Priest Rapids Hatchery Monitoring and Evaluation Annual Report for 2013-14

Steven P. Richards
Washington Department of Fish & Wildlife

And

Todd N. Pearsons
Public Utility District Number 2 of Grant County, Washington

October 20, 2014

Executive Summary

This report is the fourth annual report dedicated to monitoring and evaluating the Priest Rapids Hatchery (PRH) production of fall Chinook salmon. The PRH is located below Priest Rapids Dam adjacent to the Columbia River and has been in operation since 1963. The monitoring and evaluation program associated with PRH consists of nine objectives and is intended to evaluate the performance of the program in meeting hatchery and natural production goals. This report is intended to be cumulative, but also focus attention on the most recent year of data collection and production (2013-2014).

The PRH was originally built to mitigate for the construction and operation of Priest Rapids and Wanapum Dam. The hatchery is operated as an integrated program for the purpose of increasing harvest. The hatchery produces 5.6 million subyearling fall Chinook salmon for Public Utility District No. 2 of Grant County, Washington's (Grant PUD) mitigation requirement and 1.7 million subyearling fall Chinook Salmon under contract with the United States Army Corps of Engineers for mitigation for the construction and operation of John Day Dam. These fish contribute significantly to a variety of fisheries, such as fisheries off the coasts of Alaska and Canada and fisheries in the Columbia River.

The 2013 returns to PRH totaled a record 41,831 fall Chinook Salmon, eclipsing the 2012 record returns of 27,937. A total of 7,172 fish that returned to the volunteer trap at PRH were ponded at the hatchery for broodstock. An additional 397 fish were ponded from the Angler Broodstock Collection (ABC) fishery and 763 fish were ponded from Priest Rapids Dam Off Ladder Adult Fish Trap (OLAFT). In total, 5,441 fish were spawned to meet egg take goals for multiple hatchery programs The mortality rate of ponded adult fish was 28% which is the second highest rate on record. The cause for the elevated mortality is uncertain; however, high densities of fish in the PRH volunteer trap may have been a contributing factor.

All ages except age-6 PRH origin fall Chinook salmon returning in 2013 were otolith marked. We used a combination of marks (e.g., otoliths, adipose clips, and coded-wire tags) to determine origin which is more accurate than the expansion of coded-wire recoveries using juvenile mark rates to determine origin based on comparisons in recent years. The hatchery origin fish appear to return at a younger age than natural origin fish. The size at maturity data for the 2012 and 2013 returns suggest there are virtually no difference in fork lengths between natural and hatchery origin fish at age-2 and 3 and perhaps slight differences in fork lengths for age-4 and 5 fish.

The PRH continues to contribute substantially to ocean and river fisheries and to have higher adult recruitment rates than the natural spawning fall Chinook salmon. Adult recruitment of brood year 2007 was high for both PRH and the fish spawning in the Hanford Reach. The adult recruitment rate including harvest was 25.10 for PRH and 7.83 for fish spawning in the Hanford Reach.

Hatchery origin fish released from PRH spawn throughout the Hanford Reach. The highest proportions of hatchery origin carcasses recovered were in river sections 1, 3, and 5. Recent evidence suggests that carcass drift may confound the distribution of spawners by origin based on carcass recoveries. Stray rates into other populations appear to be low based upon coded-wire tag (CWT) recoveries.

PRH origin fish were estimated to make up 20.2% of the natural spawning population in the Hanford Reach during 2013. All hatchery fish combined (including fish released from Ringold

Hatchery and strays from outside the Hanford Reach) comprised 27.5% of the fall Chinook salmon on the spawning grounds. Otolith recoveries at PRH indicate that a very high percentage of hatchery broodstock are of PRH origin. The proportion of natural influence (PNI) for Hanford Reach fall Chinook salmon including all hatcheries is 31.7%. Grant PUD's contribution to PNI (assumes that Grant PUD is the only hatchery in the Hanford Reach) was 0.6 using a conventional pNOB and 0.65 using a gene-flow method for calculating pNOB. Low numbers of natural origin broodstock at PRH contributes to the difficulty in reaching the PNI target of 0.67. Additional natural origin broodstock for PRH was collected at the Priest Rapids Dam off ladder adult fish trap and from the ABC fishery and OLAFT. These additional fish increased the natural origin component of the broodstock from 1.8% to 12.7%.

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 Introduction

The Public Utility District No. 2 of Grant County, Washington (Grant PUD) produces and releases 5.6 million subyearling fall Chinook salmon smolts from Priest Rapids Hatchery (PRH) as part of its mitigation for the construction and operation of Priest Rapids and Wanapum dams. Mitigation is the result of three components 1) inundation of historic spawning habitat (5 million), annual losses of fish that migrate through the project (325,543), and flow fluctuation impacts in the Hanford Reach (273,961). The PRH is located on the east bank of the Columbia River immediately downstream of Priest Rapids Dam (Figure 1 and Figure 2). The Washington Department of Fish & Wildlife (WDFW) operates PRH which is owned, maintained, and funded by the Grant PUD. This report describes the monitoring and evaluation of Grant PUD's PRH program. PRH also produces and releases 1.7 million subyearling smolts on-site for the U.S. Army Corps of Engineers (USACE) John Day Mitigation.

PRH serves as a broodstock collection location for other hatcheries in the region. PRH provides approximately 3.7 million eyed eggs for the USACE John Day Mitigation at Ringold Springs Hatchery (RSH). These eggs are transferred to Bonneville Hatchery and ultimately about 3.5 million subyearlings are transported to, acclimated, and released as subyearling smolts from RSH. During previous years, PRH has accommodated egg takes and/or incubated eggs for the Yakama Nation upper river bright (URB) fall Chinook salmon releases in the lower Yakima River at their Prosser facility. Additional eggs have also been taken for other programs such as WDFW's Salmon in the Classroom program and to support various research projects.

Grant PUD has developed guiding principles and approaches for the monitoring and evaluation (M&E) of all of its hatchery programs that are provided in an overarching M&E plan that encompasses all of its programs (Pearsons and Langshaw 2009). The M&E Plan for PRH is included in Section 11 and Attachment 5 of the Priest Rapids Hatchery and Genetic Management Plan. This plan was reviewed and approved by the Priest Rapids Coordinating Committee's (PRCC) Hatchery Subcommittee (HSC). This M&E Plan was recently updated (Hillman et al. 2013).

This report of the Grant PUD PRH M&E program encompasses data collected during fiscal year 2013 - 14 as well as earlier years where data were available. The data presented in this report are preliminary and subject to change as new data and analyses become available. Please consult the most recent annual report in order to obtain the most current and accurate information. Objectives, hypotheses, measured and derived variables, and field methods that will be used to collect data are listed in Appendix A of this report.

Figure 1 **Location of Priest Rapids and Ringold Springs hatcheries and the Hanford Reach.**

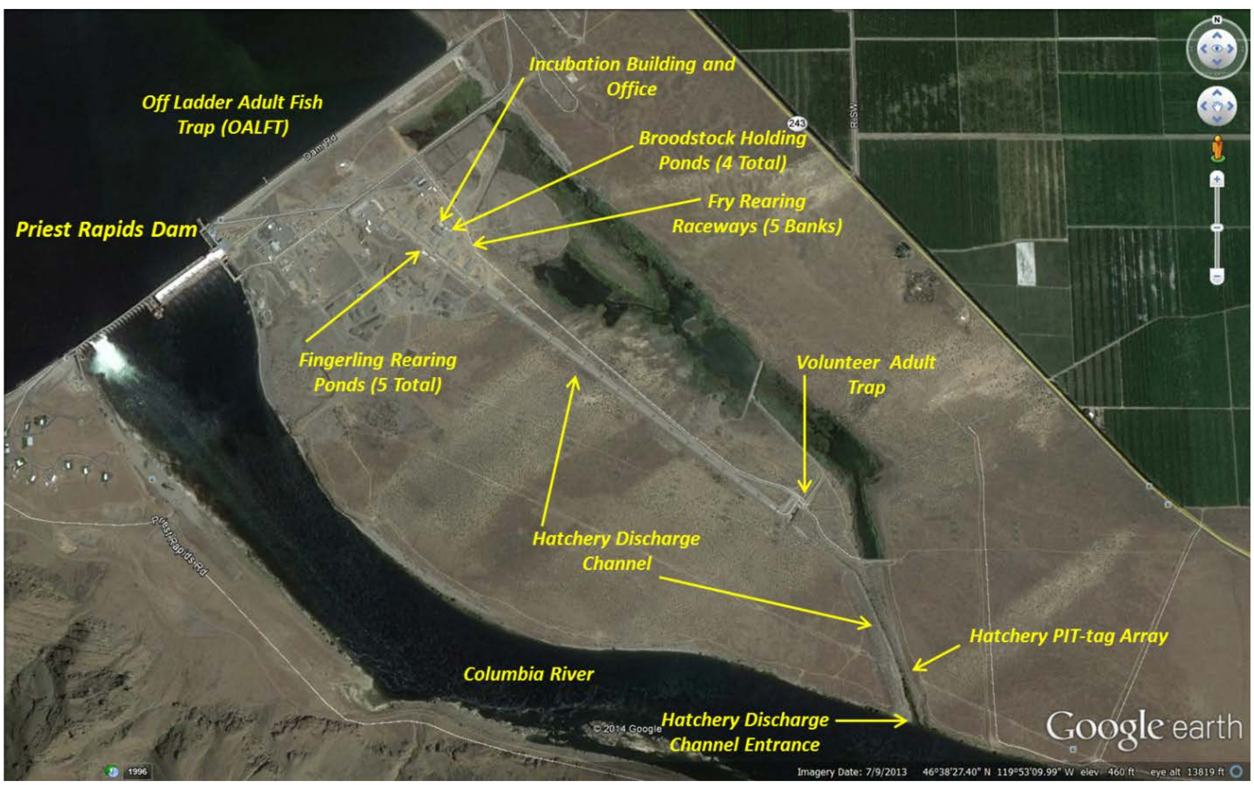

Figure 2 **Priest Rapids Hatchery facility and Priest Rapids Dam OLAFT.**

2.0 Objectives

The objective of the PRH M&E plan is to evaluate the performance of the PRH program relative to the goals and objectives of the PRH program. The overarching goal of the PRH program is to meet Grant PUD's hatchery mitigation by producing fish for harvest while keeping genetic and ecological impacts within acceptable limits. The nine M&E objectives of the PRH program are described below.

- **Objective 1**: Determine if the PRH program has affected abundance and productivity of the Hanford Reach population.
- **Objective 2**: Determine if the run timing, spawn timing, and spawning distribution of both the natural and PRH components of the Hanford Reach population are similar.
- **Objective 3**: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the PRH program. Additionally, determine if PRH programs have caused changes in phenotypic characteristics of the Hanford Reach population.
- **Objective 4**: Determine if the PRH adult-to-adult survival (i.e., hatchery replacement rate) is greater than the Hanford Reach adult-to-adult survival (i.e., natural replacement rate) and equal to or greater than the program specific hatchery replacement rate (HRR) expected value based on survival rates listed in the Biological Assessment and Management Plan (BAMP) (1998).
- **Objective 5:** Determine if the stray rate of PRH fish is below the acceptable levels to maintain genetic variation between populations.
- **Objective 6:** Determine if PRH fish were released at the programmed size and number.
- **Objective 7**: Determine if harvest opportunities have been provided using PRH returning adults.
- **Objective 8**: Determine if the PRH has increased pathogen type and/or prevalence in the Hanford Reach population.
- **Objective 9**: Determine if ecological interactions attributed to PRH fish affect the distribution, abundance, and/or size of non-target taxa of concern that were deemed to be at sufficient risk**.**

3.0 Project Coordination

WDFW M&E staff dedicated to PRH also conducts similar work at RSH. The M&E staff also works in conjunction with multiple WDFW groups to include PRH fish culture staff, the Columbia River Coded Wire Tag Recovery Program (CRCWTP), Region 3 Fish Management, the District 4 Fish Biologist, the Supplementation Research Team in Wenatchee, and the Grant PUD biological science staff to complete all tasks included in the M&E Plan. In addition, samples collected at the hatchery and in the field were transported and analyzed by WDFW laboratories including the WDFW Scale Reading Lab and WDFW Genetics Lab, and the WDFW Otolith Lab. Coded-wire tags were processed at the WDFW District 4 office and then proofed by the WDFW Coded-Wire Tag Lab in Olympia. Data and analysis collected in association with the PRH M&E and Hanford Reach population monitoring is incorporated into the WDFW Traps, Weirs, and Surveys (TWS) database which is administered by WDFW staff stationed in the Region 5 Headquarters in Vancouver. Agency managers use this data for forecasting and managing fall Chinook salmon populations in the Columbia and Snake rivers and tributaries. WDFW secured and held all environmental permits necessary for the work.

4.0 Life History – Hanford Reach Fall Chinook Salmon

The fall Chinook salmon population that spawns in the Hanford Reach is one of the largest and most productive in the United States (Harnish et al. 2012). The Hanford Reach is one of the last non-impounded reaches of the Columbia River. The Hanford Reach extends 51 miles from the city of Richland to the base of Priest Rapids Dam. Natural origin fall Chinook salmon emerge from the substrate in the spring and rear in the Hanford Reach until migration in the summer. Egg-to-fry survival has been estimated to be about 71% in the Hanford Reach (Oldenburg et al. 2012) and egg-to-pre-smolt has been estimated to be about 40.2% (Harnish et al. 2012). Both of these estimates are high when compared to other Chinook salmon populations (Harnish et al. 2012). Fall Chinook salmon interact with a variety of species in the Hanford Reach (Naiman et al. 2012). The age at maturity for naturally produced fish in the Hanford Reach varies between 2 and 6 years. The age of fish reported in this document begins with the first birthday occurring the year after the parents spawned. The abundance of mini-jacks which mature as age-1 males is currently not known. Age-2 male fall Chinook salmon or jacks return to the Hanford Reach after spending roughly one year in the ocean. The majority of the natural origin adults return after having spent three to four years in the ocean (age-4 and 5). A small portion, typically less than 2%, will spend up to five years in the ocean and return as age-6.

5.0 Annual Releases, Tagging and Marking

The annual release of fall Chinook salmon smolts from PRH range considerably since the initial release of roughly 2.38 million smolts from the 1979 brood year to over roughly 10.30 million from the 1982 brood year (Table 1). The 2014 release goal is for PRH is 7.30 million smolts. This goal includes a recent increase in the Grant PUD mitigation from 5,000,000 to 5,599,504 combined with the ongoing USACE's John Day mitigation of 1,700,000 smolts.

Various mark types and rates have occurred at PRH over the years for both the Grant PUD and USACE mitigation fish. In 1976, PRH began adipose fin clipping and coded-wire tagging a portion of the juvenile fall Chinook released to determine PRH contributions to ocean and river fisheries. Excluding the smolts released in 2008, all smolts associated with the USACE's John Day mitigation have been adipose clipped, but not coded wire tagged. Poor returns for brood year 2007 precluded the production of USACE's John Day mitigation fish for the 2008 release.

Beginning with the 1995 brood year, United States Fish and Wildlife Service (USFWS) has annually PIT tagged approximately 3,000 smolts at PRH for the purpose of evaluating migration timing at main-stem dams. Grant PUD began annually PIT tagging approximately 40,000 smolts, beginning with the 2012 release, to primarily evaluate juvenile abundance and adult migration timing and straying. A PIT tag detection array was installed in the PRH discharge channel prior to the release of 2011 brood in June of 2012. Prior to 2012, PIT tagged Chinook salmon released from PRH could only be detected at the main-stem hydroelectric facilities (fish ladders and juvenile bypasses) or by manually scanning individual fish.

All PRH releases for both mitigation programs were 100% otolith marked beginning with the 2008 release. All intra-annual releases from PRH have the same annual otolith pattern, but the pattern differs between years. Beginning with brood year 2010, the eyed eggs shipped to Bonneville Hatchery for hatching and then shipped to Ringold Spring Hatchery (RSH) for rearing and release have received a unique intra-annual otolith mark. Otolith sampling at PRH and in the Hanford Reach should provide increased precision in the determination of PRH origin returns to the hatchery and Hanford Reach compared to coded-wire tag estimates. Given sufficient samples sizes, the otolith mark rate of 100% should provide better estimates than the estimated CWT mark rate of 17-25%.

Since 1987, the U.S. Section of the Pacific Salmon Commission (PSC) has supported a coordinated project which seeks to capture and coded-wire tag 200,000 naturally produced juvenile fall Chinook salmon in the Hanford Reach. Fish are collected with seines over a ten day period between late May and early June. Fish are approximately 40-80 mm long at the time of capture. Recoveries from these tagged fish are used to estimate exploitation rates and interception rates for Hanford Reach natural origin fall Chinook salmon. These data have also more recently been used to estimate the number of natural origin juveniles produced in the Hanford Reach (Harnish et al. 2012).

WDFW operates the OLAFT at Priest Rapids Dam three days per week beginning in July and continuing through mid to late October. This project began in 1986 and was designed to sample steelhead to (1) determine upriver run size, (2) estimate hatchery to natural (wild) fish ratios, (3) determine age class distribution, and (4) evaluate the need for managing returning hatchery steelhead consistent with ESA recovery objectives. In 2009, WDFW began sampling fall Chinook salmon at the trap for run composition assessment. A study was initiated in 2010 to determine the efficacy of using the OLAFT to increase natural origin broodstock for PRH. In return years 2010 - 2013, adipose fin present and coded-wire tag absent adult fall Chinook salmon were PIT tagged and released at the OLAFT to assess migration and spawning distribution. In addition, the OLAFT was used to collect potential natural origin fall Chinook salmon for incorporation into the broodstock at PRH. This work is presented in Tonseth et al. (in preparation).

Table 1 Numbers of marked, unmarked, and tagged fall Chinook salmon smolts released from Priest Rapids Hatchery.

Brood Year	Total Released	Non Ad-Clip Released	AD/CWT	CWT Only	AD Only	PIT
1977	150,625	0	147,338	0	3,287	
1978	153,840	0	152,532	0	1,308	
1979	3,005,654	2,858,509	147,145	0		
1980	4,832,591	4,581,054	251,537	0		
1981	5,509,241	5,198,365	310,876	0		
1982	10,296,700	9,888,989	407,711	0		
1983	9,742,700	9,517,263	222,055	0	3,382	
1984	6,363,000	6,253,240	106,960	0	2,800	
1985	6,048,000	5,843,176	203,534	0	1,290	
1986	7,709,000	7,506,142	201,843	0	1,015	
1987	7,709,000	7,501,578	196,221	0	11,201	
1988	5,404,550	5,200,080	201,608	0	2,862	
1989	6,431,100	6,224,770	194,530	0	11,800	
1990	5,333,500	5,134,031	199,469	0		
1991	7,000,100	6,798,453	201,647	0		
1992	7,134,159	6,939,537	194,622	0		
1993	6,705,836	6,520,153	185,683	0		
1994	6,702,000	6,526,120	175,880	0		1,500
1995	6,700,000	6,503,811	196,189	0		3,000
1996	6,644,100	6,450,885	193,215	0		3,000
1997	6,737,600	6,541,351	196,249	0		3,000
1998	6,504,800	6,311,140	193,660	0		3,000
1999	6,856,000	6,651,664	204,336	0		3,000
2000	6,862,550	6,661,771	200,779	0		3,000
2001	6,779,035	6,559,109	219,926	0		3,000
2002	6,777,605	6,422,232	355,373	0		3,000
2003	6,814,560	6,415,444	399,116	0		3,000
2004	6,599,838	6,399,766	200,072	0		3,000
2005	6,876,290	6,676,845	199,445	0		3,000
2006	6,743,101	4,912,487	202,000	0	1,628,614	3,000
2007[a]	4,548,307	4,344,926	202,568	0	813	3,000
2008[a]	6,788,314	4,850,844	218,082	0	1,719,388	2,994
2009[a]	6,776,651	3,413,334	619,568	1,026,561	1,717,188	1,995
2010[a]	6,798,390	3,383,859	602,580	1,108,990	1,702,961	3,000
2011[a]	7,056,948	3,094,666	595,608	598,031	2,768,643	42,844
2012[a]	6,822,861	2,905,694	603,930	601,009	2,712,228	44,083
2013[a]	7,267,248	3,347,417	603,417	603,439	2,712,975	42,988

[1] PIT tagged are included in the AD Only totals
[a] Entire release was otolith marked

6.0 Project Coordination

WDFW M&E staff dedicated to PRH also conducts similar work at RSH. The M&E staff also works in conjunction with multiple WDFW groups to include PRH fish culture staff, the CRCWTP, Region 3 Fish Management, the District 4 Fish Biologist, the Supplementation Research Team in Wenatchee, and the Grant PUD biological science staff to complete all tasks included in the M&E Plan. In addition, samples collected at the hatchery and in the field were transported and analyzed by WDFW laboratories including the WDFW Scale Reading Lab and WDFW Genetics Lab, and the WDFW Otolith Lab. Coded-wire tags were processed at the WDFW District 4 office and then proofed by the WDFW Coded-Wire Tag Lab in Olympia. Data and analysis collected in association with the PRH M&E and Hanford Reach population monitoring is incorporated into the WDFW Traps, Weirs, and Surveys (TWS) database which is administered by WDFW staff stationed in the Region 5 Headquarters in Vancouver. Agency managers use this data for forecasting and managing fall Chinook salmon populations in the Columbia and Snake rivers and tributaries. WDFW secured and held all environmental permits necessary for the work.

7.0 Sample Size Considerations

We attempted to strike an appropriate balance between statistical precision, logistics, and financial investment when setting sample size targets. A phased approach was used to collect biological samples with sufficient accuracy and precision. In general, we attempted to oversample the raw samples such as carcasses and trap recoveries and then use post season analysis to determine if sub-sampling was appropriate. The sample size target of systematic field sampling is 2,500 of the carcasses in the Hanford Reach, 1,000 at the hatchery trap, and 1,000 of the hatchery volunteer broodstock, and all broodstock collected from other sources such as OLAFT and ABC.

All adult fall Chinook salmon recovered at PRH, in the Hanford Reach sport fishery, and in the stream surveys are sampled for the presence of coded-wire tags to maximize the accuracy of estimates generated from these data.

Representative otolith samples by survey type were selected for processing to estimate origin by age class. In some cases, all otolith samples for a survey were processed if the sampling rate provided relatively low numbers of otoliths sampled or if there was a need for higher precision or accuracy. Sub-samples of otoliths collected from the PRH volunteer trap, PRH volunteer broodstock, OLAFT broodstock, and Hanford Reach stream survey were submitted for processing. The sizes of the otolith sub-samples were determined for otolith analysis after the ages of the fish were determined by scale aging. In general, we randomly selected roughly 120 otoliths from stratified groups based on age and gender from each survey type (See Appendix B). All otoliths were submitted for stratified groups containing less than 120 samples. For example, typically all samples of age 5 and 6 fish were submitted because of the low number of fish represented in the field collected sample. The stratified groups also included coded-wire tagged fish recovered within the biological sample. Some of these tagged fish were randomly selected as we randomly select the desired number of otoliths to decode. This was done to increase the number of fish sampled for origin with no additional cost. The sample size refinement process is described in Appendix B.

8.0 Evaluation of Bias

There are at least two sources of bias that we attempted to evaluate during 2013. First was the bias associated with estimates generated using coded-wire tags. The second was size and gender bias during carcass recovery.

Results from sampling the fall Chinook returns for 2010, 2011, and 2012 indicated that estimates of hatchery contributions to broodstock, the terminal sport fishery, and to escapement of the Hanford Reach calculated from otoliths were substantially different from estimates generated using coded-wire tags expanded by sampling rates and juvenile mark rates. This was of significant concern because many estimates such as stray rate, survival, origin, and harvest are dependent upon estimates generated from coded-wire tags.

To assess the level of coded-wire tag recovery bias, we made comparisons of the proportion of PRH origin coded-wire tag returns to PRH with the coded-wire tag mark rate for individual ages by brood year using the following equation:

$$\text{CWT Recovery Bias} = \frac{(\text{\# of PRH Origin CWT Fish Recovered} / \text{\# of PRH Origin Fish Collected})}{\text{CWT Mark Rate for Brood Year}}$$

Where:

# of PRH origin fish collected = Estimate of the number of PRH origin fish for a specific age/brood year as determined by otoliths, scale aging, and expansion and pooling of age samples to represent total returns by age

# of PRH Origin CWT Fish Recovered = Number of PRH origin CWT fish for a specific age/brood recovered at the hatchery (100% sample rate)

CWT Mark Rate = CWT marking rate for the specific brood year which is the number of CWT placed in fish divided by the estimated total number of fish at the time of marking.

If a coded-wire tag bias did not exist, the proportion of PRH coded-wire tag returns to the PRH coded-wire tag mark rate should equal 1. As shown in Table 2, the estimated bias ranged from 0.499 to 2.026 for the different age/broods examined. In all cases that coded-wire tag recoveries were over 50, the coded-wire tag detection was lower than the mark rate. Only age 5 fish had a positive bias, but these were also the lowest sample sizes.

Table 2 Estimate of coded-wire tags bias for Priest Rapids origin returns to the hatchery.

Brood	Age	Proportion CWT Marked	# of PRH Origin CWT Fish Recovered	Estimated # of PRH origin Fish Collected	Proportion of PRH Origin Brood Return CWT	Proportion of PRH CWT Returns to the PRH CWT Mark Rate (CWT Recovery Bias)
2007	5	0.0445	48	928	0.052	1.161
2007	4	0.0445	280	10,977	0.026	0.573
2007	3	0.0445	410	14,078	0.029	0.654
2007	2	No otolith data collected during return year 2009				
2008	5	0.0318	2	31	0.065	2.026
2008	4	0.0318	81	2,983	0.027	0.853
2008	3	0.0318	127	5,606	0.023	0.712
2008	2	0.0318	57	2,578	0.022	0.694
2009	4	0.2429	1,081	5,944	0.182	0.749
2009	3	0.2429	2,309	13,544	0.170	0.702
2009	2	0.2429	628	3,082	0.204	0.839
2010	3	0.2371	5,828	31,568	0.185	0.779
2010	2	0.2371	1,498	8,896	0.168	0.710
2011	2	0.2518	349	2,777	0.126	0.499

It is unclear whether coded-wire tag estimates are biased because of 1) tag loss, 2) less than 100% detection of tags when scanned, 3) inappropriate expansion estimates, 4) differential survival or homing of tagged fish, or 5) incorrect estimates of the total number of fish released from PRH. In addition, the precision of coded-wire tag estimates for some brood years is likely influenced by the low number of CWT recoveries.

Preliminary assessment of coded-wire tag wand detection efficiency has been conducted annually at PRH since 2010 during the sampling of adult fish. During 2013, M&E staff randomly selected a total of 1,063 fall Chinook salmon from the fish being surplused that were not coded-wire tagged as determined by scanning them with the new T-wand and re-scanned them again with the older blue-wand to evaluate the performance of the T-wand. Sample fish found possessing a coded-wire tag were re-scanned by the T-wand to determine if the missed coded-wire tag was the result of operator error or the inability of the T-wand to detect the coded-wire tag. On the few occasions that the T-wand could not detect a coded-wire tag identified by the blue-wand, the snouts were removed from each fish to increase the likelihood of detection and then passed through a V-detector.

Similar to test results for previous years, there were few (N = 4) additional coded-wire tag detections observed from the 1063 fish sampled. The methods describe here do not provide a definitive estimate of undetected coded-wire tags for fish sampled at PRH. We make the assumption, that if both models of coded-wire detection wands do not detect a coded-wire tag in a given fish, then it did not possess a tag. Based on this assumption, the coded-wire detection efficiency is likely greater than 99%. Therefore, the magnitude of the coded-wire recovery bias expressed in Table 3 is not likely due to poor coded-wire detection efficiency.

In general, carcasses of female and male fish are recovered at different rates and small males were recovered at lower rates than larger male fish (Murdoch et al. 2010). This can result in underestimates of smaller male fish and overestimates of larger female fish. This is particularly a problem when comparing samples collected at the PRH trap with samples collected in the Hanford Reach stream surveys. Samples collected at the trap are more likely to represent the population in terms of size and age structure than carcasses collected in the Hanford Reach. Differences between samples could be the result of true biological differences or because of carcass recovery bias. We attempted to evaluate carcass recovery bias in the Hanford Reach, and the results of this evaluation are presented in section 15.4.

9.0 Current Operation of Priest Rapids Hatchery

In 2013, 42,991 adult fall Chinook salmon were handled at PRH (Table 3). The 2013 broodstock for PRH were collected at the hatchery volunteer trap, the Priest Rapids Dam OLAFT, and from the ABC fishery. The majority of the broodstock were collected from the PRH volunteer trap. The volunteer trap was operated from September 11 through December 2, 2013.

Daily detections of adult Chinook salmon possessing passive integrated transponder (PIT) tags passing the array located in the PRH discharge channel suggest that returns to the volunteer trap peaked around October 28 (Figure 3). Of the unique PIT tagged fish observed, 87% were tagged as adults in the lower Columbia, 5% were tagged as adults at Priest Rapids Dam and 5% were tagged as juveniles at PRH. The remaining fish were tagged as juveniles in the Snake River Basin, Umatilla River, or Yakima River Basin (i.e., strays).

Table 3 Source and disposition of Chinook salmon collected for broodstock at Priest Rapids Hatchery, return year 2013.

Collection Location	Gender	Collected	Trap Surplused	Trap Mortalities	Ponded	Spawned	Pond Surplused	Pond Mortalities
Volunteer Trap	Males	28,901	25,287	1,233	2,381	1,237	340	804
	Females	9,922	4,329	811	4,782	3,237	145	1,400
	Jacks	3,008	2,893	106	9	2	1	6
	Total	**41,831**	**32,509**	**2,150**	**7,172**	**4,476**	**486**	**2,210**
OLAFT	Males	445			445	397	0	48
	Females	317			317	260	0	57
	Jacks	1			1	1	0	0
	Total	**763**			**763**	**658**	**0**	**105**
ABC	Males	281			281	222	0	59
	Females	116			116	85	0	31
	Jacks	0			0	0	0	0
	Total	**397**			**397**	**307**	**0**	**90**
Facility	**Total**	**42,991**	**32,509**	**2,150**	**8,332**	**5,441**	**486**	**2,405**

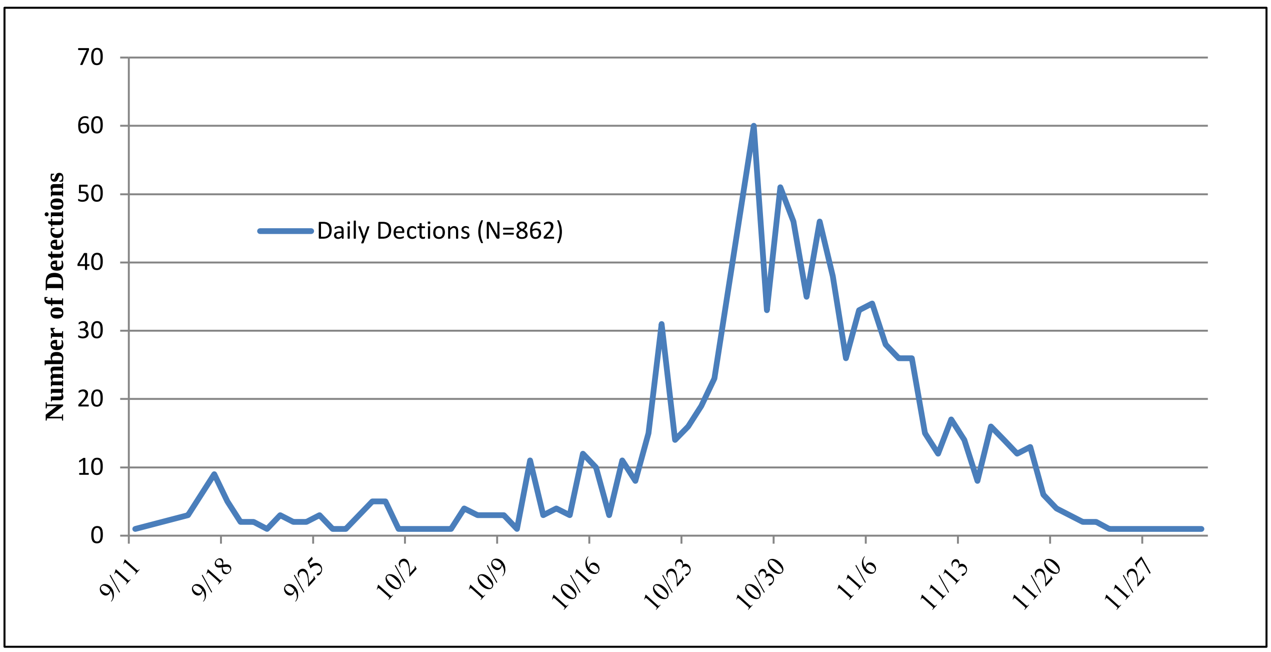

Figure 3 First observations of unique PIT tagged adult Chinook salmon at the PIT tag array located in the Priest Rapids Hatchery discharge channel, 2013.

PRH has four adult salmon holding ponds. Pond 1 was used to hold broodstock collected from the ABC and OLAFT. Ponds 2, 3, and 4 were used to hold broodstock collected at the PRH Volunteer Trap. The PRH staff generally transported fish from the volunteer trap five days per week to collect broodstock and to surplus the excess fish. Male fall Chinook salmon, both adult and jack, typically comprised the majority of the fish surplused from the trap. In addition, 642 adipose clipped females and 245 adipose clipped males from the PRH Volunteer trap were placed in Pond 1 for mating with ABC and OLAFT fish; increasing the chances of hatchery origin by natural origin crosses.

Spawning days occurred on Mondays and Tuesdays each week from October 28 through December 2 (N = 12). Hatchery staff simultaneously employed two systems for spawning broodstock to increase the number of fish processed on spawn days. Broodstock from Ponds 1 and 2 were crowded with a seine, selected for maturity, clubbed, and then either spawned adjacent to the ponds or surplused. Broodstock from Ponds 3 and 4 were crowded with the mechanical crowder into the facility's center channel, forced into an electro-anesthetic system, and then either spawned on the spawning platform, routed back into the holding ponds, or surplused.

The egg take goal for PRH is 12,692,460. The actual egg take from the 2013 broodstock was 13,276,000 (105% of the goal). During spawning, the eggs from two females were stripped into a five gallon bucket and then the sperm from a single male was mixed with the eggs. Fertilized eggs are then transferred to an incubation room and placed in vertical incubation trays.

Twelve batches of fry were moved from the vertical trays in the incubation building to outdoor raceways between February 2 and March 18, 2014. The fry are reared in the raceways until they were of sufficient size that a portion of them could be marked in some manner (i.e., adipose clipped, coded-wire tagged, and/or PIT tagged). Marking crews took fish directly from the raceways and then released the marked fish into one of five concrete holding ponds. Fish not selected for marking were transferred from the raceways into the holding ponds. All of the fry were moved to the concrete holding ponds by late May. Beginning June 12, subyearling fall Chinook salmon were released one pond at a time on alternating days. These fish migrate down a one mile long channel (formerly the spawning channel) and then down the hatchery discharge channel and into the Columbia River.

10.0 Origin of Adult Returns to Priest Rapids Hatchery

There were three sources for collection of adult Chinook salmon broodstock for PRH during the 2013 return: PRH volunteer trap, OLAFT, and ABC. The origin of fish collected at these locations was determined by examination of hatchery marks (i.e., otolith marks, adipose clips, and coded-wire tags) for the fish within the biological sample groups. PRH origin fish were identified by their otolith mark. The fish that did not possess a thermal mark or other hatchery marks were classified as natural origin. Historically, the very low recovery (<1%) of coded-wire tagged strays at PRH suggests that a high percentage of the un-marked fish may be of natural origin (See Section 9.2). In some sections of the report, we make a simplifying assumption that fish without hatchery marks are of natural origin. Similar to that observed in previous years, there is a large discrepancy between estimates of origin based on coded-wire tag and those based on otoliths. Origin based on otolith sampling provides the most accurate data under the current marking regime at PRH. According to Jeff Grimm, WDFW Otolith Lab (personal communication, July 15, 2013) the error rate associated with determination of origin by otoliths is reported at less than 1%. Each otolith is independently read by two experienced lab staff. Upon completion of the second read, any discrepancies are read a third time to resolve the conflict. If the marks are poor quality, three staff independently read the otoliths. PRH staff does a fantastic job at creating the marks. They are high quality so require only two readers. Most discrepancies are clerical in nature (data entry). Discrepancies associated with the data collect by the M&E team were generally clerical and easy to resolve.

We present estimates based on coded-wire tags (1:1 sample rate) and estimates based on sub-samples of hatchery marked fish collected from specific groups (varying sample rates) to illustrate differences in the estimates as well as the potential for creating a method to correct the historical database that was generated using coded-wire tag recoveries.

Origin Based on Hatchery Marks

The proportion of PRH origin and natural origin adult returns to the PRH volunteer trap was estimated by expanding the origin results for the broodstock and surplus/mortalities samples by the estimated age and gender composition of the total collection of each source and then pooling the expanded estimates for both collections.

For return year 2013, the proportion of broodstock obtained from the PRH volunteer trap that was natural origin is estimated at 0.018 whereas, the proportion of natural origin fish from the PRH volunteer trap surplus and mortalities is estimated at 0.034. Overall, it is estimated that 0.032 of the volunteer trap returns to PRH were natural origin (Table 4). The proportion of natural origin fish used as broodstock from the OLAFT and ABC was estimated to be 0.550 and 0.809, respectively.

Table 4 Numbers of hatchery and natural origin Chinook salmon collected at Priest Rapids Hatchery, Priest Rapids Dam Off Ladder Adult Fish Trap, and Angler Broodstock Collection fishery. Origin determined by otolith thermal marks, presence of coded-wire tags, and/or adipose clips.

Brood	Priest Rapids Hatchery Broodstock [1]	Proportion Hatchery Origin	Proportion Natural Origin [2]
2013	4,476 (N = 503)	0.982	0.018

Brood	Priest Rapids Hatchery Surplused from Trap	Proportion Hatchery Origin	Proportion Natural Origin [2]
2013	37,355 (N = 600)	0.966	0.034

Brood	Priest Rapids Hatchery Volunteer Return Total	Proportion Hatchery Origin	Proportion Natural Origin [2]
2013	41,831 (N = 1,103)	0.968	0.032

Brood	Priest Rapids Off Ladder Fish TrapBroodstock[1]	Proportion Hatchery Origin	Proportion Natural Origin [2]
2013	763 (N = 201)	0.450	0.550

Brood	Angler Broodstock Collection Broodstock[1]	Proportion Hatchery Origin	Proportion Natural Origin [2]
2013	397 (N = 289)	0.191	0.809

[1] Includes only fish that were spawned.
[2] Origin based on the absence of otolith marks, coded-wire tags, or adipose clips.

Origin Based on Coded-Wire Tag Recoveries

All Chinook salmon returning to PRH and broodstock collected from the OLAFT and ABC were sampled for the presence of coded-wire tags. Very few coded-wire tags were recovered from fish collected at the OLAFT and ABC. This was because efforts were made to exclude coded-wire tagged fish from the collections. The lack of coded-wire tag detections in these collections also supports the earlier finding that coded-wire tag detections in the field appear to be accurate.

A total of 7,509 coded-wire tags were recovered at PRH in 2013, of which 768 coded-wire tags were obtained from the PRH volunteer trap broodstock and 16 were obtained from the ABC broodstock. The remaining 6,725 were recovered in the surplus and mortalities from the PRH volunteer trap collection (Appendix C and Appendix D). Similar to previous years, expansions of coded-wire tag recoveries at PRH in 2013 suggest that 74.8% of the returns to the PRH volunteer trap were hatchery origin fish. If we were to make the assumption that these coded-wire tag expansions accurately reflect the proportion of hatchery origin fish, then the remaining 25.2% of the unaccounted fish could potentially be natural origin (Table 5). During return year 2013, PRH origin coded-wire tags accounted for 71.3% of the total return and 95.4% of the hatchery origin tags recovered. In recent years, roughly 70% of the fall Chinook salmon returning to PRH were estimated to be hatchery origin based on coded-wire tag expansions (Hoffarth and Pearsons, 2012).

There were nine natural origin Hanford Reach fall Chinook salmon coded-wire tags recovered at the hatchery in 2013; eight of these fish were surplused from the volunteer trap and one was spawned. There is not an expansion factor for the natural origin coded-wire tag fish so there was no attempt to estimate the proportion of natural origin fish based on these nine coded-wire tag recoveries.

In an effort to increase natural origin broodstock in return years 2011, 2012, and 2013, the majority of the adipose clipped Chinook salmon returning to the PRH volunteer trap were surplused. In 2012 and 2013, this method of high-grading for broodstock resulted in the surplus of approximately 86% and 88%, respectively of adipose clipped fish. In addition, the high-grading removed approximately 86% and 87%, respectively, of the adipose clipped coded-wire tagged fish from the broodstock.

Table 5 Estimated proportion of hatchery and natural origin adult Chinook salmon returning to the Priest Rapids Hatchery volunteer trap based on coded-wire tag expansion. The entire collection was sampled for coded-wire tag.

Brood	Returns to Priest Rapids Hatchery Volunteer Trap	Origin based on Coded-Wire Tag expansions		Natural Origin [1]
		Priest Rapids Hatchery	Other Hatchery	
2005	10,616	0.622	0.006	0.329
2006	8,223	0.490	0.006	0.436
2007	6,000	0.671	0.004	0.525
2008	19,586	0.491	0.008	0.409
2009	12,778	0.428	0.003	0.540
2010	19,169	0.602	0.003	0.486
2011	20,823	0.613	0.006	0.381
2012	28,039	0.692	0.004	0.304
2013	41,831	0.713	0.034	0.252

[1] The proportion not accounted for by coded-wire tag expansion is assumed to be of natural origin.

11.0 Broodstock Collection and Sampling

Similar to what was done for the 2012 broodstock, the 2013 broodstock collected at the PRH volunteer trap and the OLAFT were high-graded for gender, size, and/or origin. For example, fish that had an adipose clip or coded-wire tag were excluded from OLAFT collections to increase the probability of collecting natural origin fish. In addition, most of the fish measuring less than 74 cm FL were excluded from the OLAFT broodstock to reduce the number of age-3 fish and PRH origin fish. Age-2 and 3 males were generally excluded from the PRH volunteer trap as well. When broodstock abundance was sufficient, hatchery marked fish from all ages and genders were often excluded from the PRH volunteer trap broodstock. Although the broodstock collected from the ABC were not intentionally selected for gender and size, no adipose clipped fish were retained.

The fish collected from the OLAFT and ABC were held in Pond 1. Ideally these fish would be held separately from broodstock collected from the volunteer trap to simplify the data collection and analysis of each group. Holding pond limitations required adding adipose clipped fish from the volunteer trap to Pond 1. Placing adipose clipped fish in Pond 1 facilitated the mating of known hatchery origin with potential natural origin fish. Spawning records suggest that thirteen non-clipped broodstock from the volunteer trap ended up in Pond 1. The broodstock from the PRH volunteer trap were placed in Ponds 2, 3, and 4 for the most part.

The broodstock collected at the PRH volunteer trap were systematically sampled at a 1:4 rate for otoliths, scales (age), gender, and length. Post spawn data for this group was sub-sampled to determine origin by age, gender, and length. The broodstock collected at the OLAFT and ABC were sampled at a 1:1 rate for otoliths, scales (aging), gender, and length. All of the otolith samples from the ABC broodstock were submitted for decoding to determine origin by age, gender, and length. A random sample of 202 otoliths from the OLAFT broodstock was submitted for decoding to determine origin by age, gender, and length.

Origin of Broodstock based on CWT versus all Hatchery Marks

High-grading the broodstock to remove adipose clipped fish also removes adipose clipped fish possessing coded-wire tags. This could potentially reduce the ability to discern hatchery origin contributions to the broodstock via coded-wire tag analysis. Assuming that the fish ponded for broodstock were similar in origin as the entire PRH volunteer trap collection, all coded-wire tag returns were used to calculate the estimate of origin for the broodstock. This estimate of origin also makes the incorrect assumption that all fish that could not be identified to origin by coded-wire tags at PRH are of natural origin.

Beginning in return year 2010, the examination of hatchery marks from spawned fish was also used to determine origin. For this comparison, the assumption has been made that fish not possessing an otolith mark, adipose clip, or coded-wire tag are natural origin fish. Chinook salmon in the broodstock sub-sample that did not possess an otolith mark but were marked with an adipose clip and/or coded-wire tag were classified as strays from other hatcheries.

In the otolith sub-sample for 2013 PRH volunteer trap broodstock, there were five non-otolith marked fish that were also adipose clipped, roughly 1.0% of the subsample. When expanded to the total broodstock, it is estimated that there were 43 non-otolith marked/adipose clipped fish in the broodstock that should be classified as fish from other hatcheries.

An estimated 25.2% of the 2013 broodstock originating from the volunteer trap was comprised of natural origin fish based on coded-wire tag recoveries. An estimated 1.8% of the broodstock originating from the volunteer trap was comprised of natural origin fish based on hatchery marks (Table 6).

Table 6 Proportion of hatchery and natural origin Chinook salmon obtained from the Priest Rapids Hatchery volunteer trap used for broodstock.

Brood	Broodstock Spawned	Origin based on CWT expansions			Origin Based on Hatchery Marks		
		PRH	Other Hatchery	Natural Origin [1]	Other [5]	PRH	Natural [2]
2005	5,288	0.622	0.006	0.372		N/A	N/A
2006	5,099	0.490	0.006	0.504		N/A	N/A
2007	2,096	0.671	0.004	0.325		N/A	N/A
2008	4,897	0.491	0.008	0.501		N/A	N/A
2009	4,389	0.428	0.003	0.569		N/A	N/A
2010	5,256	0.602	0.003	0.395		0.957	0.043 [3]
2011	5,444	0.613	0.006	0.381		0.966	0.034 [4]
2012	4,974	0.692	0.004	0.304	0.004	0.882	0.119
2013	4,476	0.713	0.034	0.252	0.011	0.971	0.018

[1] Natural origin estimated from the remaining fish not accounted for by expansions of CWT recoveries
[2] Natural origin estimated from the remaining fish not accounted for by hatchery marks
[3] PRH origin determined based on origin sub-sampling of age-2 and 3 Chinook salmon in the broodstock.
[4] PRH origin determined based on origin sub-sampling of age-2, 3, and 4 Chinook salmon in the broodstock.
[5] Other hatchery fish based on origin sub-sampling that were adipose clipped fish without an otolith mark.

Broodstock Age Composition

A combined total of 5,441 fish were spawned from the three sources of broodstock. In general, hatchery origin broodstock tend to be younger than natural origin broodstock (Table 7). The historical broodstock age compositions are not directly comparable to 2012 and 2013 broodstock age compositions due to inconsistent methodology for assigning origin. Prior to 2012, the origin of broodstock was estimated by coded wire tag expansions.

Table 7 Age composition for hatchery and natural origin fall Chinook salmon spawned at Priest Rapids Hatchery, 2007 -2013 from all brood sources.

Brood	Origin	n =	Age Composition				
			Age-2	Age-3	Age-4	Age-5	Age-6
2007	Natural[1]	1	0.000	1.000	0.000	0.000	0.000
	Hatchery[1]	61	0.081	0.274	0.486	0.138	0.020
2008	Natural[1]	0	--	--	--	--	--
	Hatchery[1]	95	0.011	0.848	0.100	0.039	0.002
2009	Natural[1]	0	--	--	--	--	--
	Hatchery[1]	61	0.012	0.086	0.883	0.019	0.000
2010	Natural[1]	0	--	--	--	--	--
	Hatchery	133	0.016	0.755	0.111	0.118	0.000
2011	Natural[1]	0	--	--	--	--	--
	Hatchery[1]	22	0.010	0.229	0.753	0.008	0.000
2012	Natural[2]	379	0.032	0.435	0.400	0.131	0.002
	Hatchery[2]	871	0.006	0.487	0.376	0.130	0.000
2013	Natural[2]	342	0.000	0.446	0.517	0.037	0.000
	Hatchery[2]	628	0.001	0.658	0.339	0.002	0.000

[1] Origin determined from coded-wire tag expansions
[2] Origin determined from coded-wire and otolith samples

By design, few age-2 males are included in the broodstock. There were only three hatchery age-2 males in the 2013 broodstock. In comparison, the 2012 broodstock was comprised of 21 natural origin and 27 PRH origin age-2 males recovered at the OLAFT added to one age-2 hatchery male from the PRH volunteer trap.

A total of 6,976 Chinook salmon were collected from the PRH volunteer trap, of which 4,476 were spawned. The PRH origin fish were mostly age-3. The natural origin broodstock consisted mostly of age-4 fish (Table 8).

Table 8 Age composition for hatchery and natural origin fall Chinook broodstock collected form the Priest Rapids Hatchery volunteer.

Brood	Origin	Age Composition					
		n =	Age-2	Age-3	Age-4	Age-5	Age-6
2012	Natural[1]	39	0.000	0.295	0.585	0.121	0.000
	Hatchery[1]	646	0.000	0.477	0.389	0.134	0.000
2013	Natural[1]	11	0.000	0.390	0.610	0.000	0.000
	Hatchery[1]	497	0.000	0.656	0.342	0.002	0.000
Mean	Natural	25	0.000	0.343	0.598	0.061	0.000
	Hatchery	572	0.000	0.567	0.366	0.068	0.000

[1] Origin determined from "in-sample" otoliths, adipose clips and/or coded-wire tags.

A total of 763 Chinook salmon were collected at the OLAFT, of which 658 were spawned to supplement the 2013 broodstock. The hatchery and natural origin fish recovered at the OLAFT and spawned were primarily age-3 and age-4, respectively (Table 9).

Table 9 Age composition for hatchery and natural origin fall Chinook salmon broodstock collected from the Off Ladder Adult Fish Trap at Priest Rapids Dam.

Brood	Origin	Age Composition					
		n =	Age-2	Age-3	Age-4	Age-5	Age-6
2012	Natural[1]	281	0.048	0.540	0.257	0.151	0.004[a]
	Hatchery[1]	219	0.106	0.687	0.136	0.071	0.000
2013	Natural[1]	94	0.000	0.417	0.528	0.005	0.000
	Hatchery[1]	75	0.003	0.665	0.334	0.007	0.000
Mean	Natural	188	0.024	0.479	0.393	0.078	0.002
	Hatchery	147	0.055	0.676	0.235	0.039	0.000

[1] Origin determined from "in-sample" otoliths, adipose clips and/or coded-wire tags.
[a] One age-6 female assigned to natural origin based on the absence of marks or tags. The 2006 brood year was not otolith marked.

A total of 397 fall Chinook salmon were collected from the ABC, of which 307 were spawned to supplement the 2013 broodstock. The collection was notably larger than the 2012 collection of 65 fish. Both the PRH origin and natural origin fish spawned from the ABC broodstock were mostly age-3 (Table 10).

Table 10 **Proportion of hatchery and natural origin fall Chinook salmon for each age of broodstock collected from the Angler Broodstock Collection.**

Brood	Origin	n =	Age Composition				
			Age-2	Age-3	Age-4	Age-5	Age-6
2012	Natural[1]	59	0.000	0.542	0.339	0.119	0.000
	Hatchery[1]	6	0.000	0.667	0.333	0.000	0.000
2013	Natural[1]	237	0.000	0.511	0.468	0.021	0.000
	Hatchery[1]	56	0.000	0.839	0.161	0.000	0.000
Mean	Natural	148	0.000	0.527	0.404	0.070	0.000
	Hatchery	31	0.000	0.753	0.247	0.000	0.000

[1] Origin determined from "in-sample" otoliths, adipose clips and/or coded-wire tags.

Length by Age Class of Broodstock

Hatchery and natural origin 2013 broodstock were similar in size for age-3 and 4 fish. The comparison in size between natural and hatchery origin age-5 is inconclusive due to the very small sample size (Table 11). The historic observations for size at age obtained at PRH and the Hanford Reach suggest that hatchery origin fall Chinook salmon tend to be a little larger at ages-2 and 3 and smaller at age-4 and 5 than the natural origin fish (Table 12).

Table 11 **Mean fork length (cm) at age (total age) of fall Chinook salmon sampled from each source of broodstock spawned at Priest Rapids Hatchery, return year 2013. N = sample size and SD = 1 standard deviation.**

Return Year	Origin	Fall Chinook Fork Length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
Volunteer Returns	Natural	0			4	76	4	7	78	4	0			0		
	Hatchery	0			288	71	4	200	80	5	2	85	4	0		
OLAFT	Natural	0			36	72	6	53	82	6	4	90	7	0		
	Hatchery	0			47	72	5	27	82	4	1	94	0	0		
ABC	Natural	0			36	72	6	53	82	6	5	90	7	0		
	Hatchery	0			47	72	5	27	82	4	1	94	0	0		

It is assumed for this analysis that all fish not possessing an otolith mark, ad-clipped or hatchery origin coded-wire tag were natural origin. n = sample size and SD = 1 standard deviation.

Table 12 **Mean fork length (cm) at age (total age) of hatchery and natural origin fall Chinook salmon collected from volunteer broodstock for the Priest Rapids Hatchery program, n = sample size and SD = 1 standard deviation.**

Return year	Origin	Fall Chinook Fork Length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2007	Natural	0			1	76	0	0			0			0		
	Hatchery	31	55	3	114	70	4	216	83	6	61	91	6	9	94	9
2008	Natural	0			0			0			0			0		
	Hatchery	3	45	3	429	73	4	51	84	5	20	91	4	1	73	0
2009	Natural	0			0			0			0			0		
	Hatchery	5	50	4	42	71	4	428	84	6	9	95	7	0		
2010	Natural	0			0			0			0			0		
	Hatchery	20	51	5	1,044	72	4	164	84	6	173	91	6	0		
2011	Natural	2	43	3	36	67	5	100	82	6	19	89	4	0		
	Hatchery	7	49	6	249	70	4	837	80	5	9	91	7	0		
2012	Natural	0			12	71	4	25	82	4	5	86	4	0		
	Hatchery	0			298	70	4	253	81	5	91	88	7	0		
2013	Natural	0			4	76	4	7	78	4	0			0		
	Hatchery	0			288	71	4	200	80	5	2	85	4	0		

Gender Ratios

PRH staff sort and select broodstock from the trap to meet their egg take goals and male-to-female spawner ratio. Additional broodstock was collected from the OLAFT and ABC. The 2013 broodstock was comprised 65.9% females, resulting in an overall male to female ratio of 0.52:1.00 which is slightly lower than the historic mean ratio of 0.55:1.00 (Table 13).

Table 13 **Numbers of male and female hatchery fall Chinook salmon broodstock at Priest Rapids Hatchery. Ratios of males to females are also provided.**

Return Year	Males (M)	Females (F)	M/F Ratio
2001	1,697	3,289	0.52:1.00
2002	1,936	3,628	0.53:1.00
2003	1,667	3,176	0.52:1.00
2004	1,688	3,099	0.54:1.00
2005	1,962	3,326	0.59:1.00
2006	1,777	3,322	0.53:1.00
2007	850	1,301	0.65:1.00
2008	1,823	3,195	0.57:1.00
2009	1,531	3,000	0.51:1.00
2010	1,809	3,447	0.52:1.00
2011	1,858	3,000	0.62:1.00
2012	1,749	3,225	0.54:1.00
2013	1,855	3,586	0.52:1.00
Mean	**1,708**	**3,122**	**0.55:1.00**

Very low numbers of coded-wire tagged natural origin fall Chinook salmon are recovered in the broodstock at PRH. Therefore, there is insufficient data to determine historical male-to-female ratios by origin (natural vs. hatchery) using coded-wire tag recoveries.

The addition of broodstock from OLAFT and ABC increased the male-to-female ratio for natural origin brood stock from 0.93:100 to 1.90:1.00. The addition of the OLAFT and ABC broodstock slightly increased the male-to-female ratio for PRH origin broodstock from 0.38:1.00 to 0.42:1.00 (Table 14). For both the 2012 and 2013 return years, the inclusion of fish from OLAFT and the ABC notably increased the number of natural origin males in the PRH broodstock.

Table 14 Numbers of male and female natural origin and Priest Rapids Hatchery origin fall Chinook salmon spawned at Priest Rapids Hatchery.

Return Year	Broodstock Source	Natural Origin Fall Chinook			Hatchery Origin Fall Chinook			Total M/F ratio
		Males	Females	M/F	Males	Females	M/F	
2012	PRH Volunteer Returns	105	147	0.70:1.00	1,251	2,905	0.42:1.00	0.44:1.00
	OLAFT	185	96	1.93:1.00	168	52	3.23:1.00	2.39:1.00
	ABC	36	23	1.57:1.00	4	2	2.00:1.00	1.60:1.00
	Total	326	266	1.23:1.00	1,423	2,959	0.48:1.00	0.54:1.00
2013	PRH Volunteer Returns	32	50	0.64:1.00	1,207	3,187	0.38:1.00	0.38:1.00
	OLAFT	233	134	1.74:1.00	169	122	1.39:1.00	1.57:1.00
	ABC	184	64	2.88:1.00	38	21	1.81:1.00	2.61:1.00
	Total	499	248	2.01:1.00	1,414	3,330	0.42:1.00	0.42:1.00

Fecundity

The annual average fecundity for PRH was calculated as the proportion of the total number of females spawned to the total egg take. Fecundity for the 2013 broodstock sampled averaged 3,725 eggs per female which is less than the historical mean of 3,996 (Table 15). This lower than average fecundity for the 2013 brood stock likely resulted from the higher than normal proportion of age-3 females spawned in brood year 2013 as shown previously in Table 10.

Table 15 Mean fecundity of fall Chinook salmon collected for broodstock at Priest Rapids Hatchery.

Return year	Egg Take	Viable Females	Fecundity/Female
2001	10,750,000	3,161	3,401
2002	12,180,000	3,489	3,491
2003	12,814,000	3,078	4,163
2004	12,753,500	3,019	4,224
2005	14,085,000	3,211	4,386
2006	13,511,200	3,217	4,200
2007[1]	5,067,319	1,249	4,057
2008	12,643,600	3,074	4,113
2009	13,074,798	2,858	4,575
2010	11,903,407	3,304	3,603
2011	12,693,000	3,038	4,178
2012	12,398,389	3,234	3,834
2013	12,947,070	3,476	3,725
Mean	12,063,176	3,031	3,996

[1] Did not reach egg take goal.

Fecundity samples were taken from females subsampled at PRH during the spawn of 2010 through 2013 broodstock to estimate fecundity by length and age. For the 2013 brood year data, we show comparisons between hatchery and natural origin fall Chinook salmon sampled at PRH which include fork length/fecundity, fork length/egg size (weight) and fork length and gamete mass. In 2013, sampling was stratified by fork length categories to obtain fecundity samples for all sizes of fish and origin to better estimate the relationship between length and fecundity. Hence, comparisons between age classes are not representative of the females spawned from 2013 broodstock.

The entire gamete mass was stripped from females as they were artificially spawned, drained of most all ovarian fluid and weighed within 0.1 gram. A single sub-sample of 60 or 100 green eggs were counted out and weighed within 0.01 gram to estimate individual egg weight (g) for each female. The total fecundity of each female was estimated by dividing the weight of the total egg mass by the calculated mean individual egg weight. Each sample of the total egg mass likely contained slightly varying amounts of ovarian fluid which might over estimate fecundity.

The fecundity data was pooled for brood years 2010 through 2013 to provide a linear relationship between fecundity and fork length for natural and hatchery females combined. This data shows a strong positive correlation between size and fecundity (Figure 4). This regression formula may be useful for coarse predictions of egg production for different size fish.

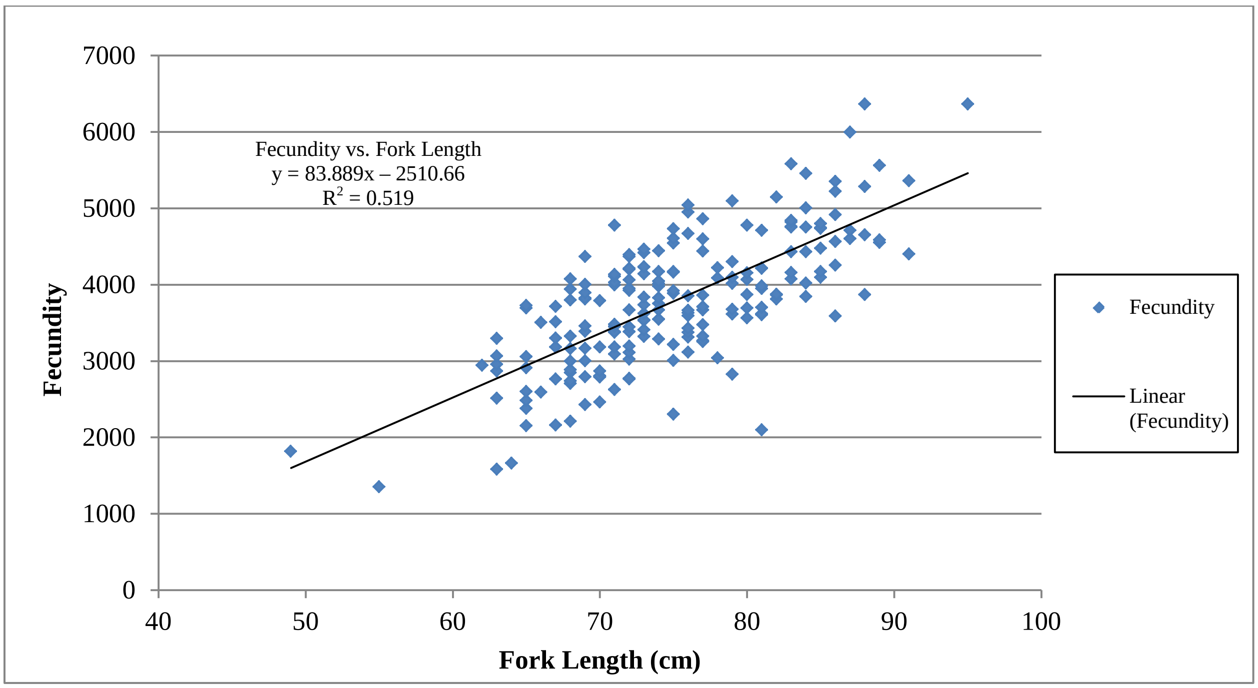

Figure 4 **Linear relationship between fecundity and fork length for combined samples of natural and hatchery origin fall Chinook salmon spawned at Priest Rapids Hatchery brood years 2010 through 2013.**

Fecundity samples collected in years 2010 through 2012 were not identified as to the origin of the females. In 2013, a total of 205 fecundity samples were taken from the broodstock at PRH to collect data associated with fecundity by age, size and origin. Not all females were sampled for age and origin due to high workloads during spawning activities.

Females were selected from both the PRH volunteer broodstock as well as from pond 1 which possessed broodstock primarily from the OLAFT and ABC. For the most part, the origin of fish during sampling was unknown; therefore, we made a concerted effort to select females that were not adipose clipped so as to increase the chances of obtaining natural origin fish which were less common than hatchery origin fish. The ages for 183 of females sampled were determined by aging scales. The origins for 186 females sampled for fecundity were determined by hatchery marks (i.e., otoliths, adipose clips and coded-wire tags).

The average fecundity by age is given in Table 16. This information is useful for forecasting potential egg takes based on the numbers and age composition of the forecasted return.

Table 16 Fecundity at age for fall Chinook salmon sampled at the Priest Rapids Hatchery.

Return Year	Age-3	Age-4	Age-5	*N*	Annual Mean
2010	3,698	4,379	4,652	441	3,603
2011	3,538	4,276	4,380	242	4,178
2012	3,638	4,034	3,600[a]	15	3,834
2013	3,451	4,145	5,539	183	3,702
Mean	3,581	4,209	4,543	220	3,829

[a] Sample includes only one small age-5 female

The low numbers of females sampled for most length categories preclude meaningful comparisons between natural and hatchery origin fecundity by fork length (Table 17). The data collected in 2013 will be pooled with similar data collected in upcoming years at PRH to create a larger dataset. Ideally, sufficient numbers of natural origin fish will be sampled in upcoming years that comparisons can be made by brood year and origin to reduce the effect of annual variability of the variables measured.

The linear relationships between fork length and variables including fecundity, mean egg weight, and total egg mass weight for natural and hatchery origin females sub-sampled are plotted in Figures 5 - 7. All relationships show a positive correlation with fork length. In addition, the relationships between fish size and egg data were similar for hatchery and natural origin fish.

Table 17 Fecundity by origin and fork length for fall Chinook salmon sampled at the Priest Rapids Hatchery, Return Year 2013.

Fork Length (cm)	Natural Origin N	Natural Origin Mean	Natural Origin SD	Hatchery Origin N	Hatchery Origin Mean	Hatchery Origin SD
49				1	1,821	n/a
55				1	1,356	n/a
62				1	2,947	n/a
63				6	2,716	610
64				1	1,667	n/a
65				8	2,877	588
66				2	3,051	644
67				6	3,108	564
68	1	4,079	n/a	10	3,064	520
69				11	3,470	581
70				4	2,735	182
71				11	3,382	1,133
72				12	3,631	583
73	1	3,542	n/a	11	3,906	410
74	1	4,447	n/a	9	3,812	280
75	1	4,545	n/a	9	3,781	792
76	2	4,858	264	8	3,668	568
77	1	3,711	n/a	7	3,813	628
78	1	4,224	n/a	1	3,043	n/a
79				6	3,994	751
80	2	4,174	860	3	4,032	146
81	4	4,093	145	3	3,506	1,317
82	2	4,513	899	2	3,839	38
83	5	4,683	609	2	4,792	40
84	4	4,408	560	1	4,434	n/a
85	3	4,464	284	3	4,549	392
86	3	5,048	423	3	4,256	665
87	2	5,357	910	1	4,603	n/a
88	2	5,826	763	2	4,263	554
89	3	4,902	572			
90						
91	2	4,883	679			
92						
93						
94						
95	1	6,365	n/a			
Total Sampled	41			145		

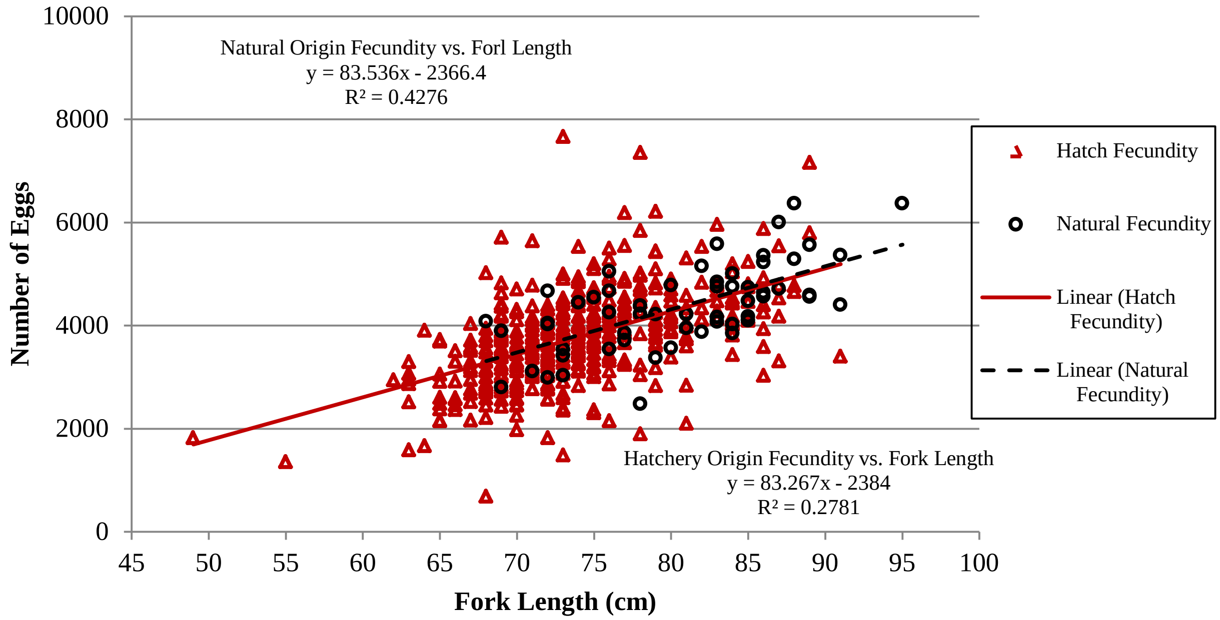

Figure 5 **Fecundity versus fork length for natural and hatchery origin fall Chinook salmon sub-sampled at Priest Rapids Hatchery, Return Year 2013.**

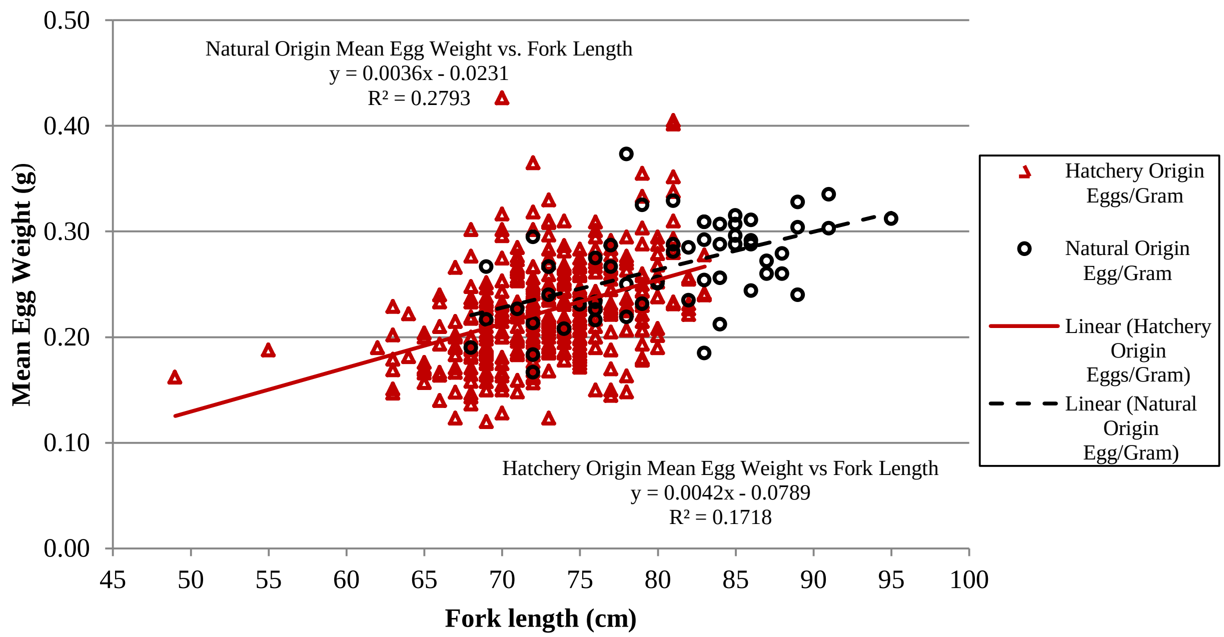

Figure 6 **Mean egg weight versus fork length for natural and hatchery origin fall Chinook salmon sub-sampled at Priest Rapids Hatchery, Return Year 2013.**

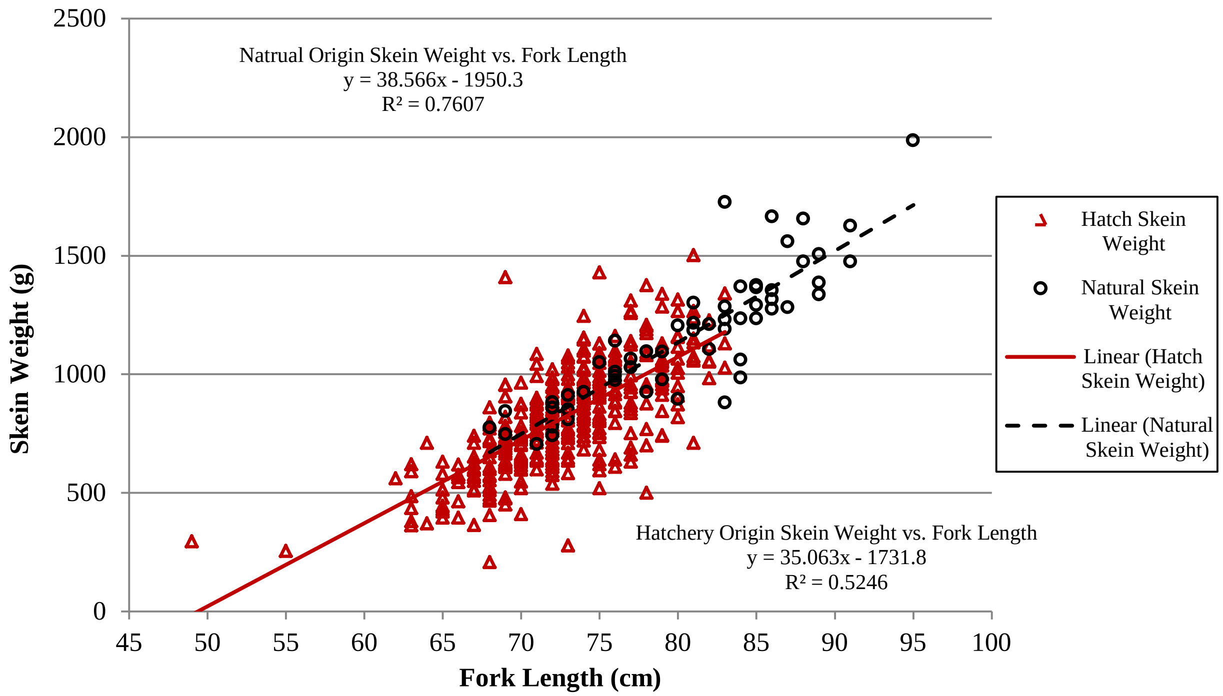

Figure 7 Total egg mass weight versus fork length for natural and hatchery origin fall Chinook salmon sub-sampled at Priest Rapids Hatchery, Return Year 2013.

We attempted to determine an appropriate number of eggs to weigh to enhance precision and minimize effort. We measured multiple100 egg samples. Ten lots of cumulative100 egg sub-samples were randomly pulled without replacement and weighed to a tenth of a gram for thirteen individual females. The scale was tared to zero between 100 egg sub-samples. The individual sub-sample weights were summed to provide cumulative sample weights for 100-egg increments. We assumed the best estimate of fecundity of each fish was calculated from the cumulative weight of 1,000 eggs. The weights for the individual sub-samples, cumulative sub-samples, and corresponding fecundities are provided in Table 18. There was no attempt to measure the variability of 100-egg lots based on origin of females. Most of the females for this sampling originated from the PRH volunteer trap which was comprised primarily of hatchery origin fish.

The difference between each of the 100-egg cumulative fecundity estimates and the 1,000-egg fecundity estimate was plotted to show the relationship between fecundity estimates calculated by the sub-samples. Fecundity estimates based on the 100-egg sub-sample and the 1,000-egg cumulative sub-sample showed a difference in the fecundity estimates greater than 100 eggs for five fish. The data in Figure 8 shows a positive difference between most of the fecundities estimated by the cumulative sub-samples and that of the cumulative 1,000-egg sub-sample. The differences quickly decrease with increasing size of the cumulative sub-samples.

Table 18 Weights and estimated fecundity for 100-egg lots sampled from fall Chinook salmon broodstock at Priest Rapids Hatchery, Return Year 2013.

Weight of 100 of egg sub-samples (g)															
Fish	FL (cm)	100	100	100	100	100	100	100	100	100	100	Mean	SD	Min	Max
1	70	16.8	16.9	17.4	17.6	17.7	17.7	17.6	17.4	17.6	17.5	17.4	0.3	16.8	17.7
2	70	23.2	24.0	23.9	24.0	24.1	24.0	24.2	24.2	24.1	24.4	24.0	0.3	23.2	24.4
3	71	17.9	18.0	18.7	18.8	18.8	18.3	18.8	18.3	18.6	18.9	18.5	0.4	17.9	18.9
4	72	23.0	23.1	24.1	24.3	23.6	23.5	23.6	23.6	23.6	24.2	23.7	0.4	23.0	24.3
5	74	26.2	26.6	26.8	26.9	27.0	27.3	26.6	27.8	26.9	27.3	26.9	0.4	26.2	27.8
6	75	20.6	21.1	20.9	21.7	21.3	21.5	20.9	21.8	20.5	21.2	21.2	0.4	20.5	21.8
7	75	18.9	18.7	19.5	18.7	18.9	19.1	19.0	19.3	18.9	19.0	19.0	0.2	18.7	19.5
8	75	26.9	26.7	26.5	27.4	27.0	26.4	27.1	26.5	26.8	26.4	26.8	0.3	26.4	27.4
9	76	27.1	27.2	27.4	27.7	27.4	27.2	26.9	27.5	27.5	27.7	27.4	0.3	26.9	27.7
10	77	26.0	26.1	26.1	26.5	26.7	26.9	26.7	26.3	26.4	26.5	26.4	0.3	26.0	26.9
11	79	25.4	25.6	26.1	25.4	25.7	25.5	25.8	25.5	25.4	26.6	25.7	0.4	25.4	26.6
12	81	27.9	29.5	29.0	29.0	28.4	28.8	28.8	29.1	28.7	29.0	28.8	0.4	27.9	29.5
13	87	29.2	28.9	29.4	29.05	29.1	28.5	29.6	28.7	28.9	29.1	29.0	0.3	28.5	29.6
Weight of cumulative of 100 egg sub-samples (g)															
Fish	FL (cm)	100	200	300	400	500	600	700	800	900	1000	Total Egg Mass (g)			
1	70	16.8	33.7	51.1	68.7	86.4	104.1	121.7	139.1	156.7	156.7	535			
2	70	23.2	47.2	71.1	95.1	119.2	143.2	167.4	191.6	215.7	215.7	880			
3	71	17.9	35.9	54.6	73.4	92.2	110.5	129.3	147.6	166.2	166.2	740			
4	72	23.0	46.1	70.2	94.5	118.1	141.6	165.2	188.8	212.4	212.4	735			
5	74	26.2	52.8	79.6	106.5	133.5	160.8	187.4	215.2	242.1	242.1	930			
6	75	20.6	41.7	62.6	84.3	105.6	127.1	148.0	169.8	190.3	190.3	975			
7	75	18.9	37.6	57.1	75.8	94.7	113.8	132.8	152.1	171.0	171.0	735			
8	75	26.9	53.6	80.1	107.5	134.5	160.9	188.0	214.5	241.3	241.3	620			
9	76	27.1	54.3	81.7	109.4	136.8	164.0	190.9	218.4	245.9	245.9	915			
10	77	26.0	52.1	78.2	104.7	131.4	158.3	185.0	211.3	237.7	237.7	1,265			
11	79	25.4	51.0	77.1	102.5	128.2	153.7	179.5	205.0	230.4	230.4	935			
12	81	27.9	57.4	86.4	115.4	143.8	172.6	201.4	230.5	259.2	259.2	1,010			
13	87	29.2	58.1	87.5	116.6	145.7	174.2	203.8	232.5	261.4	261.4	1,344			
Fecundity estimates from cumulative 100 egg sub-samples															
Fish	FL (cm)	100	200	300	400	500	600	700	800	900	1000	Mean	SD	Min	Max
1	70	3,185	3,175	3,141	3,115	3,096	3,084	3,077	3,077	3,073	3,071	3,109	43	3,071	3,185
2	70	3,793	3,729	3,713	3,701	3,691	3,687	3,680	3,674	3,672	3,665	3,701	38	3,665	3,793
3	71	4,134	4,123	4,066	4,033	4,013	4,018	4,006	4,011	4,007	3,998	4,041	50	3,998	4,134
4	72	3,196	3,189	3,141	3,111	3,112	3,114	3,114	3,114	3,114	3,107	3,131	33	3,107	3,196
5	74	3,550	3,523	3,505	3,493	3,483	3,470	3,474	3,457	3,457	3,452	3,486	32	3,452	3,550
6	75	4,733	4,676	4,673	4,626	4,616	4,603	4,611	4,594	4,611	4,610	4,635	44	4,594	4,733
7	75	3,889	3,910	3,862	3,879	3,881	3,875	3,874	3,866	3,868	3,868	3,877	14	3,862	3,910
8	75	2,305	2,313	2,322	2,307	2,305	2,312	2,309	2,312	2,312	2,316	2,311	5	2,305	2,322
9	76	3,376	3,370	3,360	3,346	3,344	3,348	3,355	3,352	3,349	3,344	3,354	11	3,344	3,376
10	77	4,865	4,856	4,853	4,833	4,814	4,795	4,786	4,789	4,790	4,788	4,817	32	4,786	4,865
11	79	3,681	3,667	3,638	3,649	3,647	3,650	3,646	3,649	3,652	3,638	3,652	13	3,638	3,681
12	81	3,620	3,519	3,507	3,501	3,512	3,511	3,510	3,505	3,507	3,505	3,520	36	3,501	3,620
13	87	4,603	4,627	4,608	4,613	4,614	4,630	4,617	4,626	4,628	4,627	4,619	10	4,603	4,630

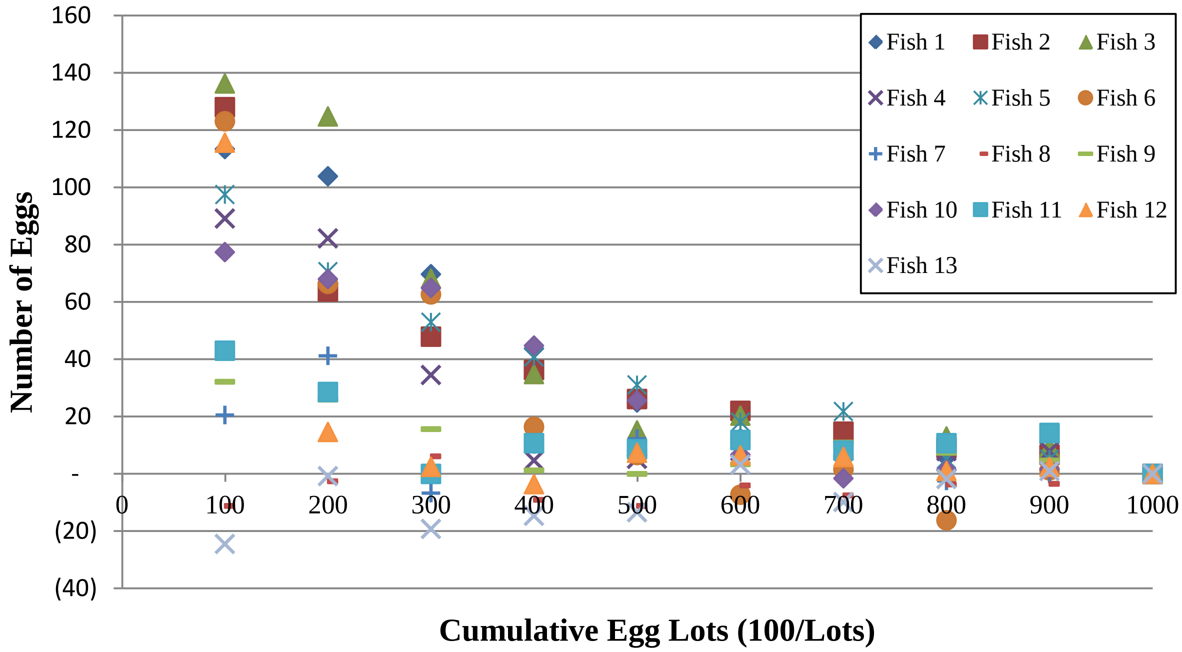

Figure 8 **Difference between the 1,000 egg fecundity estimate and the cumulative 100 egg fecundity estimates, Priest Rapids Hatchery, 2013.**

This trend suggests that the weights of the sub-samples may be biased. We would expect the differences to be more evenly distributed above and below the x-axis if no bias was present. The source of bias may be in part associated with weighing of egg samples outdoors during breezy conditions. The lighter weight samples may have been influence more than heavier samples. We plan to certify the scale used for this work for varying weights to determine if the scale can accurately measure weights between 10g and 300g. As a means to remove the potential scale-weight bias in the future, multiple separate 100 egg lots will be measured without adding them to previously weighed egg lots. In addition, future sampling will occur indoors under controlled conditions.

12.0 Hatchery Rearing

Number of eggs taken

In 2013, an estimated total of 12,947,070 eggs were collected at the PRH facility. The 2013 egg take goal was 12,692,460. The egg take goal is calculated annually based on current program needs. This goal is established to meet the fall Chinook salmon production goals at both PRH and RSH as well as provide eggs for the Salmon in the Classroom Program.

PRH incubates approximately 7.9 million eyed eggs to produce the 7.3 million smolt release at the hatchery. An additional 3.7 million eyed eggs are needed to meet the program goal of eyed egg delivery to Bonneville Hatchery for the Ringold Springs Hatchery fall Chinook salmon production (USACE - John Day mitigation). Egg takes at PRH were sufficient to meet all hatchery production goals from 1984 through 2013, with the exception of 2007 (Table 19).

Table 19 Numbers of eggs taken from fall Chinook salmon broodstock collected at Priest Rapids Hatchery for the Hanford Reach and lower Yakima River programs.

Return Year	Number of Eggs Taken	Return Year	Number of Eggs Taken
1984	10,342,000	1999	16,089,600
1985	10,632,000	2000	15,359,500
1986	22,126,100	2001	10,750,000
1987	24,123,000	2002	12,180,000
1988	16,682,000	2003	12,814,000
1989	13,856,500	2004	12,753,500
1990	9,605,000	2005	14,085,000
1991	6,338,000	2006	13,511,200
1992	11,156,400	2007	5,067,319
1993	14,785,000	2008	12,643,600
1994	16,074,600	2009	13,074,798
1995	17,345,900	2010	11,903,407
1996	14,533,500	2011	12,693,000
1997	17,007,000	2012	12,398,389
1998	13,981,300	2013	13,276,000
		10 year (03-13) Mean[1]	**12,915,289**

[1] Excludes outlier data for return year 2007

Number of acclimation days

The 2013 brood fall Chinook salmon was the first to be incubated and reared at the newly constructed PRH. Fish were incubated on well water before being transferred to intermediate concrete raceways and then transferred to the concrete holding ponds for final acclimation before release into the Columbia River in June 2014. The egg takes from the 2013 brood were distributed into twelve batches associated with the dates in which fish were spawned. The number of acclimation days ranged from 100 for the later egg takes to 129 for the earlier egg takes (Table 20).

Table 20 Number of days fall Chinook salmon fry were reared at Priest Rapids Hatchery prior release.

Brood Year	Batch	Egg Tray to Raceway Transfer Date	Release Date	Number of Days
2013	1	February 5th into bank E	June 12th	129
2013	2	February 6th into bank E	June 12th	128
2013	3	February 7th into bank E	June 12th	126
2013	4	February 8th into bank E	June 12th	125
2013	5	February 18 into Bank D	June 16th	119
2013	6	February 25 into Bank D	June 16th	112
2013	7	February 25 into Pond C	June 18th	114
2013	8	March 3 into Pond C	June 18th	108
2013	9	March 3 into Pond B	June 23rd	113
2013	10	March 4 into Pond A	June 25th	114
2013	11	March 12 into Pond A	June 25th	106
2013	12	March 18 into Pond A	June 25th	100

Number released

In 2014, PRH released an estimated 7,266,713 subyearling fall Chinook salmon from the 2013 brood (Table 2). The PRH release target goal is 7,299,000 sub-yearlings with 1,700,000 of these fish for the USACE John Day Mitigation. Fish were released between June 12 and June 26.

Fish Size and Condition at Release

The data associated with fish size and condition at release from PRH prior to brood year 2013 was obtained from the hatchery staff. The average fish weight was obtained by weighing groups of roughly 300 fish sampled from each pond to the nearest gram and then dividing the group weight by the total number of fish weighed. The fork length of each fish from the group weighed was measured to the nearest millimeter to calculate average length and coefficient of variance. Each of the four ponds was sampled just prior to release. The results were pooled to provide an average for the facility as a whole. The size and condition data for the 2013 brood was collected by M&E staff. We attempted to collect representative samples of roughly 100-120 from each of the four channel ponds within 24 hours of release. Each fish sampled was individually weighed to the nearest 0.1 gram and measured for fork length to the nearest millimeter. The results were pooled to provide an average for the facility as a whole.

The goal for PRH is to release fall Chinook salmon smolts at 50 fish per pound. At release, the smolts from the 2013 brood averaged 50 fish per pound and 92 mm in fork length (Table 21).

The coefficient of variation of the fork length was 8.4. For the most recent 23 years, smolts released from PRH have averaged 47 fish per pound (96 mm) with an average CV of 7.4.

Table 21 Mean length (FL, mm), weight (g and fish/pound), and coefficient of variations (CV) of fall Chinook smolts released from Priest Rapids Hatchery.

		Fork Length (mm)		Mean Weight		
Brood year	**Release Year**	**Mean**	**CV**	**Grams (g)**	**Fish/pound**	**n=**
1991	1992	93	8.7	8.3	55	1,500
1992	1993	92	8.6	8.3	54	1,500
1993	1994	95	6.9	9.3	49	1,500
1994	1995	96	6.7	9.7	47	1,500
1995	1996	97	6.6	10	45	1,500
1996	1997	95	11	8.7	52	1,500
1997	1998	103	8.9	10.1	45	1,500
1998	1999	95	6.5	9.6	48	1,500
1999	2000	93	6.6	8.9	51	1,500
2000	2001	97	6.3	10.2	45	1,500
2001	2002	96	6.9	10.1	45	1,500
2002	2003	95	6.9	9.5	48	1,500
2003	2004	96	6.8	9.6	48	1,500
2004	2005	95	5.9	9.4	48	1,500
2005	2006	98	6.3	10.1	45	1,500
2006	2007	98	7	9.9	46	1,500
2007	2008	101	8.3	10.2	45	1,200
2008	2009	94	6.7	9.3	49	1,500
2009	2010	94	7.3	9.2	49	1,500
2010	2011	92	9.1	9.7	47	1,500
2011	2012	94	7.1	9.2	49	1,500
2012	2013	95	7.6	9.7	47	1,500
2013	2014	92	8.4	9.0	50	648
Mean		**96**	**7.4**	**9.5**	**48**	**1,486**

Survival Estimates

The survival rate for egg to juvenile release for brood year 2013 was 80.67% which is the second lowest recorded since brood year 2002 and slightly lower than the historic mean of 85.4% (Table 22). The egg to eyed egg stage is the most critical life stage at PRH during incubation/juvenile rearing because the greatest level of loss annually occurs at this stage. The survival rate for brood year 2013 during this stage was 88.4%, slightly lower than the historic mean.

Pre-spawn survival of adult Chinook salmon ponded at PRH for broodstock has averaged 82.0% since brood year 2002. In 2013, survival of fish ponded for broodstock was only 68.4%. This was the second lowest survival rate on record. Survival of fish ponded for broodstock in brood year 2011 was 67.9% which was the lowest on recorded since brood year 2002. The cause of the elevated mortality in unknown; however, in-season observations of high fish holding densities in the volunteer trap on clean-out days may suggest that the fish were stressed prior to ponding.

Table 22 **Hatchery life-stage survival rates (%) for fall Chinook salmon at Priest Rapids Hatchery, brood years 1989 – 2013. Survival standards for egg to release are provided in the last row of the table. The survival standards are the mean survivals for the most recent 10 year period.**

Brood year	PRH Volunteers Ponded to Spawned				Fertilized to Eyed Egg	Eyed egg to Ponding	Ponding to Release	Egg to Release	Standard Egg to Release[1]
	Female	Male	Jack	Total					
2002	0.835	0.829	0.705	0.828	0.880	0.995	0.979	0.858	0.875
2003	0.893	0.817	0.698	0.858	0.882	0.989	0.989	0.868	0.870
2004	0.958	0.915	0.646	0.845	0.881	0.975	0.985	0.846	0.867
2005	0.890	0.890	0.782	0.886	0.914	0.976	0.991	0.884	0.864
2006	0.918	0.924	0.695	0.913	0.897	0.975	0.981	0.859	0.866
2007	0.967	0.748	0.642	0.861	0.858	0.996	0.981	0.898	0.862
2008	0.943	0.896	0.877	0.924	0.902	0.973	0.877	0.877	0.857
2009	0.848	0.901	0.916	0.864	0.912	0.977	0.891	0.891	0.856
2010	0.803	0.831	0.803	0.809	0.913	0.985	0.977	0.841	0.856
2011	0.611	0.847	0.737	0.679	0.903	0.985	0.985	0.875	0.870
2012	0.643	0.786	0.630	0.688	0.873	0.970	0.962	0.787	0.863
2013	0.698	0.660	0.333	0.684	0.884	0.983	0.95.1	0.806	0.867
Mean	**0.834**	**0.837**	**0.705**	**0.820**	**0.897**	**0.966**	**0.966**	**0.854**	**N/A**

[1] Standard Egg to Release equals the mean for the previous ten-year's egg to release survival rate.

Juvenile PIT Tag Detections at the Priest Rapids Hatchery Array

Roughly 3,000 subyearlings at PRH were annually PIT tagged and released from PRH for brood years 1995 through 2010 to assess timing, migration speed, and juvenile survival from PRH to McNary Dam. The analysis for these measures is reported annually by the Fish Passage Center and can be found at *www.fpc.org/documents/FPC_memos.html*

Beginning with the 2011 brood, approximately 40,000 additional juveniles were annually tagged and released to bolster the data collected for estimation of juvenile abundance at release and adult straying. These tags can also be used to estimate adult migration timing, conversion rates from Bonneville Dam to McNary Dam to PRH, smolt to adult survival rates, as well as fallback and re-ascension estimates at McNary, Ice Harbor, and Priest Rapids dams. Prior to the 2012 release, a PIT array consisting of six antennas was installed in the hatchery discharge channel to detect both juvenile out-migrants and adult returns.

The mean detection rate for the seven subyearling tag groups released in 2013 combined was 3.4% (Table 23). The detection rates by group varied from 2.7% to 13.1%. The low detection rates are likely due to the result of releasing all of the smolts in four consecutive days which appears to have overwhelmed the PIT tag detection equipment. The restricted release period was necessitated by the construction schedule of the new hatchery. The detection rate of the 2013 release was much lower than the 70% rate for the 2012 release. The 2012 release occurred over an eight day period, with only two days of consecutive releases. Detection rates for the 2012 release may have been reduced as a result of the array being inundated by high river elevations during the four consecutive days of release.

Table 23 Number of subyearlings PIT tagged, mark and release dates, and the number of unique tags detected at the array in the Priest Rapids discharge channel, brood year 2012.

Brood Year	Coordinator ID	Tag File	Tagging Date	Release Date	Number Tagged	Number of Unique Detections	Percent Detected
2012	CSM	CSM13143.A06	5/23/2013	6/14/2013	9,982	317	3.2
2012	CSM	CSM13143.A07	5/23/2013	6/13/2013	9,983	267	2.7
2012	CSM	CSM13144.A08	5/24/2013	6/12/2013	9,974	335	3.4
2012	CSM	CSM13144.A09	5/24/2013	6/15/2013	9,977	325	3.3
2012	SMP	SMP13149.PR1	5/29/2013	6/15/2013	997	131	13.1
2012	SMP	SMP13149.PR2	5/29/2013	6/14/2013	996	33	3.3
2012	SMP	SMP13150.PR3	5/30/2013	6/12/2013	999	48	4.9
			Totals		**42,908**	**1,456**	**3.4**

A concerted effort was made during the 2014 release to improve the PIT-tag detection rate at the PRH array. First, we discontinued the automatic upload function of the array to reduce the usage demand on the system's processor. We then spaced out the five releases from the hatchery over a fourteen day period beginning on June 12 (Table 24). The individual weir boards for each pond were pulled over a two day period. The performance of the PIT-tag array during the subyearling release appears to be very good. The total number of unique PIT-tag detections is 39,908 out of 42,967 (92.9%) unique PIT-tags placed in fish. We recovered 70 PIT-tags from raceway mortalities and reported the tag identifications to PTAGIS. It is very likely that not all of the PIT-tagged mortalities or expelled tags were recovered.

Table 24 Number of subyearlings PIT tagged, mark and release dates, and the number of unique tags detected at the array in the Priest Rapids discharge channel, brood year 2013.

Brood Year	Coordinator ID	Tag File	Tagging Date	Release Date	Number Tagged	Number of Unique Detections	Percent Detected
2013	CSM	CSM14148.PRA	5/28/2013	6/25/2013	7,994	7,215	90.3
2013	CSM	CSM14148.PRB	5/28/2013	6/23/2013	7,998	7,389	92.4
2013	CSM	CSM14149.PRC	5/29/2013	6/18/2013	7,996	7,443	93.1
2013	CSM	CSM14149.PRD	5/29/2013	6/16/2013	7,993	7,662	95.9
2013	CSM	CSM14149.PRE	5/29/2014	6/12/2014	7,998	7,407	92.6
2013	SMP	SMP14148.PR1	5/29/2013	6/25/2013	996	914	91.8
2012	SMP	SMP14148.PR2	5/29/2013	6/18/2013	994	927	93.3
2012	SMP	SMP14149.PR3	5/30/2013	6/12/2013	998	951	95.3
			Totals		**42,967**	**39,908**	**92.9**

13.0 Adult Fish Pathogen Monitoring

At spawning, adult fall Chinook are sampled for viral pathogens and *Renibacterium salmoninarum*, the causative agent for bacterial kidney disease (BKD). Annual testing for BKD was initiated with the 2008 brood stock to address concerns associated with shipping eyed-eggs to Bonneville Hatchery for the USACE RSH production. The risk of BKD was assayed using the ELISA. Results of adult broodstock BKD monitoring in 2013 indicated that all females had ELISA values less than an optical density of 0.10 (Table 25). Viral inspections included sampling the ovarian fluid and kidney/spleen for pathogens. All results of viral testing in 2013 were negative (Table 26).

Table 25 ELISA test results to determine risk of bacterial kidney disease of adult female fall Chinook salmon broodstock at Priest Rapids Hatchery, brood years 2008 – 2013.

Year	Stock	Number	%Below-Low	% Low	% Mod	% High
2008	Priest Rapids	60	100.0%	0.0%	0.0%	0.0%
2009	Priest Rapids	60	100.0%	0.0%	0.0%	0.0%
2010	Priest Rapids	60	100.0%	0.0%	0.0%	0.0%
2011	Priest Rapids	135	100.0%	0.0%	0.0%	0.0%
2012	Priest Rapids	60	98.3%	0.0%	1.7%	0.0%
2012	Priest Rapids	60	100.0%	0.0%	0.0%	0.0%

Table 26 Viral inspections of fall Chinook salmon broodstock at Priest Rapids Hatchery.

Year	Date(s)	Stock	Life stage	Ovarian Fluid	Kidney/Spleen	Results
1991	28-Oct, 4, 13-Nov	Priest Rapids	Adult	150	60	Negative
1992	2,9-Nov	Priest Rapids	Adult	150	60	Negative
1993	25-Oct, 1-Nov	Priest Rapids	Adult	150	60	Negative
1994	7-Nov	Priest Rapids	Adult	60	60	Negative
1995	9,13,19,21-Nov	Priest Rapids	Adult	160	160	Negative
1996	17-Nov	Priest Rapids	Adult	60	60	Negative
1997	17-Nov	Priest Rapids	Adult	60	60	Negative
1998	16-Nov	Priest Rapids	Adult	60	60	Negative
1999	8-Nov	Priest Rapids	Adult	60	60	Negative
2000	13-Nov	Priest Rapids	Adult	60	60	Negative
2001	13-Nov	Priest Rapids	Adult	60	60	Negative
2002	13-Nov	Priest Rapids	Adult	60	60	Negative
2003	17-Nov	Priest Rapids	Adult	60	60	Negative
2004	8-Nov	Priest Rapids	Adult	60	60	Negative
2005	14-Nov	Priest Rapids	Adult	60	60	Negative
2006	6-Nov	Priest Rapids	Adult	60	60	Negative
2007	5-Nov	Priest Rapids	Adult	60	60	Negative
2008	3-Nov	Priest Rapids	Adult	60	60	Negative
2009	2-Nov	Priest Rapids	Adult	60	60	Negative
2010	15-Nov	Priest Rapids	Adult	60	60	Negative
2011	7,14, 21-Nov	Priest Rapids	Adult	180	180	Negative
2012	5-Nov	Priest Rapids	Adult	60	60	Negative
2013	18-Nov	Priest Rapids	Adult	60	60	Negative

14.0 Juvenile Fish Health Inspections

Juvenile fish are visually inspected on a monthly basis following ponding. The 2012 brood year juveniles were healthy throughout the rearing period (Table 27). Historical inspection results are provided in Appendix E.

Table 27 Juvenile fish health inspections for Priest Rapids Hatchery fall Chinook salmon.

Hatchery	Date	Species/Run	Stock	Brood Year	Condition
Priest Rapids	25-Mar-11	CHF	Priest Rapids	2010	Healthy
Priest Rapids	18-Apr-11	CHF	Priest Rapids	2010	Healthy
Priest Rapids	06-Jun-11	CHF	Priest Rapids	2010	Healthy
Priest Rapids	01-Mar-12	CHF	Priest Rapids	2011	Healthy
Priest Rapids	26-Apr-12	CHF	Priest Rapids	2011	Healthy
Priest Rapids	24-May-12	CHF	Priest Rapids	2011	Healthy
Priest Rapids	11-Feb-13	CHF	Priest Rapids	2012	Healthy
Priest Rapids	3-Mar-13	CHF	Priest Rapids	2012	Healthy
Priest Rapids	29-Apr-13	CHF	Priest Rapids	2012	Healthy
Priest Rapids	28-May-13	CHF	Priest Rapids	2012	Healthy
Priest Rapids	27-Mar-14	CHF	Priest Rapids	2013	Dropout Syndrome Present
Priest Rapids	23-Apr-14	CHF	Priest Rapids	2013	Dropout Syndrome Present
Priest Rapids	29-May-14	CHF	Priest Rapids	2013	Healthy

15.0 Redd Surveys

Fall Chinook salmon redd surveys were performed in the Hanford Reach during 2013 by staff with Environmental Assessment Services, LLC under contract with Mission Support Alliance. WDFW M&E staff performed fall Chinook salmon redd surveys in the PRH discharge channel during 2013.

Hanford Reach Aerial Redd Counts

Aerial redd counts in the Hanford Reach were performed by Mission Support Alliance on October 20 and November 10 and 21, 2013 (Nugent et. al. 2014). The report can be found online at *www.hanford.gov/files.cfm/HNF-56707_-_Rev_00.pdf*

Redd counts should be considered an index of the total number of redds in the Hanford Reach. Redds may not be visible during flights due to wind, turbidity, ambient light, and depth. The first two surveys occurred on Sundays when outflows at Priest Rapids Dam were lowered to near 50 kcfs in conjunction with the Vernita Bar Settlement Agreement surveys performed by Grant PUD and WDFW. The last aerial survey occurred on a Thursday and river flows were roughly 60 kcfs. It is reported that viewing conditions during the surveys were good to excellent. The peak redd count for the Hanford Reach area of the Columbia River in 2013 was 17,398 (Table 28) which is the highest on record. The peak spawning was estimated to occur near the time of the November 10, 2013 survey.

Table 28 Summary of fall Chinook salmon peak redd counts for the 1948 – 2013 aerial surveys in the Hanford Reach, Columbia River.

Year	Redds	Year	Redds	Year	Redds	Year	Redds
1948	787	1965	1,789	1982	4,988	1999	6,068
1949	313	1966	3,101	1983	5,290	2000	5,507
1950	265	1967	3,267	1984	7,310	2001	6,248
1951	297	1968	3,560	1985	7,645	2002	8,083
1952	528	1969	4,508	1986	8,291	2003	9,465
1953	139	1970	3,813	1987	8,616	2004	8,468
1954	160	1971	3,600	1988	8,475	2005	7,891
1955	60	1972	876	1989	8,834	2006	6,508
1956	75	1973	2,965	1990	6,506	2007	4,023
1957	525	1974	728	1991	4,939	2008	5,588
1958	798	1975	2,683	1992	4,926	2009	4,996
1959	281	1976	1,951	1993	2,863	2010	8,817
1960	258	1977	3,240	1994	5,619	2011	8,915
1961	828	1978	3,028	1995	3,136	2012	8,368
1962	1,051	1979	2,983	1996	7,618	2013	17,398
1963	1,254	1980	1,487	1997	7,600	**Mean (2003-12)**	**7,304**
1964	1,477	1981	4,866	1998	5,368		

Redd Distribution

The main spawning areas observed during the 2013 counts were located near Vernita Bar and among Islands 4-6 (Table 29 & Figure 9). Historical redd counts by location from 2001 through 2013 are included in Appendix F of this report.

Table 29 Number of fall Chinook salmon redds counted in difference reaches on the Hanford Reach area of the Columbia River during the October 2013 through November 2013 aerial redd counts. (Data provided by Mission Support Alliance)

General Location	Start KM	End KM	Total Length	10/20	11/10	11/21	Peak	Average Redd Per River KM
Islands 17-21	545	558	13	0	0	0	0	0
Islands 11-16	558	573	15	1	708	798	798	53
Islands 8-10	587	593	6	27	1,835	2,200	2,200	367
Near Island 7	593	594	1	0	471	655	655	655
Island 6 (lower half)	594	599	5	3	2,338	3,340	3,340	668
Island 4, 5 and upper 6	599	602	3	4	2,560	2,650	2,650	883
Near Island 3	602	604	2	2	800	1,000	1,000	500
Near Island 2	604	606	2	13	1,320	1,700	1,700	850
Near Island 1	606	608	2	4	680	900	900	450
Near Coyote Rapids	614	619	5	0	463	520	520	104
Midway (China Bar)	628	630	2	2	80	100	100	50
Near Vernita Bar	630	635	5	11	2,630	3,505	3,505	701
Near Priest Rapids Dam	635	638	3	0	24	30	30	10
Total	--	--	--	**63**	**13,909**	**17,398**	**17,398**	--

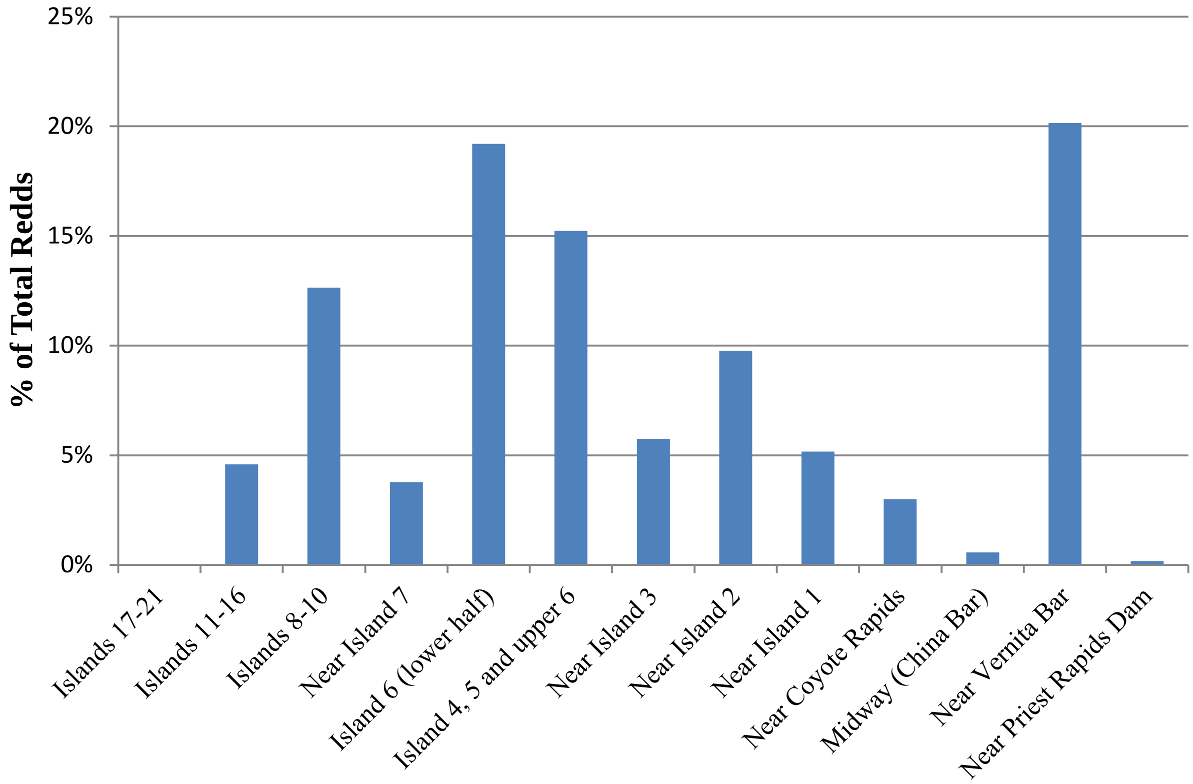

Figure 9 Distribution of fall Chinook salmon redd counts by location for the 2013 aerial surveys in the Hanford Reach, Columbia River. (Data provided by Mission Support Alliance)

Spawn Timing

Based on aerial redd counts and Vernita Bar ground surveys, fall Chinook salmon spawning in the Hanford Reach during 2013 began in mid-October and ended after the third week of November. Flights did not occur weekly during the entire 2013 spawning period; therefore, the peak and duration for fall Chinook salmon spawning in the Hanford Reach is estimated on limited information. River temperatures below Priest Rapids Dam varied from 15.5°C (October 21) to 9.8°C (November 25) during the spawning period which is similar to that recorded in 2012.

Escapement

The estimated total escapement of fall Chinook salmon to the Hanford Reach for 2013 returns was 174,651 fish; which was composed of 157,294 adults and 17,357 jacks (Table 30). This is the highest escapement on record. The previous record escapement occurred in 2003 at 89,312 fish. The ten-year mean for 2004 through 2013 is 62,707 (Table 30 and Table 31). Despite the record return, very low escapements for 2006 through 2009 suppress the ten-year average.

Table 30 Calculation of escapement estimates for fall Chinook salmon in the Hanford Reach, 2013.

Count Source	Return Year 2013 Adult	Jack	Total
Priest Rapids Adult Passage	260,962	18,363	279,325
Adjusted Priest Rapids Adult Passage[1]	147,731	10,395	158,126
Ice Harbor Adult Passage	57,850	19,133	76,983
Prosser Adult Passage	6,823	684	7,507
Priest Rapids Hatchery	38,823	3,008	41,831
PRH discharge channel	257	7	264
Wanapum Tribal Fishery	69	0	69
Ringold Springs Hatchery	16,358	528	16,886
Yakima River Escapement (Below Prosser)	1,936	194	2,130
Yakima River Sport Harvest	2,532	352	2,884
Hanford Sport Harvest	24,921	2,709	27,630
Angler Broodstock Collection	397	0	397
Total	297,697	37,010	334,707
McNary Ladder Counts	454,991	54,367	509,358
Hanford Reach Escapement	**157,294**	**17,357**	**174,651**

[1] Net passage count reduced 43.4% to correct for estimated over counts resulting from fallbacks and re-ascension. The adjustments to adult fish passage were estimated by analysis of the PIT tagged detections at PIT tag arrays located in the adult fish ways of the Priest Rapids Dam fish and the hatchery discharge channel for Priest Rapids Hatchery.

The estimated adult Chinook salmon per redd is calculated by dividing the adult escapement to the Hanford Reach by peak number of redds reported in the redd survey. The estimated annual escapements to the Hanford Reach were not adjusted for pre-spawn mortality. For 2013, the estimated 9.0 fish per redd was higher than the 10-year average of 6.9 fish per redd (Table 31).

Table 31 Escapement for fall Chinook salmon in the Hanford Reach for brood years 1964 – 2013.

Return Year	Fish per Redd #	Redds	Total Escapement		Return Year	Fish per Redd #	Redds	Total Adult Escapement
1964	16.3	1,477	24,048		1990	6.2	6,506	40,117
1965	13.6	1,789	24,360		1991	6.5	4,939	31,971
1966	9.1	3,101	28,079		1992	6.0	4,926	29,449
1967	7.1	3,267	23,188		1993	10.7	2,863	30,650
1968	6.8	3,560	24,067		1994	8.7	5,619	48,857
1969	7.8	4,508	34,939		1995	12.2	3,136	38,381
1970	7.0	3,813	26,730		1996	4.9	7,618	37,548
1971	8.7	3,600	31,398		1997	4.5	7,600	34,007
1972	30.5	876	26,749		1998	5.5	5,368	29,410
1973	11.1	2,965	33,044		1999	4.5	6,068	27,012
1974	35.5	728	25,847		2000	6.5	5,507	36,027
1975	8.3	2,683	22,242		2001	7.1	6,248	44,140
1976	10.8	1,951	21,140		2002	8.6	8,083	69,342
1977	9.7	3,240	31,527		2003	9.4	9,465	89,312
1978	6.8	3,028	20,578		2004	9.4	8,468	79,464
1979	7.9	2,983	23,558		2005	8.2	7,891	64,355
1980	14.7	1,487	21,861		2006	7.2	6,508	47,095
1981	3.1	4,866	15,115		2007	2.1	4,018	13,887
1982	4.1	4,988	20,543		2008	4.2	5,618	23,361
1983	6.8	5,290	36,022		2009	5.3	4,996	26,346
1984	5.7	7,310	41,982		2010	9.1	8,817	80,408
1985	8.6	7,645	65,796		2011	7.4	8,915	65,724
1986	8.8	8,291	72,559		2012	6.2	8,368	51,818
1987	10.3	8,616	88,762		2013	9.0	17,398	157,294
1988	8.7	8,475	74,034		**Ten-Year (04-13) Mean**	**6.9**	**8,810**	**62,707**
1989	7.5	8,834	65,913					

Hatchery Discharge Channel Redd Counts

The M&E staff performed redd surveys in the PRH discharge channel on October 29, November 7, and December 3, 2013. Similar to historical observations, the majority of spawning activity was located in a 200 meter section of the discharge channel downstream adjacent to the volunteer trap. A peak count of 54 redds occurred on the December 3, 2013, survey. We observed superimposition occurring in multiple surveys; thus making it difficult to determine the total number of redds in a given survey. Viewing conditions during each survey were good to excellent.

16.0 Carcass Surveys

Prior to 2010, the stream surveys in the Hanford Reach were generally performed by two boat crews of two staff operating seven days a week. Beginning in 2010, with support of the PRH M&E Program, the effort was increased to three boats with a three-person crew operating seven days per week. The extra staffing was necessary to maintain the overall sampling efficiency given the additional effort required to pull otoliths from fish sampled and achieve hatchery M&E objectives.

Stream (carcass) surveys were performed from November 4 through December 6, 2013. Ideally, surveys would have begun November 2 and concluded December 10; however, extreme wind conditions postponed the start date and extreme freezing conditions forced an early end to the survey season.

All recovered carcasses were sampled for the presence of a coded-wire tag. Of those, 20% were sampled (i.e., random systematic) for scales (age), otoliths, gender, length, and egg retention. All carcasses recovered were chopped in half after sampling to prevent the chance of double sampling.

Similar to methods used since 2010, the 2013 stream survey crews recorded the sections in which carcasses were recovered in the Hanford Reach and adjacent areas. The Hanford Reach survey is divided into Sections 1 through 5 (Figure 10). The Priest Rapids Pool is designated as Section 6. The PRH discharge channel and the area of the Columbia River immediately below the discharge channel are designated as Sections 7 and 8, respectively. The fall Chinook salmon carcasses recovered in Section 8 are likely wash outs from the hatchery discharge channel.

- Section 1. Priest Rapids Dam to Vernita Bridge (14 km)
- Section 2. Vernita Bridge to Island 2 (19 km)
- Section 3. Island 2 to Power line Towers at Hanford town site (21 km)
- Section 4. Power line Towers to Wooded Island (21 km)
- Section 5. Wooded Island to Interstate 182 Bridge (19 km)
- Section 6. Priest Rapids Pool (34 km)
- Section 7. Priest Rapids Hatchery discharge channel (0.5 km)
- Section 8. Columbia River at the mouth of the Hatchery discharge channel (0.5 km)

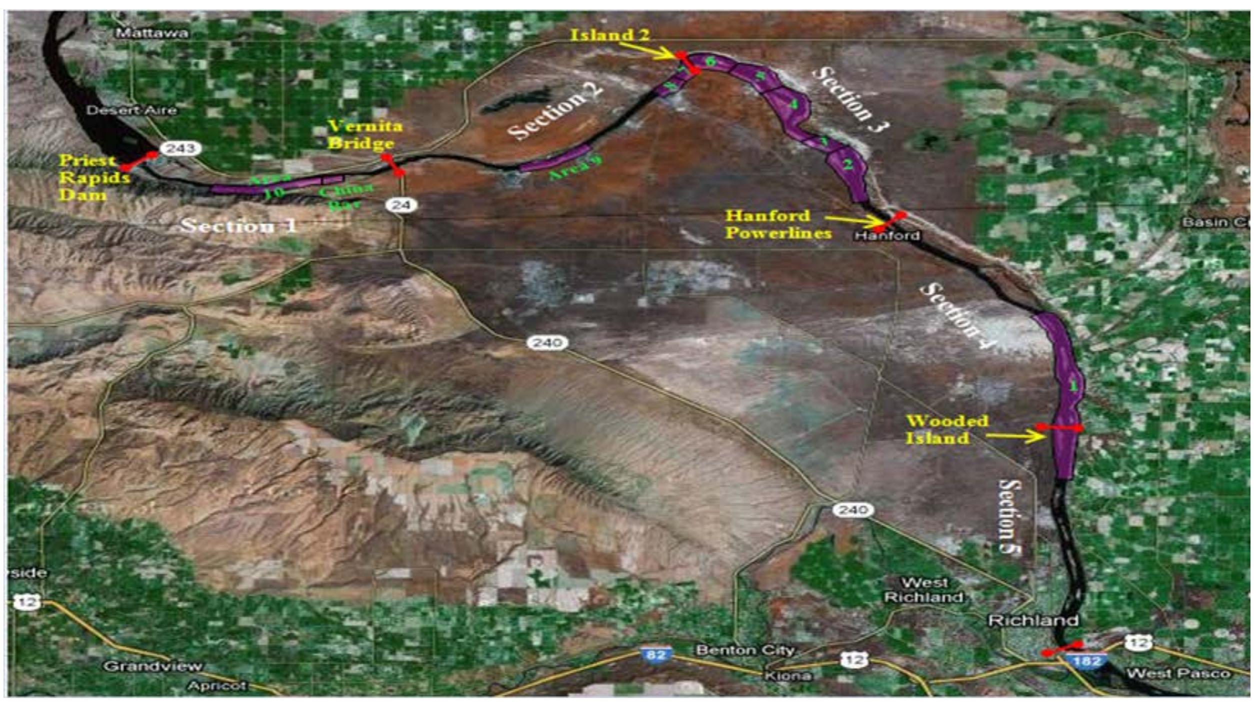

Figure 10 Locations of aerial redd index areas and river survey sections in the Hanford Reach.

Hanford Reach Carcass Survey: Section 1 – 5

Crews surveyed the river and shorelines by boat and by foot. The majority of the carcasses were collected in Sections 3 and 4 within and immediately downstream of large spawning areas (Table 26). It's apparent that carcasses from post spawn fall Chinook salmon in the Hanford Reach tend to be displaced downstream from the spawning areas and collect in eddies created by the island complexes within the Hanford Reach. Section 2 is largely comprised of relatively steep symmetrical shorelines with marginal spawning habitat. Historically, few carcasses are observed in Section 2.

Numbers Sampled: Sections 1 – 5

Staff sampled a record 13,701 Chinook salmon in the Hanford Reach in 2013, 7.5% of the estimated fall Chinook salmon escapement (Table 32). For the period of 1990 through 2013, river survey crews sampled an average of 6,434 fall Chinook salmon per year (Appendix G).

Table 32 Numbers and Percentages of fall Chinook salmon carcasses sampled within each survey section on the Hanford Reach.

Return Year	# 1	# 2	# 3	# 4	# 5	Total
2010	1,832 (18.7%)	519 (5.3%)	3,129 (32.0%)	3,362 (34.4%)	937 (9.6%)	9,779
2011	1,581 (18.8%)	160 (1.9%)	2,606 (31.1%)	2,622 (31.2%)	1,422 (16.9%)	8,391
2012	1,091 (16.0%)	149 (2.2%)	1,685 (24.7%)	2,213 (32.5%)	1,676 (24.6%)	6,814
2013	2,182 (16.7%)	1,973 (15.1%)	2,844 (21.8%)	3,774 (28.9%)	2,298 (17.6%)	13,071

The survey effort was not equal for each section. The sections 1, 3, and 4 were surveyed the most (Table 33). As the season progressed, crews focused their effort in sections which provided greater chances to recover carcasses. However, survey effort was more evenly distributed in 2013 compared to the previous three years. A concerted effort was made to apportion the survey effort equally among the five sections with the intent of acquiring representative samples for each survey section.

Table 33 Number of carcass surveys conducted by section in the Hanford Reach.

Return Year	# 1	# 2	# 3	# 4	# 5	Total
2010	21	6	26	26	11	90
2011	33	5	38	29	13	118
2012	19	4	26	28	24	101
2013	18	15	16	17	13	79

Proportion of Escapement Sampled: Section 1 – 5

The spawning escapement for sections 1 through 5 was estimated by the proportion of redds counted in aerial surveys to the estimated escapement of natural spawners to the Hanford Reach (see Section 14 - Redd Surveys). The calculations for estimating the escapement to the Hanford Reach are given in Appendix J.

We recently identified through the carcass bias assessment that an unknown number of carcasses drift into downstream sections after spawning. The recovery of these carcasses confounds the estimate of the spawning escapement sampled by section as shown in Table 34. For example, there were no redds identified in Section 5 but 2,298 carcasses were recovered in that section. It is likely that sections 1 and 3, which have the greatest number of redds and therefore the largest spawning escapements end up with a net loss of carcasses to downstream sections.

Table 34 Number of redds and carcasses, total spawning escapement, and proportion of escapement sampled for fall Chinook salmon in Section 1 through 5 of the Hanford Reach, 2013.

Survey Section	Total Number of Redds	Total Number of Carcasses	Spawning Escapement[1]	Proportion of Escapement Sampled
HR-1	3,635	2,182	36,490	0.060
HR-2	1,420	1,973	14,255	0.138
HR-3	11,545	2,844	115,895	0.025
HR-4	798	3,774	8,011	0.471
HR-5	0	2,298	0	0.000
Total	**17,398**	**13,071**	**174,651**	0.075

[1] Calculated based on percent of redds

Carcass Distribution and Origin

Two methods were used to estimate the origin of carcasses recovered in the sections 1 through 5; expansion of pooled coded-wire tag recoveries using juvenile tag rates and survey sample rate. An estimate was also calculated using the proportion of combined hatchery marks (i.e., otolith mark, adipose clips, and coded-wire tags) to non-marked carcasses. Estimates for both methods are given for the 2012 and 2013 returns.

The assumption was made that all Chinook salmon unaccounted for from hatchery origin coded-wire tag expansions were of natural origin. This assumption may underestimate the number of hatchery carcasses recovered in the annual surveys. We have compelling evidence to suggest this is the case with annual returns to PRH. The expansion of coded-wire tags suggest that 21.7% of fall Chinook salmon carcasses recovered in the 2013 Hanford Reach stream surveys were hatchery origin (Table 35). This estimate is much higher than those of previous years. The percentage of the escapement estimated from expanded coded-wire tag recoveries consists of roughly 16.5% from PRH, 4.1% from RSH and 1.1% from other hatcheries. The highest proportions of hatchery origin carcasses recovered were in Sections 1, 4, and 5.

Table 35 Numbers of natural and hatchery origin fall Chinook salmon carcasses sampled within Sections 1 through 5 of Hanford Reach based on expansions of coded-wire tag recoveries.

Return Year	Hanford Reach Sections							Proportion of Sample
	Origin	# 1	# 2	# 3	# 4	# 5	Total	
2010	Natural	1,751	473	3,020	3,242	909	9,395	0.960
	Hatchery	81	46	116	125	28	396	0.040
	Proportion Hatchery	0.044	0.089	0.037	0.037	0.030	0.040	
2011	Natural	1,350	155	2,520	2,475	1,347	7,847	0.935
	Hatchery	231	5	86	147	75	544	0.065
	Proportion Hatchery	0.146	0.031	0.033	0.056	0.053	0.065	
2012	Natural	1,142	149	1,526	2,081	1,510	6,408	0.927
	Hatchery	49	0	159	132	166	506	0.073
	Proportion Hatchery	0.041	0.000	0.094	0.060	0.099	0.073	
2013	Natural	1,572	1,587	2,433	2,895	1,748	10,235	0.783
	Hatchery	610	386	411	879	550	2,836	0.217
	Proportion Hatchery	0.280	0.196	0.145	0.233	0.239	0.217	

The second estimate of origin of carcasses recovered is based on the proportion of hatchery marked to non-marked fish. This method assumes that all hatchery origin carcasses recovered are marked in some manner (e.g., otolith marks, coded-wire tag, and adipose clips).

PRH has annually otolith marked their entire juvenile releases beginning with progeny of brood year 2007. For the 2013 return, age-1 through 6 PRH origin carcasses recovered were otolith marked. The age-6 PRH origin fish were not otolith marked during return year 2012. However, since there were no age-6 fish recovered in the carcass surveys or at PRH, it is assumed that few, if any PRH origin age-6 fish spawned in the Hanford Reach.

Most hatcheries either adipose clip and/or coded-wire tag the majority of their released fish. The presence of non-adipose clipped and non-coded-wire tagged hatchery strays into the Hanford Reach associated with double index tag (DIT) groups is estimated to be 133 fish based on code-wire tag expansions using the juvenile tag rates associated with DIT fish recovered in the Hanford Reach spawning escapement. The tag rates for these DIT groups range from 1:1 to 1:3; therefore, the estimates based on these coded-wire tag expansions (i.e., juvenile mark rates x # of coded-wire tag recovered) likely provide fair estimates of these fish groups.

Adipose clipped Chinook salmon without a coded-wire tag and without a thermal otolith mark were classified as strays from other hatcheries. The natural origin fish were identified by either a Hanford Reach origin coded-wire tag or by the presence of an adipose fin and the absence of an otolith mark.

Based on hatchery marks, the random sub-sample of the biological data suggests that 27.9% of fall Chinook salmon carcasses recovered in the 2013 Hanford Reach stream survey were hatchery origin (Table 36). The highest proportions of hatchery origin carcasses recovered were in Sections 1, 3, and 5. This trend is a similar to that observed in 2012.

Table 36 Origin of Chinook salmon carcasses recovered in the Hanford Reach by section based on recoveries of marked and unmarked carcasses within the biological sample.

Year	Origin	# 1	# 2	# 3	# 4	# 5	Total	Proportion of Sample
2012 Biological sample Rate 1:4 n = 1,609	PRH[1]	23	2	26	18	38	107	0.067
	Other Hatchery[2]	10	2	25	45	22	104	0.065
	Total Hatchery	**33**	**4**	**51**	**63**	**60**	**211**	**0.131**
	Natural[3]	228	30	347	460	333	1,398	0.869
	Proportion Hatchery	0.126	0.118	0.12	0.120	0.15	0.131	
2013[a] Biological sample rate = 1:5 and then randomly sub-sampled, n = 712	PRH[1]	32	19	34	30	32	147	0.206
	Other Hatchery[2]	6	3	16	21	6	52	0.073
	Total Hatchery	**38**	**22**	**50**	**51**	**38**	**199**	**0.279**
	Natural[3]	76	84	113	155	85	513	0.721
	Proportion Hatchery	0.333	0.208	0.30	0.248	0.30	0.279	

[a] Estimate of origin based on random sub-sample of biological sample.
[1] Priest Rapids Hatchery fish were identified by either the presence of thermal otolith mark or by the presence of a PRH origin coded-wire tag
[2] Other hatchery strays were identified as adipose clipped Chinook salmon without a Priest Rapids Hatchery coded-wire tag and without a thermal otolith mark or by the presence of other hatchery coded-wire tags.
[3] Natural origin fish were identified by either a Hanford Reach origin coded-wire tag or by the presence of an adipose fin and the absence of an otolith mark.

Priest Rapids Dam Pool Carcass Survey: Section 6

In total, seven carcass surveys were performed in Section 6 during return year 2013, which is typical of previous years (Table 37). Surveys were scheduled twice a week between November 5 and December 5, 2013. However, surveys were limited to once a week during the last week of November and the first week of December due to hazardous freezing weather.

Number sampled: Section 6

Despite the record return of fall Chinook salmon over PRD, survey crews only recovered 407 Chinook salmon in Section 6 during return year 2013 (Table 37). Carcass recoveries in the lower portion of the pool suggest that carcasses drift downstream of the spawning areas below Wanapum Dam into deeper water where they are difficult to recover.

Table 37 Number of fall Chinook salmon carcasses sampled within Section 6 (Priest Rapids Dam Pool).

Year	Section 6	
	# of Carcasses	# of Surveys
2010	123	8
2011	69	7
2012	72	4
2013	407	7
Mean	**168**	**7**

Proportion of Escapement Sampled: Section 6

The spawning escapement for Section 6 was calculated by subtracting from the Priest Rapids Dam fall Chinook salmon passage count, the fall Chinook salmon passage at Wanapum Dam, tribal and sport harvest of fall Chinook salmon in the Priest Rapids Dam pool, and the estimated fallback of fall Chinook salmon at Priest Rapids Dam (Appendix J).

The 2013 fall Chinook salmon spawning escapement estimate for Section 6 is 62,237 fish. Overall, less than 1% of the total estimated spawning escapement in Section 6 was sampled in 2013 (Table 38).

Table 38 Carcasses sampled, total spawning escapement and proportion of escapement for fall Chinook salmon in Section 6 (Priest Rapids Dam Pool).

Survey Year	# of Surveys	# of Carcasses	Spawning Escapement	Escapement Sampled
2010	8	123	11,121	0.011
2011	7	69	11,362	0.006
2012	4	72	21,919	0.003
2013	7	407	62,237	0.007

Carcass Origin: Section 6

Similar to those methods described in detail in the previous section, the carcasses included in the 1:4 biological sample, were identified as hatchery origin based on a combination of hatchery marks and tags (i.e., otoliths marks, adipose clips, and coded wire tags). Natural origin carcasses were identified by the absence of any hatchery mark or the presence of a natural origin coded-wire tag.

An estimated 68.4% of fall Chinook salmon spawning in section 6 were hatchery origin (Table 39). Of the hatchery carcasses recovered, 63.3% were PRH origin. Both of these percentages are much higher than observed in 2012.

Table 39 Origin of fall Chinook salmon spawning in Section 6 (Priest Rapids Dam Pool).

Year	Origin	Total	Proportion of Sample
2012 n = 70	PRH[1]	18	0.257
	Other Hatchery[2]	2	0.029
	Total Hatchery	**20**	**0.286**
	Natural[3]	50	0.714
2013 n = 98	PRH[1]	62	0.633
	Other Hatchery[2]	5	0.051
	Total Hatchery	67	0.684
	Natural[3]	31	0.316

[1] Priest Rapids Hatchery fish were identified by either the presence of thermal otolith mark or by the presence of a PRH origin coded-wire tag
[2] Other hatchery strays were identified as adipose clipped Chinook salmon without a Priest Rapids Hatchery coded-wire tag and without a thermal otolith mark.
[3] Natural origin fish were identified by either a Hanford Reach origin coded-wire tag or by the presence of an adipose fin and the absence of an otolith mark.

Hatchery Discharge Channel: Sections 7 and 8 Carcass Survey

During return year 2013, crews performed four carcass surveys in Section 8 by boat and three carcass surveys in Section 7 by foot. It has been observed that many carcasses drift out of the discharge channel under full flow conditions. Therefore, multiple surveys were performed in order to sample carcasses originating from the discharge channel. Performing carcass surveys in the discharge channel, when it is at full flow, is difficult and dangerous due to poor footing and high velocities. Staff performed two surveys during full flow conditions. The last survey in Section 7 occurred after the PRH discharge was shut off and the channel reduced to ground water flow.

Number sampled: Sections 7 and 8

Survey crews recovered 105 carcasses in Section 7 and 159 in Section 8 (Table 40). All fish recovered were scanned for the presence of a coded-wire tag.

Table 40 The number of fall Chinook salmon carcass surveys within Section 7 (Priest Rapids Hatchery Discharge Channel) and Section 8 (Columbia River at the confluence of the hatchery discharge channel).

	Section 7		Section 8		Total	
Year	# of Carcasses	# of Surveys	# of Carcasses	# of Surveys	# of Carcasses	# of Surveys
2010	87	1	123	9	210	10
2011	123	2	80	8	203	10
2012	99	3	108	10	207	13
2013	105	3	159	4	264	7

Proportion of Escapement Sampled: Sections 7 and 8

The 2013 fall Chinook salmon spawning escapement index for Sections 7 and 8 is 264 fish (Table 41). The spawning escapement for these Sections is a minimum estimate based on the total number of carcasses recovered in the surveys. We assume that most of the carcasses recovered in Section 8 drifted downstream from Section 7. It is likely a portion of carcasses from Sections 7 and 8 drift downstream into Sections 1 and 2.

Table 41 Number of carcasses sampled, total spawning escapement and proportion of escapement sampled for fall Chinook salmon within Section 7 (Priest Rapids Hatchery Discharge Channel) and Section 8 (Columbia River at confluence of the hatchery discharge channel).

Section	Total Number of Carcasses	Spawning Escapement	Escapement Sampled
# 7	105	264	0.398
# 8	159	0	0.000
Total	**264**	**264**	**1.000**

Carcass Distribution and Origin: Sections 7 and 8

As described in detail previously, the carcasses included the 10% biological sample were identified as hatchery origin based on a combination of hatchery marks and tags (i.e., otoliths marks, adipose clips, and coded wire tags). Natural origin carcasses were identified by the absence of any hatchery mark or the presence of a natural origin coded-wire tag.

It is estimated that 90.9% of fall Chinook salmon recovered in Sections 7 and 8 were hatchery origin (Table 42). Of the hatchery carcasses recovered, 84.8% were PRH origin and 6.1% were strays from other hatcheries. Natural origin fish comprised 9.1% of the total carcasses recovered.

Table 42 **The origin of Chinook salmon carcasses recovered within Section 7 (Priest Rapids Hatchery Discharge Channel) and Section 8 (Columbia River at the confluence of the hatchery discharge channel).**

Return Year	Origin	Total	Proportion of Sample
2012 n = 70	PRH	18	0.257
	Other Hatchery	2	0.029
	Total Hatchery	**20**	**0.286**
	Natural	50	0.714
2013 n = 33	PRH	28	0.848
	Other Hatchery	2	0.061
	Total Hatchery	**30**	**0.909**
	Natural	3	0.091

Carcass Bias Assessment

In 2013, crews tagged and released 1,076 of the carcasses collected during the river surveys to evaluate potential age (size) and gender bias that might be associated with the collection of post-spawn fall Chinook carcasses in the Hanford Reach. Carcasses collected and used for age composition were tagged with a 3.5 x 3.5 cm numbered plastic tag and systematically released either near shore or mid river (Figure 11).

Figure 11 **Tagged fall Chinook salmon, carcass biased assessment.**

Those carcasses released near shore had the highest proportion of recaptures at12.5% whereas only 8.6% of those fish marked and released mid channel were recaptured (Table 43). Overall, 10.5% of the marked fish were recaptured. Age and gender composition of the carcasses recaptured differed slightly from the composition at release for all age and gender classes except age-3 females. The recovery rate tends to be higher for adult males and larger fish. This was the third year that a carcass bias study was performed in conjunction with the Hanford Reach stream survey. Results provided in Table 44 and Table 45 for the 2012 and 2011 carcass bias study show similar results.

Table 43 Summary of mark recapture of post-spawn fall Chinook salmon in the Hanford Reach, 2013.

	Release Location		**Total**
	Bank	**Mid-Channel**	**Released**
Released	552	521	1,076
Recaptured	69	45	113
Recapture (%)	**12.5**	**8.6**	**10.5**

Mark Release Fall Chinook Salmon

Gender	**Age 2**		**Age 3**		**Age 4**		**Age 5**		**Age 6**		**Total**	
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Male	199	18.5	377	35.0	181	16.8	24	2.2	0	0	781	72.6
Female	N/A	N/A	76	7.1	201	18.7	18	1.7	0	0	295	27.4
Total	**199**	**18.5**	**453**	**42.1**	**382**	**35.5**	**42**	**3.9**	**0**	**0**	**1,076**	**100.0**

Recaptures

Gender	**Age 2**		**Age 3**		**Age 4**		**Age 5**		**Age 6**		**Total**	
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Male	16	14.0	42	36.8	24	21.1	3	2.6	0	0.0	85	74.6
Female	N/A	N/A	8	7.0	19	16.7	2	1.8	0	0.0	29	25.4
Total	**0**	**0.0**	**24**	**34.3**	**28**	**40.0**	**18**	**25.7**	**0**	**0.0**	**70**	**100.0**

Bias (%)

Gender	**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Age 6**	**Total**
Male	-4.5	1.8	4.2	0.4	0.0	-2.0
Female	N/A	0.0	-2.0	0.1	0.0	2.0
Total	**-4.5**	**1.8**	**2.2**	**0.5**	**0.0**	**0.0**

Table 44 Summary of mark recapture of post-spawn fall Chinook salmon in the Hanford Reach, 2012.

	Release Location		Total
	Bank	Mid-Channel	Released
Released	491	498	989
Recaptured	103	34	137
Recapture (%)	**21.0**	**6.8**	**13.9**

Mark Release Fall Chinook Salmon												
Gender	Age 2		Age 3		Age 4		Age 5		Age 6		Total	
	#	%	#	%	#	%	#	%	#	%	#	%
Male	43	4.3	225	22.8	155	15.7	99	10.0	0	0.0	522	52.8
Female	0	0.0	45	4.6	237	24.0	185	18.7	0	0.0	467	47.9
Total	**43**	**4.3**	**270**	**27.3**	**392**	**49.6**	**284**	**28.7**	**0**	**0.0**	**989**	**100.0**
Recaptures												
Gender	Age 2		Age 3		Age 4		Age 5		Age 6		Total	
	#	%	#	%	#	%	#	%	#	%	#	%
Male	0	0.0	22	31.4	11	15.7	7	10.0	0	0.0	40	57.1
Female	0	0.0	2	2.9	17	24.3	11	15.7	0	0.0	30	42.9
Total	**0**	**0.0**	**24**	**34.3**	**28**	**40.0**	**18**	**25.7**	**0**	**0.0**	**70**	**100.0**

Bias (%)						
Gender	Age 2	Age 3	Age 4	Age 5	Age 6	Total
Male	-4.3	8.7	0.0	0.0	0.0	4.3
Female	0.0	-1.7	0.0	-3.0	0.0	-5.0
Total	**-4.3**	**7.0**	**0.0**	**-3.0**	**0.0**	

Table 45 Summary of mark recapture of post-spawn fall Chinook salmon in the Hanford Reach, 2011.

	Release Location			Total
	Bank	Mid-River	Unknown	Released
Released	495	487	11	993
Recaptured	108	59	4	167
Recapture (%)	**21.8**	**12.1**	**36.4**	**16.8**

Mark Release Fall Chinook Salmon												
	Age 2		Age 3		Age 4		Age 5		Age 6		Total	
Gender	#	%	#	%	#	%	#	%	#	%	#	%
Male	26	2.6	82	8.3	230	23.2	63	6.3	0	0.0	401	40.4
Female	0	0	24	2.4	469	47.2	97	9.8	2	0.0	592	59.6
Total	**26**	**2.6**	**106**	**10.7**	**699**	**70.4**	**160**	**16.1**	**2**	**0.0**	**993**	**100.0**
Recaptures												
	Age 2		Age 3		Age 4		Age 5		Age 6		Total	
Gender	#	%	#	%	#	%	#	%	#	%	#	%
Male	3	1.8	15	8.8	45	26.3	10	5.8	0	0.0	73	42.7
Female		0	3	1.8	74	43.3	21	12.3	0	0.0	98	57.3
Total	**3**	**1.8**	**18**	**10.5**	**119**	**69.6**	**31**	**18.1**	**0**	**0.0**	**171**	**100.0**

Bias (%)						
Gender	Age 2	Age 3	Age 4	Age 5	Age 6	Total
Male	-0.8	0.5	3.2	-0.5	0	2.3
Female	0	0.6	-4	2.5	0	-2.3
Total	**-0.8**	**-0.2**	**-0.8**	**2.0**	**0**	0.0

17.0 Life History Monitoring

Migration timing of hatchery and natural origin Hanford Reach fall Chinook salmon is determined from arrival timing to McNary Dam based on PIT tag observations at the adult fish ladder for both PRH and Hanford Reach origin fall Chinook.

Life history characteristics of Hanford Reach fall Chinook salmon were assessed by examining carcasses on spawning grounds, fish collected or examined at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

For the 2012 and 2013 returns, the origin of fall Chinook salmon for the comparison of age and length at maturity is based on a combination of hatchery marks and tags (i.e., otolith, adipose clips, and coded-wire tags). PRH origin fall Chinook salmon were identified by either the presence of an otolith mark specific to PRH or by the presence of a PRH origin coded-wire tag. Adipose clipped Chinook salmon without a coded-wire tag and without an otolith mark were classified as fish from other hatcheries. The natural origin fish were identified by either a Hanford Reach origin coded-wire tag or by the presence of an adipose fin and the absence of an otolith mark and hatchery coded-wire tag. In order to make coarse comparisons between hatchery and natural origin fish prior to return year 2012, the determination of origin employed the assumption that all fish collected in the Hanford Reach, except for those that were of known hatchery origin (e.g., adipose clipped or coded-wire tagged), were natural origin. We know this was not the case, but we were not able to identify all of the hatchery origin fish in the biological sample and it was assumed that the majority of the fish sampled in the stream surveys were natural origin.

The age composition for the natural origin fall Chinook salmon is assembled from the carcass recoveries in sections 1-5 of the Hanford Reach. The age composition for the PRH origin fall Chinook salmon is assembled from the volunteer returns to PRH.

The samples collected from the different surveys at PRH are expanded and pooled as described in Appendix B to account for different sample rates to provide larger sample sizes for both length and age by origin analysis. Similar methods were used for the samples collected in the Hanford Reach stream survey.

Migration Timing

PIT tag observations for both PRH and Hanford Reach natural origin adult fall Chinook salmon at the PIT tag arrays in the Bonneville Dam adult fish ladders were used to assess arrival timing. The PIT observation data was obtained from the PTAGIS website. Arrival dates for each unique tagged adult was based on its first observation date and time at Bonneville Dam. Annually, the sample sizes have been relatively small due to the low numbers of both hatchery and natural origin fall Chinook salmon annually PIT tagged. Beginning with the 2011 brood, the number of juveniles PIT tagged at PRH increased from 3,000 to roughly 43,000 annually

The adult PIT tag detections at Bonneville Dam are useful to compare migration timing between Hanford Reach natural origin and PRH origin fall Chinook salmon because harvest and other losses upstream of Bonneville Dam reduce the number of potential detections at upstream sites.

The 10th, 50th, and 90th percentiles of the annual migration timing to Bonneville Dam are given in (Table 46). The observation sample size of both groups of PIT tagged fish at Bonneville Dam can be small and therefore, may not be representative of the populations. However this may be the best migration information currently available.

Table 46 The week that 10%, 50% (median), and 90% of the natural and hatchery origin fall Chinook salmon passed Bonneville Dam, 2010 – 2013. Migration timing is based on PIT tag passage of Hanford wild and Priest Rapids Hatchery in the adult fish ladder at Bonneville Dam.

Return Year	Origin	Hanford Reach Fall Chinook Migration Time (Date)							
		Priest Rapids Origin				Hanford Reach Natural Origin			
		Age 2	Age 3	Age 4	Age 5	Age 2	Age 3	Age 4	Age 5
2010	10th Percentile	28-Aug	26-Aug		24-Aug	31-Aug	5-Sep	25-Aug	
	50th Percentile	9-Sep	17-Sep		4-Sep	21-Sep	17-Sep	9-Sep	
	90th Percentile	15-Sep	24-Sep		6-Sep	4-Oct	6-Oct	15-Sep	
	n	5	20	0	3	8	22	18	0
2011	10th Percentile	8-Aug	3-Sep	23-Aug			4-Sep	24-Aug	4-Aug
	50th Percentile	8-Sep	20-Sep	8-Sep			4-Sep	10-Sep	30-Aug
	90th Percentile	21-Sep	25-Sep	21-Sep			10-Sep	2-Oct	1-Sep
	n	6	7	10	0	0	2	65	3
2012	10th Percentile	31-Aug	6-Sep	13-Sep	7-Sep	14-Sep	4-Sep	28-Aug	27-Aug
	50th Percentile	16-Sep	11-Sep	13-Sep	7-Sep	23-Sep	16-Sep	5-Sep	8-Sep
	90th Percentile	27-Sep	21-Sep	19-Sep	7-Sep	10-Oct	26-Sep	21-Sep	19-Sep
	n	7	13	2	1	10	11	19	26
2013	10th Percentile	10-Jul	24-Aug	28-Aug	25-Aug	11-Sep	2-Sep	2-Sep	9-Aug
	50th Percentile	26-Sep	8-Sep	9-Sep	3-Sep	11-Sep	22-Sep	9-Sep	27-Aug
	90th Percentile	11-Oct	18-Sep	22-Sep	15-Sep	11-Sep	10-Oct	19-Sep	2-Oct
	n	13	40	55	16	1	29	22	10

Age at Maturity

Prior to return year 2012, the age composition for hatchery origin returns to PRH was generated by pooling all of the sub-samples from the volunteer trap and ponded fish after expanding for differing biological sample rates and sub-sample rates. Only one biological sample rate was used annually in the Hanford Reach stream survey; precluding the need to expand and pool samples. In addition, the origin was assigned by location of survey due to the lack of identifiable hatchery marks and low coded-wire tag recoveries that were not representative for natural origin fish. Hence, the age composition for natural origin returns was generated from all the samples collected within the carcass survey. Likewise, the age composition for hatchery origin fish was generated from all samples collected at PRH.

The age compositions for the Hanford Reach escapement and the PRH returns are not directly comparable between locations. As discussed in Section 15, there is likely a recovery bias against smaller/younger fish in the stream surveys. Hence, the age composition for the Hanford Reach escapement is biased towards larger/ older fish. All fish recovered from the PRH volunteer trap are available for systematic sampling; reducing the potential bias of the age composition data. Although this dataset is imperfect, the dataset is maintained for future reference should a method be established to correct the data for associated age bias and origins (Table 47).

Table 47 Age compositions for fall Chinook salmon sampled in the Hanford Reach escapement compared to fall Chinook salmon sampled at Priest Rapids Hatchery (genders combined).

Survey Year	Source[1]	Age Composition				
		Age-2	Age-3	Age-4	Age-5	Age-6
1998	Escapement	0.169	0.157	0.111	0.554	0.009
	PRH Returns	0.104	0.647	0.114	0.135	0.001
1999	Escapement	0.094	0.115	0.615	0.164	0.012
	PRH Returns	0.003	0.261	0.717	0.018	0.001
2000	Escapement	0.25	0.058	0.279	0.413	0.000
	PRH Returns	0.082	0.085	0.429	0.404	0.000
2001	Escapement	0.262	0.164	0.398	0.164	0.010
	PRH Returns	0.06	0.685	0.195	0.057	0.004
2002	Escapement	0.179	0.135	0.502	0.183	0.001
	PRH Returns	0.023	0.434	0.512	0.031	0.000
2003	Escapement	0.111	0.047	0.494	0.348	0.001
	PRH Returns	0.138	0.128	0.663	0.071	0.000
2004	Escapement	0.094	0.125	0.191	0.57	0.021
	PRH Returns	0.051	0.697	0.12	0.131	0.000
2005	Escapement	0.106	0.099	0.498	0.288	0.009
	PRH Returns	0.013	0.287	0.639	0.059	0.002
2006	Escapement	0.089	0.1	0.507	0.293	0.010
	PRH Returns	0.039	0.184	0.447	0.326	0.004
2007	Escapement	0.376	0.061	0.341	0.206	0.016
	PRH Returns	0.573	0.161	0.202	0.057	0.008
2008	Escapement	0.196	0.156	0.298	0.348	0.002
	PRH Returns	0.058	0.864	0.05	0.028	0.001
2009	Escapement	0.283	0.074	0.463	0.181	0.000
	PRH Returns	0.244	0.087	0.657	0.012	0.000
2010	Escapement	0.076	0.252	0.378	0.292	0.001
	PRH Returns	0.139	0.762	0.056	0.043	0.000
2011	Escapement	0.127	0.107	0.622	0.143	0.002
	PRH Returns	0.155	0.288	0.552	0.005	0.000
2012	Escapement	0.102	0.246	0.369	0.284	0.000
	PRH Returns	0.326	0.518	0.120	0.035	0.000
2013	Escapement	0.099	0.457	0.411	0.033	0.000
	PRH Returns	0.072	0.776	0.152	0.001	0.000
Mean	**Escapement**	**0.163**	**0.147**	**0.405**	**0.279**	**0.006**
	PRH Returns	**0.171**	**0.429**	**0.352**	**0.088**	**0.001**

[1]The origin is assigned by survey.

The availability of otolith data combined with other hatchery mark data for the 2012 and 2013 return years provide the ability to estimate age compositions for both hatchery and natural origin fish within the Hanford Reach escapement. However, the hatchery origin age composition is limited by the low number of hatchery carcasses recovered in the escapement. In addition, the age composition for both groups may be biased towards larger fish.

The estimated age compositions by origin were derived from the biological sample data for each collection source. The biological data was stratified by age and gender and then randomly sub-sampled for origin data which is associated with age, gender, and length for each fish. Sub-sample sizes were determined and the age composition calculated as described in Section 7 and Appendix B.

The natural and hatchery origin age composition for 2013 escapement consists primarily of age-3 and 4 fish, but natural origin fish appeared to return at older ages than hatchery origin fish (Table 48) (Figure 12). The smaller age-2 and 3 Chinook salmon may be under represented due to a size bias in the carcass survey.

Table 48 Age compositions for hatchery and natural origin fall Chinook salmon sampled in the Hanford Reach escapement (genders combined).

Survey Year	Origin[1]	Age Composition				
		Age-2	Age-3	Age-4	Age-5	Age-6
2012	Natural (n = 1,398)	0.062	0.233	0.388	0.317	0.000
	Hatchery (n = 221)	0.317	0.314	0.266	0.103	0.000
2013	Natural (n = 629)	0.117	0.409	0.433	0.040	0.001
	Hatchery (n = 249)	0.052	0.583	0.353	0.013	0.000
Mean	Natural (n = 1014)	0.090	0.321	0.411	0.179	0.001
	Hatchery (n = 235)	0.185	0.449	0.310	0.058	0.005

[1]Origin based on the presence of otoliths marks, hatchery coded-wire tags, and adipose clips

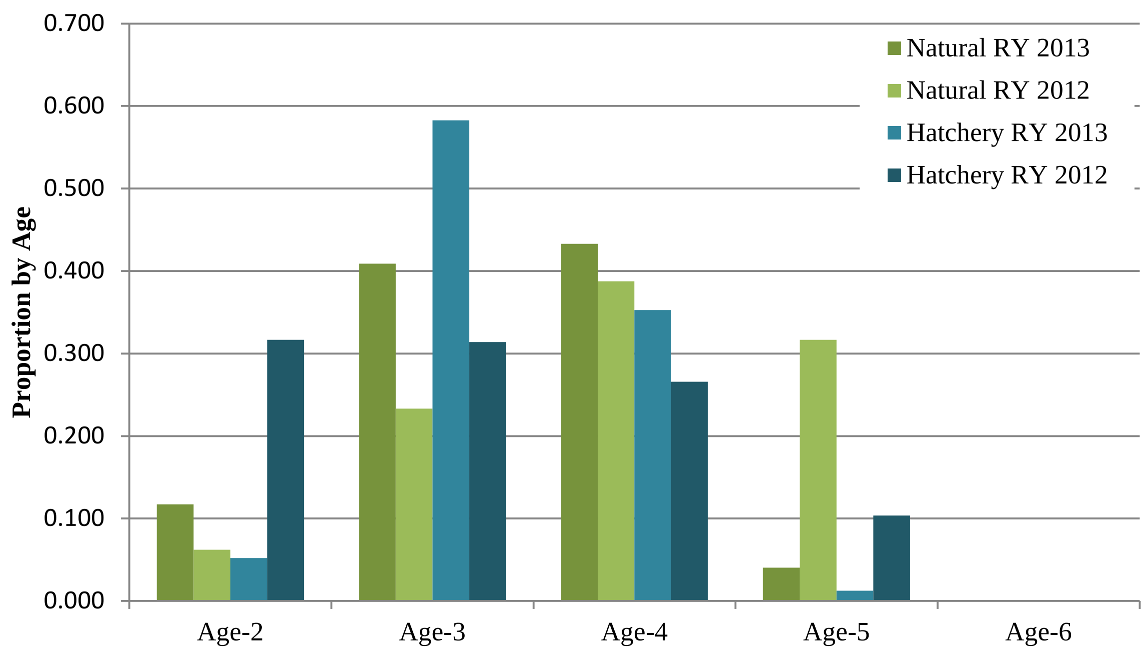

Figure 12 Age proportions of adult returns of natural and hatchery origin fall Chinook sampled on the spawning grounds in the Hanford Reach, Return Years 2012 and 2013.

Size at Maturity

Prior to return year 2012, the size (fork length) at maturity comparisons between fall Chinook salmon recovered at PRH and the Hanford Reach stream survey were calculated in the similar manner as the age composition data for the same time period (Table 49). Likewise, the assignment of origin was based on the survey (i.e., stream or hatchery). The estimates based on this method may not be representative of natural and hatchery origin fish.

Table 49 Mean fork length (cm) at age (total age) of fall Chinook salmon sampled in the Hanford Reach escapement compared to fall Chinook salmon sampled at Priest Rapids Hatchery. n = sample size and SD = 1 standard deviation.

Return Year	Origin	Fall Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2001	Escapement	83	44	4	293	70	6	748	86	6	320	96	8	17	99	10
	PRH Returns	85	46	5	973	71	5	272	85	7	81	94	7	5	99	6
2002	Escapement	17	44	4	227	70	6	860	86	7	309	98	8	1	97	0
	PRH Returns	25	44	5	488	70	5	547	85	6	33	99	8	0		
2003	Escapement	32	44	5	118	65	7	1,423	86	7	819	95	8	2	111	21
	PRH Returns	0			0			0			0			0		
2004	Escapement	31	46	4	251	69	6	428	82	6	1,085	93	7	12	96	9
	PRH Returns	80	52	4	1,040	69	5	196	82	6	170	92	6	0		
2005	Escapement	19	48	5	229	70	6	1,157	84	6	669	94	8	22	103	10
	PRH Returns	12	49	6	281	70	5	628	81	6	58	93	7	2	94	11
2006	Escapement	34	47	4	42	69	7	194	86	8	288	93	7	6	96	9
	PRH Returns	19	55	4	93	70	6	246	84	6	183	91	6	2	103	10
2007	Escapement	25	50	5	71	68	6	395	85	6	239	95	8	18	97	5
	PRH Returns	31	49	4	115	69	5	215	83	6	61	91	6	9	94	9
2008	Escapement	20	48	4	202	70	6	386	84	6	450	96	8	2	99	6
	PRH Returns	3	45	3	429	73	4	51	84	5	20	91	4	1	73	0
2009	Escapement	24	46	5	85	69	6	532	84	7	208	94	8	0		
	PRH Returns	5	50	4	42	71	4	428	84	6	9	95	7	0		
2010	Escapement	34	50	4	642	72	6	962	86	6	744	96	8	2	91	1
	PRH Returns	22	52	5	1,149	71	4	170	84	6	180	91	6	0		
2011	Escapement	50	48	4	243	70	5	1,468	84	7	340	92	7	5	96	6
	PRH Returns	308	48	4	652	69	4	1,419	80	5	13	92	7	0		
2012	Escapement	63	47	7	421	69	6	620	84	7	482	92	7	0		
	PRH Returns	883	48	4	1,690	68	5	573	81	6	179	87	6	0		
2013	Escapement	58	46	4	1,040	68	5	931	81	6	72	82	8	1	105	0
	PRH Returns	111	47	3	1,375	69	4	218	77	5	1	84	6	0		
2001–13 Mean	**Escapement**	38	47	5	297	69	6	777	84	7	463	94	8	7	84	6
	PRH Returns	122	45	4	641	65	4	382	76	5	76	85	6	1	36	3

The availability of otolith marks in addition to other hatchery marks (i.e., otoliths, adipose clips, and coded-wire tags) for the 2012 and 2013 return years provide the ability to estimate size at maturity for both hatchery and natural origin fish within the Hanford Reach escapement. Sub-sample sizes were determined as described in Section 7 and Appendix B.

The size at maturity data for the 2012 and 2013 returns suggest that at ages- 2 and 3, the natural origin fish tend to be slightly smaller than hatchery origin fish. Conversely, at ages-4 and 5, the naturally origin fish tend to be slightly larger than hatchery origin fish (Table 50) (Figure 13).

Table 50 **Mean fork length (cm) at age (total age) of natural and hatchery origin fall Chinook salmon that spawned naturally in the Hanford Reach, n = sample size and SD = 1 standard deviation.**

Return Year	Origin	Fall Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2012	Natural	33	45	4	372	68	6	604	84	7	480	92	7	0		
	Hatchery	25	50	4	45	70	6	28	83	4	14	89	7	0		
2013	Natural	77	49	5	249	68	5	228	82	6	74	92	8	1	105	0
	Hatchery	9	51	14	191	70	5	44	78	7	5	87	9	0		
2012-13 Mean	**Natural**	55	47	5	311	68	6	416	83	7	277	92	8	1	105	0
	Hatchery	17	51	4	118	70	6	36	81	6	10	88	8	0	0	0

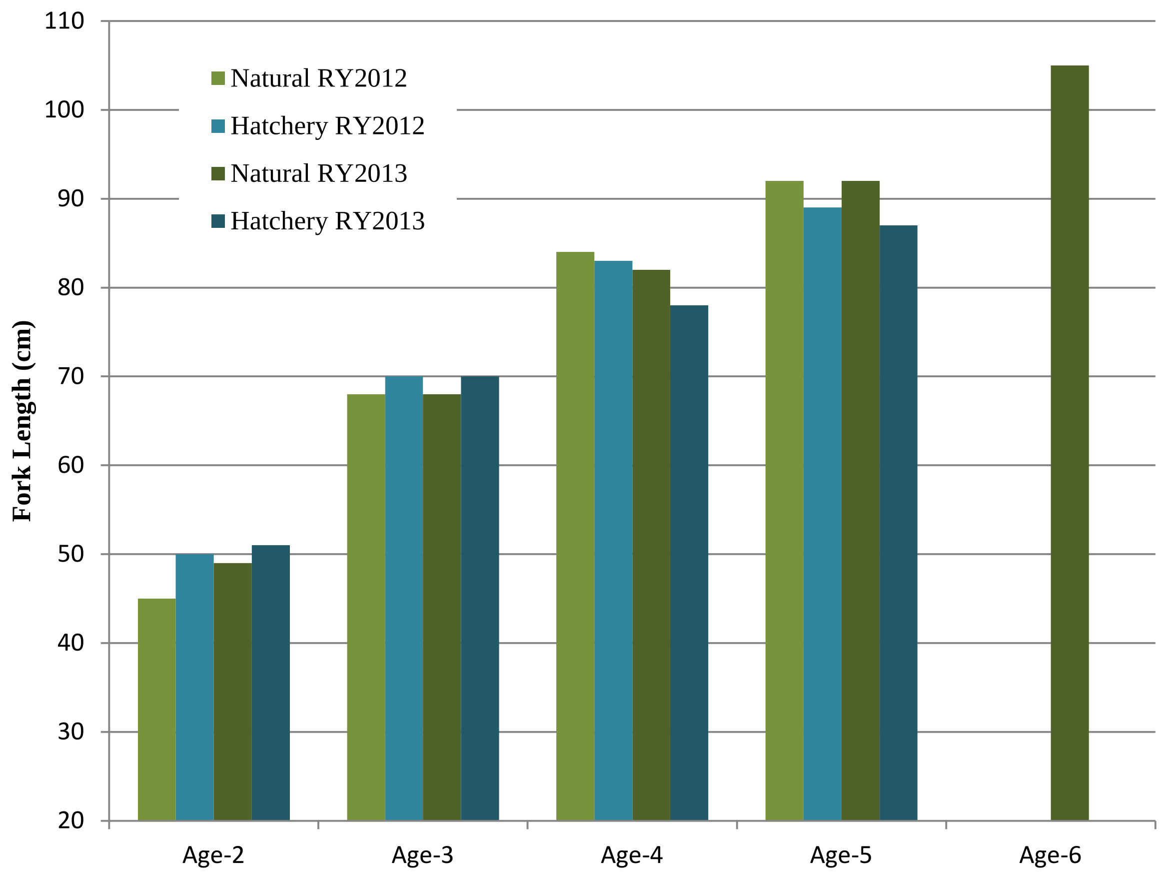

Figure 13 **Size and age for adult fall Chinook salmon returns of natural origin carcasses sampled from the Hanford Reach escapement and hatchery origin return sampled at Priest Rapids Hatchery, Return Years 2012 and 2013.**

Spawn Success

All female Chinook included in the biological sample for the Hanford Reach stream surveys were examined for egg retention to assess spawn success. The methods, results, and discussion for the assessment of spawn success are given in Appendix H. In general, it appears that hatchery origin fish recovered in the stream survey have lower spawn success than natural origin fish particularly in 2013 (Table 51). There was a notable decrease in spawn success for both hatchery and natural origin females in return year 2013. This observation coincides with the record returns of both natural origin and hatchery origin fall Chinook salmon to the Hanford Reach as well as a very high pHOS of 0.275. It is possible that increased competition for suitable spawning habitat resulted in the lower spawning success.

Table 51 Comparison of spawn success of natural and hatchery origin fall Chinook sampled in the Hanford Reach stream survey.

Return Year	Origin	Females Sampled	Egg Retention					Spawn Success	
			0%	25%	50%	75%	100%	Escapement	No Egg Retention
2010	Natural	1,125	1,101	6	12	1	5	98.8%	97.9%
	Hatchery	48	46		1		1	96.9%	95.8%
2011	Natural	1,176	1,121	1	48	4	2	97.5%	95.3%
	Hatchery	88	82		4	1	1	95.7%	93.2%
2012[a]	Natural	681	658	14	5	1	3	98.6%	96.6%
	Hatchery	90	89	0	0	0	1	98.9%	98.9%
2013[a]	Natural	461	392	51	9	3	6	94.5%	85.0%
	Hatchery	224	144	39	11	13	17	81.3%	64.3%
Mean	Natural	787	818	18	19	2	4	97.4%	93.7%
	Hatchery	93	90	10	4	4	5	93.2%	88.1%

The measure for reporting egg retention changed from that used for previous years beginning in 2010
[a] Otoliths were used to determine origin in addition to adipose clips and CWTs

18.0 Contribution to Fisheries

The Regional Mark Processing Center (RMPC) is the central repository for all coded-wire tagged and otherwise associated release, catch, sample, and recovery data regarding anadromous salmonids in the greater Pacific Coast Region of the United States of America (RMPC Strategic Plan 2006-2009). The Regional Mark Information System database (RMIS) within the RMPC provides specific recovery data for individual tag codes, along with the sample rate used to derive the total number of recoveries by fishery type. The RMIS database is the primary tool for estimating the survival and extraction rate of adipose fin-clipped and coded-wire tag hatchery releases. The RMIS database was queried for tag recoveries on April 27, 2014 to provide recoveries of coded-wire tagged PRH origin fish. The database for the 2007 brood may not be complete until January 1, 2015 due to the lag in reporting field data to RMPC.

Beginning with the 2010 release year, portions of the non-adipose clipped smolts released from PRH were coded-wire tagged as part of a double index tag study to evaluate the effect of various mark-selective fisheries occurring Oregon, Washington, and British Columbia waters (PSC 2013). We are currently reviewing the data reported to the RMPC database to evaluate the results of the double index tagging for the PRH origin fish.

Fall Chinook salmon released from PRH supplement Pacific Ocean harvest for both commercial and sport fisheries from Washington to Southeast Alaska as well as Columbia River commercial, sport, and treaty tribal harvest. The Hanford Reach sport fishery for fall Chinook salmon is an extremely popular fishery. The fishery runs from August 1 to late October annually. In 2013, 27,630 fall Chinook salmon were harvested during this fishery; 24,921 adults and 2,709 jacks. Estimates generated from coded-wire tags recovered from the Hanford Reach sport fishery suggest that 23.8% (6,553 total) of the sport harvest in the Hanford Reach was comprised of PRH origin fall Chinook salmon (Table 52). Likewise, adult returns from Ringold Springs Hatchery comprised 14.3% of the sport fishery. Strays from other hatcheries combined represent 1.9% of the harvest. Recent data from otolith sampling indicates that coded-wire tag expansions may underestimate the number of PRH origin fall Chinook salmon annually returning to PRH. A similar situation may occur when evaluating hatchery contributions to the sport fishery.

Table 52 Hatchery fall Chinook salmon contributions to harvest in the Hanford Reach fall Chinook salmon fishery. Coded-wire tag recoveries provided from RMIS database were expanded by sample rate and juvenile tag rate.

	Harvest & Sampling			CWT Expansions			% of Harvest		
Year	Harvest	Sampled	%	PRH	RSH	Other	PRH	RSH	Other
2003	7,190	1,848	25.7	510	424	43	7.1	5.9	0.6
2004	8,787	2,255	25.7	276	62	23	3.1	0.7	0.3
2005	7,974	1,834	23.0	1,200	265	35	15.0	3.3	0.4
2006	4,508	1,296	28.7	683	66	10	15.1	1.5	0.2
2007	6,466	1,812	28.0	929	50	89	14.4	0.8	1.4
2008	7,013	1,593	22.7	304	66	22	4.3	0.9	0.3
2009	8,806	1,741	19.8	520	0	10	5.9	0.0	0.1
2010	12,499	2,475	19.8	1,157	399	10	9.3	3.2	0.1
2011	14,262	2,715	19.0	1,558	663	121	10.9	4.6	0.8
2012	18,854	3,615	19.2	3,974	1,974	237	21.1	10.5	1.3
2013	27,630	5,555	20.2	6,570	3,947	537	23.8	14.3	1.9
Mean	11,272	2,430	21.6	1,130	433	65	10.0	3.8	0.6

Coded-wire tag data for PRH origin fall Chinook salmon that possessed an adipose clip were reviewed to assess contributions to marine and freshwater, commercial, tribal, and sport fisheries. The largest proportion of the harvest of PRH origin fall Chinook salmon occurred in ocean fisheries followed by Zone-6 tribal harvest. For brood years 1997 through 2007, 52% of the reported harvest was taken in ocean fisheries (Table 53).

Table 53 Coded-wire tag recoveries provided from RMIS by brood year and harvest type expanded by sample rate and juvenile tag rate.

Brood Year	Ocean Fisheries		Columbia River Fisheries: *Tribal*		*Commercial*		*Recreational*		Recoveries (*N*)
	#	%	#	%	#	%	#	%	
1997	1,100	37%	1,506	50%	304	10%	91	3%	3,001
1998	6,580	48%	3,956	29%	1,066	8%	1,981	15%	13,583
1999	14,190	55%	5,908	23%	2,410	9%	3,458	13%	25,966
2000	4,938	61%	1,583	20%	1,099	14%	412	5%	8,032
2001	17,758	57%	6,612	21%	1,554	5%	5,484	17%	31,410
2002	3,779	51%	1,240	17%	576	8%	1,869	25%	7,463
2003	1,871	55%	570	17%	226	7%	757	22%	3,424
2004	562	49%	364	32%	214	19%	0	0%	1,140
2005	10,699	52%	5,975	29%	998	5%	2,871	14%	20,543
2006	1,023	44%	713	31%	288	12%	298	13%	2,322
2007	13,838	44%	10,620	34%	2,160	7%	4,523	15%	31,340
Mean	**6,940**	**52%**	**3,550**	**26%**	**990**	**7%**	**1,977**	**15%**	**13,457**

19.0 Straying

The distribution of PRH origin fish spawning in areas outside of the target stream is presented. The presumptive target spawning location for PRH origin fish includes the section of Columbia River from McNary Dam to Wanapum Dam.

The spawning escapement of PRH origin fish by brood year is determined from coded-wire tag recoveries collected during spawning surveys. The coded-wire tag recoveries are expanded by the juvenile mark rates and survey sampling rates to estimate total spawning escapements.

The stray rates (i.e., fish that spawned outside of the presumptive target area) for each brood year were calculated from the estimated recoveries of PRH origin fish from spawning grounds within and outside of the presumptive target area. Coded-wire tag recoveries at non-target hatcheries and adult fish traps are not included. These fish are not considered strays because the fish were not able to leave the facilities on their own volition.

Coded-wire tag data reported to RMPC are expanded by sample rates generated by the agency reporting the data. In some cases, the estimated number of tags reported is less than the number actually observed. This typically occurs when the sample rate is unknown, not reported, or biased (Gilbert Lensegrav, WDFW, personal communication). In these instances, the observed number was used instead of the estimated number to calculate the numbers of PRH origin fish recovered by location.

There are three target rates for straying given in the 2010 version of the PRH M&E Plan:

1). Stray rate for PRH origin fall Chinook salmon should be less than 5% of total brood return.
2). Stray rate for PRH origin fall Chinook salmon should be less than 5% of the spawning escapement for other independent populations based on run year.
3). Stray rate for PRH origin fall Chinook salmon should be less than 10% of the spawning escapement of any non-target streams within the independent population based on run year.

With one exception, less than 5% of the PRH origin returns for each brood year were estimated to have spawned outside of the presumptive target spawning area (Table 54). The 2006 brood is the only cohort found at rates greater than 5% outside of the presumptive target area. For this cohort, 37% of the estimated strays occurred in the Chelan River. This estimate is based on an expansion of one PRH coded-wire tag recovered in the Chelan River escapement. The Chelan River spawning population is a mix of both summer and fall Chinook salmon strays and is not considered an independent population. This location was included to show contributions of PRH strays to this group of fish.

Examination of coded-wire tag recoveries by return year for presumptive non-target streams or areas show that PRH fall Chinook salmon seldom exceed more than 5% of the spawning escapement for other independent populations of fall Chinook salmon. However, for multiple return years, greater than 5% of the spawning escapement for the Chelan River consisted of PRH origin fall Chinook salmon (Table 55).

Table 54 Estimated number and proportions of Priest Rapids Hatchery fall Chinook salmon spawning escapement to Priest Rapids Hatchery and streams within and outside of the presumptive target stream by brood year. Coded-wire tag recoveries are expanded by juvenile mark rate and survey sample rate for each brood year.

Brood Year	Number of PRH Origin Recoveries	Homing Target Hatchery		Target Stream[1]		Outside of Target Stream	
		Number	Proportion	Number	Proportion	Number	Proportion
1992	9,037	7,630	0.844	1,037	0.115	370	0.041
1993	25,966	21,144	0.814	4,821	0.186	0	0.000
1994	1,692	1,385	0.818	308	0.182	0	0.000
1995	30,655	23,414	0.764	7,207	0.235	34	0.001
1996	13,552	10,034	0.740	3,517	0.260	0	0.000
1997	3,172	2,690	0.848	483	0.152	0	0.000
1998	18,167	11,833	0.651	5,867	0.323	467	0.026
1999	27,333	15,467	0.566	11,867	0.434	0	0.000
2000	4,759	3,690	0.775	1,069	0.225	0	0.000
2001	25,375	15,875	0.626	9,469	0.373	31	0.001
2002	5,288	3,769	0.713	1,519	0.287	0	0.000
2003	3,034	2,034	0.670	949	0.313	51	0.017
2004	1,133	1,133	1.000	0	0.000	0	0.000
2005	21,379	17,103	0.800	4,241	0.198	34	0.002
2006	1,000	633	0.633	0	0.000	367	0.367
2007	22,253	19,238	0.865	2,970	0.133	23	0.001
2008[a]	10,864	8,227	0.757	2,638	0.243	0	0.000
Mean	13,215	9,723	0.758	3,410	0.215	81	0.027

[1] Target stream includes the Columbia River between McNary and Wanapum dams as well as the Yakima River below Prosser Dam.

[a] The CWT recovery data in the RMIS may not be up to date at the time of the report.

Table 55 Proportion of fall/summer Chinook spawning populations by return year comprised of Priest Rapids Hatchery fall Chinook from 1990 – 2008 brood releases based on coded wire tag recoveries.

	Presumptive Non-Target Stream					
Return Year	Yakima Fall Chinook	Okanogan Summer Chinook	White Salmon Fall Chinook	Wenatchee Summer Chinook	Methow Summer Chinook	Chelan River[1]
2000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.000	0.000	0.000	0.000	0.000	0.339
2002	0.000	0.000	0.000	0.000	0.000	0.229
2003	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.015	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000	0.066
2010	0.000	0.000	0.000	0.000	0.000	0.328
2011	0.000	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000	0.000
2013[a]	0.000	0.000	0.000	0.000	0.000	0.000

[1]The Chelan River spawning population is a mix of both summer and fall Chinook salmon strays and is not considered an independent population. This location was included to show contributions of PRH strays to this group of fish.

[a] The Coded wire tag data reported in the Regional Mark Information System in not up to date at the time of this report was completed.

As previously described in Section 4, approximately 3,000 smolts at PRH have been annually PIT-tagged at PRH from brood years 1995 through 2010. The annual release of PIT-tagged smolts was increased to 43,000 beginning with brood year 2011. Observations of individual PIT-tag adult fall Chinook salmon originating from PRH at detection locations above McNary Dam are given in Table 56 for brood years 1999 through 2011. The additional PIT-tagged fish from brood year 2011 were age-2 fish in return year 2013. The number of observed PRH PIT-tagged adults should dramatically increase in the forthcoming years.

The PIT-tag observations at MCN should represent the total number of individual fish available for detections upstream. Although unlikely, it’s is possible that PIT tagged fish could pass upstream of McNary Dam undetected by the multiple arrays in the adult fishways or by passing through the dam via the navigation lock. Individual fish may be observed at multiple sites upstream which can result in greater number of observations for individual fish above McNary Dam. Since the installation of the PIT-tag array in the PRH discharge channel, we have often observed individual fish detected at both PRD and PRH; in some cases multiple times.

The majority of the PIT tagged PRH adults observed at McNary Dam have been observed at PRD and PRH. However, notable proportions have been observed at sites upstream of PRD. However, it is unclear whether fish spawned outside of the target areas because fish could return to a target location after wandering and being detected at a PIT array.

Table 56 Observations of passive-integrated-transponder tagged adult fall Chinook from Priest Rapids Hatchery at detection sites upstream McNary Dam.

		Number unique adult detections by site								
Brood Year	**# PIT-tagged**	**MCN**	**ICH**	**PRA**	**PRH**	**RIA**	**RRF**	**WEA**	**LWE**	**LMR**
2011 (age 2)	42,844	37	0	28	6	3	2	0	0	0
2010 (age 2-3)	3,000	48	0	38	25	10	5	1	1	0
2009 (age 2-4)	1,995	18	0	14	10	2	0	0	0	0
2008 (age 2-5)	2,994	12	0	7	0	1	1	0	0	0
2007	3,000	31	0	16	0	5	3	2	0	1
2006	3000	0	0	0	0	0	0	0	0	0
2005	3000	12	0	4	0	1	0	0	0	0
2004	3000	0	0	0	0	0	0	0	0	0
2003	3000	0	0	0	0	0	0	0	0	0
2002	3000	7	0	1	0	0	0	0	0	0
2001	3000	11	0	6	0	0	0	0	0	0
2000	3000	7	0	4	0	0	0	0	0	0
1999	3000	17	0	9	0	2	0	0	0	0

MCN McNary Dam Adult Fishways RKM 470
ICH Ice Harbor Dam Adult Fishways RKM 522
PRA Priest Rapids Dam Adult Fishways RKM 639
RIA Rock Island Dam Adult Fishways RKM 730
RRF Rocky Reach Dam Adult Fishway RKM 763
WEA Well Dam Adult Fishways RKM 830
LWE Lower Wentachee River RKM 754
PRH Priest Rapids Hatchery Outfall RKM 635
LMR Lower Methow River at Pateros RKM 843

20.0 Genetics

Genetic tissue was collected from each Chinook salmon spawned at PRH during 2013. Similar to the 2011 and 2012 spawn, staff from the Columbia River Inter-Tribal Fish Commission (CRITFC) obtained a tissue sample after each fish was spawned. In total 5,412 specimens were collected to support their work associated with genetic stock identification and parentage-based tagging. Tissue samples were numbered consistent with PRH M&E data so that biological information could be associated with genetic data. The tissue samples collected from 2011 through 2013 is currently being archived by CRITFC. During 2010, WDFW staff collected 100 genetic tissue samples from both the PRH broodstock and naturally spawning broodstock from the Hanford Reach. WDFW has not collected genetic samples since the 2010 return because of the large sampling and archiving effort by CRITFC.

21.0 Proportion of Natural Influence

Integrated hatchery programs by definition involve the interbreeding hatchery and natural origin fish in both the hatchery and natural environments. Gene flow and the associated risks within and between these environments can be estimated using a simple ratio estimator using the proportion of natural origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery origin fish in the natural spawning escapement (pHOS). The ratio pNOB/(pHOS+pNOB) is termed the Proportionate Natural Influence (PNI). The larger the PNI ratio, the greater selection in the natural environment as on the population relative to that of the hatchery environment. In order for the natural environment to drive selection, PNI should be greater than 0.5 and for integrated hatchery programs the Hatchery Scientific Review Group (HSRG) recommends a PNI $\geq$ 0.67 (HSRG/WDFW/NWIFC 2004). In addition to establishing goals for the proportion of natural origin Chinook salmon to be incorporated into the hatchery broodstock (pNOB), the HSRG also set targets for the maximum proportion of hatchery origin

Chinook that should be allowed to spawn in the natural environment (pHOS). The HSRG recommends a maximum proportion of hatchery influence on the spawning grounds of 0.30 for the Hanford Reach if it is to be managed as an integrated hatchery program.

Several estimates of PNI have been calculated to show the contributions of multiple programs on the overall PNI for the Hanford Reach. These programs include the hatchery production associated with the Grant PUD and USACE mitigation and the influence of strays (albeit minor). The different PNI estimates are based on pNOB and pHOS estimates specific to each source of spawning adults. The methods used to allocate pNOB and pHOS are described in the following sections.

Estimates of pNOB and pHOS were derived from biological samples collected systematically from the PRH broodstock and the carcasses recovered in the Hanford Reach. These biological samples were subsampled and expanded as described in Appendix B to assign origin and estimates of pNOB and pHOS.

Estimates of pNOB

Estimates of pNOB based on otolith samples are limited to return years 2012 and 2013. Otolith marking began with the 2009 brood. Hence, otolith marks are only available for specific age classes of PRH origin fish during return years 2010 and 2011and do not provide representative samples for estimating pNOB for the PRH broodstock.

The overall pNOB for fish spawned at PRH during return years 2012 and 2013 is provided in Table 57. The 2013 broodstock was comprised of 4,476 fish from the volunteer trap, 658 from the OLAFT and 307 from the ABC.

Table 57 Proportion of naturally produced Chinook salmon in the Priest Rapids Hatchery broodstock (pNOB) based on otolith marks, in-sample coded-wire tags and adipose clips.

Return Year	Natural Origin	Hatchery Origin Spawners			Total pNOB
		PRH	Other[1]	Total	
2012[a]	592	4362	20	4,382	0.119
2013[b]	693	4705	43	4,749	0.127

[1] Includes coded-wire tagged fish from other hatcheries and adipose clipped fish without otolith marks
[a] pNOB calculated for Ages 2 through 5
[b] pNOB calculated for Ages 2 through 6

Grant PUD funds the collection of broodstock from the ABC and OLAFT with the intent of improving the pNOB associated with the production of their 5.6 million smolt mitigation requirement (Table 58). The fish culture staff used the following procedure to segregate the progeny resulting from the mating of ABC and OLAFT broodstock for release from PRH. A total of 341 females and 624 males originating from OLAFT and ABC were spawned with known hatchery origin fish. The gametes of these, assumed natural by hatchery crosses, were mixed at a rate of one male to two females in orange buckets to denote the mating strategy. The eggs were then taken to the incubation room, counted, and placed into incubation trays. The date and mating strategy were recorded on flagging tape which was then attached to the incubation tray. The surviving fry from these incubation trays were transferred to multiple raceways and later transferred to multiple ponds to rear prior to release from PRH.

The pNOB estimate specific to the egg take for the Grant PUD mitigation requirement was calculated based on the numbers by origin of broodstock from the ABC, OLAFT, and PRH volunteer trap that were spawned to produce 5.6 million smolts for release. The pNOB estimate specific to the egg take for the USACE mitigation requirement was calculated based on the numbers by origin of broodstock solely from the PRH volunteer broodstock. The average fecundity (3,702) of the 2013 broodstock was used to calculate the number of females required by each program. The PRH volunteer broodstock comprised an estimated 32 and 50 natural origin males and females, respectively. These natural origin fish were allocated by the proportion of the PRH volunteer broodstock used for the Grant PUD and USACE egg take needs.

Table 58 Origin of broodstock and pNOB apportioned to program for fall Chinook salmon spawned at Priest Rapids Hatchery, Return Year 2013.

Program	Egg Take	Facility Average Fecundity	Natural Females	Hatchery Females	Natural Males	Hatchery Males	Total Natural	Total Hatchery	pNOB
Grant PUD	6,752,761	3,702	208	1,616	414	529	622	2,146	0.225
USACE	6,523,239	3,702	43	1,719	28	884	71	2,603	0.026
Combined	13,276,000	3,702	251	3,335	442	1,413	693	4,748	0.127

Estimates of pHOS

Estimates of pHOS based on otolith samples are limited to return years 2012 and 2013. Otolith marking began with the 2009 brood. Hence, otolith marks are only available for specific age classes of PRH origin fish during return years 2010 and 2011and do not provide representative samples for estimating population level pHOS. The population level pHOS estimate for return years 2012 and 2013 Hanford Reach spawning escapement are presented Table 59.

Table 59 Proportion of hatchery Chinook salmon on the spawning grounds (pHOS) in the Hanford Reach.

Return Year	n	Natural Origin	Hatchery Origin Spawners			Total Escapement	Total pHOS
			PRH	Other[1]	Total		
2012[a]	1,609	1,398	3,829	3,721	7,550	57,631	0.131
2013[b]	927	126,744	35,445	12,651	48,096	174,840	0.275

[1.] Includes coded-wire tagged fish from other hatcheries and adipose clipped fish without otolith marks
[a] pHOS calculated for Ages 2 through 5
[b] pHOS calculated for Ages 2 through 6

Estimates for pHOS were calculated for contributing sources of hatchery origin fall Chinook salmon spawning naturally in the Hanford Reach. The primary source of pHOS originates from fish released from PRH. This source of PRH-pHOS was apportioned to the Grant PUD and USACE programs at PRH based on the annual mitigation requirement for the number of juveniles released by each program between brood year 2008 and 2011 (Table 60). An estimated 35,445 PRH origin fish spawned naturally in the Hanford Reach during the 2013 return year. Of these, 74.6% and 25.4% were allocated to Grant PUD and USACE, respectively.

Table 60 Origin of pHOS apportioned by source for fall Chinook salmon spawning naturally in the Hanford Reach.

Return Year	Natural Origin	Hatchery Origin Spawners				pHOS by Source			
		GCPUD[1]	USACE[1]	Other[2]	Total	GCPUD	USACE	Other[2]	Combined
2013	126,744	26,451	8,994	12,651	48,096	0.151	0.051	0.072	0.275

[1]An estimated 35,445 PRH origin fish spawned naturally in the Hanford Reach. Of these, 74.6% and 25.4% were apportioned to Grant PUD and USACE, respectively. The allocation of pHOS was based on the proportion of annual juvenile mitigation goals for each agency for brood years 2008 through 2011.

[2]Includes hatchery origin fish not released from Priest Rapids Hatchery. Primary source is likely Ringold Springs Hatchery.

Estimates of PNI

The population level PNI for the Hanford Reach includes all hatchery origin fish regardless of hatchery program or funding source. The influence of PRH origin fish on PNI is given to show the contribution by the entire PRH release and funding source for production.

Prior to return year 2012, pHOS, pNOB and PNI were estimated from expansions of coded-wire tag recoveries in the hatchery and stream surveys. The pNOB estimated from coded-wire tags requires the assumption that fish unaccounted for by the code-wire tag expansions are natural origin fish. As discussed in Sections 1.8 and 1.9 of this report, this assumption significantly over estimates pNOB and PNI and under estimates pHOS. Estimates of pNOB, pHOS, and PNI based on coded-wire tag expansions are presented in Table 61.

In future years, we hope to establish a relationship between pNOB and pHOS estimates generated by coded-wire tags and otolith marks in order to adjust the historical PNI estimates generated by coded-wire tags.

Table 61 Proportionate Natural Influence (PNI) of the Hanford Reach fall Chinook salmon supplementation program based on expanded coded-wire tag recoveries of all fish surveyed.

Return Year	pNOB based on all non coded-wire tags are Natural Origin	pHOS based on coded-wire tag expansions	PNI based on coded-wire tag expansions
2001	0.155	0.094	0.622
2002	0.145	0.101	0.589
2003	0.132	0.099	0.571
2004	0.229	0.081	0.739
2005	0.370	0.106	0.777
2006	0.507	0.057	0.899
2007	0.326	0.041	0.888
2008	0.501	0.046	0.916
2009	0.568	0.077	0.881
2010	0.392	0.040	0.907
2011	0.381	0.075	0.836
2012	0.304	0.045	0.871
2013	0.252	0.217	0.537
Mean	**0.328**	**0.083**	**0.772**

We present PNI estimates to represent the pNOB associated with the Grant PUD and USACE broodstock requirements and the contributing sources of pHOS (Table 62). Utilizing natural origin broodstock from the OLAFT and ABC substantially increases the PNI associated with the Grant PUD program.

Table 62 Proportionate Natural Influence (PNI) estimates for the Hanford Reach fall Chinook salmon supplementation programs.

Return Year	pNOB GCPUD	pNOB USACE	pNOB Facility	PRH pHOS GCPUD	PRH pHOS USACE	pHOS Reach[1]	PNI GCPUD	PNI USACE	PNI System[2]
2013	0.225	0.027	0.127	0.151	0.051	0.274	0.598	0.346	0.317

[1] Includes fish from all hatcheries spawning naturally in the Hanford Reach. The primary source for these fish is from Priest Rapids and Ringold Springs Hatcheries.
[2]The combined PNI estimate includes pHOS from all hatchery origin fish spawning naturally in the Hanford Reach.

The PNI estimates based on combination of hatchery marks (i.e., otoliths, adipose clips and coded-wire tags) for return years 2012 and 2013 are presented in Table 63.

Table 63 Population level Proportionate Natural Influence (PNI) for the Hanford Reach fall Chinook salmon supplementation.

Return Year	PRH Facility pNOB	All Hatchery Combined pHOS[1]	All Hatchery Combined PNI
2012[a]	0.119	0.131	0.476
2013[b]	0.127	0.274	0.317

[a] pHOS calculated for Ages 2 through 5
[b] pHOS calculated for Ages 2 through 6
[4] Includes fish from other hatcheries and adipose clipped fish without otolith marks

Alternative pNOB and PNI

An alternative pNOB was developed to account for the genetic influence on pNOB resulting from the PRH spawning protocol of spawning one male with two females. It is intended to represent actual gene flow to the progeny instead of strictly the origin and number of parents. However, it should be noted that although PNI was intended to index gene flow, the alternative method of estimating pNOB as described below has not been used elsewhere and is currently undergoing review.

The alternative pNOB is calculated by assigning scores to the estimated matings of males and females based on origin during the spawning of the PRH broodstock.

The hatchery x hatchery matings = 0.0 points,

Hatchery x natural matings = 0.5 points, and

Natural x natural matings = 1.0 points.

The scores of all of the matings were averaged to generate the overall alternative pNOB. For example, the alternative pNOB calculation for the mating of one natural origin male x two hatchery origin females is (0.5 + 0.5) / 2 females) = 0.5, whereas the conventional pNOB calculation for this mating equals (1 natural / (1 natural + 2 hatchery) = 0.33.

The origins of fish spawned were based on a combination of otolith marks, adipose clips, and coded-wire tags, as done for the conventional pNOB calculation previously discussed. The matings were assigned assuming there were no natural x natural crosses since there was a low proportion (<7%) of natural origin fish in the PRH volunteer trap broodstock. In addition, the fish from the OLAFT and ABC were spawned with fish from the PRH volunteer trap broodstock. Hence, there is a low chance that natural origin fish from the OLAFT and ABC were mated with the relatively few natural origin fish from the PRH volunteer trap broodstock.

Similar to that done for estimates of pNOB by funding source, alternative pNOB and PNI estimates are given for the PRH facility as a whole and specific to the Grant PUD production associated with the 2013 broodstock. The pHOS used for these estimates are given in Table 62 and Table 63.

The alternative and conventional pNOB values for the total broodstock and overall pHOS for brood years 2012 and 2013 are given in Table 64. In addition, the alternative pNOB and pHOS specific to the Grant PUD production associated with the 2013 broodstock are also given.

The population level PNI and the Grant PUD PNI generated from the alternative pNOB calculations are higher than the PNI calculated from the conventional pNOB calculation.

Table 64 Conventional and alternative calculations of pNOB and PNI associated with the Priest Rapids Hatchery production and the production specific to Grant PUD.

	Conventional pNOB = pNOB/(NOB + HOB)		
Return Year	**All Broodstock Combined**	**pHOS[1]**	**PNI**
2012	0.119	0.131	0.476
2013	0.128	0.276	0.317
	Alternative pNOB = Total Score / Total Matings		
Return Year	**All Broodstock Combined**	**pHOS[1]**	**PNI**
2012	0.141	0.131	0.518
2013	0.159	0.276	0.366
Return Year	**Grant PUD Conventional pNOB**	**Grant PUD pHOS[2]**	**Grant PUD PNI**
2013	0.225	0.151	0.598
Return Year	**Grant PUD Alternative pNOB**	**Grant PUD pHOS[2]**	**Grant PUD PNI**
2013	0.284	0.151	0.653

[1]The pHOS was calculated for all sources of hatchery fish in the Hanford Reach escapement.
[2]The pHOS of 0.151 is the proportion of the overall pHOS for the 2013 escapement assigned to the Grant PUD production at PRH.

22.0 Natural and Hatchery Replacement Rates

The numbers of hatchery origin recruits (HOR) were estimated from coded-wire tag recoveries for brood year returns to the PRH and the Hanford Reach of the Columbia River. The recovered coded-wire tags are expanded by sample rate and then by the juvenile tag rate. Coded-wire tags recovered from natural origin recruits (NOR) originating from the Hanford Reach are difficult to expand accurately because the juvenile tag rates are unknown. Therefore, the assumption was made that returns not accounted for by HOR coded-wire tag recoveries are NOR. Recent data indicates that that coded-wire tag data likely underestimates the true number of HOR. Hence, our assumption likely overestimates the number of NOR.

Hatchery replacement rates (HRR) were calculated as the ratio of HOR to the parent broodstock at PRH. This broodstock is an estimate of the number of fish spawned at PRH to produce the target release of 6.7 million subyearling fall Chinook salmon. Similarly, natural replacement rates (NRR) for the Hanford Reach URB fall Chinook salmon were calculated as the ratio of NOR to the parent population spawning naturally in the Hanford Reach stream.

Harvest estimates for HOR were calculated from the proportion of the expanded coded-wire tag recoveries in the fisheries to the total number of the expanded coded-wire tags recovered. Since there is not a coded-wire tag mark rate for NOR, the harvest rates for HOR were used as an indicator for similar brood years of NOR.

For brood years 1996 through 2007, HRR without harvest for PRH fall Chinook salmon averaged 4.33 and NRR for fall Chinook salmon in the Hanford Reach without harvest averaged 1.52 (Table 65).

Based on coded-wire tag recoveries, an average of 55% of the PRH adult recruits and 68% of the natural origin adult recruits for brood years 1996 through 2007 were harvested in ocean and freshwater fisheries. For brood years 1996 through 2007, HRR, with harvest included, averaged 9.66 and NRR averaged 2.87. The HRR should be greater than or equal to 5.30 (the target value in Murdoch and Peven 2005).

Table 65 Broodstock collected, spawning escapement, natural and hatchery origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR, with and without harvest) for natural origin fall Chinook salmon in the Hanford Reach.

Brood Year	Broodstock Spawned	Natural Spawning Escapement	Harvest not included				Harvest included[1]			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1996	2,859	43,249	13,584	28,849	4.75	0.67	26,205	59,899	9.17	1.38
1997	2,726	43,493	3,002	44,416	1.10	1.02	6,037	88,349	2.21	2.03
1998	3,027	35,393	18,464	93,999	6.10	2.66	31,932	222,865	10.55	6.30
1999	2,619	29,812	27,093	114,867	10.34	3.85	52,099	239,319	19.89	8.03
2000	2,619	48,020	4,665	56,422	1.78	1.17	12,508	89,983	4.78	1.87
2001	3,621	59,848	25,059	71,359	6.92	1.19	55,789	129,548	15.41	2.16
2002	3,630	84,509	5,277	47,813	1.45	0.57	12,744	81,600	3.51	0.97
2003	3,003	100,508	3,021	31,605	1.01	0.31	5,974	63,937	1.99	0.64
2004	3,014	87,696	1,109	22,747	0.37	0.26	3,262	34,465	1.08	0.39
2005	2,898	71,967	21,107	64,011	7.28	0.89	61,122	97,777	21.09	1.36
2006	2,911	51,701	998	54,288	0.34	1.05	3,347	77,344	1.15	1.50
2007	2,151	22,274	22,520	101,643	10.47	4.56	53,999	174,359	25.10	7.83
Mean	2,923	56,539	12,158	61,002	4.33	1.52	27,085	113,287	9.66	2.87

[1] Harvest rates for NORs was estimated using the HRRs harvest rates for similar brood years as an indicator stock.

23.0 Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) are calculated by dividing the expanded number of adult coded-wire tags recovered by the number of coded-wire tagged smolts released. The following data was obtained from the RMPC's RMIS online database: http://www.rmpc.org/. The 2007 brood year data was queried on May 13, 2014. This query should account for age 2 through 5 fall Chinook salmon sampled through December 2012. The lag in reporting field data for the 2013 return year likely excludes recoveries of limited a number of age-6 fish.

The SARs for hatchery fall Chinook salmon released from PRH for brood years 1992 through 2007, have averaged 0.0040 (Table 66). The SARs for the PRH origin 2007 brood is 0.0116; the highest on record and notably higher than the historic mean.

The SARs for Hanford Reach natural origin fall Chinook salmon for brood years 1992 through 2007 have averaged 0.0033 (Table 67). The SAR for the Hanford Reach natural origin 2007 brood is 0.0083; the second highest on record and notably higher than the historic mean. The SARs for both the PRH and natural origin broods were similarly high for the 2007 brood.

Table 66 Smolt-to-adult-ratios (SARs) for Priest Rapids Hatchery fall Chinook salmon.

Brood Year	Tag Code	Number of Tagged Smolts Released	Estimated Adult Captures	SAR
1992	635010	194,622	448	0.0023
1993	635540	185,683	1,479	0.0080
1994	635711	175,880	108	0.0006
1995	636001	196,189	1,786	0.0091
1996	636328	193,215	762	0.0040
1997	630517	196,249	183	0.0009
1998	631030	193,660	946	0.0049
1999	631333	204,346	1,573	0.0077
2000	630672	200,779	370	0.0018
2001	631382	219,926	1,810	0.0082
2002a	631392	101,020	124	0.0012
2002a	631768	254,353	545	0.0021
2003a	632575	225,989	264	0.0012
2003a	632574	173,127	88	0.0005
2004	633076	200,072	100	0.0005
2005	633173	199,445	1,718	0.0086
2006	633894	202,000	100	0.0005
2007	634391	202,568	2,359	0.0116
Mean		**195,507**	**820**	**0.0040**

[a] Brood years with multiple coded-wire tag codes

Table 67 Smolt-to-adult-ratios (SARs) for Hanford Reach natural origin fall Chinook salmon.

Brood Year	Number of Tagged Smolts Released	Estimated Adult Captures	SAR
1992	203,591	829	0.0041
1993	95,897	485	0.0051
1994	148,585	74	0.0005
1995	146,887	340	0.0023
1996	92,262	111	0.0012
1997	199,896	365	0.0018
1998	129,850	784	0.0060
1999	213,259	2,378	0.0112
2000	204,925	362	0.0018
2001	127,758	519	0.0041
2002	203,557	338	0.0017
2003	207,168	199	0.0010
2004	163,884	147	0.0009
2005	203,929	301	0.0015
2006	263,478	356	0.0007
2007	53,618	446	0.0083
Mean	**166,159**	**502**	**0.0033**

24.0 ESA/HCP Compliance

Broodstock Collection

Unclipped and untagged fall Chinook salmon adults were collected at the Priest Rapids Dam OLAFT and the ABC in the Hanford Reach to be used as brood stock at PRH. Per the 2013 Priest Rapids OLAFT study plan and consistent with the 2013 broodstock collection protocols, up to 1,000 natural-origin (adipose fin present, non-coded-wire tagged) adults were targeted for collection between September 1, 2013 and November 15, 2013 at the OLAFT. Actual collections occurred between September 11, 2013 and November 14, 2013, and totaled 763 fall Chinook. ESA Permit 1347 provides authorization to conduct fall Chinook broodstock collection activities at Priest Rapids Dam with an indirect take of steelhead (hatchery and/or wild) not to exceed 10 fish.

During 2013, broodstock collection activities were concurrent with the Priest Rapids steelhead run composition sampling covered under Section Permit # 1395. As such, no steelhead take occurred from fall Chinook broodstock activities. Chinook not collected for broodstock were sampled as described in 2013 OLAFT Study Plan and released upstream. All other fish encountered were passed at the trap site and were not physically handled.

Hatchery Rearing and Release

The juvenile fall Chinook salmon from the 2013 brood year reared throughout their life-stages at PRH without incident. The 2014 smolt release totaled 6,822,361 URB fall Chinook salmon, representing 102% of the production objective and was compliant with the 10% overage allowable in ESA Section 10 Permit 1347.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There were no NPDES violations reported at Grant PUD Hatchery facilities during the September 2012 through June 2013 collection and rearing periods.

Ecological Risk Assessment

One of the regional objectives in the GPUD M&E plan is to conduct an ecological risk assessment on non-target taxa of concern to determine if additional M&E is necessary (Pearsons and Langshaw 2009). The methodology that was used to assess risks was presented in Pearsons et al. 2012 and Pearsons and Busack 2012. This objective was completed through an approved report that summarized the methods and results of the risk assessment (Mackey et al. 2014).

25.0 Acknowledgments

We thank the many individuals and organizations that helped collect the data or provided data for inclusion in this report: Shawnaly Meehan and Dennis Werlau for the leadership of their WDFW M&E crews that sorted and sampled over 70,000 fall Chinook salmon, along with entering and reviewing all the sample data collected in 2013; Paul Hoffarth for leading the creel staff and summarizing the sport harvest data; and Anthony Fritts and Andrew Murdoch provided helpful suggestions for the improvement of this report. Furthermore, I would like to thank the hatchery staff at Priest Rapids and Ringold Springs Hatcheries: Mike Lewis, Glen Pearson, Mike Erickson and their crews for accommodating the activities associated with M&E. This work was primarily funded by Grant County Public Utility District, the United States

Army Corps of Engineers, Washington Department of Fish and Wildlife, and the Columbia River Coded Wire Tag Recovery Program.

Literature Cited

Ham, K. D., and T. N. Pearsons. 2001. A practical approach for containing ecological risks associated with fish stocking programs. Fisheries 25(4):15-23.

Harnish, R.A., R. Sharma, G. A. McMichael, R.B. Langshaw, T.N. Pearsons, and D.A. Bernard. 2012. Effects of Priest Rapids Dam Operations on Hanford Reach Fall Chinook Salmon Productivity and Estimation of Maximum Sustainable Yield, 1975-2004. Prepared for: Public Utility District No. 2 of Grant County, Ephrata, WA. Contract Number 430-2464.

Hillman, T., T. Kahler, G. Mackey, J. Murauskas, A. Murdoch, K. Murdoch, T. Pearsons, and M. Tonseth. 2013. Monitoring and evaluation plan for PUD hatchery programs. Chelan PUD, Wenatchee, Washington.

Hoffarth, P. A. and T. N. Pearsons. 2012. Priest Rapids Hatchery Monitoring and Evaluation: Annual Report for 2010. Grant County Public Utility District, Ephrata, Washington.

Hoffarth, P. A. and T. N. Pearsons. 2012. Priest Rapids Hatchery Monitoring and Evaluation: Annual Report for 2011. Grant County Public Utility District, Ephrata, Washington.

Mackey, G., T. N. Pearsons, M. R. Cooper, K. G. Murdoch, A. R. Murdoch, and T. W. Hillman. 2014. Ecological risk assessment of upper Columbia hatchery programs on non-target taxa of concern. Report produced by the Hatchery Evaluation Technical Team (HETT) for the HCP Wells Hatchery Committee, HCP Rocky Reach Hatchery Committee, HCP Rock Island Hatchery Committee, and the Priest Rapids Hatchery Sub-Committee. Grant County Public Utility District, Ephrata, Washington.

McCarthy, M. A., D. Keith, J. Tietjen, M. A. Burgman, M. Maunder, L. Master, B. W. Brook, G. Mace, H. P. Possingham, R. Medellin, S. Andelman, H. Regan, T. Regan, and M. Ruckelshaus. 2004. Comparing predictions of extinction risk using models and subjective judgement. Acta Oecologica 26(2004):67-74. doi10.1016/actao.2004.01.008.

Murdoch, A., and C. Peven. 2005. Conceptual approach to monitoring and evaluating the Chelan County Public Utility District Hatchery Programs. Final report to the Chelan PUD Habitat Conservation Plan's Hatchery Committee.

Murdoch, A. R., T. N. Pearsons, and T. W. Maitland. 2010. Estimating the spawning escapement of hatchery- and natural-origin spring Chinook Salmon using redd and carcass data. North American Journal of Fisheries Management 30:361-375.

Naiman, R. J., J. R. Alldredge, D. A. Beauchamp, P. A. Bisson, J. Congleton, C. J. Henny, N. Huntly, R. Lamberson, C. Levings, E. N. Merrill, W. G. Pearcy, B. E. Riemann, G. T. Ruggerone, D. Scarnecchia, P. E. Smouse, and C. C. Wood. 2012. Developing a broader scientific foundation for river restoration: Columbia River food webs. PNAS 1-7. Online at: www.pnas.org/cgi/doi/10.1073/pnas.1213408109

Nugent, J. and C. Lindsey. 2014. Hanford Reach Fall Chinook Redd Monitoring Report for Calendar Year 2013, HNF 56707, Rev. 0, Prepared by Mission Support Alliance for the U.S. Department of Energy, Richland, Washington. Online at: http://www.hanford.gov/files.cfm/HNF-56707 - Rev 00 NC.pdf

Oldenburg, E.W., B.J. Goodman, G.A. McMichael, and R.B. Langshaw. 2012. Forms of Production Loss During the Early Life History of Fall Chinook Salmon in the Hanford Reach of the Columbia River. Prepared for the Public Utility District No. 2 of Grant County, Ephrata, WA. Contract Number 430-2464.

Pearsons, T. N., A. R. Murdoch, G. Mackey, K. G. Murdoch, T. W. Hillman, M. R. Cooper, and J. L. Miller. 2012. Ecological risk assessment of multiple hatchery programs in the upper Columbia watershed using Delphi and modeling approaches. Environmental Biology of Fishes 94:87-100. DOI 10.1007/s10641-011-9884-1.

Pearsons, T. N. and C. A. Busack. 2012. PCD Risk 1: A tool for assessing and reducing ecological risks of hatchery operations in freshwater. Environmental Biology of Fishes 94:45-65. DOI:10.1007/s10641-011-9926-8.

Pearsons, T. N., and C. W. Hopley. 1999. A practical approach for assessing ecological risks associated with fish stocking programs. Fisheries 24(9):16-23.

Pearsons, T. N., and R. B. Langshaw. 2009. Monitoring and evaluation plan for Grant PUDs Salmon and steelhead supplementation Programs. Grant PUD, Ephrata, Washington.

PSC (Pacific Salmon Commission). 2013. 2013 Exploitation Rate Analysis and Model Calibration - Volume One. A report of the Pacific Salmon Commission Joint Chinook Technical Committee. Technical Report (14)-1 V.1

.

Appendix A
Summary of Monitoring and Evaluation of Performance Indicators

This section describes how the "Performance Indicators" listed will be monitored. Results of "Performance Indicator" monitoring is evaluated annually and used to adaptively manage the Priest Rapids Hatchery URB fall Chinook salmon program to meet "Performance Standards." An outline of the objectives, hypotheses, measured and derived variables, and field methods that will be used to collect data are presented below.

Objective 1: Determine if the Priest Rapids Hatchery program has affected abundance and productivity of the Hanford Reach Population.

- Ho1.1: The annual number of hatchery produced fish that spawn naturally is less than or equal to the number of naturally and hatchery produced fish taken for broodstock.

- Ho1.2: The annual change in the number of naturally spawning fish is less than or equal to the annual change observed in the reference condition (e.g., standard to be developed by HSC).

- Ho1.3: The annual change in the number of naturally produced adults is less than or equal to the annual change observed in the reference condition (e.g., standard to be developed by HSC).

- Ho1.4: The annual change in the NRR is less than or equal to the annual change observed in the reference condition (e.g., standard to be developed by HSC).

- Ho1.5: The productivity of the natural spawning population is not influenced by the % hatchery origin fish on the spawning grounds

- Ho1.6: The juveniles/parent of the supplemented condition ≤ juveniles/parent of the reference condition (e.g., standard)

- Ho1.7: The relationship between proportion of HOS and juveniles/parent is ≤ 1.

- Ho1.8: The slope of Ln (juveniles/redd vs redds) of the supplemented condition ≤ Slope of Ln (juveniles/redd vs redds) of the reference condition. (conduct only if suitable reference can be found)

Measured and Derived Variables:

- Number of hatchery and naturally produced fish on the Hanford Reach spawning grounds annually
- Number of hatchery and naturally produced fish removed for broodstock annually
- Number of hatchery and naturally produced fish harvested
- Number of spawning fall Chinook salmon in the Hanford Reach
- Number of natural origin juveniles in the Hanford Reach

Methods that will be used to collect data

- Redd surveys, adult counts at dams, carcass surveys, Priest Rapids Hatchery trap sampling, hatchery spawning sampling, harvest sampling, juvenile marking and tagging

Objective 2: Determine if the run timing, spawn timing, and spawning distribution of both the natural and Priest Rapids Hatchery components of the Hanford Reach population are similar.

- Ho2.1: Migration timing Hatchery = Migration timing Naturally produced

- Ho2.2: Spawn timing Hatchery = Spawn timing Naturally produced

- Ho2.3: Spawner distribution Hatchery = Spawner distribution Naturally produced

Measured and Derived Variables:

- o Ages of PR Hatchery and Hanford Reach produced fish sampled via PIT tags or stock assessment monitoring
- o Time (ordinal date) of arrival at Bonneville, The Dalles, John Day, McNary and Priest Rapids Dams
- o Time (ordinal date) of PR Hatchery and Hanford Reach produced female salmon carcasses observed on spawning grounds within defined reaches
- o Time (ordinal date) of ripeness of fall Chinook salmon captured for broodstock
- o Average daily temperature of fish holding water
- o Location (GPS coordinate) of female salmon carcasses observed on spawning grounds. (The distribution of hatchery and naturally produced redds may be evaluated if marking or tagging efforts provide reasonable results)

Methods that will be used to collect data:

- Adult counts at dams, carcass surveys, Priest Rapids Hatchery trap sampling, hatchery spawning sampling, harvest sampling, juvenile marking and tagging

Objective 3: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the Priest Rapids Hatchery program. Additionally, determine if Priest Rapids Hatchery programs have caused changes in phenotypic characteristics of the Hanford Reach population.

- Ho3.1: Allele frequency Hatchery = Allele frequency Naturally produced = Allele frequency Donor pop

- Ho3.2: Age at Maturity Hatchery = Age at Maturity Naturally produced

- Ho3.3: Size at Maturity Hatchery = Size at Maturity Naturally produced

- Ho3.4: Effective population size time x = Effective population size time y

Measured and Derived Variables:

- Microsatellite genotypes
- Size (length), age, and gender of PR Hatchery and Hanford Reach produced salmon carcasses collected on spawning grounds
- Size (length), age, and gender of PR Hatchery broodstock
- Size (length), age, and gender of fish at stock assessment locations (e.g., Priest Rapids Dam)

Methods that will be used to collect data:

- Adult counts at dams, carcass surveys, Priest Rapids Hatchery trap sampling, hatchery spawning sampling, juvenile marking and tagging

Objective 4: Determine if the Priest Rapids Hatchery adult-to-adult survival (i.e., hatchery replacement rate) is greater than the Hanford Reach adult-to-adult survival (i.e., natural replacement rate) and equal to or greater than the program specific hatchery replacement rate (HRR) expected value based on survival rates listed in the BAMP (1998).

- Ho4.1: HRR Year x ≤ NRR Year x

- Ho4.2: HRR ≤ Expected value per assumptions in BAMP

Measured and Derived Variables:

- Number of PR Hatchery and Hanford Reach fish on spawning grounds
- Number of PR Hatchery and Hanford Reach fish harvested
- Number of PR Hatchery and Hanford Reach fish collected for broodstock
- Number of broodstock used by brood year (PR Hatchery and Hanford Reach fish)

Methods that will be used to collect data:

- Redd surveys, adult counts at dams, carcass surveys, Priest Rapids Hatchery trap sampling, hatchery spawning sampling, harvest sampling, juvenile marking and tagging

Objective 5: Determine if the stray rate of Priest Rapids Hatchery fish is below the acceptable levels to maintain genetic variation between stocks.

- Ho5.1: Stray rate Hatchery fish < 5% of total brood return

- Ho5.2: Stray hatchery fish < 5% of spawning escapement of other independent populations[1]

- Ho5.3: Stray hatchery fish < 10% of spawning escapement of any non-target streams within independent population[1]

[1] This stray rate is suggested based on a literature review and recommendations by the ICBTRT. It can be re-evaluated as more information on naturally-produced Upper Columbia Salmonids becomes available. This will be evaluated on a species and program-specific basis and decisions made by the PRCC HSC. It is important to understand the actual spawner composition of the population to determine the potential effect of straying.

Measured and Derived Variables:

- o Number and percent of PR Hatchery carcasses found in non-target and target spawning areas
- o Number and percent of PR Hatchery fish collected for broodstock.
- o Number and percent of PR Hatchery fish taken in fishery.
- o Number and percent of PR Hatchery carcasses found in non-target and target spawning aggregates.

Methods that will be used to collect data:

- Carcass surveys, Priest Rapids Hatchery trap sampling, hatchery spawning sampling, harvest sampling, juvenile marking and tagging, sampling at fish ladder trap

Objective 6: Determine if Priest Rapids Hatchery fish were released at the programmed size and number.

- Ho6.1: Hatchery fish Size = Programmed Size

- Ho6.2: Hatchery fish Number = Programmed Number

Measured and Derived Variables:

- o Length and weights of random samples of hatchery smolts.
- o Numbers of smolts released from the PR Hatchery.

Methods that will be used to collect data

- Sampling of juveniles in hatchery, juvenile marking and tagging

Objective 7: Determine if harvest opportunities have been provided using Priest Rapids Hatchery returning adults.

- Ho 7.1: Number of harvested Priest Rapids Hatchery fish > 0

Measured and Derived Variables:

- o Numbers of PR Hatchery fish sampled in all sport and commercial harvest.
- o Total harvest by fishery estimated from expansion analysis.

Methods that will be used to collect data:

- Harvest sampling (CWT collection from harvest, analysis of PRH Chinook from ocean and lower Columbia commercial and tribal harvest), juvenile marking and tagging

Objective 8: Determine if the Priest Rapids Hatchery has increased pathogen type and/or prevalence in the Hanford Reach population.

- Ho8.1: Pathogen index z supplemented population Time x = Pathogen index supplemented population Time y

- Ho8.2: Hatchery disease Year x = Hatchery disease Year y

Measured and Derived Variables:

- Incidence of disease in PR Hatchery juveniles and adults.
- Incidence of disease in Hanford Reach produced juveniles and adults.
- Evaluation of impacts to incidence of disease may require use of a reference population and/or controlled experiments. The above parameters would also be required for reference populations used to evaluate impacts from disease.

Methods that will be used to collect data:

- Sampling of adults and juveniles at Priest Rapids Hatchery

Objective 9: Determine if ecological interactions attributed to Priest Rapids Hatchery fish affect the distribution, abundance, and/or size of non target taxa of concern that were deemed to be at sufficient risk

- Ho9.1: NTTOC abundance Year x through y = NTTOC abundance Year y through z

- Ho9.2: NTTOC distribution Year x through y = NTTOC distribution Year y through z

- Ho9.3: NTTOC size Year x through y = NTTOC size Year y through z

Measured and Derived Variables:

- Ecological risk assessment for Hanford Reach NTTOC
- Containment objectives
- Distribution, abundance, and/or size of NTTO

Appendix B
Methods and considerations for selecting otolith sub-samples associated with Priest Rapids Hatchery Monitoring and Evaluation

Introduction:

Similar to most sampling programs, the PRH M&E program attempted to strike an appropriate balance between technical rigor, logistics, and financial investment when setting sample size targets. A multi-stage approach was used to collect biological samples with sufficient accuracy and precision. In general, we attempted to oversample the raw samples such as carcasses and trap recoveries and then use post season analysis to determine if sub-sampling otoliths was appropriate (Table 1). The sample size target of systematic field sampling is 2,500 of the carcasses in the Hanford Reach, 1,000 at the hatchery trap, and 1,000 of the hatchery volunteer broodstock, and all broodstock collected from other sources such as OLAFT and ABC.

Table 1, Fall Chinook salmon otoliths taken and sub-sampled for estimating M&E variables in the Hanford Reach and at Priest Rapids Hatchery, 2013.

	Hatchery Surveys				Stream Surveys				
	PRH Surplus & Mortalities	PRH Spawn	OLAFT spawn	ABC spawn	HR Sport Fishery	HR Stream	Priest Pool	Hatchery Discharge Channel	Totals
Population	37,355	4,476	763	397	27,630	174,841	59,039	264	304,765
Sampled	1,733	1,125	763	397	684	2,150	98	264	7,214
Population Sampled	4.6%	25.1%	100.0%	100.0%	2.5%	1.2%	0.2%	100.0%	2.37%
Otolith (n=)	1,403	880	752	378	564	1,999	82	28	6,086
Otoliths Submitted	495	431	202	378	0	1263	82	28	2,879
Population Submitted	1.3%	9.6%	26.5%	95.2%	0.0%	0.5%	0.1%	10.6%	0.94%

PRH otolith marked all fish release from PRH since brood year 2007. Otoliths have been collected since return year 2010; when only age-3 fish possessed an otolith mark. Age-4 otolith data is available for return year 2011 and 2012. Age-5 otolith data is available for return year 2012.

Estimating pNOB and pHOS from the refined sample sizes requires expanding the results from the otolith data by the total estimated collection by age and gender in order to weight and pool the origin data by age and gender class for each collection source (e.g., Hanford Reach Stream Survey, Priest Rapids volunteer returns, and combined Priest Rapids broodstock).

The goal of this appendix is to present methods to refine the minimum sample size of otoliths collected from Priest Rapids Hatchery (PRH) monitoring and evaluation samples to be submitted for decoding while maintaining acceptable precision for estimates of pNOB, pHOS, as well as age at maturity, size at age, and gender ratios by origin.

Methods:

We used a multi-staged approach to refine sample sizes. First, we attempted to systematically (e.g., 1 in 10; based upon expected run sizes) oversample the number of fish in the M&E surveys and collect age and gender information from these fish. Second, we submitted scale samples of all the systematically sampled fish and obtained ages for each gender. Third, we determined a minimum sample size to estimate the population for each age, gender, or combined population. Fourth, we submitted a random sample of otoliths for decoding that represented each age by gender or for an entire sample where appropriate. In some cases, such as rare age classes (e.g., age 5 or 6), all samples were submitted for decoding because they were below the target sample size.

The remainder of this appendix addresses stage 3 and 4 of the multi-stage approach described above. The intent of the third stage was to select the minimum sample size that would approximate the estimate generated from a much larger sample size (i.e., the population). Previous year's data were plotted to determine the differences between the proportion of Priest Rapids Hatchery origin fish (PPF) as the cumulative sub-sample size increases and the PPF for the entire cumulative sample (Figure 1). To obtain these difference values, the data were organized by age and gender class and then randomized within each class using Micro Soft Excel to assign a random number to each fish within the class. The PPF for each cumulative sub-sample was calculated and compared to the overall sample PPF. The differences were then plotted to show the relationship between sub-sample size and difference.

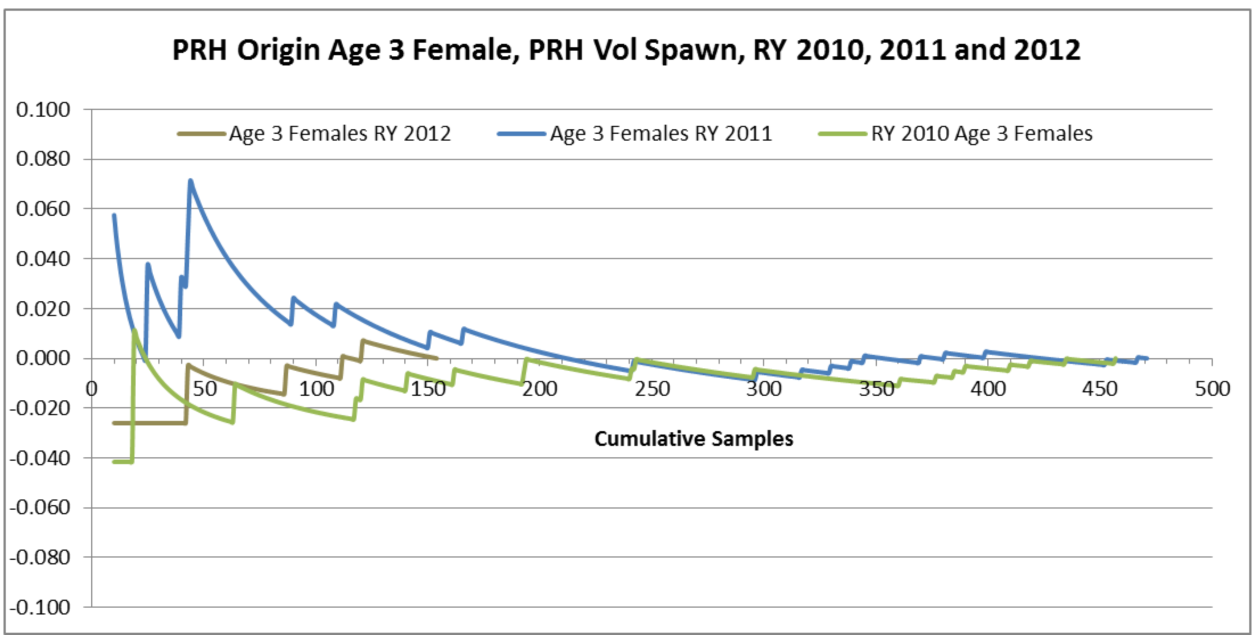

Figure 1. Example of sample size refinement by charting the differences in the proportion of Priest Rapids origin fish of cumulative sub-samples and the total sample.

The calculated estimates for pHOS and pNOB for different surveys (e.g., Hanford Reach stream survey, broodstock spawned from OLAFT, ABC and PRH Volunteer trap) employed similar methods. The exception being that the pNOB estimate required an additional step to pool weighted data from the three sources of broodstock.

The proportion of natural and hatchery origin fish for each age and gender class by survey was calculated from the results of the bolstered sub-sample data. Each sub-sample was bolstered by including coded-wire tagged fish recovered in the systematic biological sample from which the stratified random sample for otoliths was taken. For example, at an overall 20% coded-wire tag rate, we would expect to pull 120 sub-samples to reach a target of 100 otolith samples (Table 1). Since we can determine the origin of the coded-wire tagged fish, the effective sub-sample for origin is 120 fish.

Table 1, Sub-Sample sizes for 2013 returns to Priest Rapids Hatchery by age and gender for the broodstock and surplus/mortalities to determine pNOB, age and size at maturity, and gender ratios for Priest Rapids Hatchery origin fish.

Number of age and gender sub-sampled from the broodstock (includes Otolith and CWT fish)

Ages	Female	Male	Total
Age - 3	155	143	298
Age - 4	136	80	216
Age - 5	2	0	2
Total	293	223	516

Number of otoliths by age and gender sub-sampled from the broodstock

Ages	Female	Male	Total
Age - 3	122	120	242
Age - 4	120	74	194
Age - 5	2	0	2
Total	244	194	438

Number of age and gender sub-sampled from surplus and mortality (Includes Otolith and CWT fish)

Ages	Female	Male	Total
Age - 2	0	118	118
Age - 3	137	139	276
Age - 4	90	135	225
Age - 5	1	0	1
Total	228	392	620

Number of otoliths by age and gender sub-submitted from surplus and mortality

Ages	Female	Male	Total
Age - 2	0	98	98
Age - 3	110	110	220
Age - 4	74	110	184
Age - 5	1	0	1
Total	185	318	503

The estimated numbers of natural and hatchery origin recruits by age and gender were calculated by multiplying the proportion for each age and gender of natural and hatchery origin recruits within the sub-sample by the total estimated recruits by age and gender comprising the survey population. The estimated numbers of fish by age and gender comprising the survey populations at the hatchery were derived from the systematic biological samples. For example, all fish recovered in hatchery surveys are enumerated as females, males, or jacks. The population age composition for males and females is calculated from the age composition for males and females comprising the systematic biological sample. In the case of the Hanford Reach escapement, the age composition of the survey population is derived from the annual Hanford Reach escapement estimate calculated by the WDFW District 4 Fish and Wildlife Biologist. The adults in this escapement estimate are multiplied by the age and gender composition from the systematic biological sample for the Hanford Reach stream survey to provide an age composition by gender for the entire survey population.

The example in Table 2 shows the calculations for the PRH volunteer return broodstock pNOB estimate.

The pooled estimate for the pNOB at PRH was calculated by combining the estimated NOB for each survey and dividing it by the sum of the total number of fish for the combined broodstock surveys at shown in Table 3. A similar method was used to calculate the proportion of natural and hatchery origin fish comprising the volunteer returns to the PRH volunteer trap.

Results and Discussion:

The acceptable level of difference for the origin based on otolith sub-samples was set at approximately ±2% rather than the more commonly used 5%. This more conservative value was selected because it tended to reflect the asymptotic difference that was observed in sample size (Figures 2-6). It appears that the ±2% difference was generally reached for samples of 100 fish regardless of the PPF in the sample (Figures 2 - 6). In addition, the differences for all age/gender combined generally dropped below ±2% at n>100 fish samples; differences were driven by the dominant age/gender class. Sample size refinement by age and gender is limited to the broodstock groups shown in Figures 2 – 6 due to a limited otolith samples (i.e., n<100) collected from other age and gender classes.

The multi-stage approach to sample size selection provides a logical approach to balancing multiple sampling objectives. Perhaps the most significant limiting factor to this approach is being able to achieve robust sample sizes for certain variables such as size-at-age for rare age-classes (e.g., age 6 fish). This is largely a result of collecting systematic samples and is not the result of decoding too few otoliths. However, other variables such as pNOB and pHOS should not be influenced strongly from the stage 1 limitation because rare age classes will not have a strong influence on population metrics.

Annual estimates will be analyzed every five years to determine the performance of the hatchery programs. Estimates of the true mean will be made by analyzing the annual estimates (e.g., mean). The variance of most import is the variance between years. The multi-stage approach presented in this appendix should provide reasonable estimates of precision.

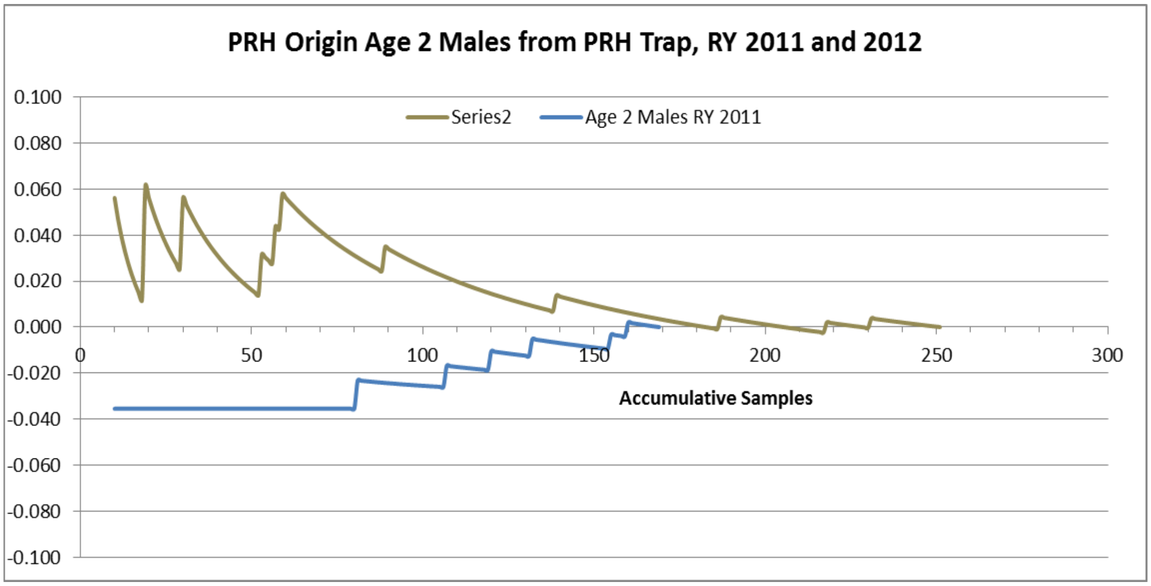

Figure 2, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 2 males sample at the Priest Rapids Hatchery Volunteer Trap during return year 2011 and 2012

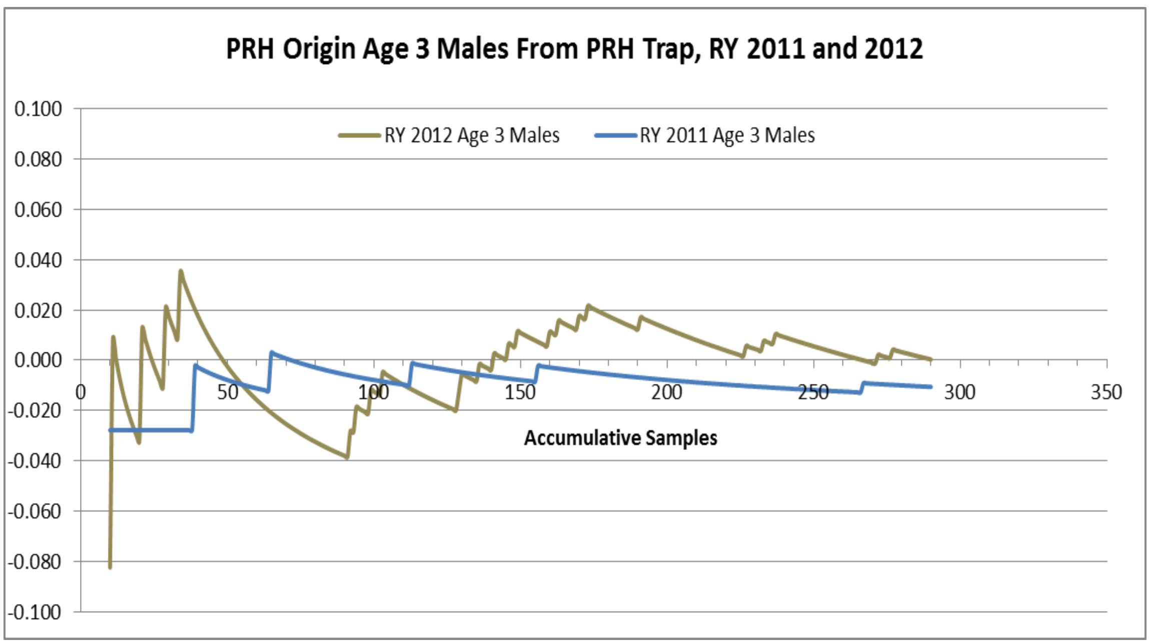

Figure 3, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 3 males sample at the Priest Rapids Hatchery Volunteer Trap during return year 2011 and 2012

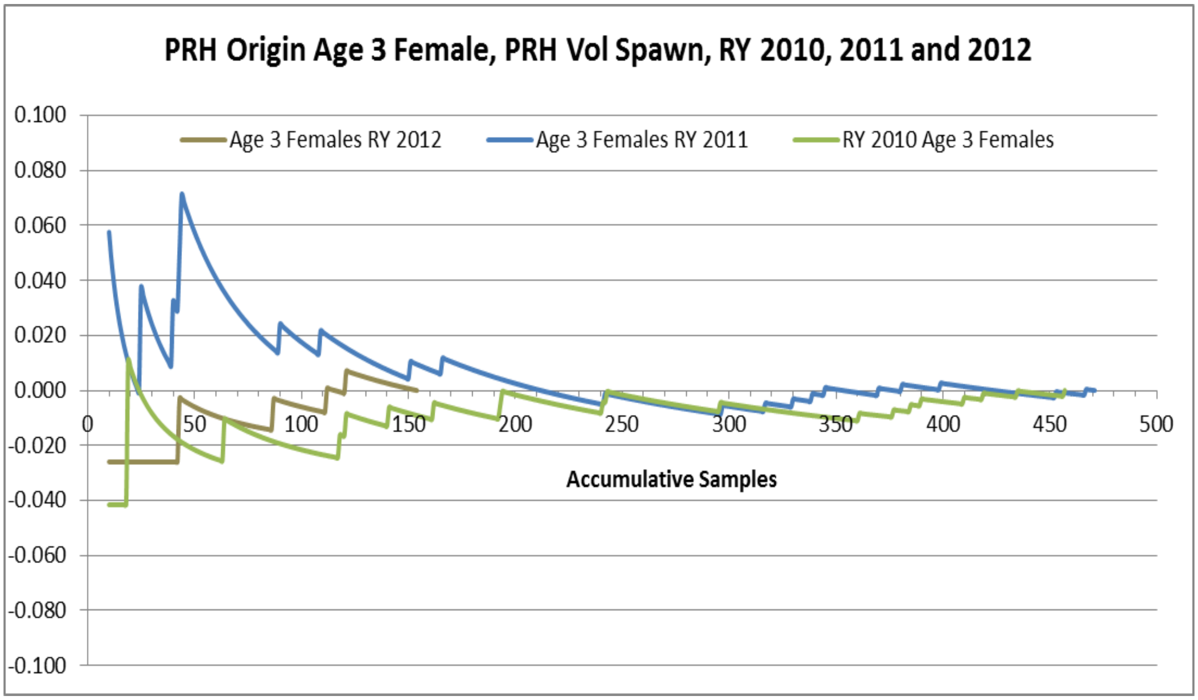

Figure 4, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 3 females sample at the Priest Rapids Hatchery Volunteer Spawn during return years 2010, 2011 and 2012

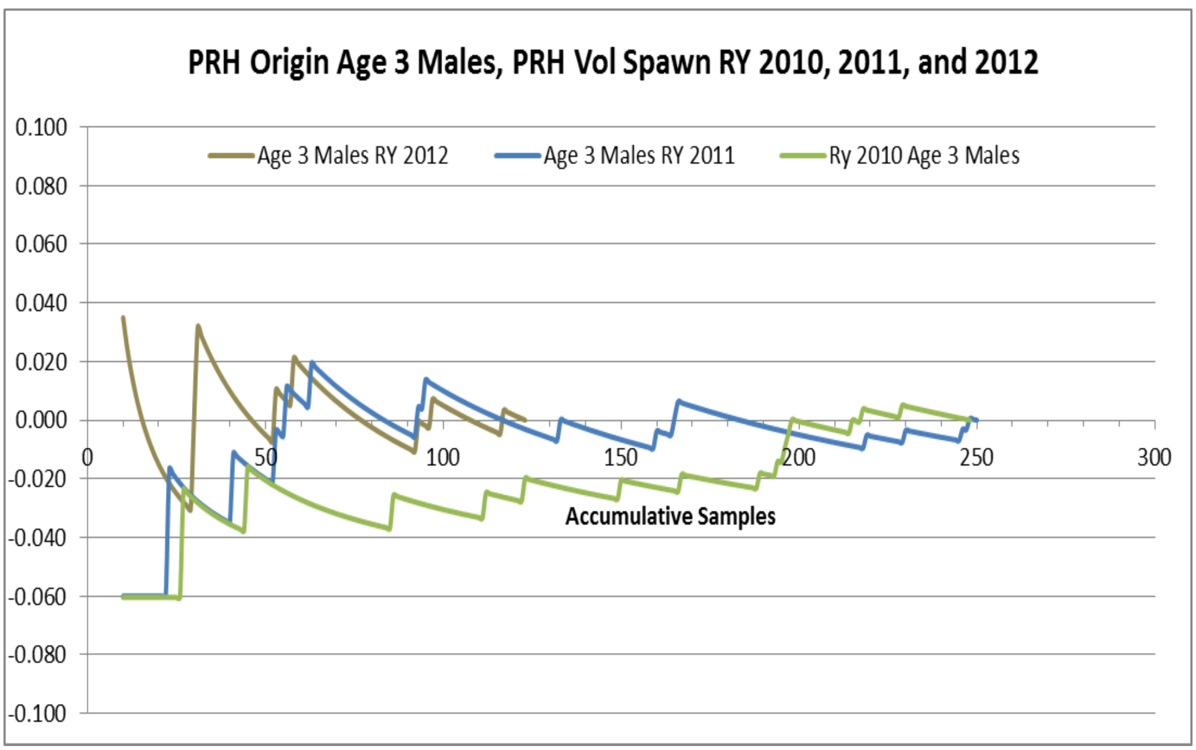

Figure 5, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 3 males sample at the Priest Rapids Hatchery Volunteer Spawn during return year 2010, 2011 and 2012

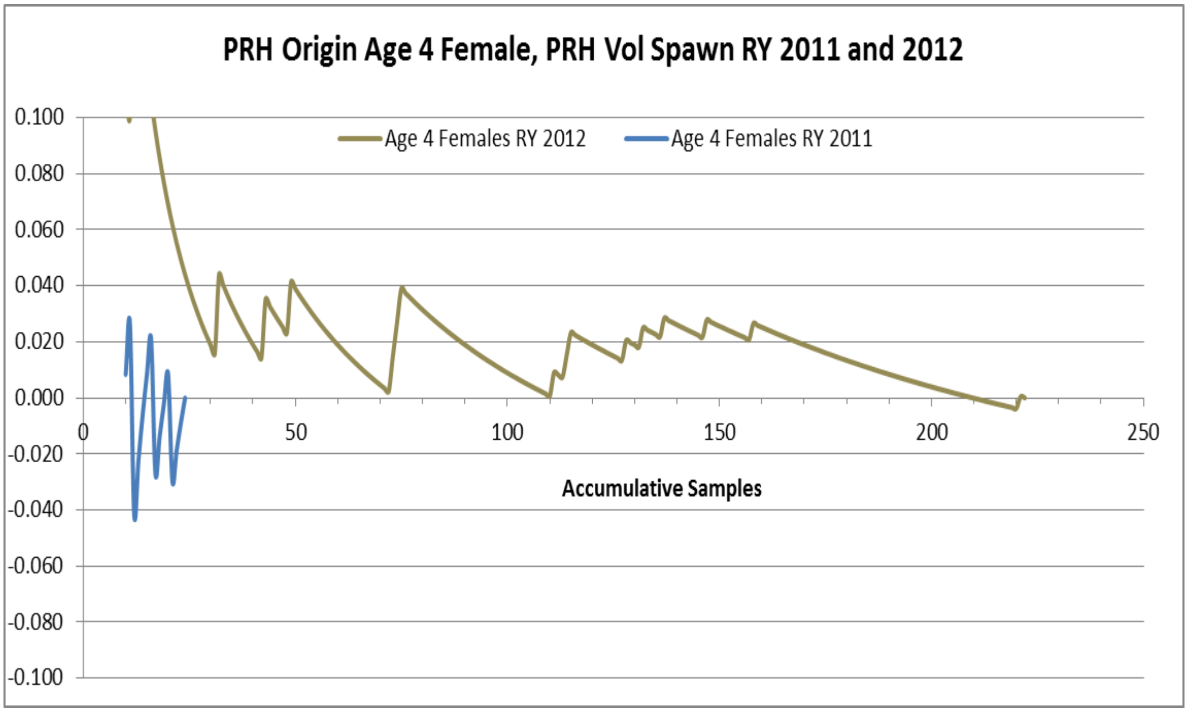

Figure 6, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 4 females sample at the Priest Rapids Hatchery Volunteer Trap during return year 2011 and 2012

Table 2. Example for estimating pNOB from sub-sample data collected for the Priest Rapids volunteer broodstock, return year 2013

Results for Priest Rapids Hatchery bolstered otolith sub-sample

	Female			Male			
Origin	3/1	4/1	5/1	2/1	3/1	4/1	5/1
Sub-Sample NOB results	1	4	0	0	3	3	0
Sub-Sample HOB results	154	128	2	2	135	76	0
Total Fish sub-sampled	155	132	2	2	138	79	0
Sub-Sample pNOB = NOB / Total Fish sub-sampled	0.006	0.030	0.000	0.000	0.022	0.038	0.000
Sub-Sample pHOB = HOB / Total Fish sub-sampled	0.994	0.970	1.000	1.000	0.978	0.962	0.000

Estimated Priest Rapids volunteer broodstock by age and gender

Ages	3/1	4/1	5/1	2/1	3/1	4/1	5/1	Total
Spawned	2,019	1,210	8	2	895	342	0	4,476
Estimated NOB = Sub-Sample pNOB x Spawned	13	37	0	0	19	13	0	82
Estimated HOB = Sub-sample pHOB x Spawned	2,006	1,173	8	2	876	329	0	4,394
pNOB = Estimated HOB / Spawned	0.006	0.030	0.000	0.000	0.022	0.038	0.000	0.018
pHOB = Estimated NOB /Total Spawned	0.994	0.970	1.000	1.000	0.978	0.962	0.000	0.982

Table 3, Combined estimate for pNOB based on pooled expanded (weighted) sub-samples from the ABC, OLAFT, and Priest Rapids volunteer broodstock, return year 2013.

ABC pNOB (The entire broodstock sampled, no need to expand data)

	Female			Male				Total
Age	3/1	4/1	5/1	2/1	3/1	4/1	5/1	
Spawned	17	62	3	0	151	58	2	293
NOB	2	57	3	0	119	54	2	237
HOB	15	5	0	0	32	4	0	56
ABC pNOB	0.118	0.919	1.000	0.000	0.788	0.931	1.000	0.809

OLAFT Sample pNOB expanded to the total OLAFT broodstock

	Female			Male				Total
Age	3/1	4/1	5/1	2/1	3/1	4/1	5/1	
Spawned	64	176	16	1	281	114	6	658
Est NOB	19	101	16	0	132	90	4	362
Est HOB	45	75	0	1	149	24	2	296
OLAFT pNOB	0.294	0.574	1.000	0.470	0.788	0.667	0.578	0.554

PRH Volunteer Sample pNOB expanded to the total PRH volunteer broodstock

	Female			Male				Total
Age	3/1	4/1	5/1	2/1	3/1	4/1	5/1	
Spawned	2,019	1,210	8	2	895	342	0	4,476
Est NOB	13	37	0	0.000	19	13	0	82
Est HOB	2,006	1,173	8	2	876	329	0	4,394
PRH Vol. pNOB	0.006	0.031	0.000	0.000	0.021	0.038	0.000	0.018

pNOB for all combined sources of broodstock spawned at PRH

	Female			Male				Total
Age	3/1	4/1	5/1	2/1	3/1	4/1	5/1	
Total Spawned	2,100	1,448	27	3	1,327	514	8	5,427
Est Total NOB	34	195	19	0	270	157	6	681
Est Total HOB	2,066	1,253	8	3	1,057	357	2	4,746
Combined pNOB	0.016	0.135	0.704	0.000	0.203	0.305	0.750	**0.125**

Appendix C

Recovery of coded-wire tags collected from Chinook salmon spawned at Priest Rapids Hatchery during return year 2013.

Priest Rapids Volunteer Broodstock														
Code	Tags (#)	Brood Year	Run	Age	Stock	Release Location	CWT Release			Expansion Factors			Total in Spawn	% of Spawn
							Date	ADCWT	CWT Only	All CWT	ADCWT	AD Only		
090324	1	2009	Fall	4	Priest Rapids	CR@Ringold	2010	203,024		16.7	16.7	16.5	**17**	2.2%
090328	2	2008	Fall	5	Umatilla Hatchery	Umatilla R.	2010	157,373		1.0	1.0	1.0	**2**	0.3%
090356	1	2009	Fall	4	Umatilla R.	Umatilla R.	2011	193,722		1.0	1.0	1.0	**1**	0.1%
090433	1	2010	Fall	3	Umatilla Hatchery	Umatilla R.	2011	138,055		1.0	1.0	1.0	**1**	0.1%
090434	1	2010	Fall	3	Umatilla Hatchery	Umatilla R.	2011	138,007		1.0	1.0	1.0	**1**	0.1%
090488	4	2010	Fall	3	Priest Rapids	CR@Ringold	2011	222,916		15.6	15.7	15.6	**62**	8.1%
610433	1	2009	Fall	3	Hanford URB Wild	Hanford Reach	2010	57,255		N/A	N/A	N/A	**1**	0.1%
634799	1	2008	Fall	5	Priest Rapids	CR@Priest Rapids	2009	216,137		31.4	31.4	8.9	**31**	4.1%
635274	23	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	99,800	0	4.0	11.3	3.8	**91**	11.9%
635290	28	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		207,185	4.1	10.9	20.5	**115**	15.0%
635294	23	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		205,892	4.1	10.9	3.8	**95**	12.3%
635484	18	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010	207,184		4.1	10.9	3.8	**74**	9.6%
635485	17	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010	207,314		4.1	10.9	3.8	**70**	9.1%
635486	27	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		206,523	4.1	10.9	3.8	**111**	14.5%
635487	38	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		221,057	4.1	10.9	3.8	**156**	20.4%
635488	29	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010	205,096		4.1	10.9	3.8	**119**	15.5%
635489	27	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		185,948	4.1	10.9	3.8	**111**	14.5%
635699	55	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	203,682	409	4.0	11.3	3.8	**218**	28.4%
635764	59	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	199,698	401	4.0	11.3	3.8	**234**	30.5%
635766	88	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		204,091	4.0	11.3	3.8	**350**	45.5%
635970	37	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	199,200	400	4.0	11.3	3.8	**147**	19.1%
635971	78	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		204,590	4.0	11.3	3.8	**310**	40.3%
635972	74	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		199,600	4.0	11.3	3.8	**294**	38.3%
635973	70	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		200,099	4.0	11.3	3.8	**278**	36.2%
635974	65	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		99,800	4.0	11.3	3.8	**258**	33.6%
Total	**768**	**4,476 Sampled in Priest Rapids Volunteer Spawn**											**3,149**	70.4%

Angler Broodstock Collection														
Code	**Tags (#)**	**Brood Year**	**Run**	**Age**	**Stock**	**Release Location**	**CWT Release**			**Expansion Factors**			**Total in Spawn**	**% of Spawn**
							Date	**ADCWT**	**CWT Only**	**All CWT**	**ADCWT**	**AD Only**		
635489	1	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		185948	4.1	10.9	3.8	**4.1**	1.0%
635274	1	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	99,800	0	4.0	11.3	3.8	**4**	1.0%
635699	1	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	203,682	409	4.0	11.3	3.8	**4**	1.0%
635764	1	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	199,698	401	4.0	11.3	3.8	**4**	1.0%
635766	3	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		204091	4.0	11.3	3.8	**12**	3.0%
635971	5	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		204590	4.0	11.3	3.8	**20**	5.0%
635972	2	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		199600	4.0	11.3	3.8	**8**	2.0%
635973	2	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		200099	4.0	11.3	3.8	**8**	2.0%
Total	16		397				Sampled in ABC						**64.1**	16.1%

Appendix D

Recovery of coded-wire tags collected from adult Chinook salmon surplus or mortalities from Priest Rapids hatchery during return year 2013.

Code	Tags (#)	Brood Year	Run	Age	Stock	Release Location	CWT Release			Expansion Factors			Total in Return	% of Harvest
							Date	ADCWT	CWT Only	All CWT	ADCWT	AD Only		
610436	1	2010	Fall	3	Hanford URB Wild	Hanford Reach	2011	42,120		N/A	N/A	N/A	**1**	0.00%
610437	1	2010	Fall	3	Hanford URB Wild	Hanford Reach	2011	37,116		N/A	N/A	N/A	**1**	0.00%
610438	1	2010	Fall	3	Hanford URB Wild	Hanford Reach	2011	55,339		N/A	N/A	N/A	**1**	0.00%
610440	2	2010	Fall	3	Hanford URB Wild	Hanford Reach	2011	18,874	18,874	N/A	N/A	N/A	**2**	0.01%
610445	3	2011	Fall	2	Hanford URB Wild	Hanford Reach	2012	29,316	29,316	0.0	1.0	1.0	**3**	0.01%
636419	1	2011	Fall	2	L. Snake River	Grande Rhonde	2012	192,996	192,996	2.0	2.0	2.0	**2**	0.01%
054596	1	2009	Fall	4	LTL White Salmon	Little White Salmon	2010	99562	0	5.2	10.4	9.4	**5**	0.01%
090547	1	2011	Spring	2	Lostine R endemic	Lostine R	2013	68,056	68,056	2.0	2.0	2.0	**2**	0.01%
635979	1	2010	Fall	3	LTL White Salmon	Klickitat Hatchery	2011	279,128	279,128	6.4	6.4	1.0	**6**	0.02%
635289	1	2009	Fall	4	LTL White Salmon	Klickitat hatchery	2010	205,481	205,481	3.8	3.8	2.0	**4**	0.01%
635368	1	2009	Fall	4	LTL White Salmon	Klickitat hatchery	2010	243,326	243,326	3.8	3.8	2.0	**4**	0.01%
220203	2	2010	Fall	3	Lyons Ferry	Clearwater River	2011		202,265	1.7	5.1	1.0	**3**	0.01%
220202	1	2009	Fall	4	Lyons Ferry	LAPWAI	2010	99,024	99,024	1.8	4.7	1.0	**2**	0.00%
220207	1	2010	Fall	3	Lyons Ferry	Luke's Gulch	2011		99,115	1.0	2.0	1.0	**1**	0.00%
220208	1	2010	Fall	3	Lyons Ferry	Luke's Gulch	2011	101,688		1.0	2.0	1.0	**1**	0.00%
612748	1	2009	Fall	4	Lyons Ferry	Luke's Gulch AF	2010	98,220	98,220	1.0	2.0	1.0	**1**	0.00%
220215	1	2011	Fall	2	Lyons Ferry	Luke's Gulch AF	2012	0	95,710	1.0	2.1	1.0	**1**	0.00%
220205	2	2010	Fall	3	Lyons Ferry	Magrudor Corridor	2011		103,007	1.0	2.1	1.1	**2**	0.01%
220206	1	2010	Fall	3	Lyons Ferry	Magrudor Corridor	2011	96,604		1.0	2.1	1.1	**1**	0.00%
220200	1	2009	Fall	4	Lyons Ferry	NPT Hatchery	2010	99,100	99,100	1.8	5.4	1.0	**2**	0.00%
220210	1	2010	Fall	3	Lyons Ferry	NPT Hatchery	2011		201,980	1.8	5.6	1.1	**2**	0.00%
220211	1	2010	Fall	3	Lyons Ferry	NPT Hatchery	2011	0	99,907	1.5	N/A	N/A	**2**	0.00%
220325	1	2011	Fall	2	Lyons Ferry	PITT LNDG	2012	0	100,500	2.0	4.0	1.0	**2**	0.01%
220321	1	2010	Fall	3	Lyons Ferry	Capn Johns	2012	72,233	72,233	1.0	2.1	1.0	**1**	0.00%
634391	1	2007	Fall	6	Priest Rapids	CR@Priest Rapids	2008	202,568	202,568	22.5	22.5	1.0	**23**	0.06%
634799	1	2008	Fall	5	Priest Rapids	CR@Priest Rapids	2009	216,137	216,137	31.4	31.4	8.9	**31**	0.08%
635290	107	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		207,185	4.1	10.9	3.8	**441**	1.18%
635294	104	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		205,892	4.1	10.9	3.8	**428**	1.15%

635484	82	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010	207,184		4.1	10.9	3.8	**338**	0.90%
635485	127	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010	207,314		4.1	10.9	3.8	**523**	1.40%
635486	101	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		206,523	4.1	10.9	3.8	**416**	1.11%
635487	128	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		221,057	4.1	10.9	3.8	**527**	1.41%
635488	126	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010	205,096		4.1	10.9	3.8	**519**	1.39%
635489	99	2009	Fall	4	Priest Rapids	CR@Priest Rapids	2010		185,948	4.1	10.9	3.8	**408**	1.09%
635274	322	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	0	99,800	4.0	11.3	3.8	**1279**	3.42%
635699	714	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	203,682	409	4.0	11.3	3.8	**2836**	7.59%
635764	612	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	199,698	401	4.0	11.3	3.8	**2431**	6.51%
635766	728	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		204,091	4.0	11.3	3.8	**2892**	7.74%
635970	509	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011	199,200	400	4.0	11.3	3.8	**2022**	5.41%
635971	618	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		204,590	4.0	11.3	3.8	**2455**	6.57%
635972	630	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		199,600	4.0	11.3	3.8	**2502**	6.70%
635973	596	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		200,099	4.0	11.3	3.8	**2367**	6.34%

Recovery of coded-wire tags collected from adult Chinook salmon surplus or mortalities from Priest Rapids Hatchery during return year 2013.

Code	Tags (#)	Brood Year	Run	Age	Stock	Release Location	CWT Release			Expansion Factors			Total in Return	% of Harvest
							Date	ADCWT	CWT Only	All CWT	ADCWT	AD Only		
635974	573	2010	Fall	3	Priest Rapids	CR@Priest Rapids	2011		99,800	4.0	11.3	3.8	**2276**	6.09%
636371	189	2011	Fall	2	Priest Rapids	CR@Priest Rapids	2012		598,031	5.9	11.8	5.6	**1117**	2.99%
636372	161	2011	Fall	2	Priest Rapids	CR@Priest Rapids	2012	595,608		5.9	11.8	5.6	**952**	2.55%
090324	9	2009	Fall	4	Priest Rapids	CR@Ringold	2010	203,024		16.7	16.7	16.5	**151**	0.40%
090488	65	2010	Fall	3	Priest Rapids	CR@Ringold	2011	222,916		15.6	15.7	15.6	**1014**	2.71%
090570	2	2011	Fall	2	Priest Rapids	CR@Ringold	2011	194,871	194,871	17.1	17.1	17.0	**34**	0.09%
635997	1	2010	Fall	3	Snake River	Couse Creek	2011	200,942	970	1.0	1.0	1.0	**1**	0.00%
635182	2	2009	Fall	4	Snake River	Grande Rhonde	2010	197,251	197,251	2.0	2.0	1.0	**4**	0.01%
090587	2	2011	Fall	2	Snake River	Hells Canyon D	2012	200,844	273	4.0	4.0	3.9	**8**	0.02%
090447	1	2010	Fall	3	Snake River	Hells Canyon D	2011	195,414	397	3.3	3.3	3.2	**3**	0.01%
104383	1	2009	Fall	4	Snake River	Hells Canyon D.	2010	50,433	50,433	0.0	1.1	1.1	**0**	0.00%
100201	4	2011	Fall	2	Snake River	Hells Canyon D.	2012	187,146		1.1	1.1	1.1	**4**	0.01%
636418	1	2011	Fall	2	Snake River	Couse Creek	2012	195,088	658	1.0	1.0	1.0	**1**	0.00%
090329	1	2008	Fall	5	Umatilla Hatchery	Umatilla R.	2010	159,167	159,167	1.0	1.0	1.0	**1**	0.00%
090433	16	2010	Fall	3	Umatilla Hatchery	Umatilla R.	2011	138,055		1.0	1.0	1.0	**16**	0.04%

090434	16	2010	Fall	3	Umatilla Hatchery	Umatilla R.	2011	138,007		1.0	1.0	1.0	**16**	0.04%
090435	16	2010	Fall	3	Umatilla Hatchery	Umatilla R.	2011	141,332		1.0	1.0	1.0	**16**	0.04%
090436	11	2010	Fall	3	Umatilla Hatchery	Umatilla R.	2011	140,958		1.0	1.0	1.0	**11**	0.03%
090330	3	2009	Fall	4	Umatilla R.	Umatilla R.	2010	160,612	160,612	1.0	1.0	1.0	**3**	0.01%
090355	1	2009	Fall	4	Umatilla R.	Umatilla R.	2011	261,953		1.0	2.4	1.0	**1**	0.00%
090489	3	2010	Fall	3	Umatilla R.	Umatilla R.	2012	50,751	50,751	1.0	2.1	1.0	**3**	0.01%
090490	1	2010	Fall	3	Umatilla R.	Umatilla R.	2012	45,937	45,937	1.0	2.1	1.0	**1**	0.00%
090492	3	2010	Fall	3	Umatilla R.	Umatilla R.	2012	90,390	90,390	1.0	2.1	1.0	**3**	0.01%
090493	3	2010	Fall	3	Umatilla R.	Umatilla R.	2012	0	254,769	1.0	2.1	1.0	**3**	0.01%
090585	5	2011	Fall	2	Umatilla River	Umatilla River	2012	154,611	154,611	1.7	1.7	1.1	**9**	0.02%
090586	1	2011	Fall	2	Umatilla River	Umatilla River	2012	166,448	166,448	1.7	1.7	1.1	**2**	0.00%
Total	**6725**	**37,354 Sampled in Priest Rapids Hatchery Volunteer Returns Surplus and Mortalities**											**28,138**	**75.3%**

Appendix E
Juvenile fish health inspections for Priest Rapids Hatchery fall Chinook salmon.

Hatchery	Date	Species	Stock	Brood Year	Condition
Priest Rapids	02-Mar-95	CHF	Priest Rapids	1994	Healthy
Priest Rapids	31-Mar-95	CHF	Priest Rapids	1994	Digestive System Dysfunction
Priest Rapids	08-May-95	CHF	Priest Rapids	1994	Healthy
Priest Rapids	08-Jun-95	CHF	Priest Rapids	1994	Healthy
Priest Rapids	04-Mar-96	CHF	Priest Rapids	1995	Healthy
Priest Rapids	15-Apr-96	CHF	Priest Rapids	1995	Healthy
Priest Rapids	20-May-96	CHF	Priest Rapids	1995	Healthy
Priest Rapids	10-Jun-96	CHF	Priest Rapids	1995	Healthy
Priest Rapids	25-Feb-97	CHF	Priest Rapids	1996	Healthy
Priest Rapids	28-Mar-97	CHF	Priest Rapids	1996	Healthy
Priest Rapids	25-Apr-97	CHF	Priest Rapids	1996	Healthy
Priest Rapids	28-Jun-97	CHF	Priest Rapids	1996	Healthy
Priest Rapids	27-Feb-98	CHF	Priest Rapids	1997	Healthy
Priest Rapids	01-Apr-98	CHF	Priest Rapids	1997	Healthy
Priest Rapids	06-May-98	CHF	Priest Rapids	1997	Healthy
Priest Rapids	03-Jun-98	CHF	Priest Rapids	1997	Healthy
Priest Rapids	23-Feb-99	CHF	Priest Rapids	1998	Healthy
Priest Rapids	22-Mar-99	CHF	Priest Rapids	1998	Healthy
Priest Rapids	23-Apr-99	CHF	Priest Rapids	1998	Healthy
Priest Rapids	25-May-99	CHF	Priest Rapids	1998	Dropout Syndrome & Bacterial
Priest Rapids	08-Sep-99	CHF	Priest Rapids	1998	Bacterial Kidney Disease
Priest Rapids	06-Mar-00	CHF	Priest Rapids	1999	Healthy
Priest Rapids	14-Apr-00	CHF	Priest Rapids	1999	Healthy
Priest Rapids	16-May-00	CHF	Priest Rapids	1999	Healthy
Priest Rapids	12-Jun-00	CHF	Priest Rapids	1999	Healthy
Priest Rapids	23-Feb-01	CHF	Priest Rapids	2000	Healthy
Priest Rapids	05-Apr-01	CHF	Priest Rapids	2000	Healthy
Priest Rapids	07-May-01	CHF	Priest Rapids	2000	Healthy
Priest Rapids	06-Jun-01	CHF	Priest Rapids	2000	Healthy
Priest Rapids	13-Feb-02	CHF	Priest Rapids	2001	Healthy
Priest Rapids	01-Mar-02	CHF	Priest Rapids	2001	Coagulated Yolk Syndrome
Priest Rapids	22-Apr-02	CHF	Priest Rapids	2001	Healthy
Priest Rapids	10-Jun-02	CHF	Priest Rapids	2001	Healthy
Priest Rapids	07-Mar-03	CHF	Priest Rapids	2002	Healthy
Priest Rapids	15-Apr-03	CHF	Priest Rapids	2002	Healthy
Priest Rapids	02-Jun-03	CHF	Priest Rapids	2002	Healthy
Priest Rapids	01-Apr-04	CHF	Priest Rapids	2003	Healthy
Priest Rapids	06-May-04	CHF	Priest Rapids	2003	Healthy
Priest Rapids	07-Jun-04	CHF	Priest Rapids	2003	Healthy
Priest Rapids	11-Mar-05	CHF	Priest Rapids	2004	Healthy
Priest Rapids	14-Apr-05	CHF	Priest Rapids	2004	Healthy

Appendix F

Summary of aerial fall Chinook salmon redd counts in the Hanford Reach, Columbia River, Washington.

Number and percent of fall Chinook salmon redds counted in different reaches of the Columbia River, 2001-2013. Data for years 2001-2010 was provided by Pacific Northwest National Laboratory. Data for years 2011 – 2013 was provided by Environmental Assessment Services, LLC.

Location	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Islands 11-21	297	509	554	337	708	36	302	371	176	562
Islands 8-10	480	865	1,133	867	1,067	435	338	416	722	870
Near Island 7	350	280	455	415	500	873	311	360	380	457
Island 6	750	940	1,241	1,084	1,229	289	615	753	878	1,135
Island 4, 5,6	1,130	1,165	1,242	1,655	1,130	934	655	960	796	1,562
Near Island 3	460	249	475	325	345	1,305	152	230	285	244
Near Island 2	780	955	850	960	895	523	455	555	459	657
Near Island 1	35	235	270	330	255	253	47	148	160	324
Coyote	16	63	354	180	304	150	10	29	34	49
China Bar	20	25	85	75	28	52	3	35	1,090	299
Vernita Bar	1,930	2,755	2,806	2,240	1,430	1,658	1,135	1,731	16	2,658
Total	**6,248**	**8,041**	**9,465**	**8,468**	**7,891**	**6,508**	**4,023**	**5,588**	**4,996**	**8,817**
Location	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Islands 11-21	5%	6%	6%	4%	9%	1%	8%	7%	4%	6%
Islands 8-10	8%	11%	12%	10%	14%	7%	8%	7%	14%	10%
Near Island 7	6%	3%	5%	5%	6%	13%	8%	6%	8%	5%
Island 6	12%	12%	13%	13%	16%	4%	15%	13%	18%	13%
Island 4, 5, 6	18%	14%	13%	20%	14%	14%	16%	17%	16%	18%
Near Island 3	7%	3%	5%	4%	4%	20%	4%	4%	6%	3%
Near Island 2	12%	12%	9%	11%	11%	8%	11%	10%	9%	7%
Near Island 1	1%	3%	3%	4%	3%	4%	1%	3%	3%	4%
Coyote	>1%	1%	4%	2%	4%	2%	>1%	1%	1%	1%
China Bar	>1%	>1%	1%	1%	>1%	1%	>1%	1%	22%	3%
Vernita Bar	31%	34%	30%	26%	18%	25%	28%	31%	>1%	30%

Location	2011	2012	2013						Ten-Year (2003-12) Mean
Islands 11-21	676	533							**426**
Islands 8-10	814	807							**747**
Near Island 7	670	700							**512**
Island 6	1,181	1,375							**978**
Island 4, 5,6	1,524	1,195							**1,165**
Near Island 3	525	475							**436**
Near Island 2	653	528							**654**
Near Island 1	295	340							**242**
Coyote	44	29							**118**
China Bar	67	68							**180**
Vernita Bar	2,466	2,318							**1,846**
Total	**8,915**	**8,368**							**7,304**
Location	**2011**	**2012**							**Ten-Year (2003-12) Mean**
Islands 11-21	8%	6%							**6%**
Islands 8-10	9%	10%							**10%**
Near Island 7	8%	8%							**7%**
Island 6	13%	16%							**13%**
Island 4, 5, 6	17%	14%							**16%**
Near Island 3	6%	6%							**6%**
Near Island 2	7%	6%							**9%**
Near Island 1	3%	4%							**3%**
Coyote	>1%	>1%							**2%**
China Bar	1%	1%							**2%**
Vernita Bar	28%	28%							**25%**

Appendix G

Historical numbers of Chinook salmon carcasses recovered during the annual Hanford Reach fall Chinook salmon carcass survey.

Return Year	Total
1990	2,194
1991	2,519
1992	2,221
1993	3,340
1994	5,739
1995	3,914
1996	4,529
1997	5,053
1998	4,456
1999	4,412
2000	10,556
2001	6,072
2002	8,402
2003	13,573
2004	11,030
2005	8,491
2006	5,972
2007	3,115
2008	5,455
2009	5,318
2010	9,779
2011	8,391
2012	6,814
2013	13,071
Mean	**6,434**

Appendix H
Internal Management Brief for Hanford Reach PNI

Spawning Success of URB Fall Chinook in the Hanford Reach

2000 – 2013

Prepared by
Paul Hoffarth

Washington Department of Fish and Wildlife
Pasco, Washington

Hanford Reach Fall Chinook Stream Surveys

The Columbia River Coded Wire Tag Program (CRCWTP) in conjunction with the Priest Rapids and Ringold Springs Hatcheries Monitoring and Evaluation Programs conducts stream surveys of post spawn Up River Bright Fall Chinook in the Hanford Reach. This area is an integral component of the coded wire tag (CWT) recovery effort in the Columbia River. The Hanford Reach is sampled from Richland, Washington, river kilometer 538 upstream to Priest Rapids Dam, river kilometer 639, a distance of approximately 100 kilometers. Technicians sample the Hanford Reach natural spawning areas from outboard jet boats or by walking the Columbia River shorelines. Prior to 2010, the survey crew typically consisted of two boats with a two-person crew operating seven days a week. In 2010, WDFW, under the funding and cooperation from Grant County PUD and the US Army Corps of Engineers, began a robust monitoring and evaluation plan (M&E) to assess the influence of Priest Rapids Hatchery and Ringold Springs Hatchery fall Chinook releases and adult returns on the natural population of the Hanford Reach. A third boat and additional staff have been added to the stream sampling effort since 2010. Each boat surveys approximately 16 km of river per day. Carcasses are retrieved from water depths up to four meters and along shoreline areas de-watered by the daily operations of Priest Rapids Dam. The Hanford Reach fall Chinook stream survey is conducted annually from November 1 through the first week of December. The goal of the stream survey is to collect and sample 10% of the naturally spawning fall Chinook in the Hanford Reach (escapement) for coded wire tag recovery and to collect biological samples to determine age, gender, and origin of the Hanford Reach population.

All fish are visually inspected for fin clips and scanned for the presence of coded wire tags. The snout is collected from all coded wire tagged Chinook along with the biological data. Sampling of the population for run reconstruction is obtained through random, systematic design (i.e., every k^{th} fish). Data is recorded on length, gender, age (scales), origin (otolith), and spawning success (egg retention) in females for all "in-sample" fish (k^{th} fish). Over the most recent 24 years adult fall Chinook escapement in the Hanford Reach has varied from 13,887 adults (2007) to 157,484 adults (2013). The "in sample" goal was originally established at 510 to ensure that the sample size is statistically valid (Thompson 1987) but has been increased in recent years to meet the objectives of the M&E Programs.

During the past 14 years Hanford Reach stream survey crews have sampled between 7.5% and 23.4% of the estimated escapement (Table 1). Survey crews only scanned adipose clipped fall Chinook to determine the presence of coded wire tags prior to 2011. In 2011, all fish were scanned to recover CWTs. For the most recent 14 years an average of 20% of the carcasses collected during the stream surveys were sampled for run reconstruction (gender, age, and length). All “in-sample” females are sampled for egg retention (spawn success).

Table 1. Summary of annual fall chinook escapement, biological sampling, and coded wire tags recoveries from the Hanford Reach fall Chinook stream surveys, 2000 - 2012.

Year	Escapement	Carcass Recovered		Biological Samples	
		#	% of Escapement	#	% Sampled
2013	174,841	13,071	7.5%	2,150	16.4%
2012	57,715	6,810	11.2%	1,657	24.3%
2011	75,256	8,391	11.1%	2,210	26.3%
2010	87,016	9,791	11.3%	2,385	24.4%
2009	36,720	5,318	14.5%	849	16.0%
2008	29,058	5,455	23.4%	1,061	19.5%
2007	22,272	3,115	14.0%	748	24.0%
2006	51,701	5,972	11.6%	565	9.5%
2005	71,967	8,491	11.8%	2,096	24.7%
2004	87,696	11,030	12.6%	1,807	16.4%
2003	100,840	13,573	13.5%	2,227	16.4%
2002	84,509	8,402	9.9%	1,414	16.8%
2001	60,576	6,072	10.1%	1,465	24.1%
2000	47,960	10,556	22.0%	2,557	24.2%
Mean	**70,581**	**8,289**	**13.2%**	**1,657**	**20.2%**

Spawn Success

All “in-sample” females recovered during stream surveys in the Hanford Reach are dissected to determine egg retention. This provides an indication of spawn success. Eggs are not counted or weighed during this process. Egg retention is based on a rough estimate of the proportion of eggs remaining in the female, 0%, 25%, 50%, 75%, or 100%. If no eggs or minimal numbers of eggs are retained, the Chinook is recorded as 100% spawned. If all eggs are retained, the chinook is recorded as “unsuccessful”. From 2004 to 2012, spawn success averaged 98% with 97% of the female Chinook categorized as completely spawned (Table 2). Spawn success for fall Chinook in the Hanford Reach has been very high and very consistent between years ranging from 97.4% to 99.2% with a large proportion of the fish sampled having little to no egg retention.

In 2013 spawn success declined to 90% with 78% of the Chinook categorized as completely spawned. The 2013 escapement was the largest escapement to the Hanford Reach on record dating back to 1964. In addition, 28% of the fall Chinook escapement was hatchery origin that also led to an increase in the proportion of Age 3 females (24%), both atypical for the Hanford Reach population. The reduction in spawn success in 2013 was likely a combination of the two factors, high escapement and a large percentage of hatchery origin fall Chinook in the escapement.

Table 2. Annual summary of egg retention and spawning success for fall Chinook in the Hanford Reach, 2004-2013.

Year	Females Sampled	Egg Retention					Spawn Success	
		0%	25%	50%	75%	100%	No Egg Retention	Escapement
2013	685	536	90	20	16	23	78.2%	90.1%
2012	771	747	14	5	1	4	96.9%	98.6%
2011	1,264	1,203	1	52	5	3	95.2%	97.4%
2010	1,173	1,147	6	13	1	6	97.8%	98.7%
2009a	499	484	0	5	0	10	97.0%	97.5%
2008	584						na	na
2007	454	443	0	8	0	3	97.6%	98.5%
2006	352	343	0	8	0	1	97.4%	98.6%
2005	1,323	1,310		6		7	99.0%	99.2%
2004	1,176	1,151		21		4	97.9%	98.8%
Mean	828						97.3%	98.4%

[a] Prior to 2010, egg retention was only categorized as fully spawn, partial spawn, or did not spawn in the database.

Comparison of Spawning Success for Natural Origin and Hatchery Origin Fall Chinook

For brood year returns 2001 through 2012 approximately 12% of the escapement has been comprised of hatchery origin fall Chinook in the Hanford Reach, range 5.9% - 16.6%. Based on sampling of post spawn female fall Chinook carcasses in the Hanford Reach, spawning success for natural origin fall Chinook has been slightly higher than hatchery origin fall Chinook. Mean spawning success was 98.4% for natural origin fall Chinook compared to 96.9% for hatchery origin fall Chinook that spawned in the Hanford Reach. Spawning success was very high for both groups and the minor difference in spawn success could be attributed to the small sample size for hatchery origin spawners. Hatchery origin fall Chinook could only be identified by adipose clips and coded wire tags for all return years except 2012. As the majority of Priest Rapids Hatchery returns are not adipose clipped a portion of the fish identified as natural origin in the Hanford Reach may be hatchery origin. In 2012 and 2013, otoliths were collected from all "in-sample" fish to determine origin in addition to CWTs and adipose clips. All Priest Rapids Hatchery releases have been otolith marked for brood years 2007 to present.

As presented in the prior section, in 2013 there was a record escapement coupled with a two fold increase in the proportion of hatchery fall Chinook that spawned in the Hanford Reach. Spawn success was lower than typical for both hatchery and natural origin fall Chinook in 2013. Natural origin fall Chinook spawn success in 2013 was 94.5% compared to the four-year mean for 2009 through 2012 of 98.4%, range 97.5% - 98.8%. Spawn success for hatchery origin fall Chinook in 2013 averaged 81.3% declining by 16% from the four-year mean of 96.9%, range 96.2% - 98.9%.

Table 3. Comparison of spawn success of fall Chinook spawning in the Hanford Reach for natural origin and hatchery origin returns, 2009-2013.

Year	Origin	Females Sampled	Egg Retention					Spawn Success	
			0%	25%	50%	75%	100%	Escapement	No Egg Retention
2013[1]	Natural	461	392	51	9	3	6	94.5%	85.0%
	Hatchery	224	144	39	11	13	17	81.3%	64.3%
2012[a]	Natural	681	658	14	5	1	3	98.6%	96.6%
	Hatchery	90	89	0	0	0	1	98.9%	98.9%
2011	Natural	1,176	1,121	1	48	4	2	97.5%	95.3%
	Hatchery	88	82		4	1	1	95.7%	93.2%
2010	Natural	1,125	1,101	6	12	1	5	98.8%	97.9%
	Hatchery	48	46		1		1	96.9%	95.8%
Mean	Natural	787						97.6%	94.5%
	Hatchery	93						93.8%	88.9%

[a] Otoliths were used to determine origin in addition to adipose clips and CWTs

Appendix I
Historical proportion of hatchery and natural origin Chinook salmon estimated by expanded coded-wire tag recoveries collected during the fall Chinook salmon carcass surveys in the Hanford Reach.

Return Year	Origin	Total	Hatchery Origin (%)
1997	Natural	4,377	
	Hatchery	676	13.4%
1998	Natural	4,210	
	Hatchery	246	5.5%
1999	Natural	3,645	
	Hatchery	767	17.4%
2000	Natural	7,947	
	Hatchery	2,609	24.7%
2001	Natural	5,697	
	Hatchery	375	6.2%
2002	Natural	7,704	
	Hatchery	698	8.3%
2003	Natural	12,278	
	Hatchery	1,246	9.2%
2004	Natural	9,935	
	Hatchery	907	8.4%
2005	Natural	7,606	
	Hatchery	885	10.4%
2006	Natural	5,627	
	Hatchery	345	5.8%
2007	Natural	3,186	
	Hatchery	129	3.9%
2008	Natural	5,202	
	Hatchery	253	4.6%
2009	Natural	4,907	
	Hatchery	411	7.7%
2010	Natural	9,395	
	Hatchery	396	4.0%
2011	Natural	7,847	
	Hatchery	544	6.5%
2012	Natural	6,308	
	Hatchery	506	7.4%
2013	Natural	10,235	
	Hatchery	2,836	21.7%

Appendix J
Estimated escapement for fall Chinook spawning in the Priest Rapids Dam pool

2013 Hanford Reach Fall Chinook Escapement Estimate

Count Source		2013		
		Adult	Jack	Total
Adult Fish Counts	**McNary[1]**	454,991	54,367	509,358
	Wanapum[2]	91,618	7,489	99,107
	Priest Rapids[3]	260,962	18,363	279,325
	Fallback Adjustment[4]	113,231	7,968	121,199
	Ice Harbor[5]	57,850	19,133	76,983
	Prosser[6]	6,823	684	7,507
Hatcheries	Priest Rapids Hatchery	38,823	3,008	41,831
	Priest Rapids Hatchery Channel	257	7	264
	ABC	397		397
	Ringold Springs Hatchery	16,358	528	16,886
Harvest	Hanford Sport Harvest	24,921	2,709	27,630
	Yakima River Sport Harvest	2,532	352	2,884
	Wanapum Tribal Fishery	69	0	69
Escapement	Yakima River (Lower)[5]	1,936	194	2,130
	Hanford Reach + Priest Pool	213,407	20,263	233,670
	Priest Pool Return	56,113	2,906	59,019
	Hanford Reach Escapement	**157,294**	**17,356**	**174,651**

[1] McNaryDam fish counts: August 9 - October 31

[2] Wanapum Dam fish counts, August 14 through November 5

[3] Priest Rapids Dam fish counts, August 18 through November 5. Grant PUD continued counts through Nov 15 but McNary counts ended on Oct 31. Allowed 5 days to account for difference in passage timing

[4] Fallback estimate (43.4%) based on 1,025 run of the river PIT tagged fish from the BO AFF and the lower Columbia River test fishery observed at Priest Rapids Dam and Priest Rapids Hatchery PIT tag arrays

[5] Ice Harbor counts ended on Oct 31

[6] Prosser counts, August 16 through November 5

Priest Rapids Pool Escapement

Count Source	2013		
	Adult	Jack	Total
Wanapum Adult Passage[1]	88,926	5,515	94,441
Wanapum Dam Fallback Adjustment	Unknown	Unknown	Unknown
Priest Rapids Fallback Adjustment[2]	113,231	7,968	121,199
Wanapum Tribal Fishery Above PRD	406		
OLAFT	762	1	763
Priest Rapids Pool Sport Fishery	685	0	685
Total	204,010	13,484	217,088
Priest Rapids Adult Passage[3]	260,962	18,363	279,325
Priest Rapids Dam Pool Escapement	**56,952**	**4,879**	**62,237**

[1] Wanapum Dam passage for fall Chinook based on counts from August 14 through November 5.

[2] Fallback estimate based on fallback rate for 3 run of the river PIT tag groups (BO AFF, OLAFT, COLR3)

[3] Priest Rapids passage for fall Chinook based on counts from August 18 through November 15.