was assigned by applying a length cutoff after visually reviewing length frequencies. An example of where age data was not available from either PBT or CWT recoveries is the East Fork Salmon River trapping facility, where only fish of natural origin are used for broodstock and fish of hatchery origin are released back into the river to spawn naturally.

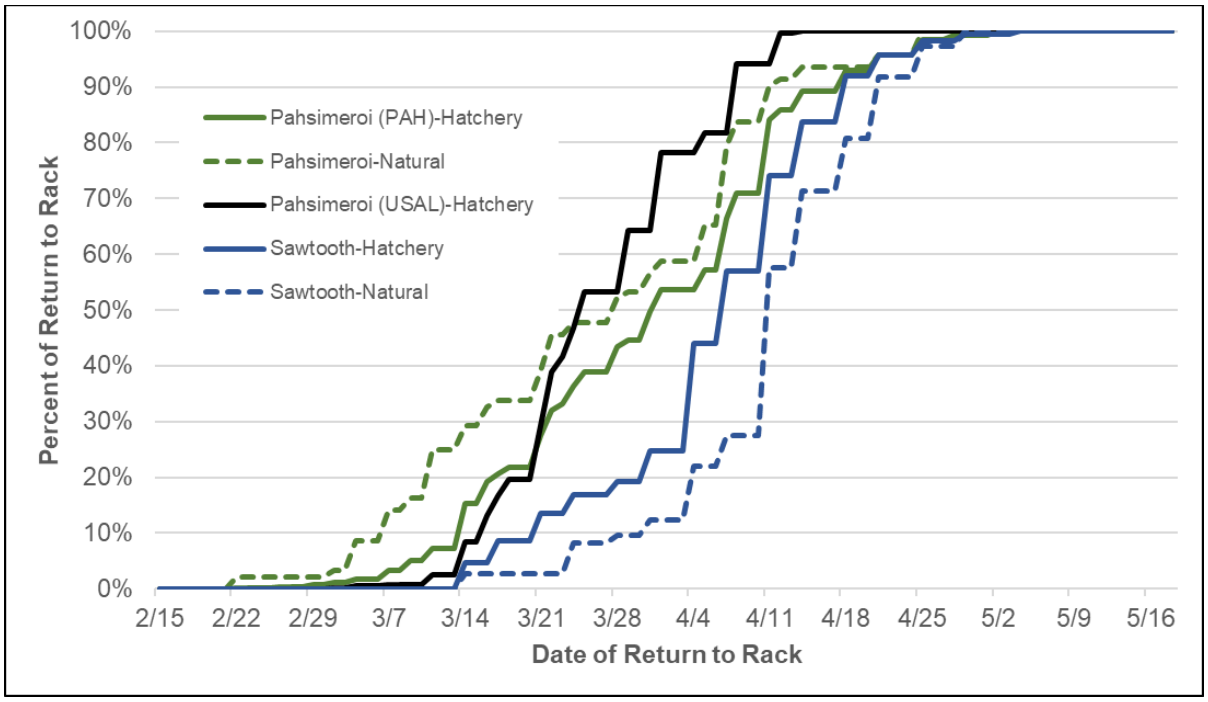

Figure 8. Run timing of adult hatchery and natural origin steelhead arriving at the Pahsimeroi and the Sawtooth trap in 2016.

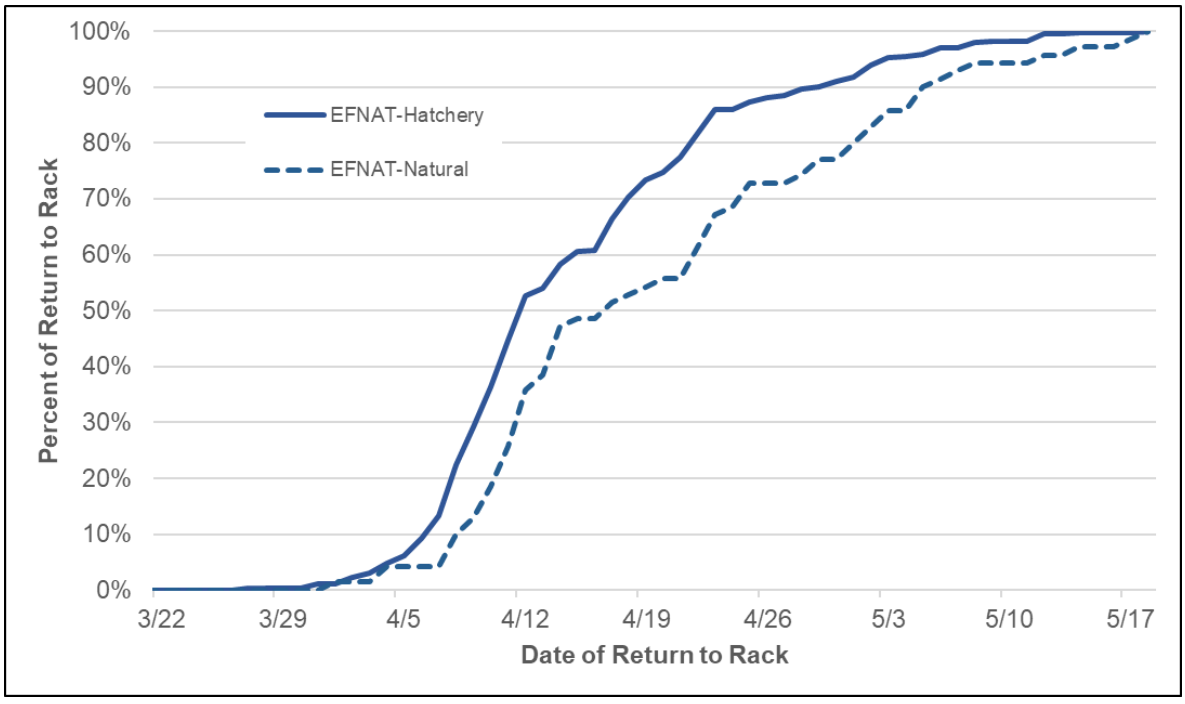

Figure 9. Run timing of adult hatchery and natural origin steelhead arriving at the East Fork Salmon River trap in 2016.

Table 17. Age composition and average fork length (cm) of adult steelhead returning to hatchery traps in 2016.

			Males				Females				
			One-ocean		Two-ocean		One-ocean		Two-ocean		
Hatchery Trap	Stock	Origin	Number Trapped	Average Length	Number Trapped	Average Length	Number Trapped	Average Length	Number Trapped	Average Length	Total Return
Sawtooth	SAW	H	1,828	60	225	68	1,012	58	397	66	3,462
		N	18	60	11	74	11	58	33	68	73
East Fork	EFNAT	H	136	61	50	72	190	64	17	72	393
		N	20	60	15	73	19	62	16	71	70
Pahsimeroi	PAH	H	2,042	59	454	69	1,773	58	1,175	67	5,444
		N	26	60	9	71	39	59	18	67	92
	USAL	H	25	64	227	78	0	-	314	75	566
Hells Canyon	OX	H	610	59	179	69	531	57	393	66	1,713
		N	14	62	7	71	5	60	12	66	38
Clearwater[1]	SFCR	H	12	69	108	81	3	65	231	77	354

[1] Clearwater adult steelhead acquired from anglers donating to SFCR localized broodstock program.

LOCALIZED BROODSTOCK DEVELOPMENT

East Fork Natural Program

The East Fork Salmon River Trap is a satellite facility of Sawtooth Fish Hatchery (SFH) and is utilized to collect broodstock for the EFNAT steelhead supplementation program. The goal of this hatchery program is to aid in the recovery of the natural steelhead population in the East Fork Salmon River by supplementing the natural spawning population.

Hatchery production and release goals for the EFNAT program are to annually release 60,000 integrated steelhead smolts into the East Fork Salmon River near the adult trap. To achieve this production goal, approximately 86,300 green eggs are needed from approximately 15 females. Naturally produced adults will be prioritized for inclusion into the broodstock but if insufficient natural adults are available, hatchery-origin adults will be included in the broodstock. Steelhead determined to be strays are killed and are not incorporated into the program. All progeny released back into the East Fork Salmon River will be ad-intact with a CWT for later identification. An Annual Operating Plan summarizing the current year's broodstock and spawning protocols is jointly developed preseason by Nampa Fisheries Research and SFH staff.

For the 2016 brood year, the trap was operated from March 22 through May 18. During this time 463 adult steelhead were trapped, including 171 males and 198 females of hatchery origin (HO), 35 males and 35 females of natural origin (NO), and 24 fish that were identified as HO non-program strays (Table 18). A total of 191 male (171 HO, 20 NO) and 218 female (198 HO, 20 NO) adult steelhead were released above the velocity barrier to spawn naturally. Steelhead which were held for spawning included 19 males (4 HO, 15 NO) and 16 females (0 HO, 16 NO). One NO male died in holding before spawning. Of the males, 13 NO were spawned twice and 1 NO was spawned three times, then killed and placed downstream of the weir for nutrient enhancement in the river. One HO male was spawned once and then released above the weir to spawn naturally. The remainder of the males (3 HO) were not spawned and released above the weir to spawn naturally. Of the females, 15 NO were spawned, killed, and placed below the weir for nutrient enhancement in the river; while one NO female was released above the weir to spawn naturally.

The proportion of fish released upstream to spawn naturally that were HO was 97.7%. All HO non-program fish were killed and not used for spawning. Spawning activities yielded a total of 100,504 green eggs for an average fecundity of 6,700 eggs per female. A total of 92,025 eyed eggs were obtained for a 91.6% eye-up survival rate. Due to higher than expected fecundity and eyed egg survival, this year's production will likely exceed the release goal of 60,000 smolts, which will result in an evaluation and possible adjustment of future spawning goals for the program.

Table 18. Disposition of adult hatchery origin (HO) and natural origin (NO) steelhead trapped at the East Fork Salmon River facility in 2016.

Fish Disposition	HO Males	NO Males	HO Females	NO Females
Total Trapped	186	35	207	35
Released Above Weir Before Spawning	170	20	198	20
Spawned and Released	1	0	-	-
Spawned and Killed	0	14	0	15
Killed and Not Used (Strays)	15	0	9	0
Pre-Spawn Morts	0	1	0	0

Upper Salmon River B-index Program

The current effort to develop a locally adapted hatchery stock in the upper Salmon River, which matures predominantly (approximately 90%) after two or more years in the ocean, began in 1997 with the release of DWOR stock smolts in Squaw Creek. Adults from these releases returned as two-ocean fish in 2002 and provided the founding stock (USAL) for the Upper Salmon B-index program. Returns of USAL stock adults are being evaluated annually with modifications made as needed to continue to further develop the program into a completely self-sustaining broodstock.

The USAL broodstock collection was shifted from Squaw Creek to the Pahsimeroi River in 2010 with the release of 95,023 USAL smolts (ad-intact and 100% CWT) into the Pahsimeroi River below the weir. The eventual goal is to shift the broodstock collection facility to the Yankee Fork Salmon River in the near future. Field operations related to development of the USAL program continue at the Pahsimeroi Fish Hatchery with the release of 93,600 DWOR stock smolts and 155,000 USAL stock smolts tagged with CWT at the Pahsimeroi weir in 2016 (Table 3). Goals for progeny of 2016 USAL broodstock are to continue releasing smolts into the Pahsimeroi River as well as the Yankee Fork Salmon River, Salmon River at Squaw Creek, and the Little Salmon River (Table 19). There is also a request for 500,000 eyed eggs for the Yankee Fork egg box program operated by the Shoshone-Bannock Tribal Fisheries Program. Additionally, 155,000 smolts of DWOR origin are scheduled to be released into the Pahsimeroi River to maintain genetic diversity of the USAL broodstock collection program. The DWOR stock release program will also continue to be used to backfill releases where USAL broodstock goals are not met.

Table 19. Release goals for the Upper Salmon River B-Index (USAL) program.

Stock	Location	Ad-intact/CWT	Ad-clipped	Eyed Eggs
DWOR	Pahsimeroi River	93,000		
USAL	Pahsimeroi River	155,000		
DWOR/USAL	Yankee Fork Salmon River	221,000	243,000	
DWOR/USAL	Squaw Creek		126,000	
DWOR/USAL	Little Salmon River		206,000	
DWOR/USAL	Yankee Fork Salmon River Egg Box Program			500,000

Pahsimeroi Hatchery personnel installed the weir and opened the fish trap on February 16, 2016. Adult steelhead caught and sorted at the trap were checked for adipose fin clips and scanned for coded wire tags (CWT). Any ad-intact fish with CWT was considered a returning USAL-B stock fish and was retained in the brood holding pond for use as USAL-B broodstock. On March 2, the first USAL stock fish (a female) fish was caught. A total of 314 females and 252 males were handled and classified as USAL-B stock fish by hatchery personnel in 2016. During spawning, all adult steelhead used for brood stock had a tissue sample taken for genetic analysis. A total of 301 females were crossed with 217 males, producing approximately 1,844,371 green eggs that were incubated to the eye-up stage at Pahsimeroi Fish Hatchery for an eye-up rate of 89.9%. Approximately 1,178,477 eyed eggs were shipped to Magic Valley Fish Hatchery (MVFH), to be reared to full-term smolts, before stocking in the upper Salmon River basin and the Little

Salmon River in the spring of 2017. The rest were provided to the Sho-Ban Tribe for their Yankee Fork egg box program.

Subsequent analysis of PBT samples indicated that two females used as broodstock were nonprogram fish of PAH stock origin, one failed to genotype, and eight genotyped but failed to assign to a cohort or release group after accounting for the expansion of the tag rates of steelhead that did assign to the hatchery baseline (Table 20). The rest assigned to the Upper Salmon River B-Index program as progeny of DWOR or USAL broodstock collected at Pahsimeroi Weir or at Squaw Creek. There were 23 males used as broodstock that were genetically identified as progeny of brood year 2013 (one-ocean) DWOR broodstock.

Table 20. Genotyping results of 517 adult steelhead used for USAL broodstock at Pahsimeroi Fish Hatchery in 2016.

Stock/Brood Year[1]	Females	Males
DWOR/2013		23
DWOR/2012	27	20
PAH/2012	2	
USAL/2012	263	167
USAL/2011	2	4
Failed to Assign	6	2
Failed to Genotype		1
Total Genotyped	**300**	**217**

[1] USAL stock designations are returning adult steelhead that are progeny of broodstock trapped and spawned at Squaw Creek in 2011 and 2012.

South Fork Clearwater River Program

In 2010, IDFG initiated a program to develop a hatchery broodstock that was locally adapted to the South Fork Clearwater River. Although hatchery fish have 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 partial migration barrier near Golden, Idaho. Since there are no adult collection facilities in the South Fork Clearwater River downstream of the partial barrier, a volunteer angler contribution program has been used to collect broodstock directly from the South Fork Clearwater River. The goal of this program is to meet Clearwater FH's release goal of 843,000 smolts into the South Fork Clearwater River drainage. Prior to brood year 2015, this program was supplemented with broodstock caught at the Dworshak trap facility. Adult steelhead contributing to the program are caught by anglers who provide them to hatchery personnel stationed on the South Fork Clearwater River. Hatchery tanker trucks transport the fish to Dworshak where they are held until spawning. In February and March of 2016 anglers caught and donated a total of 354 adult steelhead of hatchery-origin to the broodstock program (Table 19). These efforts resulted in the collection of 1,454,243 green eggs from spawning 226 females crossed with 119 males for an average fecundity of 6,435 eggs per female.

RESEARCH

Evaluation of Steelhead Reared in a Reuse Aquaculture System at Hagerman National Fish Hatchery

A pilot study is being conducted at Hagerman National Fish Hatchery to evaluate the effectiveness of a partial reuse aquaculture system (PRAS) to rear steelhead. Hagerman was chosen because the source of water in the Hagerman Valley is limited and has been declining over the past several years. As a result, managers are facing the choice of either reducing production of steelhead or adopting methods, such as water reuse, that will maintain current production with less flow. The PRAS system selected uses three circular rearing tanks and associated reuse infrastructure housed in a stand-alone building. The circular tank system was selected because of suggested benefits of ease of operation and improved fitness to the fish reared in a higher velocity environment, as well as the lower flow requirements of the system.

The PRAS building includes three rectangular tanks (not on reuse) to rear steelhead from incubation to marking (~100 fish/lb.) before transferring to the PRAS system. Each of the three PRAS tanks measures 30 ft. in diameter, 6 ft. deep, with 3,885 ft^3 of rearing volume, sufficient in size to allow loading up to approximately 30,000 fish per tank at 4.5 fish/lb. Each tank is equipped with a bottom center drain for effluent/waste removal and a side drain port for effluent and reuse water withdraw. Reuse water is passed through a common drum filter, sump pumps, degas/reaeration tower and returned to circular tanks. Inflow jets create circular flow to produce velocities of 0.5 - 2.0 fps.

Evaluation of the system beginning with brood year 2014 and continuing with brood years 2015 and 2016 include a paired treatment test comparing steelhead reared in the PRAS to those reared in the conventional raceways at the same loading densities (0.20 Lbs./ft^3). Variables between treatment and control groups are being reduced by using only SAW stock fish from eggs taken on the same spawning day (egg lot) released at Sawtooth weir. The PRAS was operated at 50% reuse water for the brood year 2014 cohort then operated at 75% reuse water for the brood year 2015 and brood year 2016 cohort. Primary variables of interest are associated with survival and condition (fitness) of steelhead in the two systems. Measurements of whole body proximate composition and smoltification were made as part of the evaluation to determine whether steelhead reared in PRAS vary significantly from that of steelhead reared in traditional concrete raceways (Twibell et al. 2016; Twibell et al. 2017). Evaluation metrics after release include smolt survival through the Snake and Columbia river hydropower system and adult returns to the weir. Comparisons of adult returns will be based on the recovery of CWTs used to differentiate between fish reared in the PRAS and those reared in the raceways. Spawn year 2017 will be the first year that fish reared in the PRAS will be returning to the weir as age-3 (one-ocean) adults. Sawtooth Fish Hatchery personnel will be CWT scanning all adult steelhead that return to the weir in consecutive years until the evaluation is complete.

Results of physiological comparisons between the treatment and control groups indicate that whole body lipid concentration was significantly higher in PRAS steelhead compared with control fish from brood year 2014, but was significantly lower in PRAS steelhead compared to control fish from brood year 2015 (Twibell et al. 2016). Observations from brood year 2016 show lipid concentration was significantly lower in PRAS steelhead compared with control fish throughout most of the rearing cycle (Twibell et al. 2017). Differences may be related to water velocity and feed rate or feeding methods in the PRAS in brood year 2014 and 2015, as staff was gaining experience with the PRAS during the first year of operation. Brood year 2015 smolt survival estimates from release at Sawtooth Fish Hatchery to LGD in 2016 is provided in Table

21. Similar to the previous year (Warren et al. 2017), results indicate a significantly lower survival rate of fish raised in the PRAS compared to fish reared in conventional raceways. Apparent differences in juvenile survival are being evaluated with the involvement of personnel from Abernathy Fish Technology Center (FWS), who are considering a more comprehensive comparison of PIT tag retention rates in future release groups. Results of the adult return of this cohort reared in the PRAS will not be available until the adult return and recovery of treatment and control group CWTs from the 2018 spawn year.

Table 21. Metrics used to estimate adjusted smolt survival from release to LGD in 2016 of brood year 2015 steelhead reared in the PRAS tanks, the control raceways, and the raceways not included in the study.

Release Group	Number Released	Rearing Density (lbs./ft^3)	PIT Tags Released	Number of Unique Detections at LGD	Probability of Detection at LGD	Adjusted % Survival (95% CI)
Sawtooth Weir Non-study Production	1,128,320	0.23	8,305	2,257	0.372	73.1 (70.9-75.3)
Sawtooth Weir PRAS	94,217	0.20	8,761	1,619	0.379	48.8 (46.8-50.8)
Sawtooth Weir Control	94,590	0.20	8,712	2,732	0.441	71.1 (69.4-72.78)

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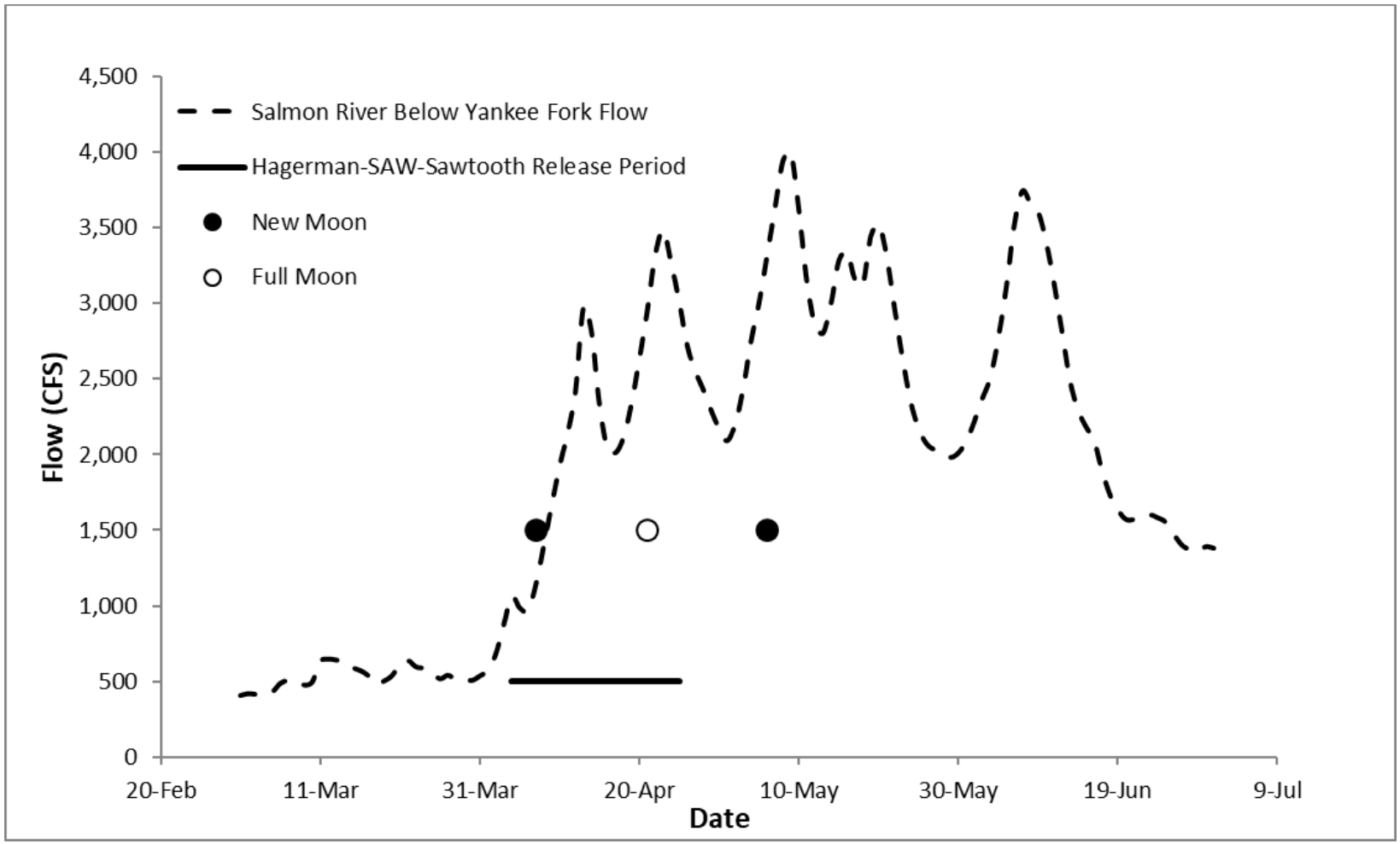
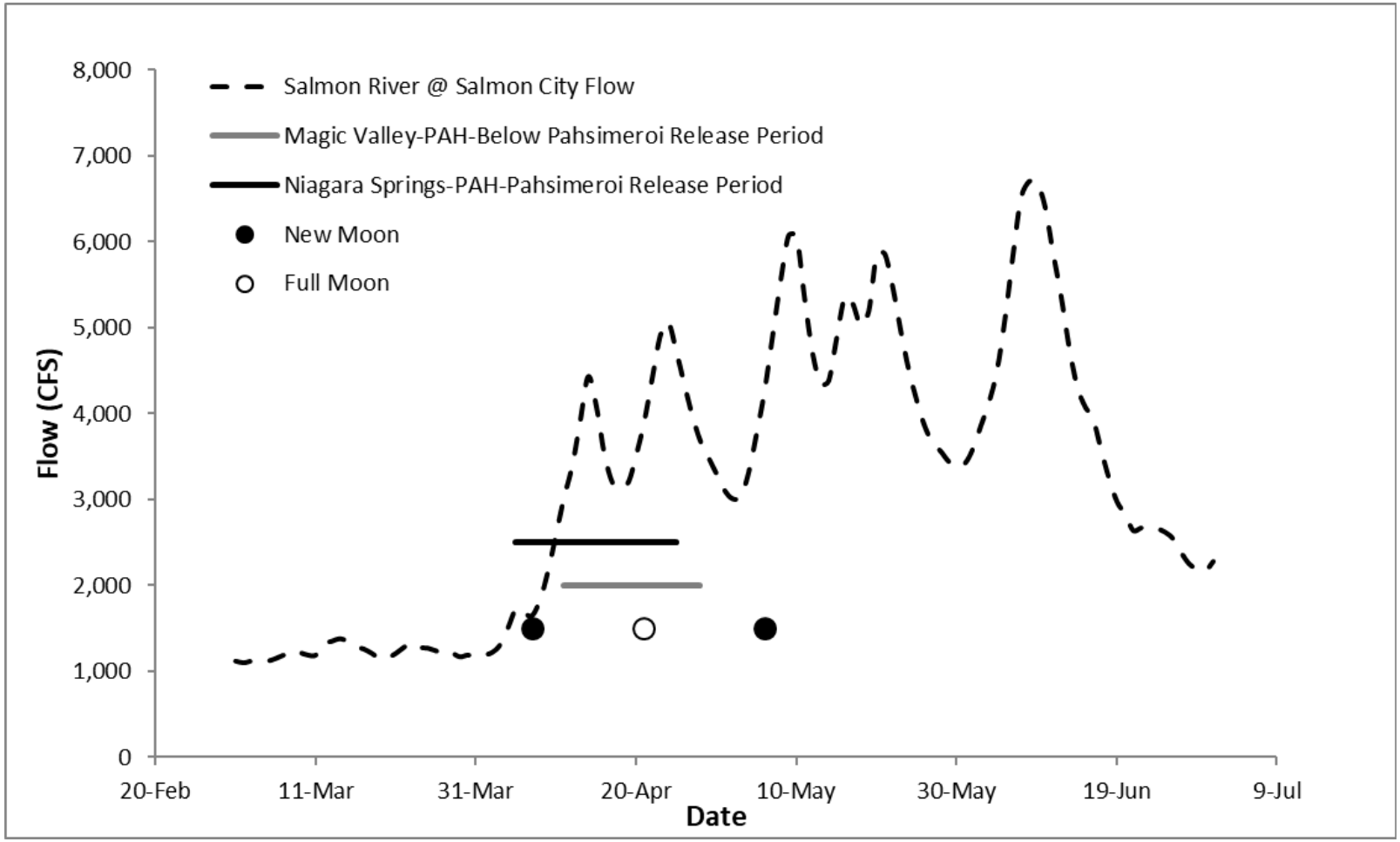
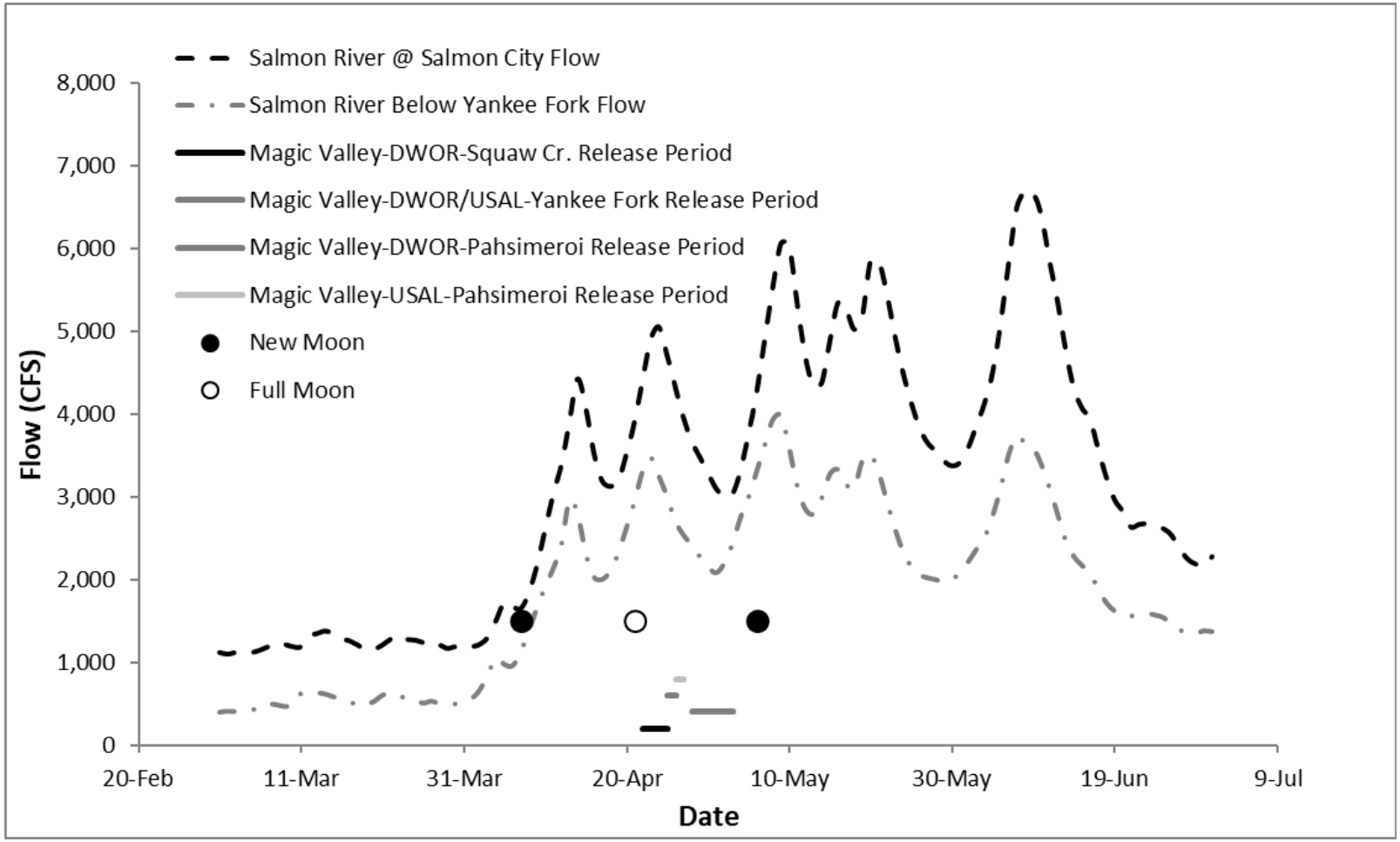
APPENDICES



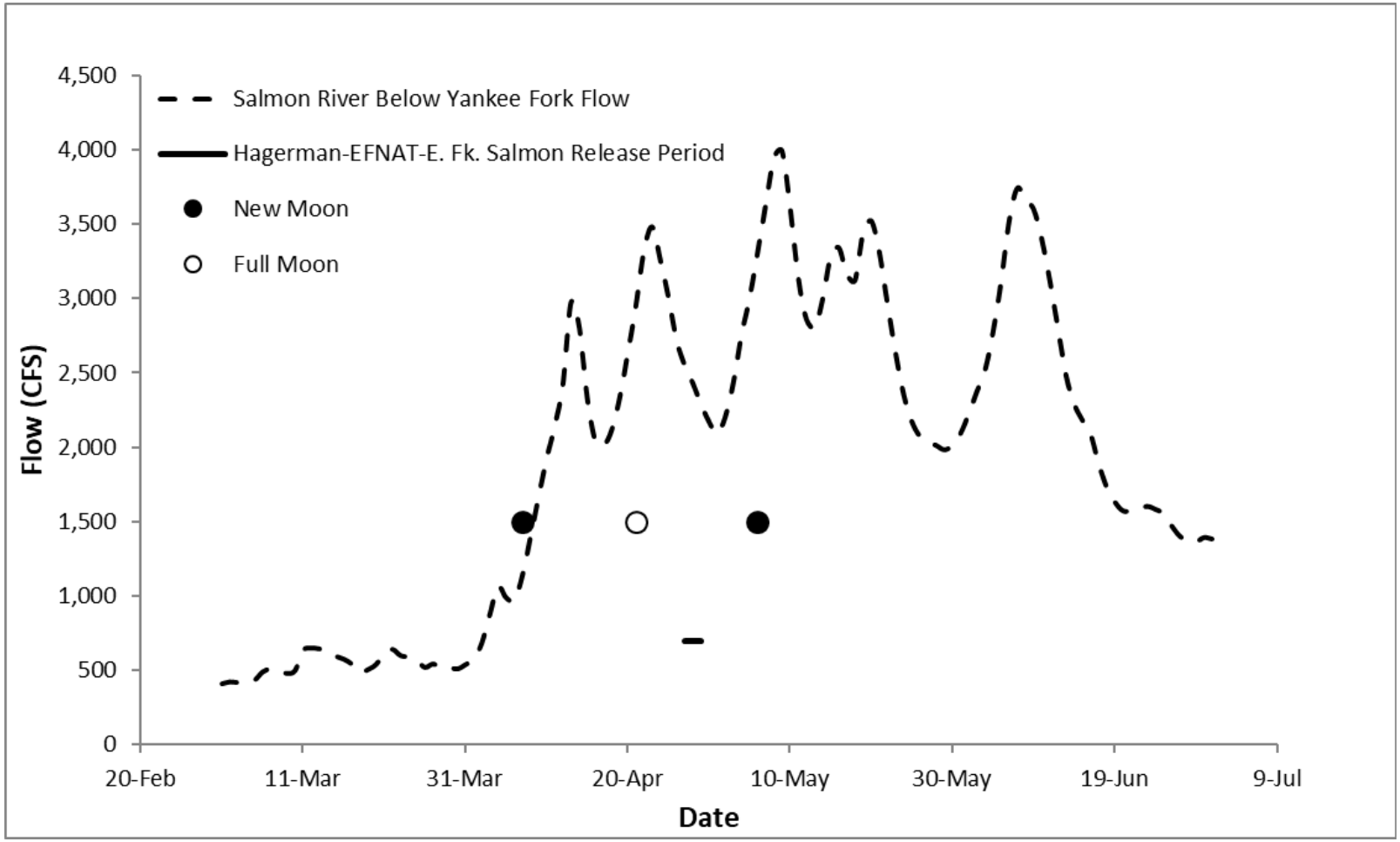
Appendix A1. Release timing of SAW stock smolts from Hagerman National Fish Hatchery into the Salmon River at Sawtooth weir vs moon phase and Salmon River flows below Yankee Fork in 2016.



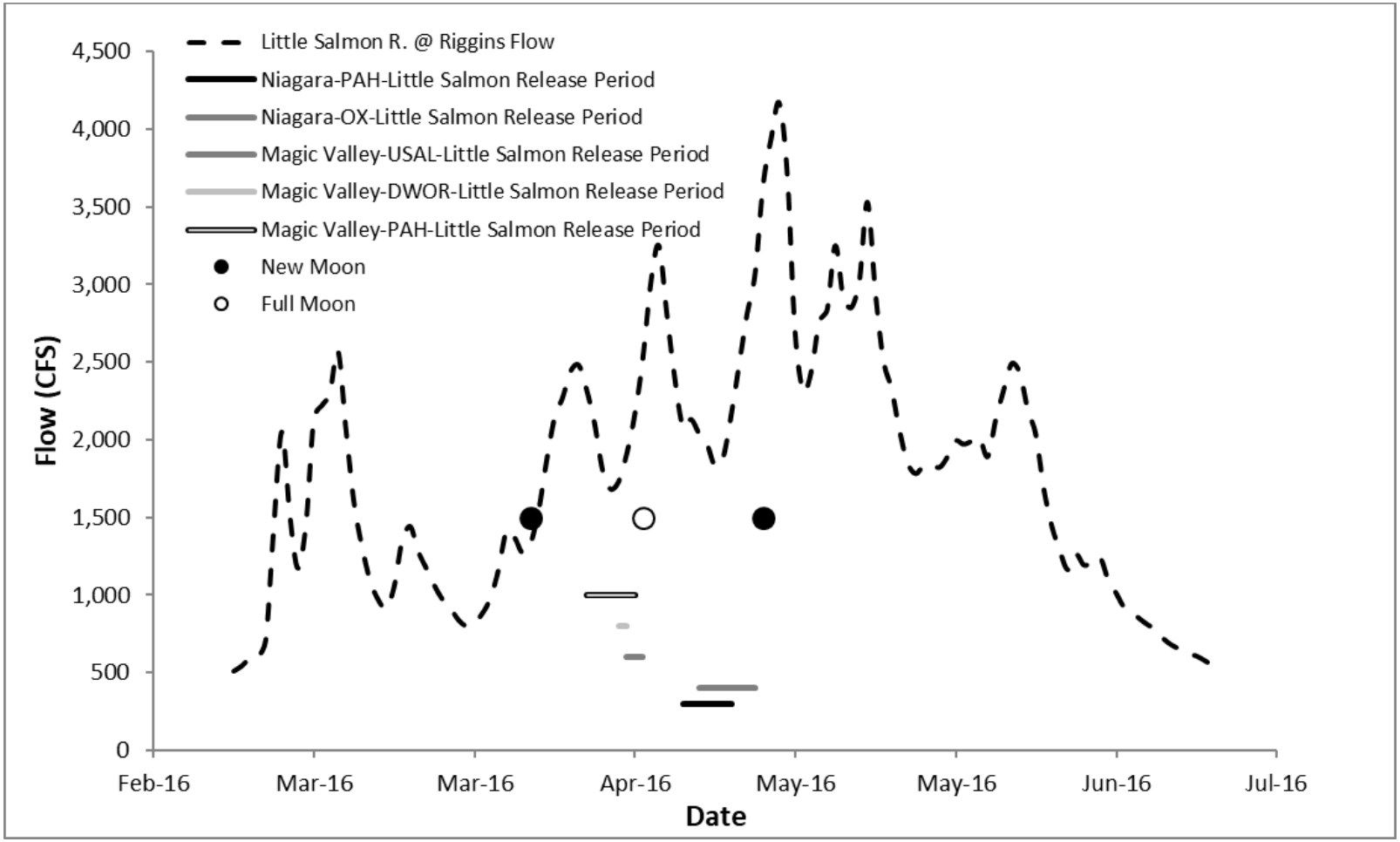
Appendix A2. Release timing of PAH stock smolts from Magic Valley Fish Hatchery and Niagara Springs Fish Hatchery into the Salmon River below the Pahsimeroi River and the Pahsimeroi River vs moon phase and Salmon River flows at Salmon City in 2016.



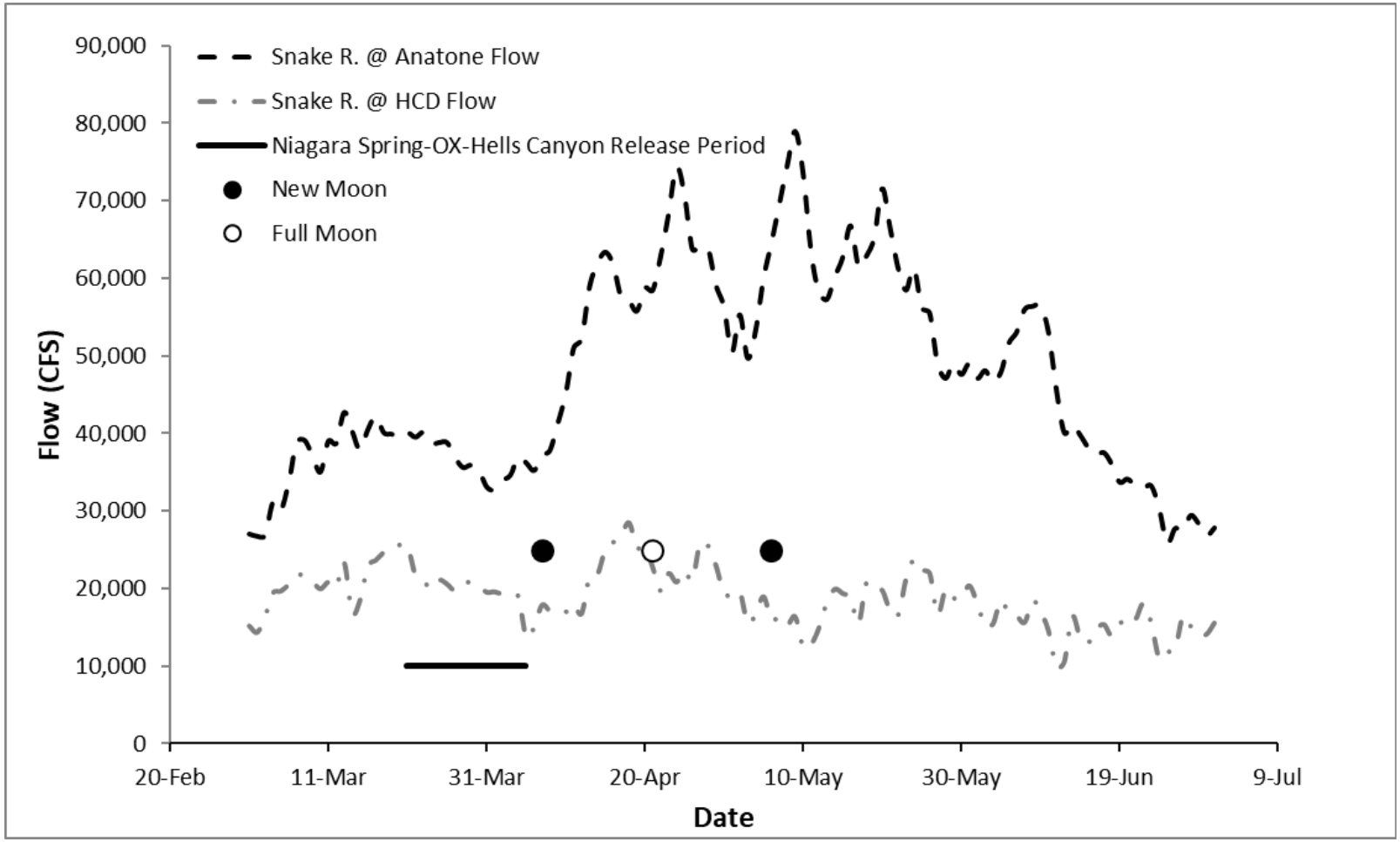
Appendix A3. Release timing of DWOR and USAL stock smolts from Magic Valley Fish Hatchery into the Salmon River at Squaw Creek, Yankee Fk., and Pahsimeroi River vs moon phase, Salmon River flows below Yankee Fk., and Salmon River flows at Salmon City in 2016.



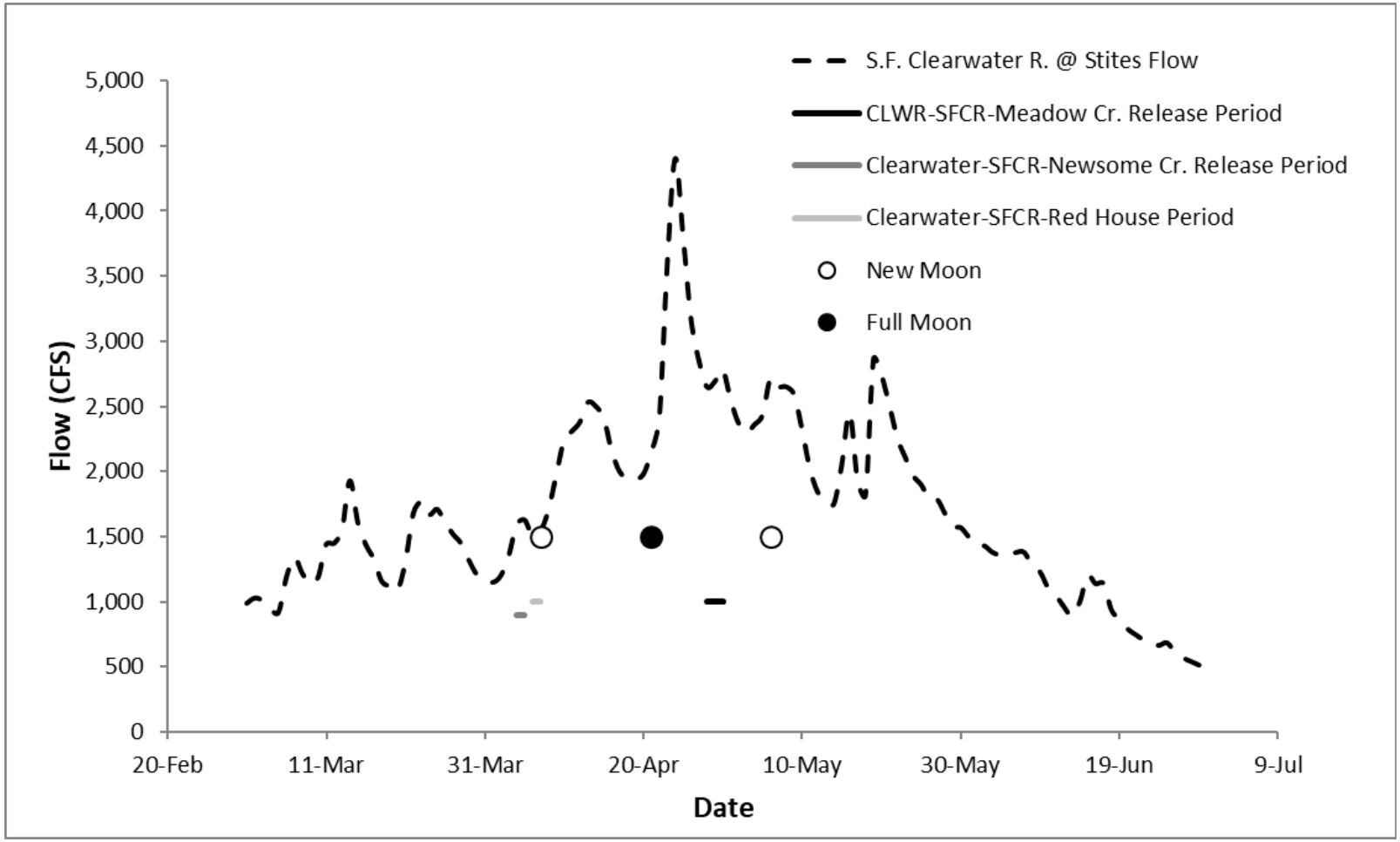
Appendix A4. Release timing of EFNAT stock smolts from Hagerman into the East Fork Salmon River vs moon phase and Salmon River flows below Yankee Fork in 2016.



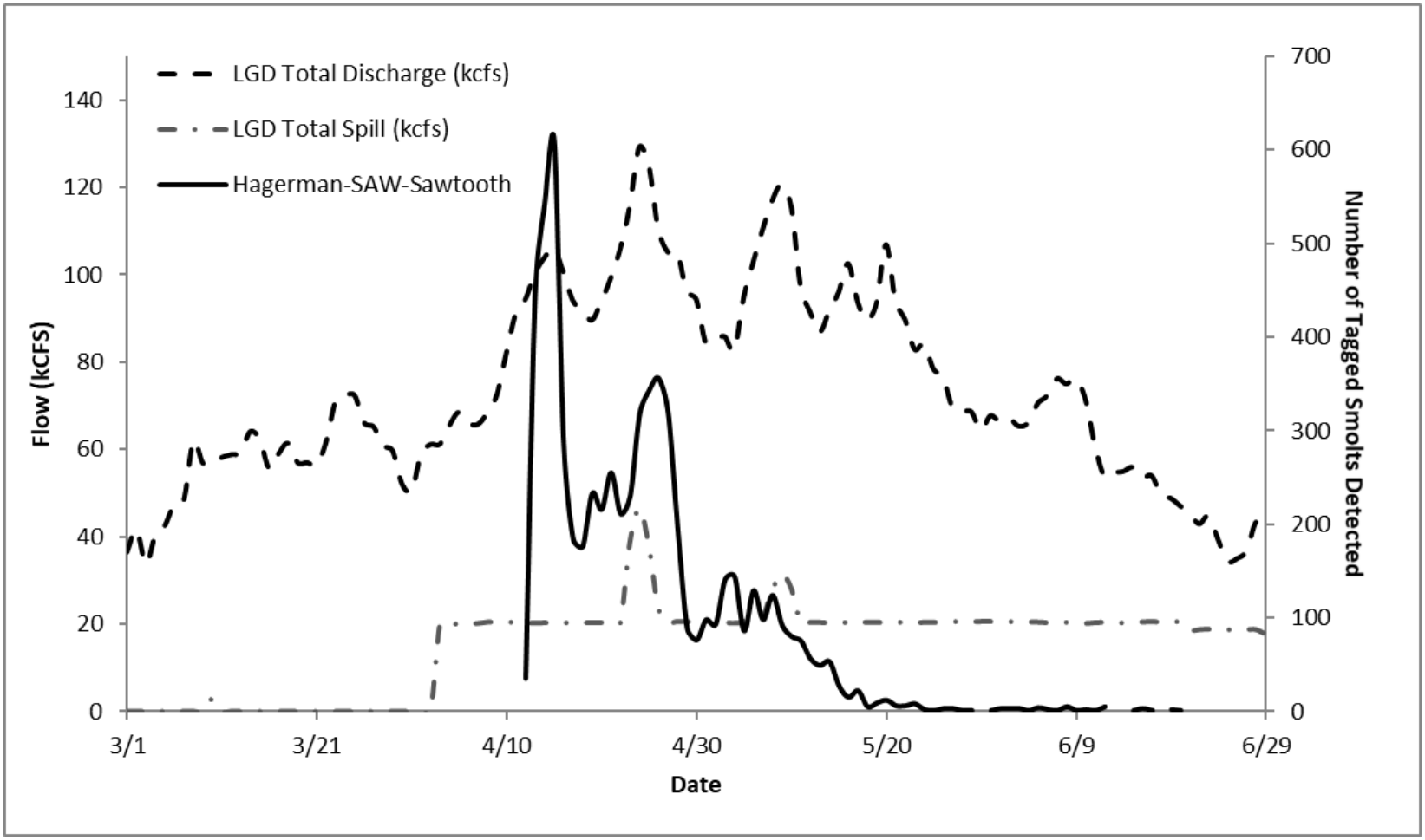
Appendix A5. Release timing of DWOR, USAL, OX, and PAH stock smolts from Magic Valley Fish Hatchery and Niagara Springs Fish Hatchery vs moon phase and Little Salmon River flows in 2016.



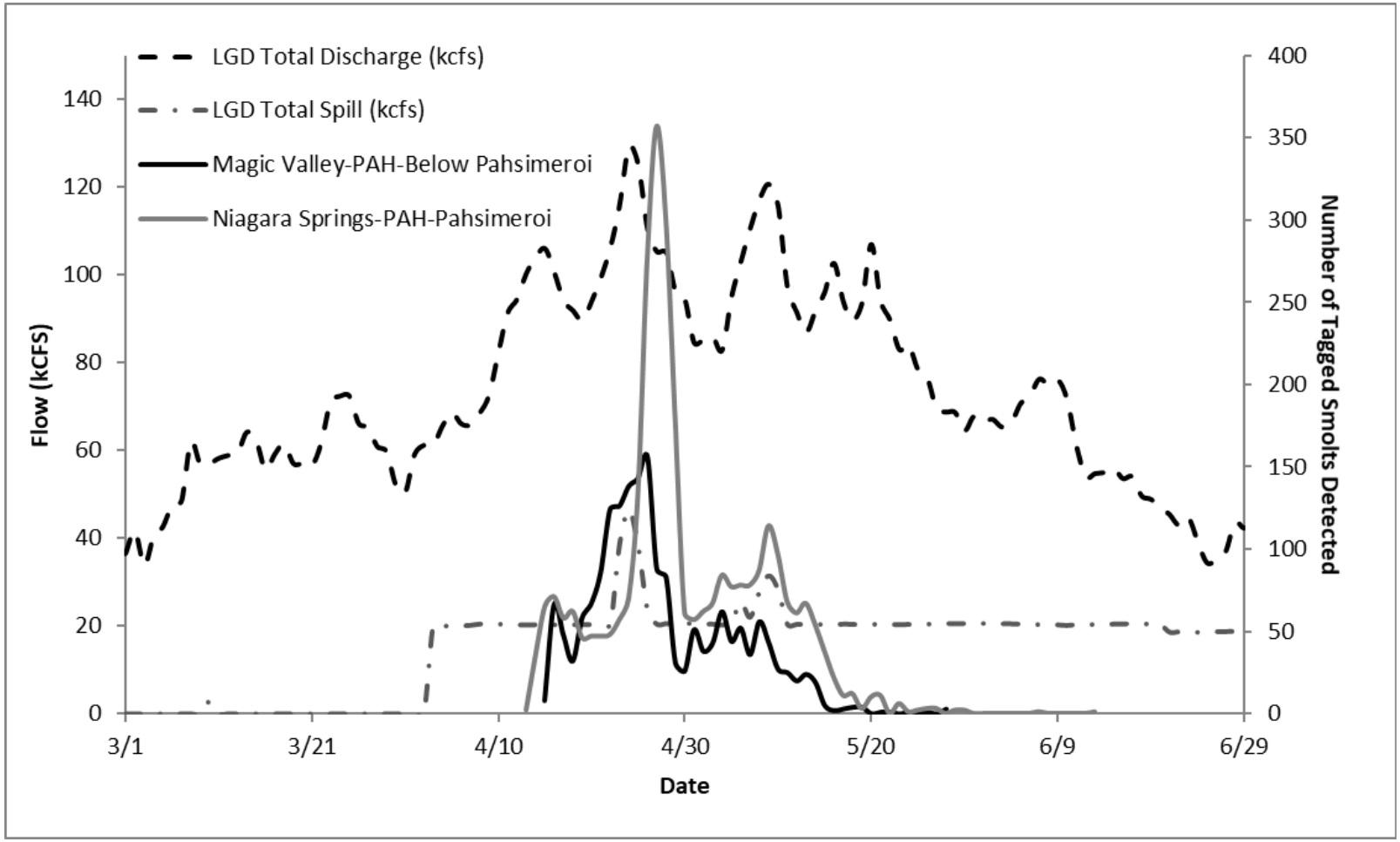
Appendix A6. Release timing of OX stock smolts from Niagara Springs into the Snake River below Hells Canyon Dam vs moon phase and Snake River flows at Hells Canyon Dam and at Anatone in 2016.



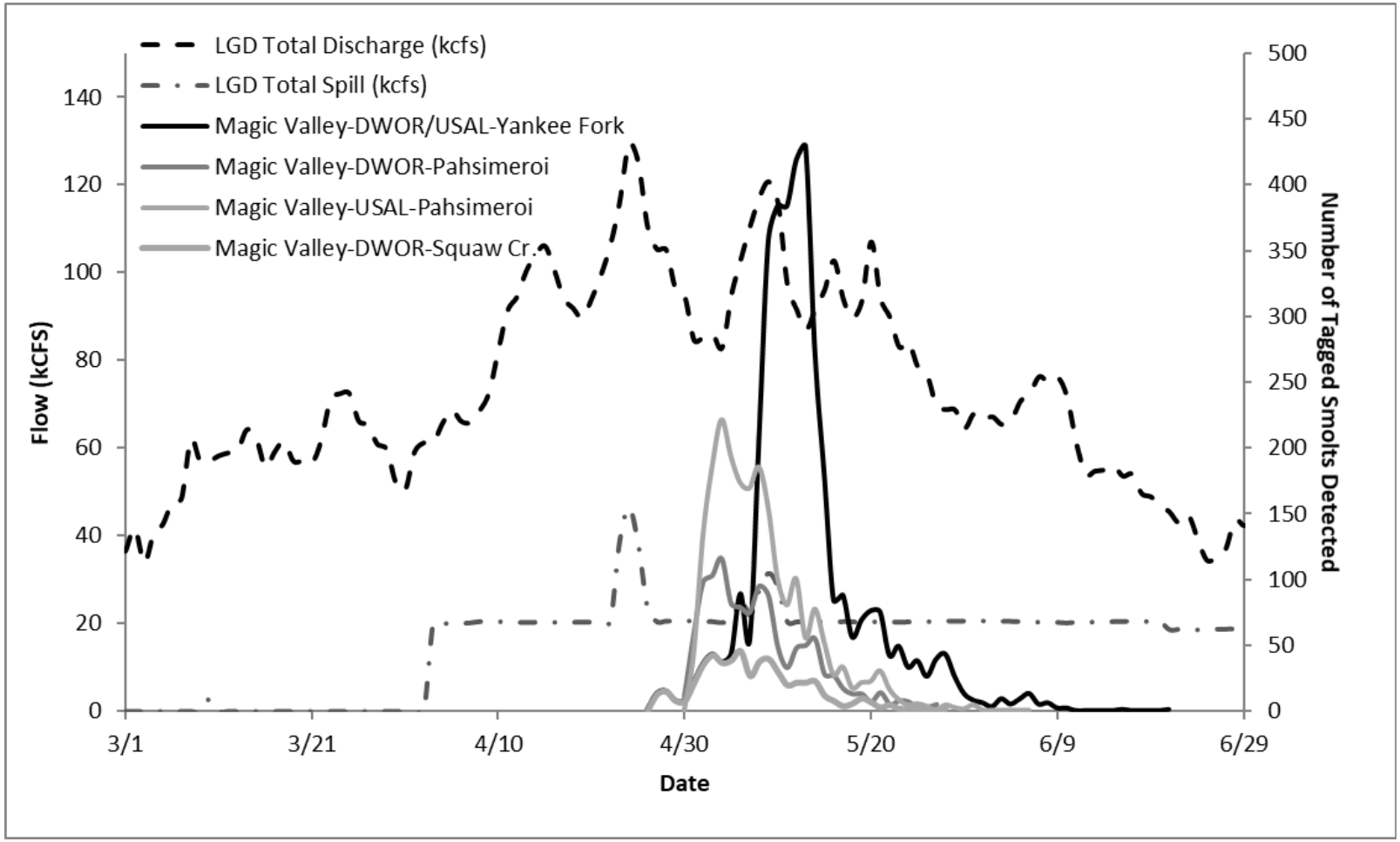
Appendix A7. Release timing of SFCR stock smolts from Clearwater Fish Hatchery into the South Fork Clearwater River vs moon phase and South Fork Clearwater River flows in 2016.



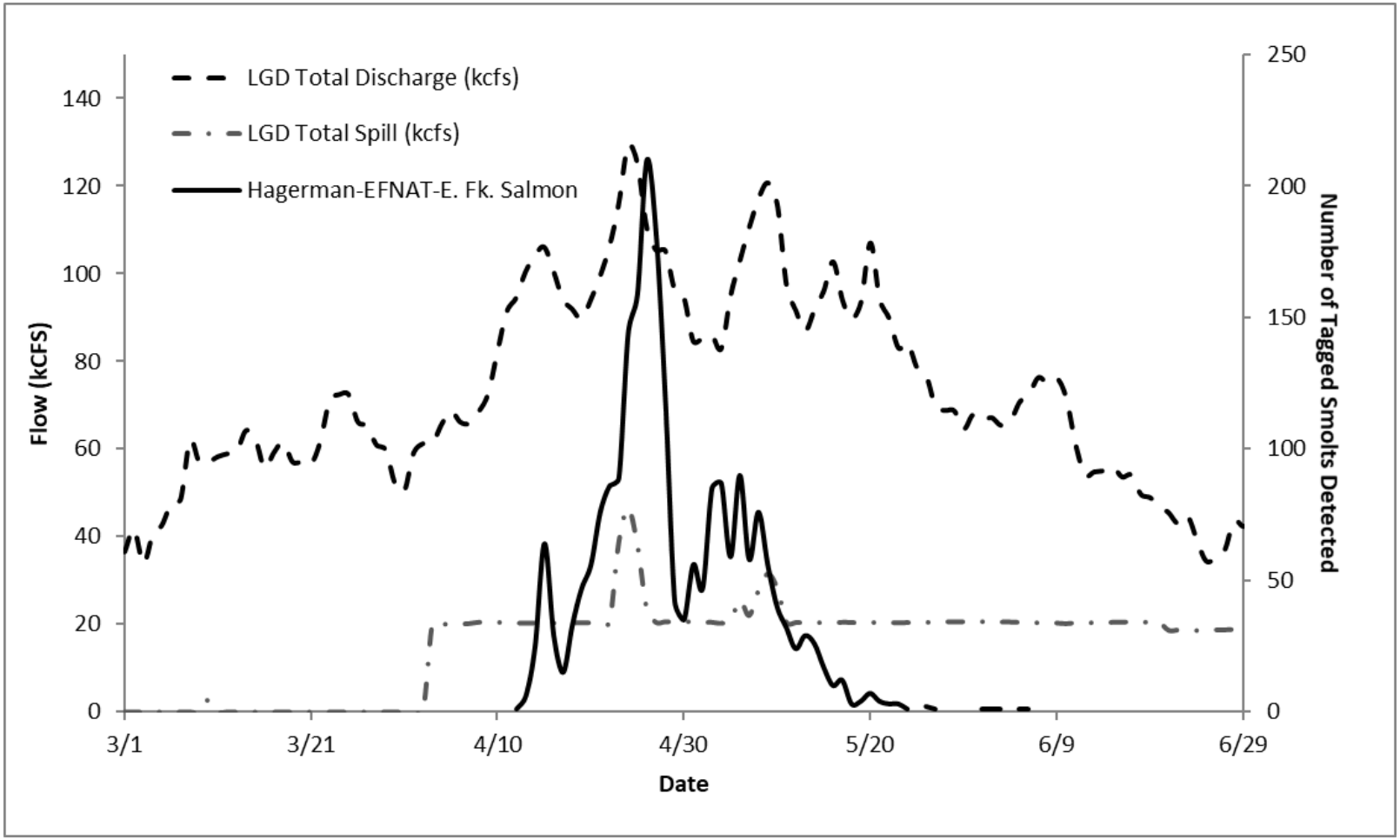
Appendix B1. Smolt arrival timing at LGD of SAW stock smolts from Hagerman National Fish Hatchery released into the upper Salmon River vs. total discharge and spill at LGD in 2016.



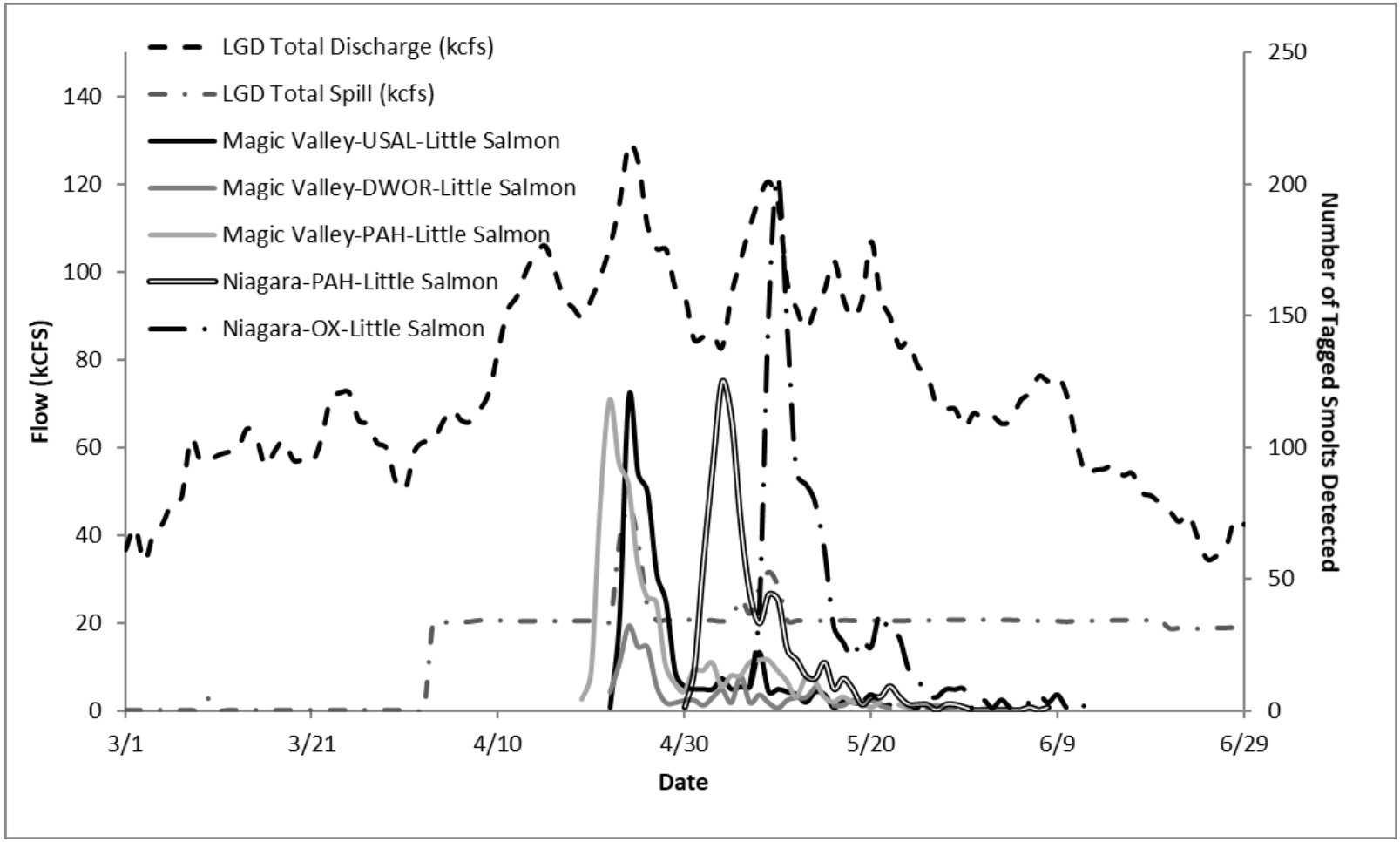
Appendix B2. Smolt arrival timing at LGD of PAH stock smolts from Magic Valley Fish Hatchery and Niagara Springs Fish Hatchery released into the upper Salmon River and Pahsimeroi River vs. total discharge and spill at LGD in 2016.



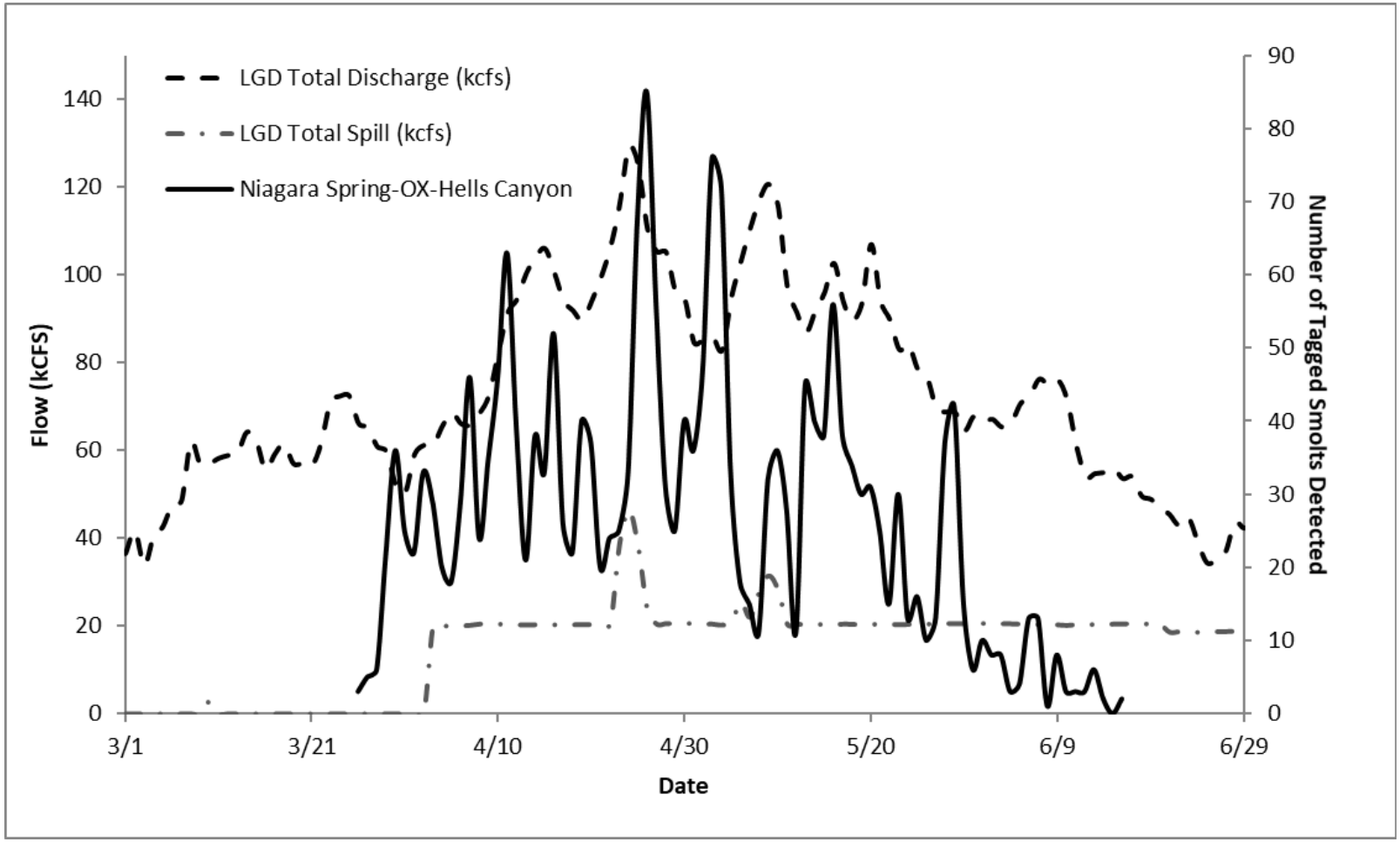
Appendix B3. Smolt arrival timing at LGD of DWOR and USAL stock smolts from Magic Valley Fish Hatchery released into the Yankee Fork and Pahsimeroi river vs. total discharge and spill at LGD in 2016.



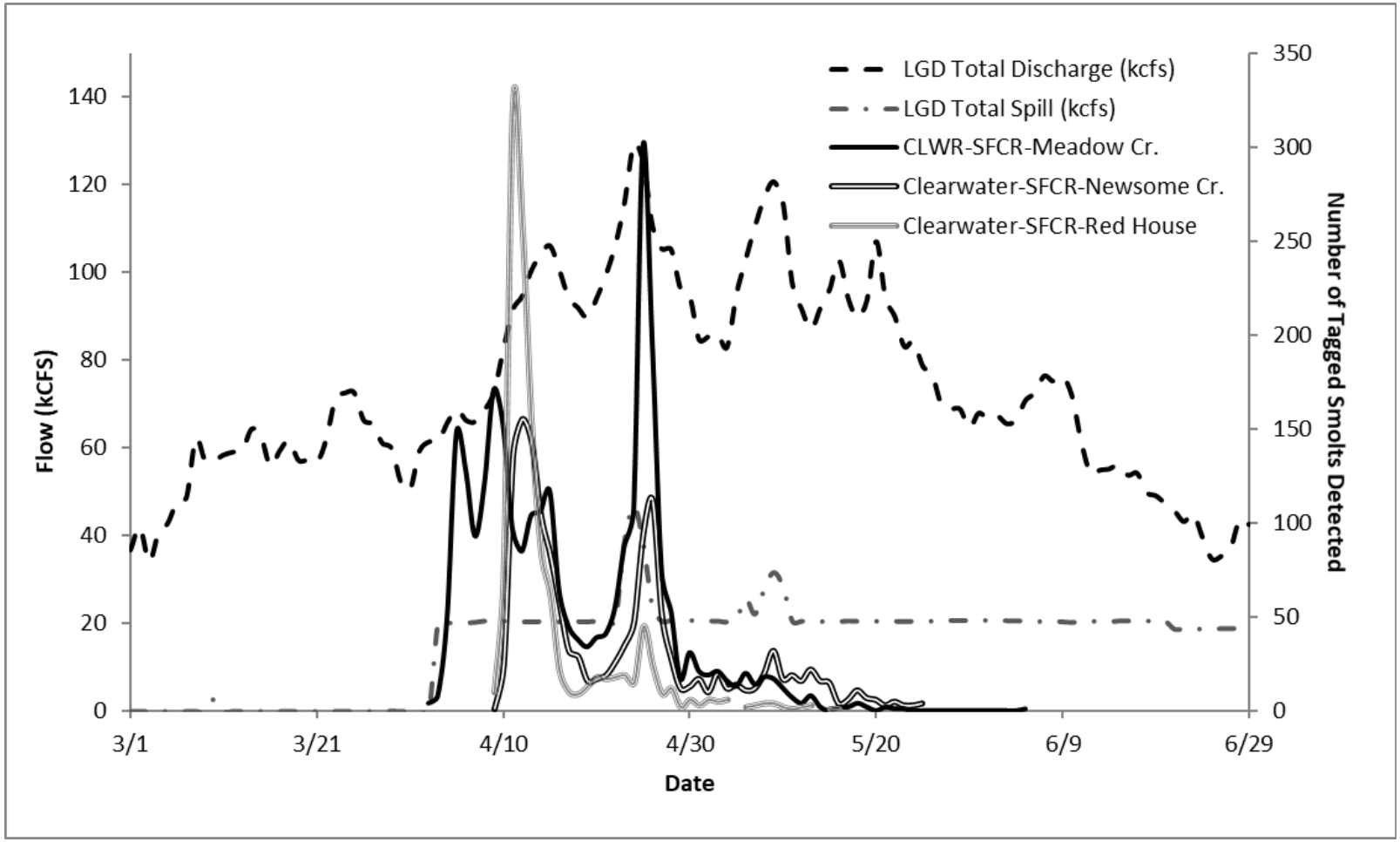
Appendix B4. Smolt arrival timing at LGD of EFNAT stock smolts from Hagerman National Fish Hatchery released into the East Fork Salmon River vs. total discharge and spill at LGD in 2016.



Appendix B5. Smolt arrival timing at LGD of PAH and USAL stock smolts from Magic Valley Fish Hatchery and Niagara Springs Fish Hatchery released into the Little Salmon River vs. total discharge and spill at LGD in 2016.



Appendix B6. Smolt arrival timing at LGD of OX stock smolts from Niagara Springs Fish Hatchery released into the Snake River below Hells Canyon Dam vs. total discharge and spill at LGD in 2016.



Appendix B7. Smolt arrival timing at LGD of DWOR and SFCR stock smolts from Clearwater Fish Hatchery released into the South Fork Clearwater River vs. total discharge and spill at LGD in 2016.

Appendix C1. Sum of expanded stock and cohort assignments of PBT subsamples taken from ad-clipped adult steelhead at the Lower Granite Dam trap during the 2015-16 run.

Hatchery	Stock	Brood Year 2013	Brood Year 2012	Brood Year 2011	Brood Year 2010	Total
Dworshak	DWOR	49	197	4		**250**
Clearwater	DWOR	17	43	2		**62**
	SFCR	2	15	1		**18**
Hagerman	EFNAT	2				**2**
	SAW	265	57			**322**
Magic Valley	DWOR		21			**21**
	PAH	74	26			**100**
	USAL	25				**25**
Niagara Springs	OX	48	23	1		**72**
	PAH	249	84		1	**334**
Lyons Ferry WA	CGRW	135	42	1		**178**
	LYON		10			**10**
	TUCA	2				**2**
Irrigon OR	LSCR	35	17			**52**
	WALL	140	128	1		**269**
Unassigned						**43**
Total		**1,043**	**663**	**10**	**1**	**1,760**

Appendix C2. Sum of expanded stock and cohort assignments of PBT subsamples taken from ad-intact adult steelhead at the Lower Granite Dam trap during the 2015-16 run.

Hatchery	Stock	Brood Year 2013	Brood Year 2012	Brood Year 2011	Brood Year 2009	Total
Dworshak	DWOR	23	108	3		**134**
Clearwater	DWOR	52	101			**153**
	SFCR	26	72	1		**99**
Hagerman	EFNAT	34	51	2		**87**
	SAW	8	2			**10**
Magic Valley	DWOR	6	27	1		**35**
	PAH		1			**1**
	USAL	30	82	2		**114**
Niagara Springs	OX		1			**1**
	PAH	1	2			**3**
Sho-Ban Egg Box	PAH		2	1	1	**4**
Lyon's Ferry WA	CGRW	7	1			**8**
	TOUW	10	1	1		**12**
	TUCW	31	15			**45**
Irrigon OR	WALL		2			**2**
Unassigned						**1**
Total		**228**	**468**	**11**	**1**	**709**

Appendix D1. Number of tissue samples analyzed using PBT to estimate the stock composition of the adult steelhead harvest from the fall 2015 recreational fishery. No PBT samples were collected in Section 7 or Section 18-19 during the fall sampling period (CLFH=Clearwater Fish Hatchery, DNFH=Dworshak National Fish Hatchery, HNFH=Hagerman National Fish Hatchery, MVFH=Magic Valley Fish Hatchery, NIAG=Niagara Springs Fish Hatchery, IRRI=Oregon's Irrigon Fish Hatchery, LYON=Washington's Lyon's Ferry Fish Hatchery).

Smolt Release Group (BY-Hatchery-Stock-Release)	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	Salmon Sect. 10-12	Salmon Sect. 13-17	Little Salmon Sect. 20
2011-CLWH-DWOR-SFClearwater	1		1				
2012-CLWH-DWOR-SFClearwater			15				
2012-CLWH-SFCR-SFClearwater			3				
2013-CLWH-DWOR-SFClearwater			5				
2011-DNFH-DWOR-Unk			2	1			
2012-DNFH-DWOR-NFClearwater			12	7			
2012-DNFH-DWOR-Unk	2		48	16			
2013-DNFH-DWOR-ClearCr/SFClearwater			3	2			
2013-DNFH-DWOR-NFClearwater			15	16			
2013-DNFH-DWOR-NFClearwater/SFClearwater			3	2			
2013-DNFH-DWOR-SFClearwater			4	1			
2012-HNFH-SAW-UpperSalmon-McNabb	1						
2012-HNFH-SAW-UpperSalmon-SawtoothFH	2		2		4	16	
2012-HNFH-SAW-YankeeFork			1		2		
2013-HNFH-SAW-UpperSalmon-McNabb	2					7	
2013-HNFH-SAW-UpperSalmon-SawtoothFH	15	1	4		7	74	
2012-IRRI-LSCR-Imnaha (OR)	5	6			1		
2013-IRRI-LSCR-Imnaha (OR)	11	6			1		
2012-LYON-CGRW-CottonWoodGR (WA)	6				2	1	
2012-LYON-LYON-LyonsFerry (WA)	5		1				
2013-LYON-CGRW-CottonWoodGR (WA)	15		1		1		

Smolt Release Group (BY-Hatchery-Stock-Release)	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	Salmon Sect. 10-12	Salmon Sect. 13-17	Little Salmon Sect. 20
2013-LYON-TUCA-Tucannon (WA)			1				
2012-MVFH-DWOR-LittleSalmon	2	1			8		
2012-MVFH-DWOR-SquawCr	1				4	2	
2012-MVFH-DWOR-YankeeFork					5	3	
2012-MVFH-PAH-LittleSalmon	3				4		
2012-MVFH-PAH-UpperSalmon					1	2	
2013-MVFH-PAH-UpperSalmon			1		3	6	
2013-MVFH-USAL-LittleSalmon	4				8	1	
2013-MVFH-USAL-SquawCr					1	1	
2013-MVFH-USAL-YankeeFork	2		1		2	1	
2013-MVFH-USAL-YankeeFork						2	
2011-NIAG-OX-LittleSalmon					1		
2011-NIAG-OX-HellsCanyon							1
2012-NIAG-OX-HellsCanyon	2	43	2				
2012-NIAG-PAH-LittleSalmon	2		1		17	3	
2012-NIAG-PAH-Pahsimeroi			1			7	
2012-NIAG-PAH-Pahsimeroi/HellsCanyon	1				1	1	
2012-NIAG-PAH-HellsCanyon	3	4					
2013-NIAG-OX-HellsCanyon	5	72	2				
2013-NIAG-PAH-LittleSalmon	21		2		65	8	10
2013-NIAG-PAH-LittleSalmon/Pahsimeroi	1				2	1	
2013-NIAG-PAH-Pahsimeroi	6		3		13	40	
2013-NIAG-PAH-HellsCanyon		1					
2012-WALL-WALL-GrRonde (OR)	12		3		1		
2013-WALL-WALL-GrRonde (OR)	7		8		3		
Unassigned	13	8	11	5	1	1	1
Total Samples	**150**	**142**	**156**	**50**	**157**	**177**	**12**

Appendix D2. Number of tissue samples analyzed using PBT to estimate the stock composition of the adult steelhead harvest from the spring of 2016 recreational fishery (CLFH=Clearwater Fish Hatchery, DNFH=Dworshak National Fish Hatchery, HNFH=Hagerman National Fish Hatchery, MVFH=Magic Valley Fish Hatchery, NSFH=Niagara Springs Fish Hatchery, IRRI=Oregon's Irrigon Fish Hatchery, LYON=Washington's Lyon's Ferry Fish Hatchery).

Smolt Release Group (BY-Hatchery-Stock-Release)	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	S. FK. Clearwater Sect. 07	Salmon Sect. 10-12	Salmon Sect. 13-17	Salmon Sect. 18-19	Little Salmon Sect. 20
2011-CLWH-DWOR-SFClearwater			1						
2012-CLWH-DWOR-SFClearwater			18	1	21				
2012-CLWH-SFCR-SFClearwater			2		8				
2013-CLWH-DWOR-SFClearwater			12		9				
2011-DNFH-DWOR-Unk			5		1				
2012-DNFH-DWOR-NFClearwater			28	10	1				
2012-DNFH-DWOR-Unk			62	23	15				
2013-DNFH-DWOR-SFClearwater			2		2				
2013-DNFH-DWOR-Unk			2	2	3				
2013-DNFH-DWOR-NFClearwater			14	7	2				
2013-DNFH-DWOR-ClearCr/SFClearwater			6	3	1				
2013-DNFH-DWOR-ClearCr			5		1				
2012-HNFH-SAW-McNabb						1		1	
2012-HNFH-SAW-Sawtooth						2	6	22	
2012-HNFH-SAW-YankeeFk								7	
2013-HNFH-SAW-McNabb	1						6	3	
2013-HNFH-SAW-Sawtooth						16	61	141	
2012-LSCR-LSCR-Imnaha-OR	2	6							
2013-LSCR-LSCR-Imnaha-OR	1	9				1			
2012-LYON-CGRW-GrRonde (WA)	1	1							
2013-LYON-CGRW- GrRonde (WA)	4	3							
2012-MVFH-DWOR-LittleSalmon		2				5			6
2012-MVFH-DWOR-SquawCr	1					3	3	1	
2012-MVFH-DWOR-YankeeFk							2	1	

Smolt Release Group (BY-Hatchery-Stock-Release)	Snake Sect. 01	Snake Sect. 02	Clearwater Sect. 03-04	N. Fk. Clearwater Sect. 05	S. FK. Clearwater Sect. 07	Salmon Sect. 10-12	Salmon Sect. 13-17	Salmon Sect. 18-19	Little Salmon Sect. 20
2012-MVFH-DWOR-Unk							1	1	
2012-MVFH-PAH-LittleSalmon						3			4
2012-MVFH-PAH-Salmon						3	2		
2013-MVFH-PAH-Salmon						2	11	1	
2013-MVFH-USAL-LittleSalmon		1				9			9
2013-MVFH-USAL-SquawCr	1					1	1	1	
2013-MVFH-USAL-YankeeFk						3	6	1	
2011-NIAG-PAH-Pahsimeroi						1			
2012-NIAG-OX-HellsCanyon	2	13							
2012-NIAG-PAH-LittleSalmon						15			26
2012-NIAG-PAH-Pahsimeroi						1	8		
2012-NIAG-PAH-Pahsimeroi/HellsCanyon						1	12		
2012-NIAG-PAH-HellsCanyon		9							1
2013-NIAG-OX-HellsCanyon	2	14							
2013-NIAG-PAH-LittleSalmon	3	3				51	3		110
2013-NIAG-PAH-LittleSalmon/Pahsimeroi						1	1		5
2013-NIAG-PAH-Pahsimeroi	3					28	53		
2013-NIAG-PAH-HellsCanyon		1							
2012-WALL-WALL-GrRonde (OR)	2	2				1			
2013-WALL-WALL-GrRonde (OR)	4	5				1			
Unassigned	4	17	14	2		1	1	1	3
Total Samples	**31**	**86**	**171**	**48**	**64**	**150**	**177**	**181**	**164**

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