Priest Rapids Hatchery Monitoring and Evaluation Annual Report for 2014-15

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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 (2014-2015).

The PRH was originally built to mitigate for the construction and operation of Priest Rapids and Wanapum dams. 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 (GPUD) 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 2014 returns to PRH volunteer trap totaled a record 77,779 fall Chinook salmon, eclipsing the 2013 record returns of 41,831. A total of 6,916 fish that returned to the volunteer trap at PRH were ponded at the hatchery for broodstock. An additional 296 fish were ponded from the Angler Broodstock Collection (ABC) fishery and 951 fish were ponded from Priest Rapids Dam Off Ladder Adult Fish Trap (OLAFT) in an effort to increase the number of natural-origin broodstock. In total, 5,443 fish were spawned to meet egg take goals for multiple hatchery programs. The mortality rate of ponded adult fish was 18% which is lower than recent years. The volunteer trap was operated daily and the majority of fish removed from the trap by each afternoon. Most of the fish that were surplus to broodstock needs were provided to food-banks.

All ages of PRH origin fall Chinook salmon returning in 2014 were otolith marked. We used a combination of marks (e.g., otoliths, adipose clips, and coded-wire tags) to determine origin which is likely more accurate than the expansion of coded-wire tag recoveries using juvenile tag rates to determine origin. The hatchery origin fish appear to return at a younger age than natural origin fish. The size at maturity data for recent brood years 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 in the Hanford Reach of the Columbia River. 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 25.61 for PRH and 7.85 for fish spawning in the Hanford Reach. The adult recruitment for brood year 2008 was near the historic mean for both natural and PRH origin fish and was 8.73 and 2.73 for hatchery and natural origin fish respectively.

Hatchery origin fish released from PRH spawn throughout the Hanford Reach. The highest proportions of hatchery origin carcasses recovered were in river sections 1 and 2 which are near PRH. 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 recoveries.

PRH origin fish were estimated to make up 5.2% of the natural spawning population in the Hanford Reach during 2014. All hatchery fish combined (including fish released from Ringold Hatchery and strays from outside the Hanford Reach) comprised 9.6% of the fall Chinook salmon on the spawning grounds. Otolith recoveries at the PRH volunteer trap indicate that a very high percentage of fish returning to the PRH are of PRH origin. The proportion of natural influence (PNI) for Hanford Reach fall Chinook salmon including all hatcheries is 0.63. This value is the highest that has been estimated for the Hanford Reach in recent years and is close to the PNI target of 0.67. Additional natural origin broodstock for PRH was collected from the ABC fishery and OLAFT. These additional fish increased the proportion of natural origin broodstock from 0.045 to 0.206. Adult management of fish at the PRH volunteer trap and alternative broodstock collection techniques to increase natural origin fish in the broodstock have contributed to improvements in PNI for the PRH program.

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1.0 Introduction

The Public Utility District No. 2 of Grant County, Washington (GCPUD) 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 in large part by the GCPUD. This report describes the monitoring and evaluation of the GCPUD PRH program.

PRH also produces fish for other organizations. PRH produces and releases 1.7 million subyearling smolts on-site for the U.S. Army Corps of Engineers (USACE) John Day Mitigation. PRH collects broodstock, spawns, and incubates eggs 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 (YN) 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 Umatilla Hatchery, WDFW's Salmon in the Classroom program and to support various research projects.

A cooperative effort between Grant, Douglas, and Chelan County Public Utility Districts and Washington Department of Fish and Wildlife (WDFW) has resulted in an updated Monitoring and Evaluation Plan for PUD Hatchery Programs (Hillman et al. 2013). This document provides guiding principles and approaches for the monitoring and evaluation (M&E) of PRH. Objectives, hypotheses, measured and derived variables, and field methods that will be used to collect data are listed in this document.

This report of the GCPUD PRH M&E program encompasses data collected during fiscal year (FY) 2014 - 15 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.

Figure 1 **Location of Priest Rapids and Ringold Springs hatcheries and the Hanford Reach (indicated by stars).**

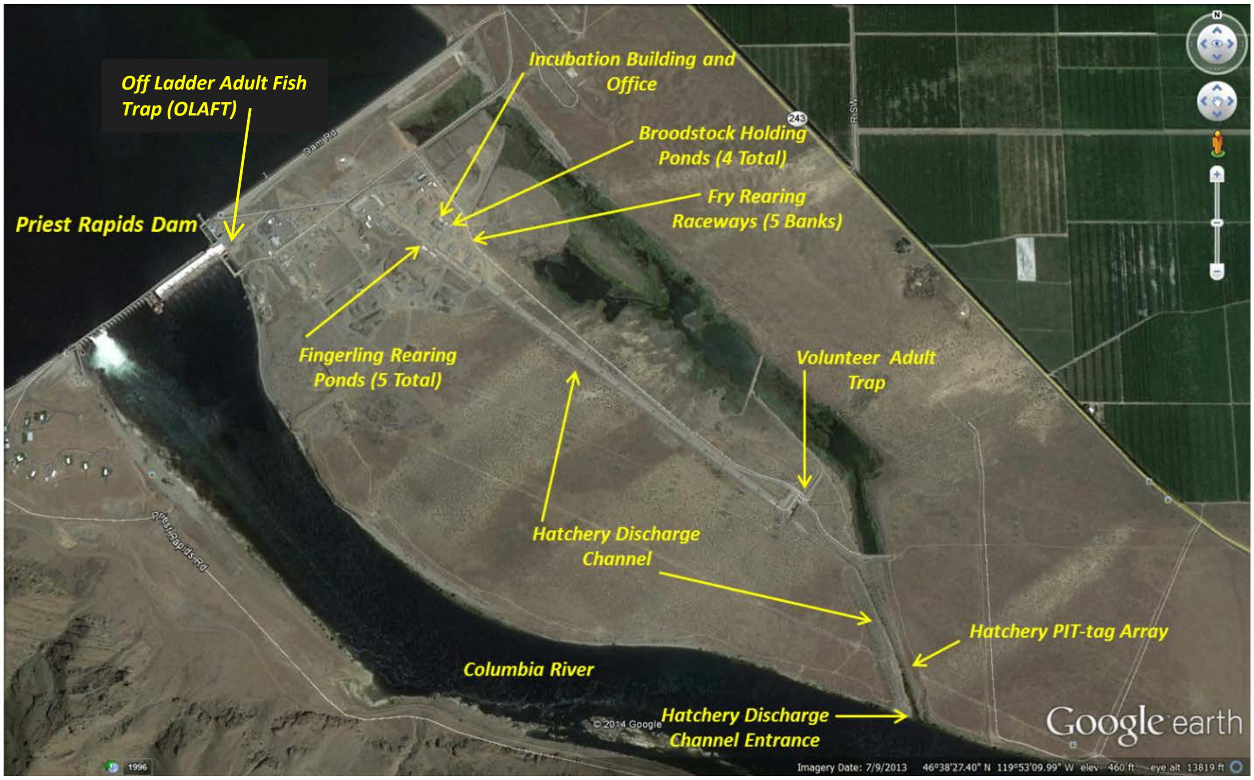

Figure 2 **Priest Rapids Hatchery facility and Priest Rapids Dam OLAFT.**

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 GCPUD'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 Priest Rapids Hatchery 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 Priest Rapids Hatchery 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 Priest Rapids Hatchery program. Additionally, determine if Priest Rapids Hatchery programs have caused changes in phenotypic characteristics of the Hanford Reach population.
- **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).
- **Objective 5:** Determine if the stray rate of Priest Rapids Hatchery fish is below the acceptable levels to maintain genetic variation between populations.
- **Objective 6:** Determine if Priest Rapids Hatchery fish were released at the programmed size and number.
- **Objective 7**: Determine if harvest opportunities have been provided using Priest Rapids Hatchery returning adults.
- **Objective 8**: Determine if the Priest Rapids Hatchery has increased pathogen type and/or prevalence in the Hanford Reach population.
- **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**.**

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 that 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 GCPUD 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 survival 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). The age at maturity for naturally produced fish in the Hanford Reach generally varies between age 1 mini-jack and age 6 adults. 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 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 fishery.

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 precision 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 type were processed if the sampling rate provided relatively low numbers of otoliths collected 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. The methodologies for selecting random otolith samples have differed between return years. In general, we randomly selected otoliths from various survey types to obtain roughly 120 otoliths for each age and gender. In some cases, all otoliths were submitted for stratified groups (age/gender) 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 A.

6.0 Evaluation of Bias

We attempted to evaluate the bias associated with estimates of the number of hatchery origin returns to PRH generated using coded-wire tags during 2014. Results from sampling the fall Chinook returns for 2010 through 2013 indicate 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 1, the estimated bias ranged from 0.573 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 rate was lower than the mark rate. Only age 5 fish had a positive bias, but these were also the lowest sample sizes.

Table 1 Estimate of coded-wire tags bias for Priest Rapids origin returns to the hatchery, Brood Years 2007- 2012.

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	5	0.2429	407	1,827	0.223	0.917
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	4	0.2371	8,719	41,076	0.212	0.895
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	3	0.1691	2,596	18,905	0.137	0.812
2011	2	0.1691	349	2,777	0.126	0.743
2012	2	0.1766	1,910	11,123	0.172	0.972

The level of bias appears to be less for recent return years. 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 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 coded-wire tag recoveries.

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 quality control results for previous years, there were few (4 tags; 0.4%) additional coded-wire tag detections observed from the 1,063 fish sampled that were not detected from the T-wands.

During 2013 and 2014, we found the T-wands to be overly sensitive which resulted in false positive detections and additional work related to collecting and extracting coded-wire tags. On October 2, we setup two series R9500 detectors to expedite the scanning for coded-wire tags (Figure 3). The detectors were checked for proper operation each day prior to scanning fish. Informal quality control checks occurred daily during the first two weeks of operation in order to identify the detection efficiency of each detector. These checks involved running 100 fish through each machine and then re-scanning the fish with the T-wands. A total of 2,000 fish were passed through the R9500 units of which 422 were identified to possess coded-wire tags. Of these fish, 419 signaled positive for coded-wire tags during the initial scanning. The three fish possessing CWT that were not identified by the R9500 during the initial scanning were correctly detected when re-ran though the detectors. The missed fish were likely the result of passing fish through the detectors too rapidly.

Figure 3 Series R9500 Coded-wire tag detectors used at Priest Rapids Hatchery, 2014

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 the coded-wire detection wands and R9500 units 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 at PRH is likely greater than 99%. Therefore, the magnitude of the coded-wire recovery bias expressed in Table 1 is not likely due to poor coded-wire detection efficiency.

7.0 Current Operation of Priest Rapids Hatchery

In 2014, a record 79,026 adult fall Chinook salmon were handled at PRH (Table 2). The 2014 broodstock for PRH were collected at the hatchery volunteer trap, the OLAFT, and from the ABC fishery. The majority of the broodstock were collected from the PRH volunteer trap which was operated from September 9 through December 1, 2014.

Daily detections of adult Chinook salmon possessing passive integrated transponder (PIT) tags passing the array located in the PRH discharge channel suggest a bi-modal peak return to the volunteer trap occurred in late September and again in later October (Figure 4). Of the unique PIT tagged fish observed, 63% were tagged as juveniles at PRH, 34% were tagged as adults in the lower Columbia, and the remaining 3% were tagged as juveniles in the Snake River Basin or the Columbia River below the confluence of the Snake and Columbia Rivers.

Table 2 **Source and disposition of Chinook salmon collected for broodstock at Priest Rapids Hatchery, Return Year 2014.**

Collection Location	Gender	Collected	Trap Surplused	Trap Mortalities	Ponded	Spawned	Pond Surplused	Pond Mortalities
Volunteer Trap (Sept 9 - Dec 1)	Males	34,150	31,602	487	2,061	1,363	450	248
	Females	31,556	26,257	521	4,778	3,064	904	810
	Jacks	12,073	11,022	974	77	0	77	0
	Total	**77,779**	**68,881**	**1,982**	**6,916**	**4,427**	**1,431**	**1,058**
OLAFT (Sept 12 - Nov 11)	Males	305			305	297	0	8
	Females	646			646	528	47	71
	Jacks	0			0	0	0	0
	Total	**951**	**0**	**0**	**951**	**805**	**47**	**79**
ABC (Oct 24, 25, 26)	Males	164			164	145	0	19
	Females	132			132	76	7	49
	Jacks	0			0	0	0	0
	Total	**296**	**0**	**0**	**296**	**211**	**17**	**68**
Facility	**Total**	**79,026**	**68,881**	**1,982**	**8,163**	**5,473**	**1,485**	**1,205**

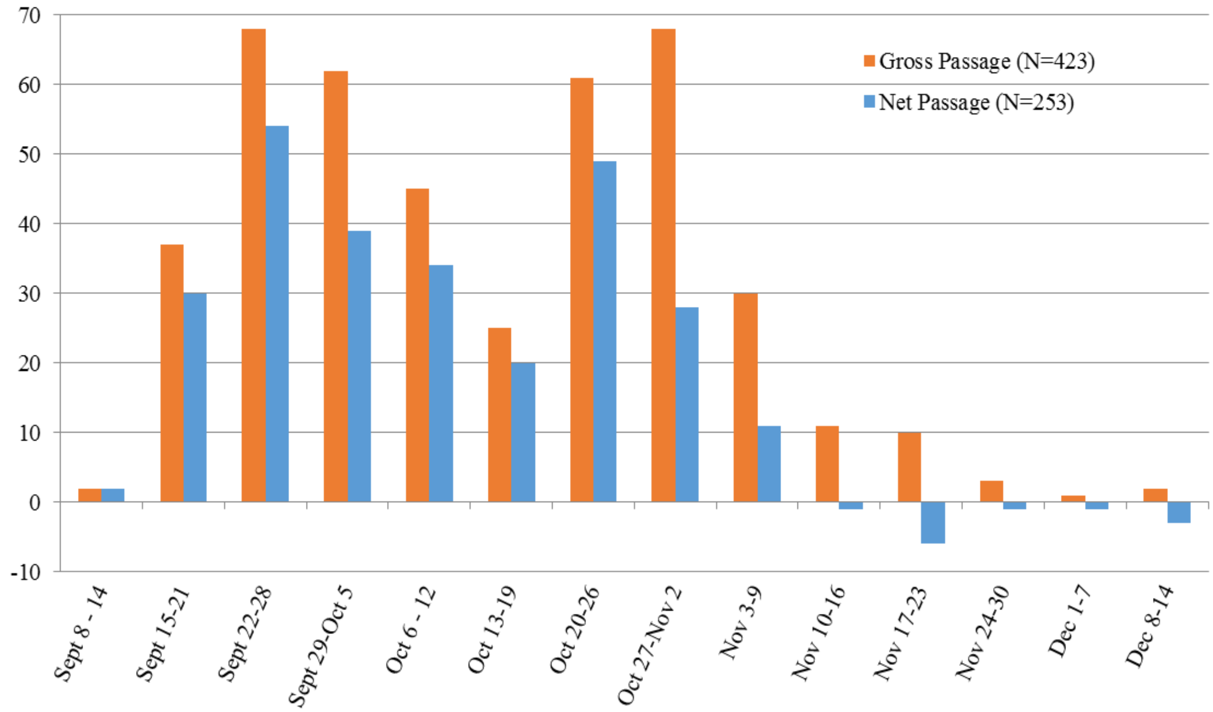

Figure 4 **Weekly upstream and downstream (gross) and upstream (net) passage of unique PIT tagged adult Chinook salmon at the PIT tag array located in the Priest Rapids Hatchery discharge channel, 2014.**

PRH has four adult salmon holding ponds. Ponds 1, 2, and 3 were used to hold broodstock collected at the PRH Volunteer Trap. Pond 4 was used to hold broodstock collected from the ABC and OLAFT. Several hundred adipose clipped adults were held in Pond 4 to facilitate hatchery x natural origin crosses during spawning. The PRH staff generally transported fish from the volunteer trap seven days per week to collect broodstock and or to surplus the excess fish. Male fall Chinook salmon, both adult and jack, typically comprised the majority of the fish surplused from the trap.

Spawning days occurred on Tuesdays and Wednesday each week from October 28 through November 25 (N = 8). 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 guided with the mechanical crowder into the facility's center channel, directed 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 12,692,400. The actual egg take from the 2014 broodstock was 14,321,818 (112.8% of the goal). During routine spawn days, the eggs from two females were stripped into a five gallon bucket and then the milt from a single male was mixed with the eggs. Fertilized eggs were then transferred to the incubation room, combined with multiple egg takes, weighed to estimate numbers of eggs, and then placed in vertical incubation trays at roughly 10,000 eggs per tray.

New for 2014, a cooperative effort between WDFW and GCPUD staff to test real-time otolith reading coinciding with an alternative mating strategy occurred on November 12 and 13. This activity entailed examining 172 otoliths during the spawn to facilitate matings of presumed natural origin males to known hatchery origin females at ratios of 1:4. Known hatchery origin males were mated with presumed natural origin females at ratios of 1:2 or 1:1. There were 138 1-natural male x 4-females crosses, 89 1-hatchery male x 2- females crosses, and 3 1-hatchery male x 1- female crosses. An estimated 2,492,000 eggs were taken from the natural x hatchery crosses, 124,000 from natural x natural crosses, and 316,000 from hatchery x hatchery crosses: This assumes an average fecundity of 4,000 eggs per female.

After shipping groups of live eggs to other facilities, seven batches of fry were moved from the vertical trays in the incubation building to outdoor raceways between January 21 and March 13, 2015. The fry were 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 with two or three days between each release. 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. The fish were released from the last holding pond on June 25.

8.0 Origin of Adult Returns to Priest Rapids Hatchery

There were three sources for collection of adult Chinook salmon broodstock for PRH during the 2014 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 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. The error rate associated with determination of origin by otoliths is reported at less than 1% (J. Grimm, WDFW Otolith Lab, personal communication). 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 of abundance 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 for the proportions of natural and hatchery origin fish recovered at PRH 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 2014, the proportion of broodstock obtained from the PRH volunteer trap that was natural origin is estimated at 0.045. The proportion of natural origin fish from the PRH volunteer trap surplus and mortalities is estimated at 0.059. Overall, it is estimated that 0.058 of the volunteer trap returns to PRH were natural origin (Table 3). The proportion of natural origin fish used as broodstock from the OLAFT and ABC was estimated to be 0.829 and 0.923, respectively.

A minimum fork-length threshold of 74 cm was used to reduce the number of age-2 and 3 broodstock collected at OLAFT along with the exclusion of hatchery marks and tags. Historical data suggests that a larger proportion of age-2 and 3 fall Chinook salmon returning to the Hanford Reach are of hatchery origin versus age-4 and 5 fish. This selection method may have contributed to the higher than previously observed proportion of natural origin fish in this collection.

Table 3 **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 Years 2013 - 2014**

Priest Rapids Hatchery Broodstock [1]			Proportion		Number	
Brood	Total	Sample size (N)	Hatchery Origin	Natural Origin [2]	Hatchery Origin	Natural Origin [2]
2013	4,476	503	0.982	0.018	4,395	81
2014	4,427	574	0.955	0.045	4,228	199
Priest Rapids Hatchery Surplused from Trap			**Proportion**		**Number**	
Brood	**Total**	**Sample size (N)**	**Hatchery Origin**	**Natural Origin [2]**	**Hatchery Origin**	**Natural Origin [2]**
2013	37,355	600	0.966	0.034	36,085	1,270
2014	73,352	639	0.941	0.059	69,024	4,328
Priest Rapids Hatchery Volunteer Return Total			**Proportion**		**Proportion**	
Brood	**Total**	**Sample size (N)**	**Hatchery Origin**	**Natural Origin [2]**	**Hatchery Origin**	**Natural Origin [2]**
2013	41,831	1,103	0.968	0.032	40,480	1,351
2014	77,779	1,213	0.942	0.058	73,252	4,527
Priest Rapids Off Ladder Fish Trap Broodstock[1]			**Proportion**		**Proportion**	
Brood	**Total**	**Sample size (N)**	**Hatchery Origin**	**Natural Origin [2]**	**Hatchery Origin**	**Natural Origin [2]**
2013	763	201	0.450	0.550	343	420
2014	825	225	0.170	0.829	140	684
Angler Broodstock Collection Broodstock [1]			**Proportion**		**Proportion**	
Brood	**Total**	**Sample size (N)**	**Hatchery Origin**	**Natural Origin [2]**	**Hatchery Origin**	**Natural Origin [2]**
2013	397	289	0.191	0.809	76	321
2014	221	111	0.077	0.923	17	204

[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. A total of 14,063 coded-wire tags were recovered at PRH in 2014, of which 737 were obtained from the PRH volunteer trap broodstock (Appendix B). Only two coded-wire tags were recovered in the ABC broodstock. The ABC fish were not screened for code-wire tags during collection. OLAFT fish were screened to exclude coded-wire tags during the collection: they were not re-scanned for presence of coded-wire tags once at the hatchery. The remaining 13,324 coded-wire tags were recovered in the surplus and mortalities from the PRH volunteer trap collection (Appendix C). Slightly higher than previous years, the juvenile mark rate expansions of coded-wire tag recoveries at PRH in 2014 suggest that 83.0% 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 17.0% of the unaccounted fish could potentially be natural origin (Table 4). During return year 2014, PRH origin coded-wire tags accounted for

80.9% of the total return and 97.5% of the hatchery origin tags recovered. There were 21 natural origin Hanford Reach fall Chinook salmon coded-wire tags recovered at the hatchery in 2014; all of these fish were surplused from the volunteer trap. 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 21 coded-wire tag recoveries.

Table 4 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 tags, Return Years 2005 - 2014

Return Year	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
2014	77,259	0.809	0.020	0.170

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

9.0 Broodstock Collection and Sampling

Similar to what was done during recent years, the 2014 broodstock collected at the PRH volunteer trap and the OLAFT were high-graded for gender, size, and/or origin to increase the probability of collecting natural origin fish. For example, fish that had an adipose clip or coded-wire tag were excluded from OLAFT collections. 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 likely PRH origin fish. Early in the broodstock collection from the PRH volunteer trap attempts were made to exclude all adipose clipped fish, all fish less than 73 cm fork-length, and all coded-wire tagged fish. This intense level of high-grading proved too arduous and was diminished to omitting fish less than 73 cm. The broodstock collected from the ABC excluded jacks and adipose clipped fish: these fish were not screened for coded-wire tags at time of collection.

The majority of both adipose and non-adipose clipped broodstock from the PRH volunteer trap were placed in Ponds 1, 2, and 3. The fish collected from the OLAFT and ABC were held in Pond 4. 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 4. Placing adipose clipped fish in Pond 4 does facilitate the matings of adipose clipped fish (i.e., hatchery origin) with the potential natural origin fish from ABC and OLAFT.

The broodstock collected at the PRH volunteer trap were systematically sampled at a 1:4 rate for otoliths, scales (age), gender, and length. The broodstock collected at the OLAFT and ABC were sampled at a 1:1 rate for otoliths, scales (age), gender, and length. Post spawn data for each of these groups were randomly sub-sampled to determine origin by age, gender, and length.

Origin of Broodstock based on Coded-Wire Tags versus all Hatchery Marks

High-grading the broodstock to remove adipose clipped fish also removes adipose clipped fish possessing coded-wire tags. This reduces 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 2012, 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.

An estimated 18.5% of the 2014 broodstock originating from the volunteer trap was comprised of natural origin fish based on coded-wire tag recoveries. Whereas, an estimated 4.5% of the broodstock originating from the volunteer trap was comprised of natural origin fish based on hatchery marks (Table 5).

Table 5 Proportion of hatchery and natural origin Chinook salmon obtained from the Priest Rapids Hatchery volunteer trap used for broodstock, Return Years 2012 – 2014

		Origin based on CWT expansions			Origin Based on Hatchery Marks		
Return Year	Broodstock Spawned	PRH	Other Hatchery	Natural Origin [1]	PRH	Other Hatchery[2]	Natural Origin [3]
2012	4,974	0.692	0.004	0.304	0.882	0.004	0.119
2013	4,476	0.713	0.034	0.252	0.971	0.011	0.018
2014	4,427	0.793	0.023	0.185	0.937	0.018	0.045

[1] Proportion of natural origin fish estimated from the remaining fish not accounted for by expansions of CWT recoveries.
[2] Other hatchery fish based on origin sub-sampling that were adipose clipped fish without an otolith mark.
[3] Natural origin estimated from the remaining fish not accounted for by hatchery marks

Broodstock Age Composition

A combined total of 5,472 fish were spawned from the three sources of broodstock. In general, hatchery origin broodstock tend to be younger than natural origin broodstock (Table 6). The historical broodstock age compositions are not directly comparable to 2012, 2013, and 2014 broodstock age compositions due to inconsistent methodology for assigning origin. Prior to 2012, the origin of broodstock was estimated by coded wire tag expansions of the juvenile mark rate.

A total of 6,916 Chinook salmon broodstock were ponded from the PRH volunteer trap during brood year 2014, of which 4,427 were spawned. Both the hatchery and natural origin fish were mostly age-4. In previous brood years, the hatchery origin fish have been primarily age-3 (Table 7). The very strong return of age-4 fish in conjunction with a length based high-grading procedure (>73cm) likely resulted in the shift to an older age composition.

Table 6 **Age composition for hatchery and natural origin fall Chinook salmon spawned at Priest Rapids Hatchery (includes all sources of broodstock), Return Years 2007 - 2014**

Return Year	Origin	Age Composition					
		N	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
2014	Natural[2]	314	0.000	0.045	0.886	0.070	0.000
	Hatchery[2]	596	0.000	0.064	0.897	0.039	0.000

[1] Origin determined from coded-wire tag expansions of juvenile mark rate.
[2] Origin determined from presence of hatchery marks (i.e., coded-wire tags, adipose clips, and otoliths)

Table 7 **Age composition for hatchery and natural origin fall Chinook broodstock collected form the Priest Rapids Hatchery volunteer trap, Return Years 2102 - 2014**

Return Year	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
2014	Natural[1]	26	0.000	0.115	0.885	0.000	0.000
	Hatchery[1]	548	0.000	0.065	0.899	0.036	0.000
Mean	Natural	25	0.000	0.267	0.693	0.040	0.000
	Hatchery	564	0.000	0.399	0.543	0.057	0.000

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

A total of 951 Chinook salmon were collected at the OLAFT, of which 825 were spawned to supplement the 2014 broodstock. The hatchery and natural origin fish recovered at the OLAFT and spawned were primarily age-4 (Table 8). A length based high-grading procedure (>73cm) was used during broodstock collection.

A total of 296 fall Chinook salmon were collected from the ABC, of which 221 were spawned to supplement the 2014 broodstock. Both the PRH origin and natural origin fish spawned from the ABC broodstock were mostly age-4 (Table 9). This collection was supposed to be high-graded to exclude jacks.

Table 8 Age composition for hatchery and natural origin fall Chinook salmon broodstock collected from the Off Ladder Adult Fish Trap at Priest Rapids Dam, Return Years 2012 - 2014

Return Year	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
2014	Natural[1]	186	0.000	0.000	0.902	0.098	0.000
	Hatchery[1]	39	0.000	0.000	0.870	0.130	0.000
Mean	Natural	187	0.016	0.319	0.562	0.085	0.001
	Hatchery	111	0.036	0.451	0.447	0.069	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.

Table 9 Proportion of hatchery and natural origin fall Chinook salmon for each age of broodstock collected from the Angler Broodstock Collection, Return Years 2012 - 2014

Return Year	Origin	Age Composition					
		N	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
2014	Natural[1]	102	0.000	0.126	0.830	0.044	0.000
	Hatchery[1]	9	0.059	0.369	0.572	0.000	0.000
Mean	Natural	133	0.000	0.393	0.546	0.061	0.000
	Hatchery	24	0.020	0.625	0.355	0.000	0.000

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

Length by Age Class of Broodstock

The average fork length (cm) by age for each source of broodstock is provided in Table 10.

The historic observations for size at age of natural and hatchery origin broodstock sampled PRH suggest that natural and hatchery origin fish are similar in size within each age class (Table 11).

The historic observations for size at age of natural and hatchery origin broodstock sampled PRH suggest that natural and hatchery origin fish are similar in size within each age class (Table 11).

Table 10 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 2014. 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			3	74	2	23	80	5	0			0		
	Hatchery	0			36	70	3	491	78	5	21	87	6	0		
OLAFT	Natural	0			0			165	85	5	21	94	8	0		
	Hatchery	0			0			33	82	4	6	93	8	0		
ABC	Natural	0			12	70	4	86	81	8	4	92	11	0		
	Hatchery	0			4	66	2	5	80	4	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 11 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
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		
2014	Natural	0			3	74	2	23	80	5	0			0		
	Hatchery	0			36	70	3	491	78	5	21	87	6	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.

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 2014 broodstock was comprised 67.0% females, resulting in an overall male to female ratio of 0.49:1.00 which is slightly lower than the historic mean ratio of 0.55:1.00 (Table 12). This lower ratio of males to females resulted from the 234 matings of 1-male x 4-females during the real-time otolith read/alternative mating strategy study.

Table 12 **Numbers of male and female hatchery fall Chinook salmon broodstock at Priest Rapids Hatchery, Return Years 2001 - 2014. 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	1,865	3,578	0.52:1.00
2014[a]	1,805	3,668	0.49:1:00
Mean	**1,716**	**3,161**	**0.54:1.00**

[a] Alternative mating strategy resulted in 234 matings of 1-male x 4-females (936 fish total)

Fecundity

The annual average fecundity for PRH was calculated as the proportion of the total number of females spawned to the total estimated take of green eggs. The total number of green eggs is calculated after the first pick of dead eggs from the incubation trays. Fish culture staff weighs large lots of either dead or live eggs and then sub-samples the lots to calculate a mean individual egg weight. The number of eggs per lot is estimated by dividing the weight of the each egg lot by the calculated mean individual egg weight. The egg count for each lot is summed to estimate the facility egg take. Each egg lot likely contained slightly varying amounts of interstitial water which might overestimate the egg count.

Fecundity for the 2014 broodstock sampled averaged 3,833 eggs per female which is less than the historical mean of 3,988 (Table 13). Fecundity samples of individual females were taken from subsamples at PRH during the spawn of 2010 through 2014 broodstock to estimate fecundity by length and age. For the 2013 and 2014 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. Both years 2013 and 2014, we attempted to stratify the females sampled by fork length categories to obtain fecundity samples for all sizes of fish to better estimate the relationship between length and fecundity. Hence, comparisons between age classes are not representative of the females spawned from 2013 and 2014 brood stocks.

Table 13 Mean fecundity of fall Chinook salmon collected for broodstock at Priest Rapids Hatchery, Return Years 2001 - 2014

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
2014	14,321,183	3,688	3,883
Mean	12,224,507	3,078	3,988

[1] Did not reach egg take goal.

M&E staff performed the fecundity estimates on live eggs during the spawn days. 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. Sub-sample sizes ranged between years from 60 or 100 green eggs which 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 return year 2010 through 2014 to provide a simple linear regression to predict fecundity based on fork-length (natural and hatchery females combined). This data shows a strong positive correlation between size and fecundity (Figure 5). The regression formula may be useful for coarse predictions of egg production for different size fish.

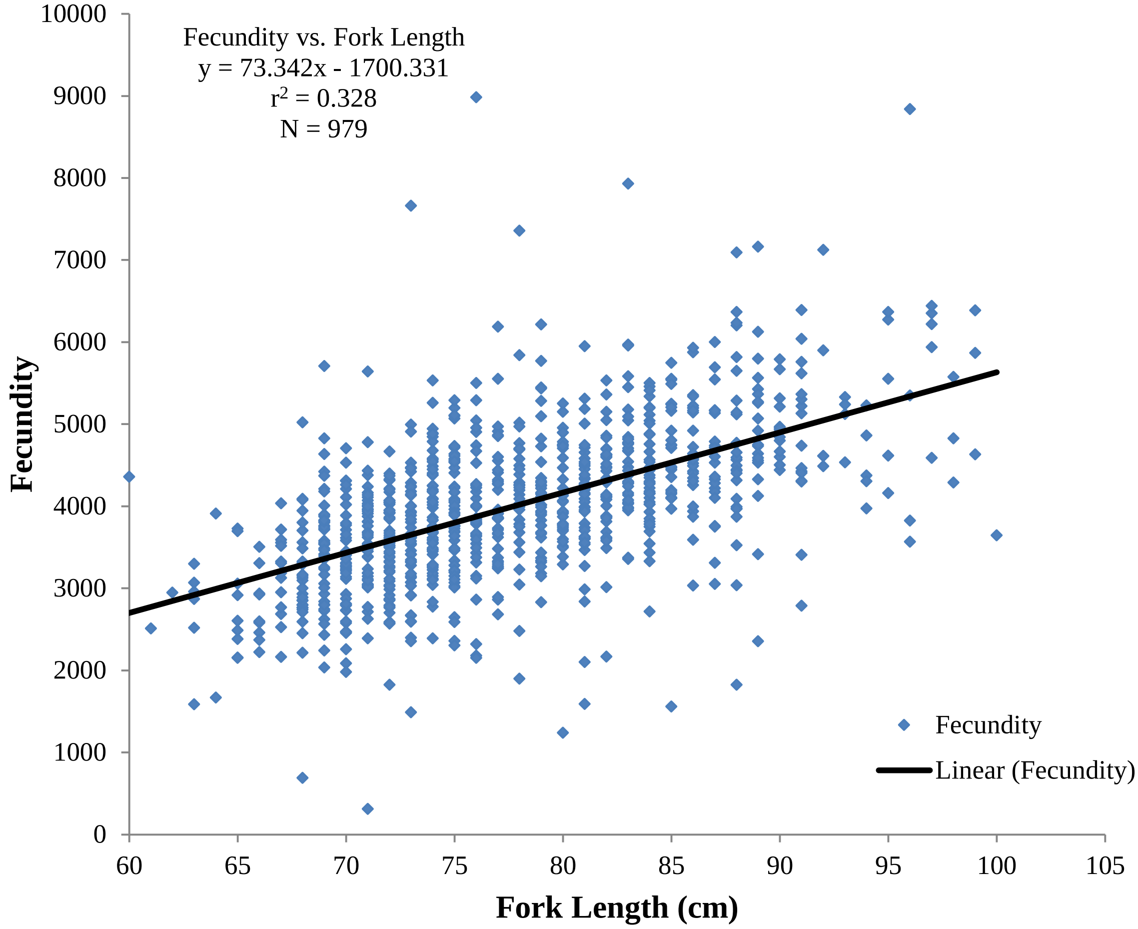

Figure 5 **Linear relationship between fecundity and fork length for combined samples of natural and hatchery origin fall Chinook salmon spawned at Priest Rapids Hatchery, Return Years 2010 - 2014**

Fecundity samples collected in years 2010 through 2012 were not identified as to the origin of the females. For years 2013 and 2014, a total of 283 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 ponds 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 origins of females sampled for fecundity were determined by hatchery marks (i.e., otoliths, adipose clips and coded-wire tags). We make the assumption that fish not possessing any type of hatchery marks were of natural origin.

The average fecundity by age is given in Table 14. This information is useful for forecasting potential egg takes based on the numbers and age composition of the forecasted return.

Table 14 Mean fecundity at age for fall Chinook salmon sampled at the Priest Rapids Hatchery, Return Years 2010 – 2014. N = sample size and SD = 1 standard deviation.

Return Year	Age-3			Age-4			Age-5		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
2010	273	3,658	834	17	3,664	585	1	4,217	0
2011	30	3,538	842	206	4,276	884	1	4,380	0
2012	2	3,639	882	3	4,282	1089	0		
2013	105	3,488	768	68	4,152	788	4	5,339	805
2014	1	3,358	0	73	4,126	755	5	4,416	407
Combined Years	411	3,605	818	367	4,95	839	11	4,730	884

The data collected from return years 2010 through 2014 was pooled to increase the number of samples for a given fork length. The linear relationships between fork length and variables including fecundity, mean egg weight, and total egg mass weight for natural and hatchery origin females subsampled are plotted in Figure 6 -Figure 8. 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.

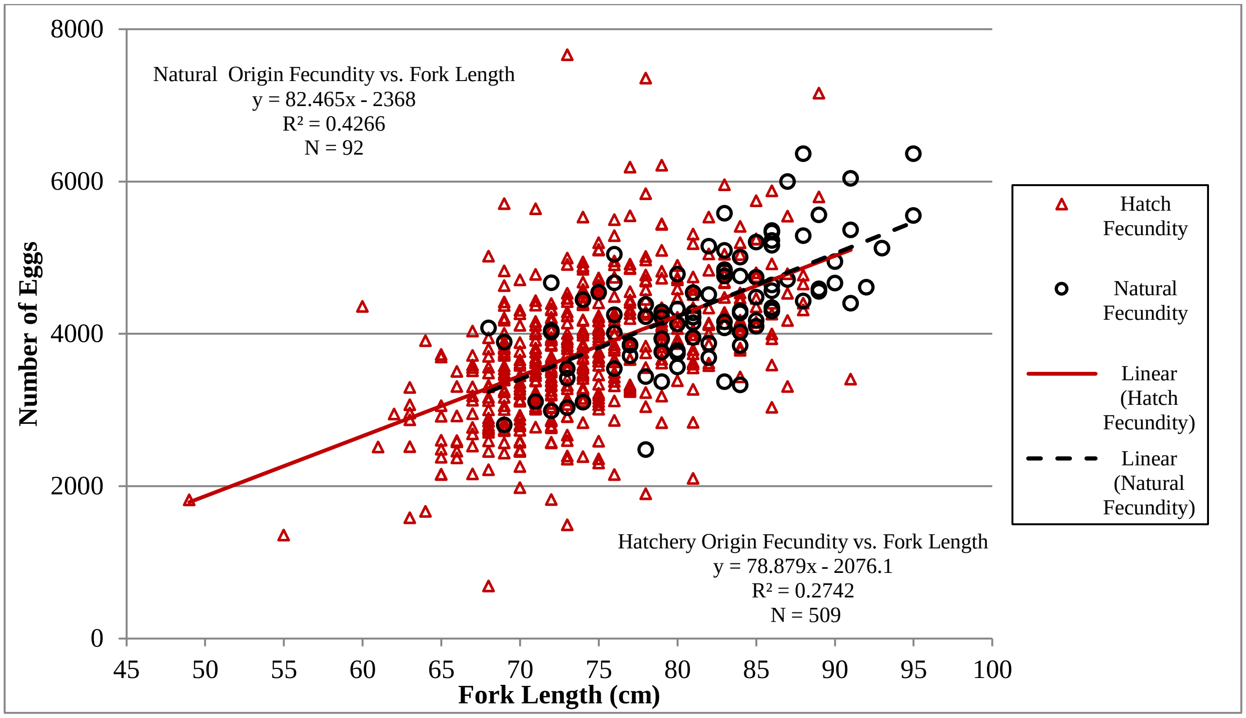

Figure 6 Fecundity versus fork length for natural and hatchery origin fall Chinook salmon sub-sampled at Priest Rapids Hatchery, Return Years 2010 - 2014

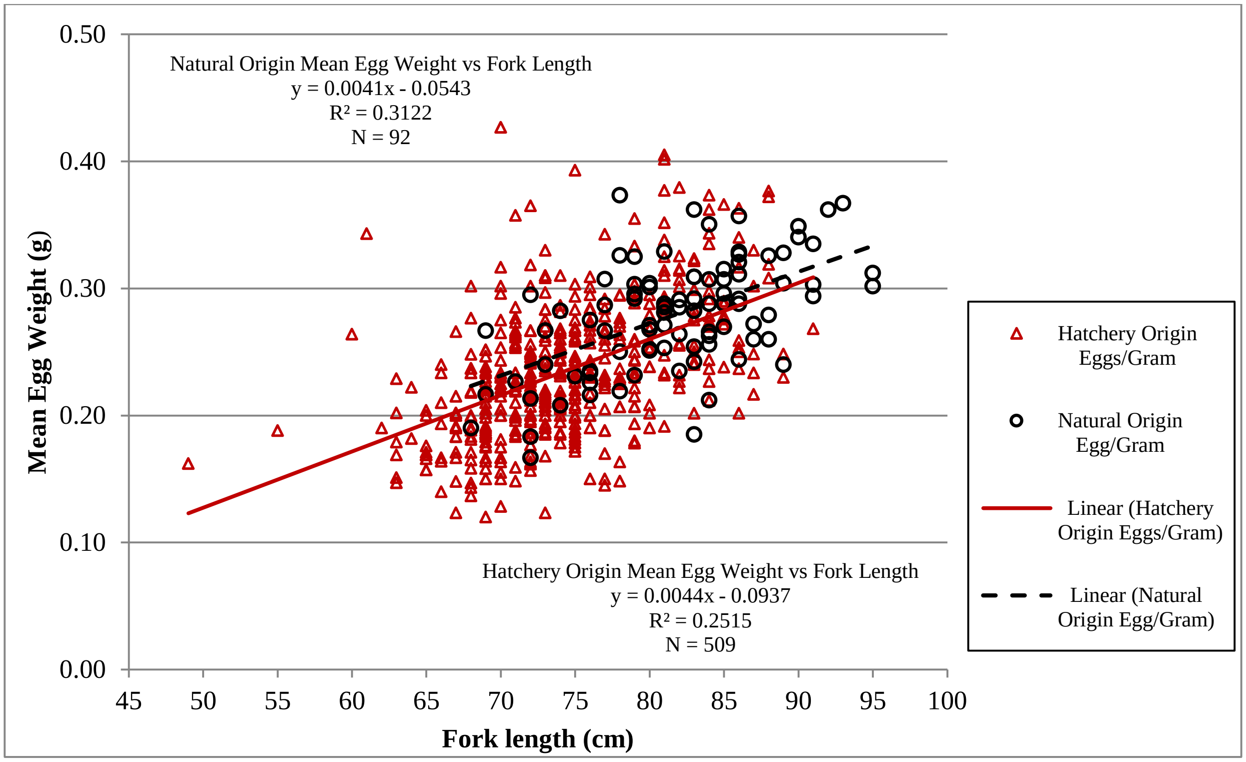

Figure 7 **Mean egg weight versus fork length for natural and hatchery origin fall Chinook salmon sub-sampled at Priest Rapids Hatchery, Return Years 2010 – 2014**

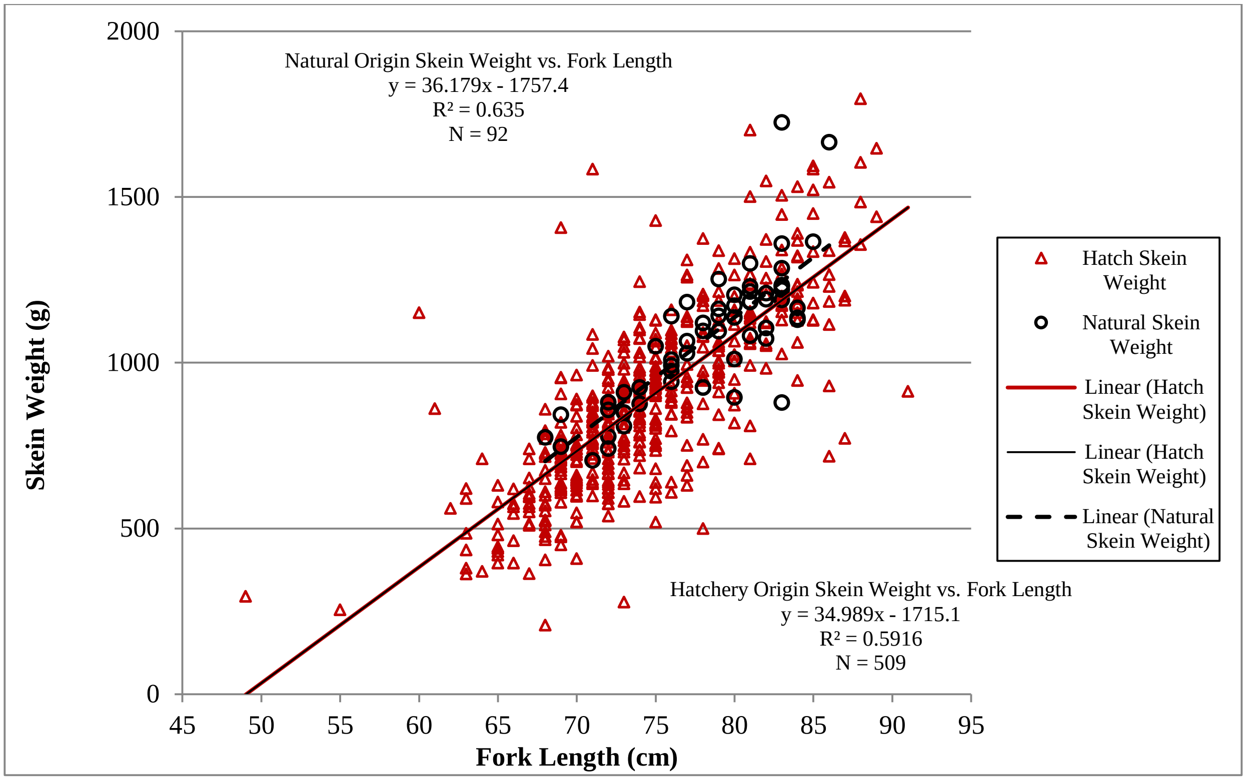

Figure 8 **Total egg mass weight versus fork length for natural and hatchery origin fall Chinook salmon sub-sampled at Priest Rapids Hatchery, Return Years 2010 - 2014**

10.0 Hatchery Rearing

Number of eggs taken

In 2014, an estimated total of 14,321,818 eggs were collected at the PRH facility. The egg take goal for return year 2014 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. Eggs taken in excess of the program needs for brood year 2014 were either culled (49,900) or shipped to other hatcheries. At total of 374,000 and 487,838 eyed eggs were shipped to the Umatilla and Prosser Hatcheries, respectively.

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 3.5 million subyearling release at RSH. Egg takes at PRH were sufficient to meet all hatchery production goals from 1984 through 2014, with the exception of 2007 (Table 15).

Table 15 Numbers of eggs taken from fall Chinook salmon broodstock collected at Priest Rapids Hatchery, Return Years 1984 - 2014

Return Year	Number of Eggs Taken		Return Year	Number of Eggs Taken
1984	10,342,000		2000	15,359,500
1985	10,632,000		2001	10,750,000
1986	22,126,100		2002	12,180,000
1987	24,123,000		2003	12,814,000
1988	16,682,000		2004	12,753,500
1989	13,856,500		2005	14,085,000
1990	9,605,000		2006	13,511,200
1991	6,338,000		2007	5,067,319
1992	11,156,400		2008	12,643,600
1993	14,785,000		2009	13,074,798
1994	16,074,600		2010	11,903,407
1995	17,345,900		2011	12,693,000
1996	14,533,500		2012	12,398,389
1997	17,007,000		2013	13,276,000
1998	13,981,300		2014	14,321,818
1999	16,089,600		**7 year (08-14) Mean[1]**	**12,901,573**

[1] Began additional annual egg takes starting in return year 2008 for the 3.5 million Ringold Springs Hatchery

Number of acclimation days

The 2014 brood were incubated on a combination of well water and river 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 2015. The egg takes for the 2014 brood were distributed into twelve batches associated with the dates in which fish were spawned. The number of acclimation days ranged from 102 for the later egg takes to 142 for the earlier egg takes (Table 16).

Table 16 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
2014	1	January 21 into Bank E	June 12	142
2014	2	January 29 into Bank E	June 12	134
2014	3	February 13 into Bank D	June 15	122
2014	4	February 27 into Bank D	June 15	108
2014	5	February 27 into Bank C	June 18	111
2014	6	March 2 into Bank C	June 18	108
2014	7	March 2 into Bank B	June 22	112
2014	8	March 12 into Bank B	June 22	102
2014	9	March 12 into Bank A	June 25	105
2014	10	March 13 into Bank A	June 25	104
2014	11	March 12 into Bank A	June 25	105

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 17). The 2014 release goal is for PRH is 7,299,504 smolts. This goal includes a recent increase in the GCPUD mitigation from 5,000,000 to 5,599,504 combined with the ongoing USACE's John Day mitigation of 1,700,000 smolts.

In 2015, PRH released an estimated 7,039,544 subyearling fall Chinook salmon from the 2014 broodstock (Table 18). Fish were released between June 12 and June 25.

Various mark types and rates have occurred at PRH over the years for both the GCPUD 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. All smolts associated with the USACE's John Day mitigation have been adipose clipped, but only a fraction were coded-wire tagged. Poor returns for in 2007 precluded the production of USACE's John Day mitigation fish for the 2008 release.

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 coded-wire tag 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 harvest 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 origin (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 17 Numbers of marked, unmarked, and tagged fall Chinook salmon smolts released from Priest Rapids Hatchery, Brood Years 1977 – 2014.

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	42,908
2013[a]	7,267,248	3,347,417	603,417	603,439	2,712,975	42,908
2014[a]	7,039,543	3,125,734	600,688	600,730	2,712,392	42,621

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

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 weight 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 and 2014 broods were collected by M&E staff. We attempted to collect representative samples 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 2014 brood averaged 52 fish per pound and 91 mm in fork length (Table 18). The coefficient of variation of the fork length was 6.6. For brood years 1991 through 2014, smolts released from PRH have averaged 48 fish per pound with an average fork of 96 and an average CV of 7.4.

Table 18 Mean length (FL, mm), weight (g and fish/pound), and coefficient of variations (CV) of fall Chinook smolts released from Priest Rapids Hatchery, Brood Years 1991 - 2014.

		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
2014	2015	91	6.6	8.7	52	1,728
Mean		**96**	**7.4**	**9.5**	**48**	**1,486**

Survival Estimates

The survival rate for egg to juvenile release for brood year 2014 was 81.7% which is the third lowest recorded since brood year 2002 and slightly lower than the historic mean of 85.4% (Table 19). 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 2014 during this stage was 87.0% and the lowest report since brood year 2002.

In 2014, survival of fish ponded for broodstock was 84.7% which is higher than the historic average of 82.2% and those of the previous four years. The trapping operations in 2014 were carried out in a manner which generally reduce holding densities and may have resulted in the reduced ponding mortality.

Table 19 Hatchery life-stage survival rates (%) for fall Chinook salmon at Priest Rapids Hatchery, brood years 1989 – 2014.

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	0.869
2012	0.643	0.786	0.630	0.688	0.873	0.970	0.962	0.787	0.870
2013	0.698	0.660	0.333	0.684	0.884	0.983	0.951	0.806	0.863
2014	0.830	0.880	N/A	0.847	0.870	0.970	0.973	0.817	0.856
Mean	**0.834**	**0.840**	**0.705**	**0.822**	**0.890**	**0.981**	**0.964**	**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. The annual detection rates are given in Table 20. Prior to the 2012 release (brood year 2011), a PIT array consisting of six antennas was installed in the hatchery discharge channel to detect both juvenile out-migrants and adult returns.

The overall detection rate for the releases in of the 2011 brood year was 70.4%. The 2012 release occurred over an eight day period, with only two days of consecutive releases. Detection rates for the 2011 brood year release may have been reduced as a result of the array being inundated by high river elevations during the four consecutive days of release. The overall detection rate for the 2012 brood year was 3.4%. The low detection rates were likely due to 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.

A concerted effort was made during both the 2013 and 2014 brood year releases to improve the PIT tag detection efficiency at the PRH array. First, the automatic upload function of the array was discontinued to reduce the usage demand on the system’s processor. Secondly, the five releases from the hatchery were conducted over a fourteen day period beginning on June 12 to spread out over time the number of PIT tags passing the array. This was managed by pulling the individual weir boards for each pond over a two day period.

Overall proportion of PIT tagged fish detected of the total number tagged for both the 2013 and 2014 brood years were 92.9% and 94.5%, respectively. The two rates account for PIT tagged mortalities found in the rearing raceways. The mortalities recovered from the rearing ponds were not scanned for PIT tags which prohibits knowing the actual total number of PIT tagged fish released. Hence, the overall proportion detected would likely be higher than reported if we knew the actual number of live PIT tagged fish that left the ponds.

Table 20 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 Years 2011 - 2014.

Brood Year	Tag File	Tagging Date	Release Date	# Tagged	# of Tags Recovered from Facility Mortalities	# of Unique Detections	% Detected
2011	CSM12114.A01	4/23/2012	6/20/2012	9937	No Data	6,277	63.2
2011	CSM12114.A03	4/23/2012	6/14/2012	9948	No Data	6,674	67.1
2011	CSM12114.A04	4/24/2012	6/15/2012	9997	No Data	6,963	69.7
2011	CSM12115.A02	4/24/2012	6/16/2012	9967	No Data	8,115	81.4
2011	SMP12151.PR1	5/30/2012	6/20/2012	1000	No Data	499	49.9
2011	SMP12151.PR2	5/30/2012	6/16/2012	998	No Data	806	80.8
2011	SMP12152.PR3	5/31/2012	6/12/2012	996	No Data	810	81.3
			Totals	**42,844**	**N/A**	**30,144**	**70.4**
2012	CSM13143.A06	5/23/2013	6/14/2013	9,982	No Data	317	3.2
2012	CSM13143.A07	5/23/2013	6/13/2013	9,983	No Data	267	2.7
2012	CSM13144.A08	5/24/2013	6/12/2013	9,974	No Data	335	3.4
2012	CSM13144.A09	5/24/2013	6/15/2013	9,977	No Data	325	3.3
2012	SMP13149.PR1	5/29/2013	6/15/2013	997	No Data	131	13.1
2012	SMP13149.PR2	5/29/2013	6/14/2013	996	No Data	33	3.3
2012	SMP13150.PR3	5/30/2013	6/12/2013	999	No Data	48	4.9
			Totals	**42,908**	**N/A**	**1,456**	**3.4**
2013	CSM14148.PRA	5/28/2014	6/25/2014	7,994	21	7,215	90.5
2013	CSM14148.PRB	5/28/2014	6/23/2014	7,998	14	7,389	92.5
2013	CSM14149.PRC	5/29/2014	6/18/2014	7,996	11	7,443	93.2
2013	CSM14149.PRD	5/29/2014	6/16/2014	7,993	6	7,662	95.9
2013	CSM14149.PRE	5/29/2014	6/12/2014	7,998	7	7,407	92.7
2013	SMP14148.PR1	5/29/2014	6/25/2014	996	0	914	91.8
2013	SMP14148.PR2	5/29/2014	6/18/2014	994	0	927	93.3
2013	SMP14149.PR3	5/30/2014	6/12/2014	998	0	951	95.3
			Totals	**42,967**	**59**	**39,908**	**92.9**
2014	CSM15147.PRE	5/27/2015	6/12/2015	7,999	169	7,438	95
2014	CSM15147.PRD	5/27/2015	6/15/2015	7,996	39	7,685	96.6
2014	CSM15147.PRC	5/27/2015	6/18/2015	7,996	63	7,524	94.8
2014	CSM15147.PRB	5/28/2015	6/22/2015	7,998	50	7,696	96.8
2014	CSM15147.PRA	5/28/2015	6/25/2015	7,994	31	7,447	93.5
2014	SMP15140.PR1	5/20/2015	6/25/2015	993	0	940	94.7
2014	SMP15140.PR2	5/20/2015	6/18/2015	998	0	946	94.8
2014	SMP15141.PR3	5/21/2015	6/12/2015	999	0	935	93.6
			Totals	**42,973**	**352**	**40,611**	**95.3**

11.0 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 broodstock to address concerns associated with shipping eyed-eggs to Bonneville Hatchery for the USACE RSH production. The risk of BKD was assayed using the enzyme linked immunosorbent assay (ELISA). Results of adult broodstock BKD monitoring in 2014 indicated that all females had ELISA values less than an optical density of 0.10 (Table 21). Viral inspections included sampling the ovarian fluid and kidney/spleen for pathogens. All results of viral testing in 2014 were negative (Table 22).

Table 21 ELISA test results to determine risk of bacterial kidney disease of adult female fall Chinook salmon broodstock at Priest Rapids Hatchery, Return Years 2008 – 2014

Year	Stock		%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%
2013	Priest Rapids	60	100.0%	0.0%	0.0%	0.0%
2014	Priest Rapids	60	100.0%	0.0%	0.0%	0.0%

Table 22 Viral inspections of fall Chinook salmon broodstock at Priest Rapids Hatchery, Return Years 1991 - 2014

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
2014	18-Nov	Priest Rapids	Adult	60	60	Negative

12.0 Juvenile Fish Health Inspections

Juvenile fish are visually inspected on a monthly basis following ponding. The 2014 brood year juveniles were healthy throughout the rearing period (Table 23). Inspection results for brood years 1995 through 2005 are provided in Appendix D.

Table 23 Juvenile fish health inspections for Priest Rapids Hatchery fall Chinook salmon, Brood Years 2006 - 2014

Date	Stock	Brood Year	Condition
9-Mar-07	Priest Rapids	2006	Healthy
19-Apr-07	Priest Rapids	2006	Healthy
1-Jun-07	Priest Rapids	2006	Healthy
12-Feb-08	Priest Rapids	2007	Coagulated Yolk Syndrome observed in some fish sampled
23-Apr-08	Priest Rapids	2007	Healthy
4-Jun-08	Priest Rapids	2007	Healthy
12-Feb-09	Priest Rapids	2008	Coagulated Yolk Syndrome observed in some fish sampled
22-Apr-09	Priest Rapids	2008	Healthy
8-Jun-09	Priest Rapids	2008	Healthy
18-Feb-10	Priest Rapids	2009	Coagulated Yolk Syndrome observed in some fish sampled
1-Apr-10	Priest Rapids	2009	Healthy
19-May-10	Priest Rapids	2009	Healthy
25-Mar-11	Priest Rapids	2010	Healthy
18-Apr-11	Priest Rapids	2010	Healthy
06-Jun-11	Priest Rapids	2010	Healthy
01-Mar-12	Priest Rapids	2011	Healthy
26-Apr-12	Priest Rapids	2011	Healthy
24-May-12	Priest Rapids	2011	Healthy
11-Feb-13	Priest Rapids	2012	Healthy
3-Mar-13	Priest Rapids	2012	Healthy
29-Apr-13	Priest Rapids	2012	Healthy
28-May-13	Priest Rapids	2012	Healthy
27-Mar-14	Priest Rapids	2013	Dropout Syndrome present
23-Apr-14	Priest Rapids	2013	Dropout Syndrome present
29-May-14	Priest Rapids	2013	Healthy
26-Feb-15	Priest Rapids	2014	Coagulated Yolk Syndrome observed in some fish sampled
26-Mar-15	Priest Rapids	2014	Healthy
21-Apr-15	Priest Rapids	2014	Healthy
28-May-15	Priest Rapids	2014	Healthy
22-June-15	Priest Rapids	2014	Columnaris present in some fish sampled from Pond B.

13.0 Redd Surveys

Fall Chinook salmon redd surveys were performed in the Hanford Reach during 2014 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 2014.

Hanford Reach Aerial Redd Counts

Aerial redd counts in the Hanford Reach were performed by Mission Support Alliance on October, November 10 and 24, and December 1, 2014 (Lindsey et. al. 2014). The report can be found online at *www.hanford.gov/files.cfm/HNF-58823_-_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 surveys occurred on Monday instead of the Sundays when outflows at Priest Rapids Dam were lowered to near 40 kcfs in conjunction with the Vernita Bar Settlement Agreement surveys performed by Grant PUD and WDFW. River flows were higher during the Monday flights than what would have been encountered if the flights had occurred on Sundays. 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 2014 was 15,951 (Table 24). The peak number of redds observed in 2014 is an 8% decrease from the peak number of redds reported during 2013 despite an estimated 48% increase in the number of females in the 2014 escapement. The peak spawning was estimated to occur near the time of the November 24, 2014 survey.

Table 24 Summary of fall Chinook salmon peak redd counts for the 1948 – 2014 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	2014	15,951
1964	1,477	1981	4,866	1998	5,368	**Mean (2005-14)**	**8,056**

Redd Distribution

The main spawning areas observed during the 2014 counts were located near Vernita Bar and among Islands 4-6 (Table 25 & Figure 9). Historical redd counts by location from 2001 through 2014 are included in Appendix E of this report.

Table 25 Number of fall Chinook salmon redds counted in difference reaches on the Hanford Reach area of the Columbia River during the October 2014 through November 2014 aerial redd counts. (Data provided by Mission Support Alliance)

General Location	Start KM	End KM	Total Length	10/20	11/10	11/24	12/01	Peak	Average Redd Per River KM
Islands 17-21	545	558	13	0	0	0	0	0	0
Islands 11-16	558	573	15	0	76	767	906	767	60
Islands 8-10	587	593	6	0	427	1,470	1,565	1,565	261
Near Island 7	593	594	1	0	400	1,100	1,100	1,100	1,100
Island 6 (lower half)	594	599	5	10	1,020	2,230	2,530	2,530	506
Island 4, 5 and upper 6	599	602	3	25	730	2,030	2,080	2,080	693
Near Island 3	602	604	2	0	100	900	1,000	900	500
Near Island 2	604	606	2	23	1,010	2,030	2,050	2,050	1,025
Near Island 1	606	608	2	0	200	400	500	500	250
Near Coyote Rapids	614	619	5	25	255	400	500	500	100
Midway (China Bar)	628	630	2	0	20	50	60	60	30
Near Vernita Bar	630	635	5	55	1,830	3,600	3,650	3,650	730
Near Priest Rapids Dam	635	638	3	0	5	10	10	10	3
Total	--	--	--	**138**	**6,073**	**14,987**	**15951**	**15,951**	--

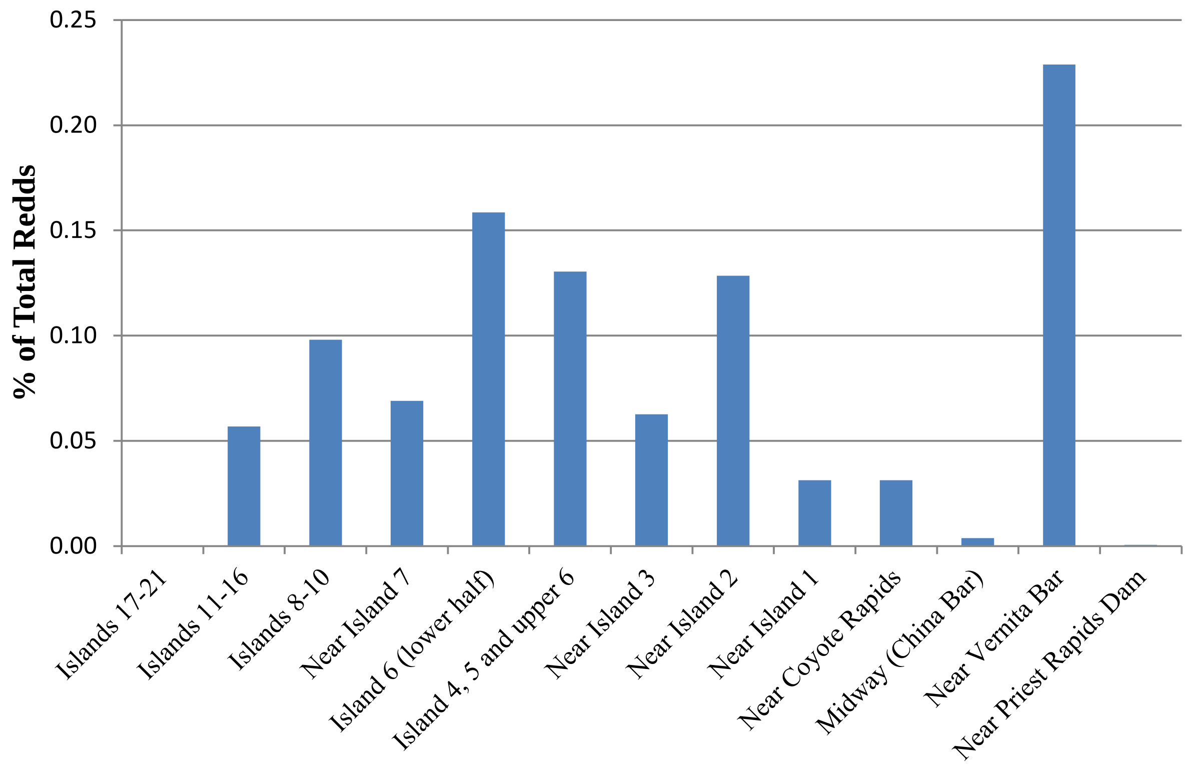

Figure 9 Distribution of fall Chinook salmon redd counts by location for the 2014 aerial surveys in the Hanford Reach, Columbia River (Data provided by Mission Support Alliance)

Spawn Timing

Based on aerial redd counts and Vernita Bar ground surveys, fall Chinook salmon spawning in the Hanford Reach during 2014 began in mid-October and ended after the first week of December. Flights did not occur weekly during the entire 2014 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 16.7°C (October 21) to 8.2°C (December 7) during the spawning period which is initially several degrees warmer to that recorded in 2013.

Escapement

The estimated total escapement of fall Chinook salmon to the Hanford Reach for 2014 returns was 183,680 fish; which was composed of 152,395 adults and 31,285 jacks (Table 26). This is the highest escapement on record. The previous record escapement occurred in 2013 at 174,651 fish. The ten-year mean for 2005 through 2014 is 62,707 (Table 27). Despite the record return, very low escapements for 2006 through 2009 suppress the ten-year average.

Table 26 Calculation of escapement estimates for fall Chinook salmon in the Hanford Reach, Return Year 2014

	Return Year 2014		
Count Source	**Adult**	**Jack**	**Total**
Adjusted Priest Rapids Adult Passage[1]	79,506	8,157	87,663
Ice Harbor Adult Passage	61,389	17,944	79,333
Prosser Adult Passage	7,004	654	7,658
Priest Rapids Hatchery	64,721	11,945	76,666
PRH discharge channel	78	0	78
Wanapum Tribal Fishery	29	1	30
Ringold Springs Hatchery	12,205	2,049	14,254
Yakima River Escapement (Below Prosser)	2,897	271	3,168
Yakima River Sport Harvest	1,568	66	1,634
Hanford Sport Harvest	28,689	3,738	32,427
Angler Broodstock Collection	305	0	305
Total	258,391	44,825	303,216
McNary Ladder Counts	410,786	76,110	486,896
Hanford Reach Escapement	152,395	31,285	183,680

[1] Gross passage count reduced 33.8% 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 2014, the estimated 12 fish per redd was higher than the historical average of 9 fish per redd (Table 29).

Table 27 Escapement for fall Chinook salmon in the Hanford Reach, Return Years 1991 – 2014

Return Year	# Fish per Redd	Redds	Total Escapement[1]
1991	11	4,939	52,196
1992	9	4,926	41,952
1993	13	2,863	37,347
1994	11	5,619	63,103
1995	18	3,136	55,208
1996	6	7,618	43,249
1997	6	7,600	43,493
1998	7	5,368	35,393
1999	5	6,068	29,812
2000	9	5,507	48,020
2001	10	6,248	59,848
2002	10	8,083	84,509
2003	9	9,465	100,508
2004	10	8,468	87,696
2005	9	7,891	71,967
2006	8	6,508	51,701
2007	6	4,018	22,272
2008	5	5,618	29,058
2009	7	4,996	36,720
2010	10	8,817	87,016
2011	8	8,915	75,256
2012	7	8,368	57,710
2013	10	17,398	174,651
2014	12	15,951	183,749
Mean	**9**	**7,266**	**65,518**
Median	**9**	**6,378**	**53,702**

[1] Escapement includes adults and jacks

Hatchery Discharge Channel Redd Counts

The M&E staff conducted redd surveys in the PRH discharge channel on October 30, November 6, November 25, and December 4, 2014. 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 39 redds occurred on the December 4 survey. We observed superimposition occurring during 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.

14.0 Carcass Surveys

Prior to 2010, the carcass 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. The sampling goal for coded-wire tag recovery is 10% of the escapement. The recent record returns to the Hanford Reach have increased the level of effort required to achieve the 10% sampling goal.

Carcass surveys were performed from October 31 through December 18, 2014. 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 carcass 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 were 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)

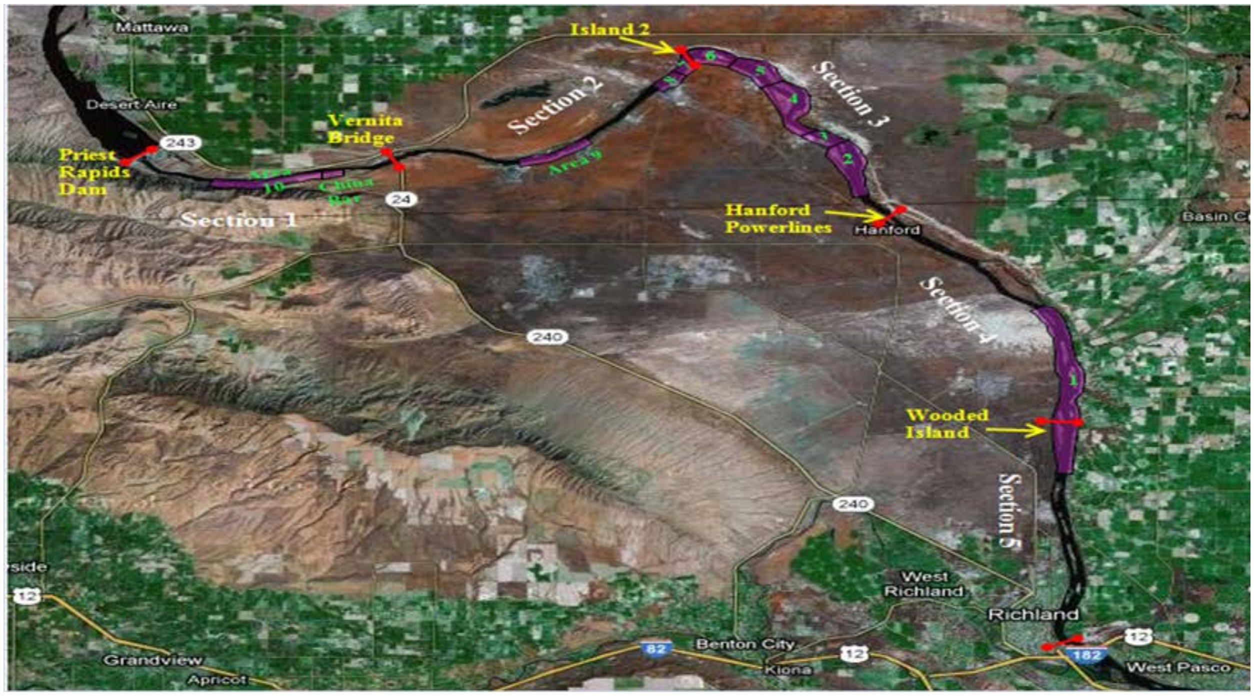

Figure 10 Locations of aerial redd index areas and river survey sections in the Hanford Reach.

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 28). 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. However, the proportion of recoveries in Section 2 has increased in recent years likely due to increased survey effort.

Numbers Sampled: Sections 1 – 5

Staff sampled a record 16,756 Chinook salmon in the Hanford Reach in 2014; equating to 9.1% of the estimated fall Chinook salmon escapement (Table 29). For the period of 1991 through 2014, river survey crews sampled an average of 6,847 fall Chinook salmon per year (Appendix F).

Table 28 Numbers and Percentages of fall Chinook salmon carcasses sampled within each survey section and of the total escapement on the Hanford Reach, Return Years, 2010 - 2014.

Return Year	# 1	# 2	# 3	# 4	# 5	Total Sampled	Escapement
2010	1,832 (18.7%)	519 (5.3%)	3,129 (32.0%)	3,362 (34.4%)	937 (9.6%)	9,779 (11.2%)	87,016
2011	1,581 (18.8%)	160 (1.9%)	2,606 (31.1%)	2,622 (31.2%)	1,422 (16.9%)	8,391 (11.1%)	75,256
2012	1,091 (16.0%)	149 (2.2%)	1,685 (24.7%)	2,213 (32.5%)	1,676 (24.6%)	6,814 (11.8%)	57,715
2013	2,182 (16.7%)	1,973 (15.1%)	2,844 (21.8%)	3,774 (28.9%)	2,298 (17.6%)	13,071 (7.5%)	174,651
2014	2,682 (16.0%)	1,142 (6.8)	5,544 (33.1%)	4,573 (27.3%)	2,815 (16.8%)	16,756 (9.1%)	183,680
Mean	1,874 (17.1%	789 (7.2%)	3,162 (28.8%)	3,309 (30.2%)	1,830 (16.7%)	10,962 (9.5%)	115,664

The survey effort was not equal for each section; however, the effort was more evenly distributed in 2013 and 2014 compared to the previous three years. Sections 3 and 4 were surveyed the most (Table 31). As the season progressed, crews focused their effort in sections which provided greater chances to recover carcasses.

Table 29 Number of carcass surveys conducted by section in the Hanford Reach, Return Years 2010 - 2014

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
2014	23	17	30	31	24	125
Mean	23	9	27	26	17	103

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 G.

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 30. For example, there were no redds identified in Section 5 but 2,815 carcasses were recovered in that section. It is likely that sections 1 and 3 which have the greatest number of redds and largest spawning escapement end up with a net loss of carcasses to downstream sections. In 2014, we initiated a pilot study to evaluate the magnitude and distribution of post spawn carcass drift. The preliminary results of this study are included in Appendix H.

Table 30 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, Return Year 2014.

Survey Section	Total Number of Redds	Total Number of Carcasses	Spawning Escapement[1]	Proportion of Escapement Sampled
HR-1	3,660	2,682	44,857	0.060
HR-2	800	1,142	9,805	0.116
HR-3	9,760	5,544	119,618	0.046
HR-4	767	4,573	9,400	0.486
HR-5	0	2,815	0	N/A
Total	**14,987**	**16,756**	**183,680**	0.091

[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. The first method includes the expansion of pooled coded-wire tag recoveries using juvenile tag rates and survey sample rate. The second method includes calculating 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, 2013, and 2014 adult returns: these years include otolith marks for all common ages of PRH origin fish.

The assumption was made that all Chinook salmon not accounted by 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 5.5% of fall Chinook salmon carcasses recovered in the 2014 Hanford Reach stream surveys were hatchery origin (Table 31). This estimate is similar to those of previous years excluding 2013. The percentage of the escapement estimated from expanded coded-wire tag recoveries consists of roughly 4.3% from PRH, 0.7% from RSH and 0.5% from other hatcheries. The highest proportions of hatchery origin carcasses recovered were in Sections 1, and 2.

Table 31 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 Years 2010 - 2014

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	
2014	Natural	2,469	1,072	5,264	4,329	2,703	15,838	0.945
	Hatchery	213	70	280	244	112	918	0.055
	Proportion Hatchery	0.079	0.061	0.050	0.053	0.040	0.055	

The second estimate of origin of carcasses recovered is based on the proportion of hatchery marked to non-marked fish. For this method, we assume that all hatchery origin carcasses recovered are marked in some manner (e.g., otolith marks, coded-wire tag, and adipose clips) and that we are able to accurately detect these marks and tags.

PRH has marked their entire juvenile releases with annual marks on the otoliths beginning with progeny of brood year 2007. For the 2013 and 2014 returns, age-2 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.

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 demographic data suggests that 9.0% of fall Chinook salmon carcasses recovered in the 2014 Hanford Reach stream survey were hatchery origin (Table 32). The highest proportions of hatchery origin carcasses recovered were in Section 1, but the hatchery proportions were fairly similar across sections 1-5. This pattern is similar to that observed in prior years.

Table 32 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	0.126	0.118	0.128	0.120	0.153	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	0.333	0.208	0.307	0.248	0.309	0.279	
2014[a] Biological sample rate = 1:5 and then randomly sub-sampled, N = 2,426	PRH[1]	37	7	45	35	11	135	0.056
	Other Hatchery[2]	12	5	16	32	18	83	0.034
	Total Hatchery	49	12	61	67	29	218	0.090
	Natural[3]	347	142	711	612	396	2208	0.910
	Proportion	0.124	0.078	0.079	0.099	0.068	0.090	
Means N = 1,582	PRH[1]	31	9	35	28	27	130	0.110
	Other Hatchery[2]	9	3	19	33	15	80	0.057
	Total Hatchery	40	13	54	60	42	209	0.167
	Natural[3]	217	85	390	409	271	1373	0.833
	Proportion	0.194	0.135	0.171	0.156	0.177	0.167	

[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 2014, which is typical of previous years (Table 33). Surveys were scheduled once or twice a week between October 31 and December 1, 2014.

Table 33 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
2014	237	7
Mean	**168**	**7**

Number sampled: Section 6

Survey crews recovered 237 Chinook salmon in Section 6 during return year 2014 (Table 33). 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.

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 G).

The 2014 fall Chinook salmon spawning escapement estimate for Section 6 is 25,179 fish. Overall, less than 1% of the total estimated spawning escapement in Section 6 was sampled in 2014 (Table 34).

Table 34 Carcasses sampled, total spawning escapement and proportion of escapement for fall Chinook salmon in Section 6 (Priest Rapids Dam Pool), return years 2010 - 2014.

Return 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
2014	7	237	25,179	0.009

Carcass Origin: Section 6

Similar to those methods described in detail in the previous section, the carcasses included in the 1:1 demographic 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 37.6% of fall Chinook salmon spawning in section-6 were hatchery origin of which 94.2% were PRH origin (Table 35).

Table 35 Origin of fall Chinook salmon spawning in Section 6 (Priest Rapids Dam Pool), Return Years 2012 - 2014

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
2014 N = 229	PRH[1]	81	0.354
	Other Hatchery[2]	5	0.022
	Total Hatchery	**86**	0.376
	Natural[3]	143	0.624
Means N = 132	PRH[1]	161	0.415
	Other Hatchery[2]	4	0.034
	Total Hatchery	58	0.449
	Natural[3]	75	0.551

[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 2014, crews performed seven carcass surveys in Section 8 by boat and one carcass survey in Section 7 by foot. It has been observed that many carcasses drift out of the discharge channel under full flow conditions. 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 the one survey in Section 7 on December 4 during full flow conditions because hatchery staff were experiencing difficulties regulating the discharge from the hatchery.

Number sampled: Sections 7 and 8

Survey crews recovered 9 carcasses in Section 7 and 52 in Section 8 (Table 36). All fish recovered were scanned for the presence of a coded-wire tag.

Table 36 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
2014	9	1	52	7	61	8

Proportion of Escapement Sampled: Sections 7 and 8

The 2014 fall Chinook salmon spawning escapement index for Sections 7 and 8 is 78 fish (Table 37). The spawning escapement for these Sections is a minimum estimate based on the peak number of 39 redds observed in the discharge channel. We assume that most of the carcasses recovered in Section 8 drifted downstream from Section 7. In addition, it is likely a portion of carcasses from Sections 7 and 8 drift downstream into Sections 1 and 2.

Table 37 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), Return Year 2014

Section	Total Number of Carcasses	Spawning Escapement	Escapement Sampled
# 7	9	78	0.115
# 8	52	0	0.667
Total	**61**	**78**	**0.782**

Carcass Distribution and Origin: Sections 7 and 8

The demographic sample rate was set at 1:5 to match the sample rate for Sections 1 – 5. As described in detail previously, the carcasses included the demographic 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 60% of fall Chinook salmon recovered in Sections 7 and 8 were hatchery origin of which most all were PRH origin (Table 38).

Table 38 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
2014 N= 5	PRH	3	0.600
	Other Hatchery	0	0.000
	Total Hatchery	3	0.600
	Natural	2	0.400
Means N = 36	PRH	16	0.568
	Other Hatchery	1	0.030
	Total Hatchery	18	0.598
	Natural	18	0.402

Carcass Drift Assessment

A common objective of hatchery monitoring and evaluation programs is to identify the spawning distribution of both hatchery and natural origin fish within the Hanford Reach. Initially, we believed that the proportion of hatchery origin spawners (pHOS) could be calculated for each of the five reaches. However, previous carcass bias assessments within the Hanford Reach suggest a substantial amount of downstream carcass drift into lower reaches (Richards and Pearsons, 2013). Hence, it is uncertain that the carcass recovery locations directly represent spawner distributions in some locations.

In order to gain a better understanding of natural post-spawn carcass drift, we Floy-tagged 994 carcasses in-place with no handling of the carcasses prior to being collected days later during the stream surveys. Long tagging poles were used to attach Floy dart tags to limit artificial carcass disturbance (Figure 11). Tagging efforts occurred throughout the spawning period (late October through late November, 2014) to increase the chances of tagging fish near their redds.

The primary objectives of this pilot study were to determine the feasibility of locating and tagging fresh carcasses in-place while minimizing disturbance, as well as to gain a better understanding of the degree of drift from donor to recipient sections.

Results suggest that a low proportion of the recovered tagged fish drifted out of the donor reach, though a number of fish were recovered considerably further downstream from their donor sites in "carcass sinks" located throughout the Hanford Reach. We now believe it's likely that carcasses generally remain in-place once they settled into a low current location along shorelines or amongst aquatic vegetation. Many of the study fish were tagged in these types of locations and possibly resulted in lower levels of observed carcass drift than what is actually occurring for post-spawn fish. The carcass drift report is given in Appendix H

Figure 11 Floy dart tag female fall Chinook in the Hanford Reach, 2014 Carcass Drift assessment.

15.0 Life History Monitoring

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

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, 2013 and 2014 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 combined with the absence of any hatchery marks. The age composition for both the natural and hatchery origin fall Chinook salmon recovered in return years 2012 - 2014 were assembled from the carcass recoveries in sections 1-8 of the Hanford Reach.

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 demographic samples and it was assumed that the majority of the fish sampled in the stream surveys were natural origin.

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 tag 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 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 39). 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 39 **The week that 10%, 50% (median), and 90% of the natural and hatchery origin fall Chinook salmon passed Bonneville Dam, 2010 – 2014. Migration timing is based on PIT tag passage of Hanford natural origin 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	24-Aug	28-Aug	25-Aug		11-Sep	2-Sep	2-Sep	9-Aug
	50th Percentile	8-Sep	9-Sep	3-Sep		11-Sep	22-Sep	9-Sep	27-Aug
	90th Percentile	18-Sep	22-Sep	15-Sep		11-Sep	10-Oct	19-Sep	2-Oct
	N	40	55	16	0	1	29	22	10
2014	10th Percentile	6-Sep	4-Sep	5-Sep		24-Sep	10-Sep	3-Sep	29-Aug
	50th Percentile	16-Sep	13-Sep	12-Sep		25-Sep	11-Sep	12-Sep	1-Sep
	90th Percentile	28-Sep	25-Sep	23-Sep		1-Oct	28-Sep	26-Sep	15-Sep
	N	175	228	50	0	3	4	62	5

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 demographic sample rates and sub-sample rates. Only one demographic sample rate was used annually in the Hanford Reach stream survey; precluding the need to expand and pool samples. In addition, the fish 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 of 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 of the Hanford Reach escapement and the PRH returns are not directly comparable between locations. There is likely a recovery bias against smaller/younger fish in the stream surveys (Zhou 2002; Murdoch et al. 2010; Richards and Pearsons, 2013). 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 40).

Table 40 Age compositions for fall Chinook salmon sampled in the Hanford Reach escapement compared to fall Chinook salmon sampled at Priest Rapids Hatchery (genders combined), brood years 1998 - 2009

Brood Year	Source[1]	Age Composition				
		Age-2	Age-3	Age-4	Age-5	Age-6
1998	Escapement	0.119	0.097	0.420	0.346	0.018
	PRH Returns	0.034	0.575	0.353	0.038	0.000
1999	Escapement	0.123	0.089	0.390	0.392	0.005
	PRH Returns	0.061	0.366	0.432	0.140	0.001
2000	Escapement	0.262	0.081	0.290	0.359	0.009
	PRH Returns	0.070	0.303	0.467	0.152	0.007
2001	Escapement	0.152	0.149	0.488	0.206	0.005
	PRH Returns	0.061	0.506	0.309	0.122	0.002
2002	Escapement	0.178	0.154	0.568	0.099	0.001
	PRH Returns	0.103	0.386	0.466	0.043	0.001
2003	Escapement	0.249	0.170	0.248	0.331	0.000
	PRH Returns	0.041	0.443	0.355	0.160	0.000
2004	Escapement	0.216	0.064	0.406	0.311	0.003
	PRH Returns	0.133	0.398	0.406	0.063	0.000
2005	Escapement	0.151	0.082	0.306	0.458	0.003
	PRH Returns	0.116	0.572	0.284	0.028	0.000
2006	Escapement	0.109	0.052	0.632	0.206	0.000
	PRH Returns	0.331	0.325	0.314	0.030	0.000
2007	Escapement	0.109	0.230	0.490	0.171	0.001
	PRH Returns	0.103	0.483	0.381	0.033	0.000
2008	Escapement	0.159	0.193	0.511	0.137	0.000
	PRH Returns	0.221	0.497	0.279	0.002	0.000
2009[a]	Escapement	0.091	0.136	0.689	0.084	
	PRH Returns	0.125	0.564	0.240	0.071	
Mean	Escapement	0.160	0.125	0.453	0.258	0.004
	PRH Returns	0.117	0.452	0.357	0.074	0.001

[1]The origin is assigned by survey.
[a] Does not include age-6 returns.

The availability of otolith data combined with other hatchery mark data from the Hanford Reach carcass recoveries for the 2012 through 2014 return years provide the ability to estimate age compositions for both hatchery and natural origin fish within the Hanford Reach escapement (Table 41). However, the hatchery origin age composition may be influenced by the low number of hatchery origin fish present in the demographic samples which is further reduced by sub-sampling the demographic data for age and gender by origin. In addition, the age composition for both groups may be biased towards larger fish due to potential size recovery biases in the carcass surveys. Larger demographic samples per return year may be required to better represent the age composition data before conclusions can be made. The limited available data suggests that natural origin fish return at older ages than hatchery origin fish.

Table 41 **Age compositions for natural and hatchery origin fall Chinook salmon sampled in the Hanford Reach escapement, Brood Years 2007 – 2009.**

Brood Year	Origin[1]	N[2]	Male Age Composition				
			Age-2	Age-3	Age-4	Age-5	Age-6
2007	Natural	1,093	No otolith data	0.377	0.483	0.139	0.002
	Hatchery	121		0.801	0.116	0.083	0.000
2008	Natural	1,234	0.044	0.336	0.502	0.118	0.000
	Hatchery	49	0.255	0.299	0.353	0.092	0.000
2009[a]	Natural	816	0.034	0.233	0.667	0.065	
	Hatchery	139	0.033	0.270	0.678	0.019	
Mean	Natural	1,048	0.039	0.315	0.551	0.107	0.001
	Hatchery	103	0.144	0.457	0.382	0.065	0.000
Brood Year	Origin[1]	N[2]	Female Age Composition				
			Age-2	Age-3	Age-4	Age-5	Age-6
2007	Natural	1,299	No otolith data	0.047	0.706	0.247	0.000
	Hatchery	167		0.532	0.317	0.151	0.000
2008	Natural	426	0.000	0.117	0.679	0.204	0.000
	Hatchery	74	0.000	0.176	0.651	0.172	0.000
2009[a]	Natural	485	0.000	0.034	0.813	0.153	
	Hatchery	188	0.000	0.061	0.921	0.018	
Mean	Natural	737	0.000	0.066	0.733	0.201	0.000
	Hatchery	143	0.000	0.256	0.630	0.114	0.000

[1]Origin based on the presence of otoliths marks, hatchery coded-wire tags, and adipose clips present in the sub-sample.
[2] N equals the number fish included in the demographic sample for a specific brood year. Sample rates varied between return years; therefore the age composition is based on pooled sample data expanded for total returns by year.
[a] Does not include age-6 returns

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 42). 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 due to size bias during recovery of carcasses.

Table 42 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, Brood Years 1999 - 2009. N = sample size and SD = 1 standard deviation.

Brood 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
1999	Escapement	83	44	4	227	70	6	1,423	86	7	1,085	93	7	22	103	10
	PRH Returns	85	46	5	488	70	5	762	84	6	170	92	6	2	94	11
2000	Escapement	17	44	4	118	65	7	428	82	6	669	94	8	6	96	9
	PRH Returns	25	44	5	136	69	6	196	82	6	58	93	7	2	103	10
2001	Escapement	32	44	5	251	69	6	1,157	84	6	288	93	7	18	97	5
	PRH Returns	121	48	4	1,040	69	5	628	81	6	183	91	6	9	94	9
2002	Escapement	31	46	4	229	70	6	194	86	8	239	95	8	2	99	6
	PRH Returns	80	52	4	281	70	5	246	84	6	61	91	6	1	73	0
2003	Escapement	19	48	5	42	69	7	395	85	6	450	96	8	0		
	PRH Returns	12	49	6	93	70	6	215	83	6	20	91	4	0		
2004	Escapement	34	47	4	71	68	6	386	84	6	208	94	8	2	91	1
	PRH Returns	19	55	4	115	69	5	51	84	5	9	95	7	0		
2005	Escapement	25	50	5	202	70	6	532	84	7	744	96	8	5	96	6
	PRH Returns	31	49	4	429	73	4	428	84	6	180	91	6	0		
2006	Escapement	20	48	4	85	69	6	962	86	6	340	92	7	0		
	PRH Returns	3	45	3	42	71	4	170	84	6	13	92	7	0		
2007	Escapement	24	46	5	642	72	6	1,468	84	7	482	92	7	1	105	0
	PRH Returns	5	50	4	1,149	71	4	1,419	80	5	179	87	6	0		
2008	Escapement	34	50	4	243	70	5	620	84	7	72	92	8	1	84	0
	PRH Returns	22	52	5	652	69	4	573	81	6	1	84	0	0		
2009[a]	Escapement	50	48	4	421	69	6	931	81	6	183	92	10			
	PRH Returns	308	48	4	1,690	68	5	218	77	5	70	86	7			
1999–09 Mean	**Escapement**	34	47	4	230	69	6	772	84	7	433	94	8	5	70	3
	PRH Returns	65	49	4	556	70	5	446	82	6	86	90	6	1	33	3

[a] Does not include age-6 returns

The availability of otolith marks in addition to other hatchery marks (i.e., otoliths, adipose clips, and coded-wire tags) for the 2012, 2013, and 14 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 A.

The size at maturity data is essentially complete brood years 2007 through 2009. The sizes at age by gender are generally similar between hatchery and natural origin within a given brood year. The exception being that at age-5, natural origin males tend to be larger than hatchery origin males (Table 43)

Table 43 Mean fork length (cm) at age (total age) of natural and hatchery origin fall Chinook salmon that spawned naturally in the Hanford Reach, Brood Years 2007 – 2009. N = sample size and SD = 1 standard deviation

Brood Year	Origin	Male 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	No otolith Data			362	70	5	206	84	8	154	98	8	1	105	0
	Hatchery				44	72	4	16	82	5	6	93	7	0		
2008	Natural	22	49	4	134	69	5	260	85	8	25	99	7	0		
	Hatchery	8	52	3	20	69	5	7	86	4	2	91	15	0		
2009[a]	Natural	3	48	3	325	68	6	123	82	6	40	99	7			
	Hatchery	2	55	5	34	71	6	21	79	10	2	96	6			
Brood Year	**Origin**	**Female 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			83	72	5	376	83	5	326	89	5	0		
	Hatchery	0			48	72	4	48	80	4	8	86	6	0		
2008	Natural	0			36	70	3	344	83	5	49	88	5	1	84	0
	Hatchery	0			23	70	5	21	82	4	7	85	6	0		
2009[a]	Natural	0			44	71	5	105	80	4	82	87	11			
	Hatchery	0			12	68	4	49	78	6	4	85	4			

[a] Brood year does not include age-6 returns

Gender Composition for Adult Escapement

Gender ratios (male/females) by brood year and origin of adult fall Chinook salmon sampled in the Hanford Reach carcass survey are given in Table 44. Annually, higher male to female ratios have been observed in the natural origin fish than that of the hatchery origin fish. This may be the result of earlier age of maturity of hatchery origin fish and a size related bias of collecting these fish in the Hanford Reach.

Table 44 Comparison male to female ratio of fall Chinook salmon sampled in the Hanford Reach stream surveys, brood years 2007 - 2009

Brood Year	Source	Male[1] : Female Ratio
2007[a]	Natural	0.86:1.00
	Hatchery	0.74:1.00
2008	Natural	1.06:1.00
	Hatchery	0.64:1.00
2009[b]	Natural	1.38:1.00
	Hatchery	0.57:1.00

[1] Includes both adults and jacks. [a] Does not include age-2. [b] Includes age 2-5.

Spawn Success

All female Chinook included in the demographic sample for the Hanford Reach stream surveys were examined for egg retention to assess spawn success. The assessment of egg retention is compromised by the loss of eggs during the collection and transport of carcasses prior to sampling. In addition, the methods for quantifying egg retention and assignment of origin for each female have varied between years. The amount of egg retention for years 2010 through 2013 were determined by visual estimates; whereas, in year 2014, the amount of retention was based on egg counts when the gametes were not completely intact. The percent of egg retention for the 2014 data was calculated by dividing the amount of egg retention by an average fecundity of females at specific lengths. These fish were partitioned into the Egg Retention Bins of 0%, 25%, 50%, 75% and 100%. The assignment of origin for each female for years 2010 and 2011 were based on the presence or absence of an adipose fin. This adipose intact group may include non-adipose clipped fish from PRH. A combination of hatchery marks (i.e., adipose clips, coded-wire tags, and otolith marks were used to identify hatchery origin fish in years 2013 and 2014. For all years, we assume that fish not possessing any hatchery marks are natural origin fish.

Spawn success was slightly lower for both hatchery and natural origin females in return year 2013 compared to other years. This observation coincides with the record returns of both natural origin and hatchery origin fall Chinook salmon to the Hanford Reach and an elevated pHOS. It is possible that increased competition for suitable spawning habitat resulted in the lower spawning success, particularly for hatchery origin females (Table 45).

Table 45 Comparison of spawn success of natural and hatchery origin fall Chinook sampled in the Hanford Reach stream survey, Return Years 2010 - 2014

Return Year	Origin	Females Sampled	Egg Retention Bins					No Egg Retention (%)	Adj Spawn Success for Escapement (%)
			0 %	25%	50%	75%	100%		
2004	Combined	1,176	1,151	NA	21	NA	4	97.9	98.8
2005	Combined	1,323	1,310	NA	6	NA	7	99.0	99.2
2006	Combined	352	343	NA	8	NA	1	97.4	98.6
2007	Combined	454	443	NA	8	NA	3	97.6	98.5
2008	Combined	No spawn success data collected							
2009	Combined	499	484	NA	5	NA	10	97.0	97.5
2010	Combined	1,173	1,147	6	13	1	6	97.8	98.7
2011	Combined	1,264	1,203	1	52	5	3	95.2	97.4
2012[b]	Natural	681	658	14	5	1	3	96.6	98.6
	Hatchery	90	89	0	0	0	1	98.9	98.9
	Total	771	747	14	5	1	4	96.9	98.6
2013[b]	Natural	461	392	51	9	3	6	85.0	94.5
	Hatchery	224	144	39	11	13	17	64.3	81.3
	Total	685	536	90	20	16	23	78.2	90.1
2014[b]	Natural	1,082	1,074	1	0	0	7	99.3	99.3
	Hatchery	153	141	3	0	0	9	92.2	93.6
	Total	1,235	1,215	4	0	0	16	98.4	98.6
Mean (RY 2010-14)	Combined	989	925	27	19	6	12	93.6	96.8

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

16.0 Contribution to Fisheries

The contribution of fish produced at PRH to fisheries was estimated by querying a regional harvest database. 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 estimated 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 March 30, 2015 to provide recoveries of coded-wire tagged PRH origin fish. The database for the 2008 brood may not be complete until January 1, 2016 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 in 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. This fishery typically runs annually from August 1 to late October. In 2014, 32,417 fall Chinook Salmon were harvested during this fishery; 28,679 adults and 3,738 jacks. Estimates generated from coded-wire tags recovered from the Hanford Reach sport fishery suggest that 12.3% (3,987 fish) of the total sport harvest in the Hanford Reach was comprised of fall Chinook salmon released from PRH (Table 46). Likewise, fall Chinook salmon released from Ringold Springs Hatchery comprised 4.4% (1,419 fish) of the sport fishery. Strays from other hatcheries combined represent 1.0% (332 fish) 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 46 **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, return years 2003 – 2014**

Return Year	Harvest & Sampling			CWT Expansions			% of Harvest		
	Harvest	Sampled	%	PRH	RSH	Other Hatcheries	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
2014	32,417	8,319	25.7	3,987	1,419	332	12.3	4.4	1.0
Mean	13,034	2,922	23.1	1,806	778	122	11.9	4.2	0.7

Coded-wire tag data for PRH origin fall Chinook salmon that were marked with 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 2008, 50% of the reported harvest was taken in ocean fisheries (Table 47).

Table 47 **Coded-wire tag recoveries provided from RMIS by brood year and harvest type expanded by sample rate and juvenile tag rate, Brood Years 1997 – 2008**

Brood Year	Ocean Fisheries		Columbia River Fisheries						Recoveries (*N*)
			Tribal		*Commercial*		*Recreational*		
	#	%	#	%	#	%	#	%	
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%	31,232
2008	5,763	43%	4,447	35%	887	7%	2,080	15%	13,504
Mean	**6,842**	**50%**	**3,625**	**28%**	**982**	**9%**	**1,985**	**13%**	**13,468**

17.0 Straying

The distribution of PRH origin fish spawning in areas outside of the target stream is presented to assess the level of straying and potential impacts on other populations. The presumptive target spawning location for PRH origin fish includes the section of Columbia River from McNary Dam to Wanapum Dam as well as the lower Yakima River below Prosser 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 the number of PRH origin fish recovered on spawning grounds.

The stray rates (i.e., fish that spawned outside of the presumptive target area / total escapement) 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 Monitoring and Evaluation Plan for PUD Hatchery Programs (Hillman et al. 2013):

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 non-target 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 48). 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 the 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 suggest 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 49).

Table 48 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 (1992-2008). 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 Number	Homing Target Hatchery Proportion	Target Stream[1] Number	Target Stream[1] Proportion	Outside of Target Stream Number	Outside of Target Stream 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	1,001	634	0.633	0	0.000	367	0.367
2007	22,206	19,220	0.866	2,964	0.133	22	0.001
2008	11,867	9,002	0.759	2,864	0.241	0	0.000
Mean	13,271	9,768	0.758	3,422	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.

Table 49 **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	0.000	0.000	0.000	0.000	0.000	0.000
2014	0.000	0.000	0.000	0.000	0.000	0.000
Mean	0.000	0.001	0.000	0.000	0.000	0.064

[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 50 for brood years 1999 through 2012. 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/or PRH. In addition, notable proportions of the returns for several brood years have been observed at sites upstream of PRD. It is unclear whether fish spawned outside of the target areas because fish could return to a target location after being detected at a PIT arrays outside of the target stream. Observations for PIT tagged presumptive Hanford Reach natural origin adults show few detections at PRD and above projects (Table 51).

Table 50 Observations of passive-integrated-transponder tagged adult fall Chinook from Priest Rapids Hatchery at detection sites upstream McNary Dam, Brood Years 1999 - 2011

		Number of unique adult detections by site								
Brood Year	# PIT tagged	MCN	ICH	PRA	PRH	RIA	RRF	WEA	LWE	LMR
1999	3000	17	0	9	0	2	0	0	0	0
2000	3000	7	0	4	0	0	0	0	0	0
2001	3000	11	0	6	0	0	0	0	0	0
2002	3000	7	0	1	0	0	0	0	0	0
2003	3000	0	0	0	0	0	0	0	0	0
2004	3000	0	0	0	0	0	0	0	0	0
2005	3000	12	0	4	0	1	0	0	0	0
2006	3000	0	0	0	0	0	0	0	0	0
2007	3,000	31	0	16	0	5	3	2	0	1
2008	2,994	12	0	7	0	1	1	0	0	0
2009 (age 2-5)	1,995	22	0	14	10	2	0	0	0	0
2010 (age 2-4)	3,000	73	0	52	40	12	7	2	1	0
2011 (age 2-3)	42,844	223	1	115	167	10	10	2	0	1

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 Wenatchee River RKM 754
PRH Priest Rapids Hatchery Outfall RKM 635
LMR Lower Methow River at Pateros RKM 843

Table 51 Observations of passive-integrated-transponder tagged natural origin Hanford Reach fall Chinook at detection sites upstream McNary Dam, Brood Years 2002, 2003, 2006- 2011

		Number of unique adult detections by site								
Brood Year	# PIT tagged	MCN	ICH	PRA	PRH	RIA	RRF	WEA	LWE	LMR
2002	2,975	3	0	0	0	0	0	0	0	0
2003	2,989	1	0	0	0	0	0	0	0	0
2006	21,007	21	0	0	0	0	0	0	0	0
2007	16,651	95	0	11	0	1	1	0	0	0
2008	16,551	19	0	1	2	0	0	0	0	0
2009 (age 2-5)	4,850	30	0	4	0	2	2	0	0	0
2010 (age 2-4)	10,337	76	0	8	4	2	0	0	0	0
2011 (age 2-3)	4,891	3	0	0	0	0	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 Wenatchee River RKM 754
PRH Priest Rapids Hatchery Outfall RKM 635
LMR Lower Methow River at Pateros RKM 843

18.0 Genetics

Genetic tissue was collected from each Chinook salmon spawned at PRH during 2014 by staff from the Columbia River Inter-Tribal Fish Commission (CRITFC). In total 5,444 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 return years 2011 through 2014 is currently being archived by CRITFC. During 2010, WDFW staff collected 100 genetic tissue samples from both the Priest Rapids Hatchery 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.

19.0 Proportion of Natural Influence

The intent of integrated hatchery programs is to have hatchery and natural origin fish as a common gene pool. Gene flow and the associated risks within and between the hatchery and natural 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 has 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 ≥ 0.67 (HSRG/WDFW/NWIFC 2004). The HSRG recommends a minimum target of 0.15 for the proportion of natural origin Chinook salmon to be incorporated into the hatchery broodstock (pNOB) as well as a maximum target of 0.30 for the proportion of hatchery origin Chinook allowed to spawn in the natural environment (pHOS) 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 GCPUD and USACE mitigation and the influence of strays. 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 randomly subsampled and expanded as described in Appendix A 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 through 2014. Otolith marking began with the 2007 brood. Therefore, otolith marks are only available for specific age classes of PRH origin fish during return years 2010 and 2011 and do not provide representative samples for estimating pNOB for the PRH broodstock.

The annual pNOB for fish spawned at PRH and used for GCPUD and USACE smolt releases into the Hanford Reach during return years 2012 through 2014 is provided in Table 52.

Table 52 Origin of broodstock and pNOB apportioned to program for fall Chinook salmon spawned at Priest Rapids Hatchery, Return Years 2012 - 2014

Return Year	N	GCPUD pNOB	USACE pNOB	PRH and RSH Combined pNOB	Other Programs pNOB[1]
2012	4,974	0.182	0.057	0.119	N/A
2013	5,442	0.225	0.026	0.127	N/A
2014	5,443	0.343	0.076	0.206	0.000

[1] Represents pHOB associated with egg takes utilized outside of the Hanford Reach.

The 2014 broodstock included 5,443 adults which were comprised of 4,427 fish from the volunteer trap, 805 from the OLAFT and 211 from the ABC. In general, broodstock from ABC and OLAFT are mated with adipose clipped broodstock obtained from the PRH volunteer trap. In addition, adipose intact broodstock from the PRH volunteer trap are mated with adipose clipped broodstock from the volunteer trap. The fish culturists segregate the progeny resulting from these potential natural x hatchery matings for release from PRH.

GCPUD funds the collection of non-marked or tagged 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. The inclusion of these fish contributed greatly to the GCPUD program's egg take goal and the resulting pNOB. The 2014 PRH volunteer broodstock comprised an estimated 86 and 115 natural origin males and females, respectively. These natural origin fish were allocated by the proportion of the PRH volunteer broodstock used for the GCPUD and USACE egg takes associated with release at PRH. The average fecundity (3,883) for the 2014 broodstock was used to calculate the number of females required by each program (Table 53).

The GCPUD program included sufficient numbers of eggs from natural x hatchery and hatchery x hatchery matings (identified by adipose clip) to meet the program egg take goals for brood year 2014. Egg takes from the hatchery x hatchery matings that were in excess of the combined GCPUD and USACE egg take goals for eventual release from PRH were either culled or provided to other hatchery programs or educational programs (e.g., RSH, Umatilla Hatchery, and Prosser Hatchery, Salmon in the Classroom). Shipping excess eggs resulting from hatchery x hatchery matings to locations outside of the Hanford Reach resulted in a pNOB of 0.206 for the combined GCPUD and USACE fall Chinook salmon production in the Hanford Reach versus the pNOB of 0.189 for the entire broodstock spawned at PRH.

Table 53 Origin of broodstock and pNOB apportioned to program for fall Chinook salmon spawned at Priest Rapids Hatchery, Brood Year 2014

Program	Egg Take	Facility Average Fecundity	Natural Females	Hatchery Females	Natural Males	Hatchery Males	Total Natural	Total Hatchery	pNOB
GCPUD – PRH	6,613,071	3,883	505	1,198	331	401	835	1,599	0.343
USACE – PRH	*2,007,717*	*3,883*	*109*	*408*	*84*	*174*	*193*	*582*	*0.249*
USACE – RSH	*4,596,503*	*3,883*	*0*	*1,184*	*0*	*592*	*0*	*1,776*	*0.000*
USACE Combined	6,604,220	3,883	109	1,592	84	766	193	2,358	0.076
Combined PRH and RSH Programs	13,217,291	3,883	614	2790	415	1167	1028	3957	0.206
Other Programs[1]	1,103,891	3,883	0	284	0	173	0	457	0.000

[1] Includes eggs from presumed hatchery x hatchery crosses shipped to Umatilla and Prosser hatcheries, educational organizations, and culled eggs.

Estimates of pHOS

Estimates of pHOS based on otolith samples are limited to return years 2012 through 2014. Otolith marking began with the 2007 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 estimates for recent annual Hanford Reach spawning escapements are presented Table 54.

Table 54 Proportion of hatchery Chinook salmon on the spawning grounds (pHOS) in the Hanford Reach, Brood Years 2012 – 2014

Return Year	N	Total Escapement	Hatchery Origin Spawners (pHOS)			
			PRH	RSH	Other[1]	Total
2012[a]	1,609	57,631	0.062	0.066	0.005[a]	0.135
2013	927	126,744	0.203	0.054	0.018[a]	0.275
2014	2,426	183,750	0.052	0.015	0.028[b]	0.096
Mean	1,654	122,708	0.106	0.045	0.017	0.169

[a] Includes fish from other hatcheries based on coded-wire tags expanded by the juvenile mark rate and survey sample rate

[b] Includes fish from other hatcheries based on adipose clip fish without otolith mark

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 GCPUD 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 2012 (Table 55). An estimated 9,632 PRH origin fish spawned naturally in the Hanford Reach during the 2014 return year. Of these, 74.6% and 25.4% were allocated to GCPUD and USACE production at PRH, respectively. The USACE's 25.4% portion of PRH origin pHOS was combined with the pHOS associated with the USACE's RSH production to estimate the total pHOS associated with the USACE programs in the Hanford Reach.

The calculation of pHOS specific to each program includes proportions which are based on the entire population of natural origin fish in the denominators. Therefore this method of calculating program specific pHOS results in lower values than the population level pHOS and may only be useful for assessing the individual program's contribution of hatchery origin fish to the spawning population in the natural environment.

Table 55 Origin of pHOS apportioned by program source for fall Chinook salmon spawning naturally in the Hanford Reach, Return Years 2012 – 2014

Return Year	Natural Origin	Hatchery Origin Spawners				pHOS by Source			
		GCPUD[1]	USACE[1,2]	Other[3]	Total	GCPUD[1]	USACE[1,2]	Other[3]	Combined
2012	50,072	3,943	3,598	261	7,803	0.068	0.062	0.005	0.135
2013	126,782	26,507	18,427	3,123	48,057	0.152	0.105	0.018	0.275
2014	166,183	7,185	5,262	5,120	17,567	0.039	0.029	0.028	0.096

[1]Estimated number of PRH origin fish that spawned naturally in the Hanford Reach. Of these, 74.6% and 25.4% were apportioned to GCPUD-PRH and USACE-PRH, respectively. The allocation of pHOS was based on the proportion of annual juvenile mitigation goals for each agency for brood years 2008 through 2012.
[2]Includes hatchery origin fish released from Ringold Springs Hatchery.
[3]Includes hatchery origin fish released from other hatcheries based on CWT recoveries.

Estimates of PNI

We present a hierarchy of PNI estimates based on pNOB and pHOS values calculated to reflect differing methodologies driven by the type of data available to assign origin of adult Chinook salmon returns. In addition different PNI estimates were calculated to identify the level of impact of differing hatchery programs on the Hanford Reach natural spawning population.

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 mitigation program.

Prior to return year 2012, pHOS, pNOB and PNI rates are based coded-wire tag recoveries of adult returns. Historically we used juvenile mark rate expansions of coded-wire tag recoveries in the hatchery and stream surveys for these calculations. The pNOB estimated from coded-wire tags requires the assumption that fish unaccounted for by the juvenile mark rate expansions are natural origin fish. As discussed in Section 10 of this report, this assumption significantly over estimates pNOB and PNI. The pHOS estimates based on juvenile mark rate expansions of coded-wire tag recoveries also likely underestimate the presences of PRH origin fish as explained in Section 10. For comparison, we present a new estimate of PNI derived from coded-wire tags expansions based on coded-wire tagged adult expansions for PRH and RSH origin adult recoveries at their respective hatcheries. An explanation of methods is given in Appendix I. Estimates of pNOB, pHOS, and PNI based on both methods of coded-wire tag expansions are presented in Table 56. It is likely the PNI based on adult-to-adult coded wire tag expansion is the more accurate of the two methods.

For return years 2012-2014 we present PNI estimates based on the pNOB associated with the GCPUD and USACE broodstock requirements and the contributing sources of pHOS are given in Table 57. The pNOB and pHOS were calculated as previously described in Section 20. Utilizing natural origin broodstock from the OLAFT and ABC substantially increases the PNI associated with the GCPUD program. The PNI for the entire system was estimated using a weighted average pNOB because multiple hatchery programs contributed spawners to the population in the Hanford Reach and these contributions were unequal.

PNOB for each hatchery was weighted based upon the estimated pHOS and then a weighted average was calculated. PNOBs for hatcheries that contributed the most to pHOS were weighted the highest because they contributed the most to gene flow. The main sources of known hatchery strays (i.e., Umatilla, Lyons Ferry, and Little White Salmon) have an associated pNOB of approximately zero. The estimated PNI of 0 for the hatchery strays was a primary reason for being slightly less than the PNI target in 2014. Without the strays, the PNI target would have been exceeded in 2014. The calculation of PNI specific to each program includes a program specific pHOS which is based on the entire population of spawning fish in the denominator. The program specific pHOS calculation can result in all program specific PNI values greater than the population level PNI value. In these cases, program specific PNI values must be notably larger than the target population level PNI (0.67) in order meet the PNI standard given in the HGMPs for both PRH and RSH.

Table 56 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 2001 – 2014.

Return Year	pNOB[1]	pHOS[1]	pNOB[2]	PHOS[2]	PNI based on pNOB[1] and pHOS[1]	PNI based on pNOB[2] and pHOS[2]
2001	0.155	0.094	0.046	0.066	0.622	0.411
2002	0.145	0.101	0.046	0.125	0.589	0.269
2003	0.132	0.099	0.046	0.117	0.571	0.282
2004	0.229	0.081	0.046	0.099	0.739	0.317
2005	0.370	0.106	0.046	0.155	0.777	0.229
2006	0.507	0.057	0.046	0.124	0.899	0.271
2007	0.326	0.041	0.046	0.065	0.888	0.414
2008	0.501	0.046	0.046	0.087	0.916	0.346
2009	0.568	0.077	0.046	0.174	0.881	0.209
2010	0.392	0.040	0.046	0.076	0.907	0.377
2011	0.381	0.075	0.046	0.154	0.836	0.230
2012	0.304	0.045	0.119[a]	0.106	0.871	0.529
2013	0.252	0.217	0.127[a]	0.297	0.537	0.300
2014	0.443	0.056	0.206[a]	0.065	0.888	0.760
Mean (RY01-10)	**0.333**	**0.074**	**0.046**	**0.109**	**0.779**	**0.311**

pNOB[1] Assumes that all fish not accounted for by juvenile coded-wire tag expansions are natural origin.
pHOS[1] based on hatchery origin coded-wire recoveries expanded by juvenile mark rate and survey sample rate.
pNOB[2] is assigned to years 2001 – 2011 based on an average proportion of natural origin returns to PRH for return years 2012 - 2014 as determined by otolith and other hatchery marks.
pHOS[2] is based on an adult coded-wire tag expansion rate for PRH and RSH origin adults recovered in the Hanford Reach escapement combined with juveniles coded-wire tag mark rate expansions for other hatchery strays. Both groups were expanded by the survey sample rate.
[a]pNOB of broodstock used for production of PRH and RSH programs as determined from otoliths and other hatchery marks.

Table 57 Proportionate Natural Influence (PNI) estimates for the Hanford Reach fall Chinook salmon supplementation programs, Return Years 2012 – 2014.

Return Year	pNOB			pHOS			pHOS	PNI		
	GCPUD[1]	USACE[2]	Facility[3]	GCPUD[4]	USACE[5]	Other[6]	Reach[7]	GCPUD	USACE	System[8]
2012	0.182	0.057	0.119	0.068	0.062	*0.005*	0.135	0.727	0.477	0.468
2013	0.225	0.027	0.127	0.152	0.105	*0.018*	0.275	0.597	0.346	0.329
2014	0.343	0.076	0.206	0.039	0.029	*0.028*	0.096	0.898	0.724	0.628

[1]Includes broodstock associated with GCPUD production at PRH.
[2] Includes broodstock associated with USACE production at PRH and RSH.
[3] Includes broodstock spawned at PRH for all production
[4] Includes pHOS associated with GCPUD mitigation smolt releases at PRH
[5] Includes pHOS associated with USACE mitigation smolt releases at PRH and RSH
[6] Includes pHOS associated with strays from hatcheries outside of the Hanford Reach
[7] Population level pHOS in the Hanford Reach
[8] Population level PNI for the Hanford Reach. Assumes strays from hatcheries outside of the Hanford Reach have an associated pNOB of zero.

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 one, two, or four 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 origin assignments 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 fish from the OLAFT and ABC were spawned with adipose clipped broodstock fish from the PRH volunteer trap to try to increase the hatchery x natural matings which generally resulted in 0.5 points per mating. Adipose intact and adipose clipped broodstock from the volunteer trap were often mated together to increase the chance of natural by hatchery matings. These matings generally resulted in 0.0 points. Likewise, known hatchery by hatchery matings of PRH broodstock occurred to meet egg take goals which resulted in 0.0 points. It’s unlikely that natural x natural matings occurred since staff intentionally did not mate adipose intact fish with other adipose intact fish.

Similar to that done for estimates of pNOB by program, alternative pNOB and PNI estimates are given for the PRH facility as a whole and specific to the GCPUD production associated with each brood year. The pHOS used for these estimates are given in Table 55.

The conventional pNOB values for GCPUD production spawned at PRH and GPUD level pHOS are presented along with the alternative pNOB and program specific pHOS in Table 58. The alternative pNOB and program specific pHOS provide PNI values in excess of the stated PNI target of 0.67 for most years. The alternative pNOB resulted in an increase of PNI of 0.013 in 2012, 0.054 in 2013, and 0.018 in 2014.

Table 58 Conventional and alternative calculations of pNOB and PNI associated with the production specific to Grant County PUD, Return Years 2012 – 2014

	Conventional pNOB = pNOB/(NOB + HOB)		
Return Year	**GCPUD Broodstock Combined**	**GCPUD pHOS[1]**	**PNI**
2012	0.182	0.068	0.729
2013	0.225	0.151	0.598
2014	0.343	0.039	0.898
	Alternative pNOB = Total Score / Total Matings		
Return Year	**GCPUD Broodstock**	**GCPUD pHOS[1]**	**PNI**
2012	0.197	0.068	0.744
2013	0.284	0.151	0.653
2014	0.423	0.039	0.916

[1]The proportion of the pHOS specific to the GCPUD mitigation smolt releases from PRH

20.0 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 natural environment. This spawning population is based on the escapement estimate to the Hanford Reach without adjustments for spawn success.

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. The recovered coded-wire tags are expanded by sample rate of the survey and juvenile mark rate for the coded wire tag group. 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 2008, HRR without harvest for Priest Rapids Hatchery fall Chinook salmon averaged 4.33 and NRR for fall Chinook salmon in the Hanford Reach without harvest averaged 1.53 (Table 59).

Based on coded-wire tag recoveries, an average of 56% of the PRH adult recruits and 44% of the natural origin adult recruits for brood years 1996 through 2008 were harvested in ocean and freshwater fisheries. For brood years 1996 through 2008, HRR with harvest included averaged

9.63 and NRR averaged 2.89. The HRR should be greater than or equal to 5.30 (the target value in Murdoch and Peven 2005).

Table 59 Broodstock spawned at Priest Rapids Hatchery, estimated escapement to the Hanford Reach, 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 Years 1993 – 2008

Brood Year	Broodstock Spawned	Hanford Reach Escapement[1]	Harvest not included				Harvest included[2]			
			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	115,237	10.34	3.87	52,099	240,090	19.89	8.05
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	31,788	1.01	0.32	5,974	64,307	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	2,096	22,274	22,453	101,753	10.71	4.57	53,685	174,905	25.61	7.85
2008	2,890	29,058	11,935	41,809	4.13	1.44	25,234	79,330	8.73	2.73
Mean	2,921	54,425	12,136	60,180	4.33	1.53	26,942	111,628	9.63	2.89
Median	2,898	45,757	11,935	54,288	4.13	1.05	25,234	88,349	8.73	1.87

[1] Includes estimated adult and jack escapement to the Hanford Reach natural environment.

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

21.0 Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SAR) were calculated by dividing the expanded number of adult coded-wire tags recovered by the number of coded-wire tagged smolts released. This estimate could be biased low for both hatchery and natural origin fish because of some of coded-wire tag bias identified previously in this report. The following data was obtained from the RMPC's RMIS online database: http://www.rmpc.org/. The 2008 brood year data was queried on May 13, 2015. This query should account for age 2 through 5 fall Chinook salmon sampled through December 2013. The lag in reporting field data for the 2014 return year likely excludes recoveries of a limited number of age-6 fish.

The SAR for hatchery fall Chinook salmon released from PRH for brood years 1992 through 2008 have averaged 0.0044 with a lower median of 0.0034 (Table 60). The SAR for the PRH origin 2008 brood is 0.0034 which is equal to the historic median.

The SAR for Hanford Reach natural origin fall Chinook salmon for brood years 1992 through 2008 have averaged 0.0029 and a lower median of 0.0018 (Table 61). The SAR for the Hanford Reach natural origin 2008 brood is 0.0017 which is very near the historical median. The SAR for both the PRH and natural origin 2008 broods showed similar decreases from the 2007 brood year SAR.

Table 60 Smolt-to-adult-Survival ratios (SAR) for Priest Rapids Hatchery fall Chinook salmon, Brood Years 1992 -2008

Brood Year	Number of Tagged Smolts Released	Estimated Adult Captures	SAR
1992	194,622	448	0.0023
1993	185,683	1,479	0.0080
1994	175,880	108	0.0006
1995	196,189	1,786	0.0091
1996	193,215	762	0.0040
1997	196,249	183	0.0009
1998	193,660	946	0.0049
1999	204,346	1,573	0.0077
2000	200,779	370	0.0018
2001	219,926	1,810	0.0082
2002	355,373	669	0.0019
2003	399,116	352	0.0009
2004	200,072	100	0.0005
2005	199,445	1,718	0.0086
2006	202,000	100	0.0005
2007	202,568	2,391	0.0118
2008	218,082	740	0.0034
Mean	**219,836**	**914**	**0.0044**
Median	**200,072**	**740**	**0.0034**

Table 61 Smolt-to-adult-Survival ratios (SAR) for Hanford Reach natural origin fall Chinook salmon, Brood Years 1992 - 2008

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	456	0.0085
2008	203,947	520	0.0025
Mean	**168,382**	**504**	**0.0032**
Median	**199,896**	**362**	**0.0018**

22.0 ESA/HCP Compliance

Broodstock Collection

Section 10(a)(1)(B) Permit 1347 authorizes collection of fall Chinook broodstock at the OLAFT for the Priest Rapids hatchery program with an incidental take limit of 10 steelhead (an aggregate of hatchery or wild). Due to the absence of an identified steelhead take limit for operation of the PRH volunteer trap in permit 1347 and through ongoing coordination with NOAA Fisheries, the 10 fish take limit for broodstock collection at the OLAFT, on an interim basis (until a new permit is issued), has been re-conceptualized to include broodstock collection at the PRH volunteer trap, and in the ABC fishery. During the 2014 fall Chinook broodstock collection activities, a total of 23 steelhead were encountered at the PRH volunteer trap with an incidental mortality of three (hatchery origin) steelhead. No steelhead mortalities were associated with broodstock collection at the OLAFT or in the ABC fishery. Combined steelhead mortality for the three broodstock collection activities was 30% (3/10) of the allowable impact under permit 1347 (Table 62).

Table 62 Recoveries and disposition of steelhead at the Priest Rapids Hatchery volunteer trap, Return Year 2014

		No Mark	Ad Only	Ad-RV	Total
Released	Males	0	3	8	11
	Females	1	1	7	9
	Sub Total	1	4	15	20
Killed	Males	0	0	2	2
	Females	0	0	1	1
	Sub Total	0	0	3	3
	Total	1	4	18	23

Hatchery Rearing and Release

The juvenile fall Chinook salmon from the 2014 brood year reared throughout their life-stages at PRH without incident. The 2015 smolt release totaled 7,039,544 URB fall Chinook salmon, representing 96% 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 2013 through June 2014 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).

23.0 Acknowledgments

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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

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.

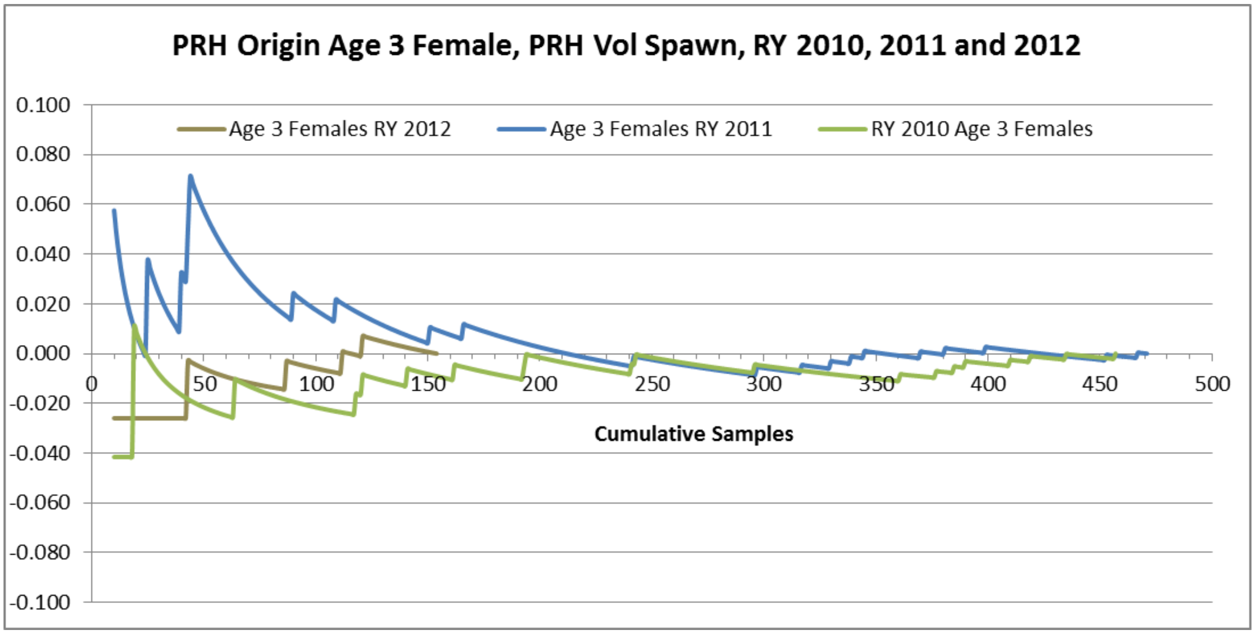

Figure 1. Example of sample size refinement by charting the differences in the proportion of Priest Rapids origin fish of cumulative sub-samples and the total sample.

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.

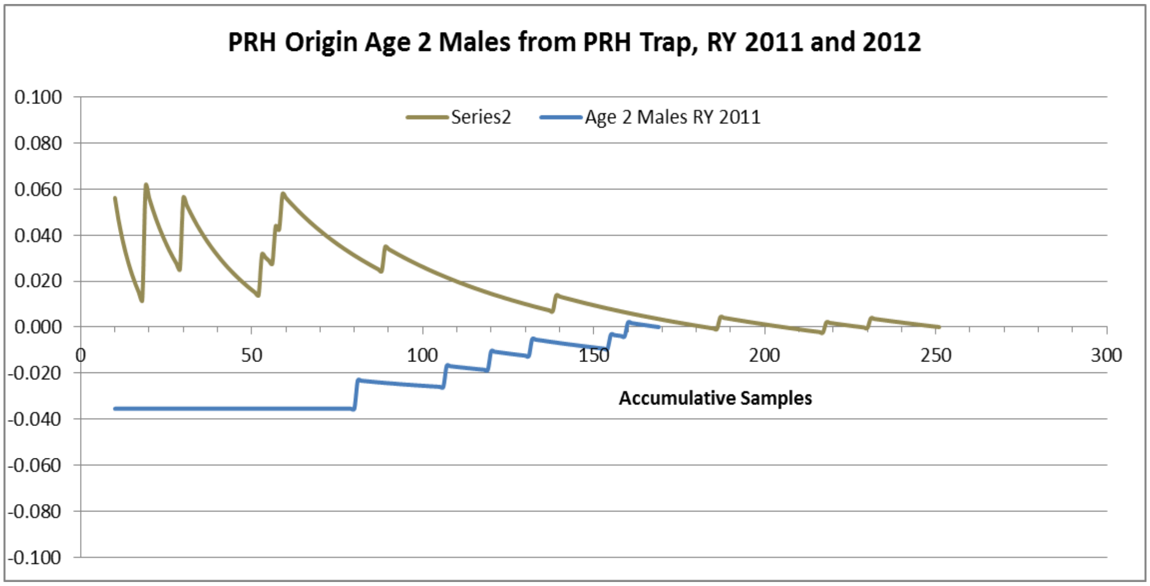

Figure 2, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 2 males sample at the Priest Rapids Hatchery Volunteer Trap during return year 2011 and 2012

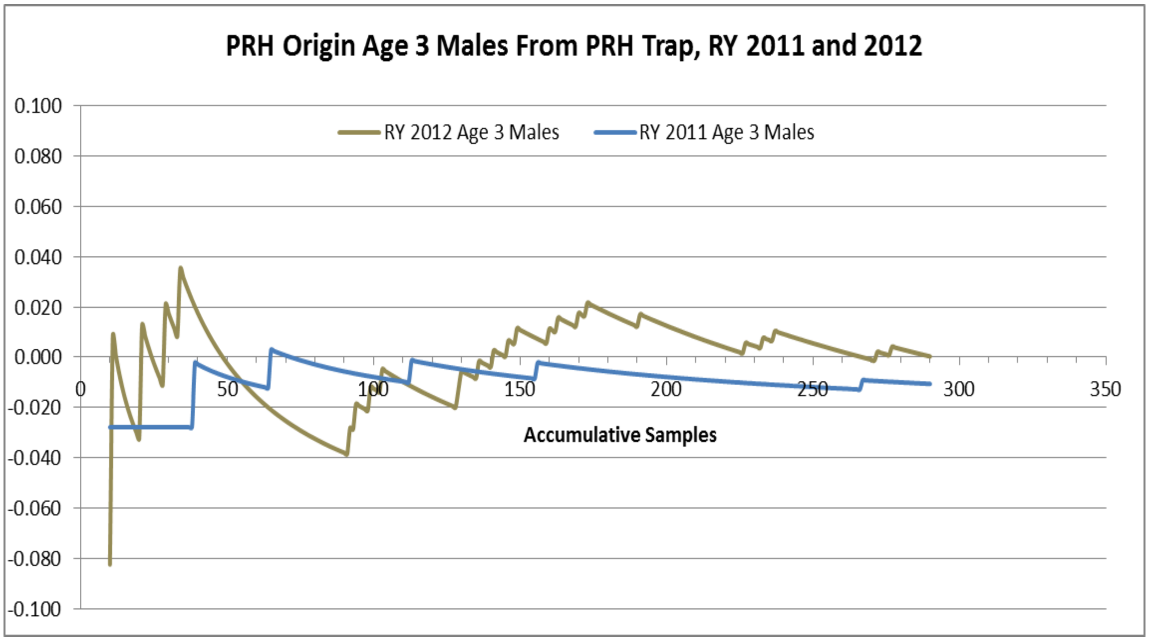

Figure 3, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 3 males sample at the Priest Rapids Hatchery Volunteer Trap during return year 2011 and 2012

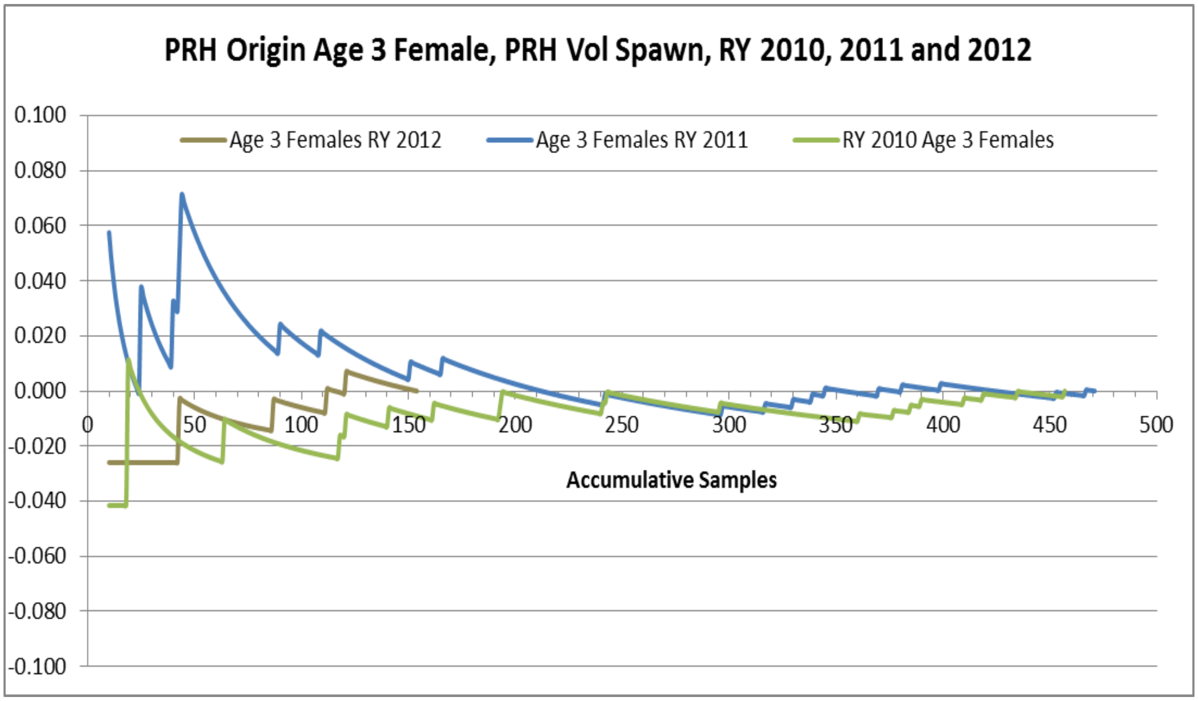

Figure 4, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 3 females sample at the Priest Rapids Hatchery Volunteer Spawn during return years 2010, 2011 and 2012

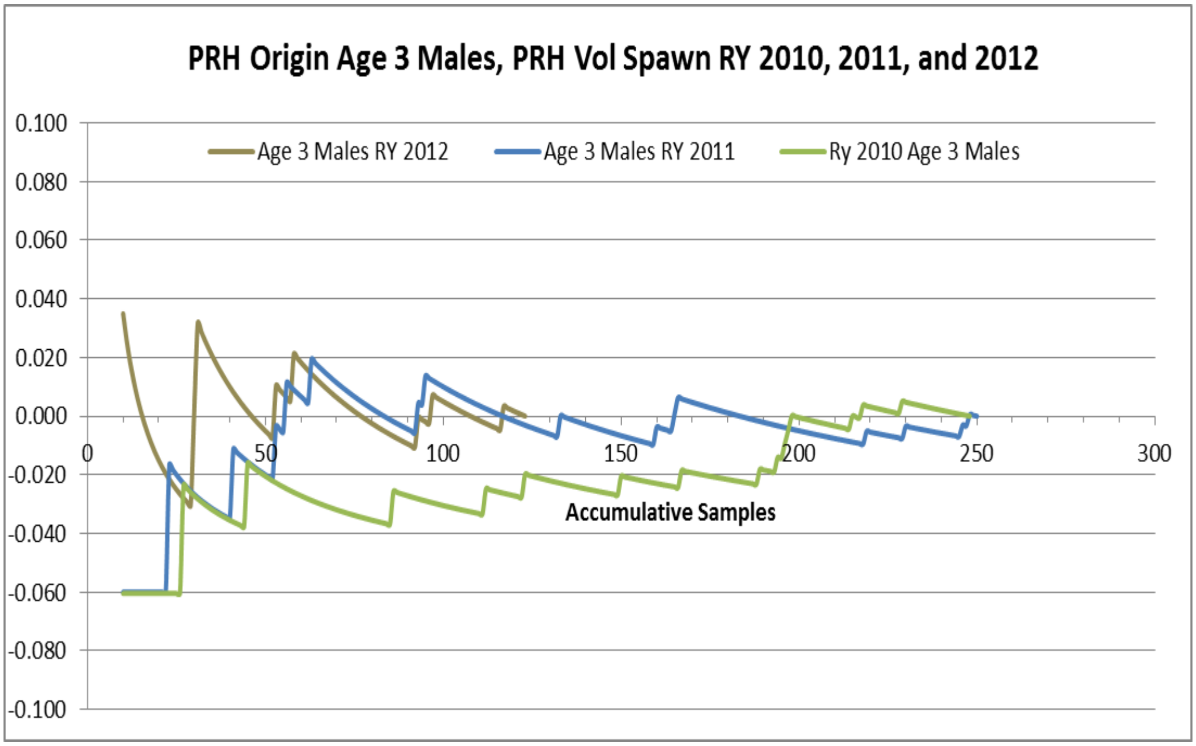

Figure 5, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 3 males sample at the Priest Rapids Hatchery Volunteer Spawn during return year 2010, 2011 and 2012

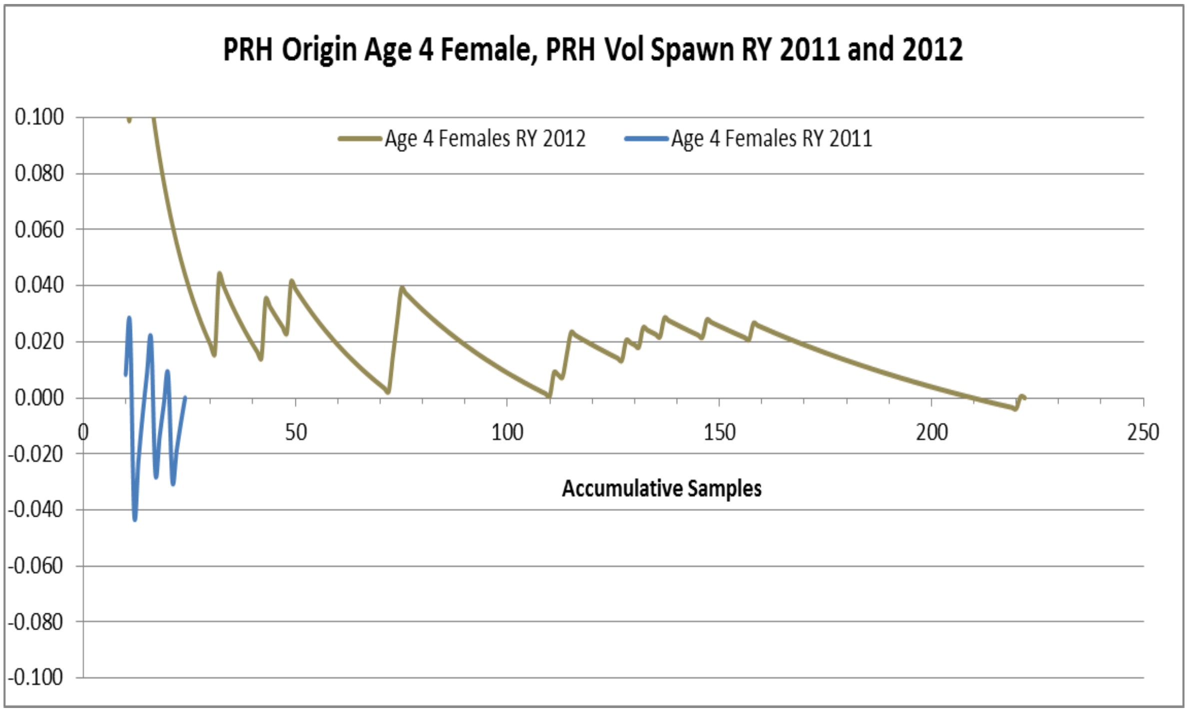

Figure 6, Difference between cumulative sub-samples and the total sample of the proportion of Priest Rapids Hatchery origin age 4 females sample at the Priest Rapids Hatchery Volunteer Trap during return year 2011 and 2012

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 B

Recovery of coded-wire tags collected from adult Chinook salmon broodstock spawned at Priest Rapids hatchery during return year 2014.

Code	Tag #	BY	Run	Age	Stock	Release Location	CWT Release			Expansion		Esc #	% Esc
							Date	AD CWT	CWT Only	All CWT	ADCWT		
635290	3	2009	Fall	5	Priest Rapids	CR@Priest Rapids	2010	0	207,185	4.1	10.9	**12**	0.28%
635294	3	2009	Fall	5	Priest Rapids	CR@Priest Rapids	2010		205,892	4.1	10.9	**12**	0.28%
635484	4	2009	Fall	5	Priest Rapids	CR@Priest Rapids	2010	207,184		4.1	10.9	**16**	0.37%
635485	6	2009	Fall	5	Priest Rapids	CR@Priest Rapids	2010	207,314		4.1	10.9	**25**	0.56%
635486	3	2009	Fall	5	Priest Rapids	CR@Priest Rapids	2010		206,523	4.1	10.9	**12**	0.28%
635487	5	2009	Fall	5	Priest Rapids	CR@Priest Rapids	2010		221,057	4.1	10.9	**21**	0.46%
635488	7	2009	Fall	5	Priest Rapids	CR@Priest Rapids	2010	205,096		4.1	10.9	**29**	0.65%
635489	5	2009	Fall	5	Priest Rapids	CR@Priest Rapids	2010		185,948	4.1	10.9	**21**	0.46%
635274	39	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011	0	99,800	4.0	11.3	**155**	3.50%
635699	83	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011	203,682	409	4.0	11.3	**330**	7.45%
635764	74	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011	199,698	401	4.0	11.3	**294**	6.64%
635766	100	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011		204,091	4.0	11.3	**397**	8.97%
635970	56	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011	199,200	400	4.0	11.3	**222**	5.02%
635971	59	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011	199,200	400	4.0	11.3	**234**	5.29%
635972	93	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011		199,600	4.0	11.3	**369**	8.34%
635973	74	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011		200,099	4.0	11.3	**294**	6.64%
635974	70	2010	Fall	4	Priest Rapids	CR@Priest Rapids	2011		99,800	4.0	11.3	**278**	6.28%
636371	20	2011	Fall	3	Priest Rapids	CR@Priest Rapids	2012		598,031	5.9	11.8	**118**	2.67%
636372	14	2011	Fall	3	Priest Rapids	CR@Priest Rapids	2012	595,608		5.9	11.8	**83**	1.87%
090488	6	2010	Fall	4	Priest Rapids	CR@Ringold	2011	222,916		15.6	15.7	**94**	2.11%
635289	1	2009	Fall	5	Little White salmon hatchery	Klickitat hatchery	2010	205,481	205,481	3.8	3.8	**4**	0.08%
635299	1	2009	Spring	5	Methow River	Methow River	2011	0	222,120	1.0	1.0	**1**	0.02%
090330	1	2009	Fall	5	Umatilla R.	Umatilla R.	2010	160,612	0	1.0	1.0	**1**	0.02%
090434	3	2010	Fall	4	Umatilla Hatchery	Umatilla R.	2011	138,007		1.0	1.0	**3**	0.07%
090435	2	2010	Fall	4	Umatilla Hatchery	Umatilla R.	2011	141,332		1.0	1.0	**2**	0.05%
090436	3	2010	Fall	4	Umatilla Hatchery	Umatilla R.	2011	140,958		1.0	1.0	**3**	0.07%
090492	1	2010	Fall	4	Umatilla R.	Umatilla R.	2012	90,390		1.0	2.1	**1**	0.02%
090585	1	2011	Fall	3	Umatilla River	Umatilla River	2012	154,611	0	1.7	1.7	**2**	0.04%
Total	**737**		**4,427**	**Sampled in Priest Rapids Hatchery Broodstock Spawned**								**3,033**	**68.5%**

Appendix C

Recovery of coded-wire tags collected from adult Chinook salmon surplus or mortalities from Priest Rapids hatchery during return year 2014.

Code	Tag #	BY	Run	Ag	Stock	Release Location	CWT Release			Expansion		Est Total	% Esc
							Dat	Ad-Clip CWT	CWT Only	All CW	Ad-Clip CWT		
22033	1	201	Fall	3	Lyons Ferry	Big canyon acclimation	201	0	85,359	1.0	2.3	**1**	0.00%
22033	1	201	Fall	3	Lyons Ferry	Big canyon acclimation	201	71,973	0	1.0	2.3	**1**	0.00%
22033	1	201	Fall	2	Lyons Ferry	Big canyon acclimation	201	0	86,280	1.0	2.2	**1**	0.00%
22034	1	201	Fall	2	Lyons Ferry	Big canyon acclimation	201	75,180	0	1.0	2.2	**1**	0.00%
22032	1	201	Fall	3	Lyons Ferry	Clearwater R	201	101,565	0	2.5	5.0	**3**	0.00%
22021	1	201	Fall	3	Lyons Ferry	Clearwater R	201	98,697	0	1.9	5.7	**2**	0.00%
22022	1	201	Fall	3	Lyons Ferry	Clearwater R	201	0	191,69	1.9	5.7	**2**	0.00%
63599	1	201	Fall	4	Snake River	Couse CR	201	200,942	970	1.0	1.0	**1**	0.00%
63657	1	201	Fall	2	Snake River	Couse Creek	201	202,036	2,135	1.0	1.0	**1**	0.00%
63529	59	200	Fall	5	Priest Rapids	Priest Rapids	201	0	207,18	4.1	10.9	**243**	0.31%
63529	52	200	Fall	5	Priest Rapids	Priest Rapids	201		205,89	4.1	10.9	**214**	0.28%
63548	39	200	Fall	5	Priest Rapids	Priest Rapids	201	207,184		4.1	10.9	**161**	0.21%
63548	63	200	Fall	5	Priest Rapids	Priest Rapids	201	207,314		4.1	10.9	**259**	0.34%
63548	45	200	Fall	5	Priest Rapids	Priest Rapids	201		206,52	4.1	10.9	**185**	0.24%
63548	44	200	Fall	5	Priest Rapids	Priest Rapids	201		221,05	4.1	10.9	**181**	0.23%
63548	55	200	Fall	5	Priest Rapids	Priest Rapids	201	205,096		4.1	10.9	**226**	0.29%
63548	50	200	Fall	5	Priest Rapids	Priest Rapids	201		185,94	4.1	10.9	**206**	0.27%
63527	496	201	Fall	4	Priest Rapids	Priest Rapids	201	0	99,800	4.0	11.3	**1,970**	2.55%
63569	1127	201	Fall	4	Priest Rapids	Priest Rapids	201	203,682	409	4.0	11.3	**4,476**	5.79%
63576	1045	201	Fall	4	Priest Rapids	Priest Rapids	201	199,698	401	4.0	11.3	**4,151**	5.37%
63576	1165	201	Fall	4	Priest Rapids	Priest Rapids	201		204,09	4.0	11.3	**4,627**	5.99%
63597	893	201	Fall	4	Priest Rapids	Priest Rapids	201	199,200	400	4.0	11.3	**3,547**	4.59%
63597	1019	201	Fall	4	Priest Rapids	Priest Rapids	201	199,200	400	4.0	11.3	**4,047**	5.24%
63597	1135	201	Fall	4	Priest Rapids	Priest Rapids	201		199,60	4.0	11.3	**4,508**	5.84%
63597	986	201	Fall	4	Priest Rapids	Priest Rapids	201		200,09	4.0	11.3	**3,916**	5.07%
63597	853	201	Fall	4	Priest Rapids	Priest Rapids	201		99,800	4.0	11.3	**3,388**	4.39%
63637	1348	201	Fall	3	Priest Rapids	Priest Rapids	201		598,03	5.9	11.8	**7,970**	10.32%

Code	Tag #	BY	Run	Ag	Stock	Release Location	CWT Release			Expansion		Est Total	% Esc
							Dat	Ad-Clip CWT	CWT Only	All CW	Ad-Clip CWT		
63637	1248	201	Fall	3	Priest Rapids	Priest Rapids	201	595,608		5.9	11.8	**7,378**	9.55%
63650	916	201	Fall	2	Priest Rapids	Priest Rapids	201	603,930	0	5.7	11.3	**5,187**	6.71%
63650	994	201	Fall	2	Priest Rapids	Priest Rapids	201	0	601,00	5.7	11.3	**5,628**	7.29%
63668	1	201	Fall	1	Priest Rapids	Priest Rapids	201	0	603,81	6.0	12.1	**6**	0.01%
09032	5	200	Fall	5	Priest Rapids	Ringold	201	203,024		16.7	16.7	**84**	0.11%
09048	52	201	Fall	4	Priest Rapids	Ringold	201	222,916		15.6	15.7	**811**	1.05%
09068	8	201	Fall	2	Priest Rapids	Ringold	201	214,873	5,943	14.7	15.1	**118**	0.15%
63641	6	201	Fall	3	L. Snake River	Grande Rhonde	201	192,996	192,99	2.0	2.0	**12**	0.02%
63657	2	201	Fall	2	Snake River	Grande Rhonde	201	216,889	430	1.8	1.9	**4**	0.00%
61043	4	201	Fall	4	Hanford URB Wild	Hanford Reach	201	42,120				**0**	0.00%
61043	3	201	Fall	4	Hanford URB Wild	Hanford Reach	201	37,116				**0**	0.00%
61043	4	201	Fall	4	Hanford URB Wild	Hanford Reach	201	55,339				**0**	0.00%
61044	1	201	Fall	4	Hanford URB Wild	Hanford Reach	201	18,874				**0**	0.00%
61044	1	201	Fall	4	Hanford URB Wild	Hanford Reach	201	10,438				**0**	0.00%
61043	2	201	Fall	3	Hanford URB Wild	Hanford Reach	201	27,173				**0**	0.00%
61044	1	201	Fall	3	Hanford URB Wild	Hanford Reach	201	54,142				**0**	0.00%
61044	1	201	Fall	2	Hanford URB Wild	Hanford Reach	201	17,272				**0**	0.00%
61044	3	201	Fall	2	Hanford URB Wild	Hanford Reach	201	46,496				**0**	0.00%
61044	1	201	Fall	2	Hanford URB Wild	Hanford Reach	201	26,771				**0**	0.00%
09033	1	200	Fall	5	Snake River	Hells Canyon	201	208,330	1,242	3.3	3.3	**3**	0.00%
09070	1	201	Fall	2	Snake River	Hells Canyon	201	228,054	156	3.9	3.9	**4**	0.00%
63597	1	201	Fall	4	LTL White salmon	Klickitat Hatchery	201	182,195	0	6.4	6.4	**6**	0.01%
63528	1	200	Fall	5	LTL White salmon	Klickitat hatchery	201	205,481	205,48	3.8	3.8	**4**	0.00%
63596	1	201	Fall	4	LTL White salmon	Klickitat River	201	157,855		6.4	6.4	**1**	0.00%
05507	1	201	Fall	4	LTL White salmon	Little White Salmon	201	0	99,070	5.1	10.4	**5**	0.01%
05459	1	201	Fall	4	LW URB	LTL White Salmon H	201	96,925	2,403	5.1	10.4	**5**	0.01%
05506	1	201	Fall	4	LW URB	LTL White Salmon H	201	0	98,724	5.1	10.4	**5**	0.01%
05523	1	201	Fall	4	LW URB	LTL White Salmon H	201	96,360	2,199	5.1	10.4	**5**	0.01%
09048	2	201	Fall	4	LW URB	LTL White Salmon H	201	168,392	0	14.7	14.7	**29**	0.04%
22020	1	201	Fall	4	Lyons Ferry	Luke's Gulch	201	101,688	0	1.0	2.0	**1**	0.00%
22020	1	201	Fall	4	Lyons Ferry	Magrudor Corridor	201		103,00	1.0	2.1	**1**	0.00%

							CWT Release			Expansion			
Code	Tag #	BY	Run	Ag	Stock	Release Location	Dat	Ad-Clip CWT	CWT Only	All CW	Ad-Clip CWT	Est Total	% Esc
22021	1	201	Fall	3	Lyons Ferry	Magrudor Corridor	201	94,079	0	1.0	2.1	**1**	0.00%
22031	1	201	Fall	3	Lyons Ferry	Magrudor Corridor	201	0	99,570	1.0	2.1	**1**	0.00%
22023	1	201	Fall	1	Lyons Ferry	Magrudor Corridor	201	0	99,344	1.3	2.5	**1**	0.00%
63529	1	200	Spr	5	Methow River	Methow River	201	0	222,12	1.0	1.0	**1**	0.00%
10020	2	201	Fall	3	Snake River	Oxbow	201	187,146		1.1	1.1	**2**	0.00%
10019	1	201	Sum	3	Pah ch-2	Pah simeroi Hatchery	201	0	161,79	1.0	0.0	**1**	0.00%
09057	9	201	Fall	3	Priest Rapids	Ringold	201	194,871	194,87	17.1	17.1	**154**	0.20%
09365	1	201	Fall	2	Salmon	Salmon R	201	23,416	0	1.0	1.0	**1**	0.00%
09365	1	201	Fall	2	Salmon	Salmon R	201	6,707	0	1.0	1.0	**1**	0.00%
63537	1	200	Summe	5	Methow River-	Similkameen River	201	254,655	1,180	1.0	1.0	**1**	0.00%
63629	1	201	Summe	2	Methow River-	Similkameen River	201	112,895	410	1.0	1.0	**1**	0.00%
63617	1	201	SU	3	Methow&Okanogan	Similkameen River	201	207,049	814	1.0	1.0	**1**	0.00%
09058	9	201	Fall	3	Snake River	Snake R@ Hells	201	200,844	273	4.0	4.0	**36**	0.05%
22012	1	201	Fall	4	Lyons Ferry	Snake R@Capn Johns	201	0	100,98	2.6	5.1	**3**	0.00%
22032	2	201	Fall	3	Lyons Ferry	Snake R@Capn Johns	201	101,194	0	2.5	5.0	**5**	0.01%
22014	2	201	Fall	2	Lyons Ferry	Snake R@Capn Johns	201	101,234		2.5	4.9	**5**	0.01%
22031	1	201	Fall	4	Lyons Ferry	Snake R@Pittsburg L	201	0	90,110	1.0	2.2	**1**	0.00%
22032	2	201	Fall	3	Lyons Ferry	Snake R@Pittsburg L	201	100,850	0	2.0	4.0	**4**	0.01%
22032	4	201	Fall	3	Lyons Ferry	Snake R@Pittsburg L	201	0	100,50	2.0	4.0	**8**	0.01%
22033	1	201	Fall	3	Lyons Ferry	Snake R@Pittsburg L	201	0	88,908	1.0	2.3	**1**	0.00%
22014	3	201	Fall	2	Lyons Ferry	Snake R@Pittsburg L	201	0	0	2.0	4.0	**6**	0.01%
09048	1	201	Fall	4	Columbia R Tules	Tanner Creek	201	170,842	0	16.1	16.1	**16**	0.02%
09065	1	201	Fall	3	Umatilla R	Umatilla R	201	50,112	613	1.0	2.8	**1**	0.00%
09068	2	201	Fall	2	Umatilla R	Umatilla R	201	0	229,65	1.0	2.0	**2**	0.00%
09068	2	201	Fall	2	Umatilla R	Umatilla R	201	102,499	1,784	1.0	2.0	**2**	0.00%
09070	4	201	Fall	2	Umatilla R	Umatilla R	201	140,915	120	2.0	2.0	**8**	0.01%
09032	4	200	Fall	6	Umatilla Hatchery	Umatilla R.	201	159,167		1.0	1.0	**4**	0.01%
09043	32	201	Fall	4	Umatilla Hatchery	Umatilla R.	201	138,055		1.0	1.0	**32**	0.04%
09043	25	201	Fall	4	Umatilla Hatchery	Umatilla R.	201	138,007		1.0	1.0	**25**	0.03%
09043	30	201	Fall	4	Umatilla Hatchery	Umatilla R.	201	141,332		1.0	1.0	**30**	0.04%
09043	26	201	Fall	4	Umatilla Hatchery	Umatilla R.	201	140,958		1.0	1.0	**26**	0.03%

Code	Tag #	BY	Run	Ag	Stock	Release Location	CWT Release			Expansion		Est Total	% Esc
							Dat	Ad-Clip CWT	CWT Only	All CW	Ad-Clip CWT		
09033	1	200	Fall	5	Umatilla R.	Umatilla R.	201	160,612	0	1.0	1.0	**1**	0.00%
09035	3	200	Fall	5	Umatilla R.	Umatilla R.	201	261,953		1.0	2.4	**3**	0.00%
09048	2	201	Fall	4	Umatilla R.	Umatilla R.	201	50,751	0	1.0	2.1	**2**	0.00%
09049	6	201	Fall	4	Umatilla R.	Umatilla R.	201	45,937	0	1.0	2.1	**6**	0.01%
09049	2	201	Fall	4	Umatilla R.	Umatilla R.	201	45,148	0	1.0	2.1	**2**	0.00%
09049	6	201	Fall	4	Umatilla R.	Umatilla R.	201	90,390		1.0	2.1	**6**	0.01%
09049	10	201	Fall	4	Umatilla R.	Umatilla R.	201	0	254,76	1.0	2.1	**10**	0.01%
09070	6	201	Fall	2	Umatilla R.	Umatilla River	201	166,640	0	2.0	2.0	**12**	0.02%
09058	18	201	Fall	3	Umatilla River	Umatilla River	201	154,611	0	1.7	1.7	**30**	0.04%
09058	28	201	Fall	3	Umatilla River	Umatilla River	201	166,448	0	1.7	1.7	**47**	0.06%
09065	1	201	Fall	3	Umatilla River	Umatilla River	201	88,668	359	1.0	2.8	**1**	0.00%
09065	1	201	Fall	3	Umatilla River	Umatilla River	201	0	223,55	1.0	2.8	**1**	0.00%
63617	1	201	Sum	3	Wenatchee River	Wenatchee River	201	201,974	4,089	1.0	1.0	**1**	0.00%
Total	**14,007**	**77,259 Sampled in Priest Rapids Hatchery Volunteer Returns Surplus and Mortalities**										**64,09**	**83.0%**

Appendix D

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
Priest Rapids	1-Jun-05	CHF	Priest Rapids	2004	Healthy

Appendix E

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	2014				Ten-Year (2005-14) Mean
Islands 11-21	676	533	798	906				**462**
Islands 8-10	814	807	2,200	1,565				**852**
Near Island 7	670	700	655	1,100				**545**
Island 6	1,181	1,375	3,340	2,530				**1,199**
Island 4, 5,6	1,524	1,195	2,650	2,080				**1,267**
Near Island 3	525	475	1,000	1,000				**507**
Near Island 2	653	528	1,700	2,050				**714**
Near Island 1	295	340	900	500				**302**
Coyote	44	29	520	500				**130**
China Bar	67	68	100	60				**194**
Vernita Bar	2,466	2,318	3,535	3,660				**1,883**
Total	**8,915**	**8,368**	**17,398**	**15,961**				**8,056**

Location	2011	2012	2013	2014				Ten-Year (2005-14) Mean
Islands 11-21	8%	6%	5%	6%				**6%**
Islands 8-10	9%	10%	13%	10%				**11%**
Near Island 7	8%	8%	4%	7%				**7%**
Island 6	13%	16%	19%	16%				**15%**
Island 4, 5, 6	17%	14%	15%	13%				**16%**
Near Island 3	6%	6%	6%	6%				**6%**
Near Island 2	7%	6%	10%	13%				**9%**
Near Island 1	3%	4%	5%	3%				**4%**
Coyote	>1%	>1%	3%	3%				**2%**
China Bar	1%	1%	1%	0%				**2%**
Vernita Bar	28%	28%	20%	23%				**23%**

Appendix F

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

Return Year	Total Recoveries	Total Escapement	Proportion of Escapement Recovered
1991	2,519	52,196	0.048
1992	2,221	41,952	0.053
1993	3,340	37,347	0.089
1994	5,739	63,103	0.091
1995	3,914	55,208	0.071
1996	4,529	43,249	0.105
1997	5,053	43,493	0.116
1998	4,456	35,393	0.126
1999	4,412	29,812	0.148
2000	10,556	48,020	0.220
2001	6,072	59,848	0.101
2002	8,402	84,509	0.099
2003	13,573	100,840	0.135
2004	11,030	87,696	0.126
2005	8,491	71,967	0.118
2006	5,972	51,701	0.116
2007	3,115	22,272	0.140
2008	5,455	29,058	0.188
2009	5,318	36,720	0.145
2010	9,779	87,016	0.112
2011	8,391	75,256	0.111
2012	6,814	57,710	0.118
2013	13,071	174,651	0.075
2014	16,756	183,749	0.091
Mean	**6,847**	**65,532**	**0.101**

Appendix G

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

2014 Hanford Reach Fall Chinook Escapement Estimate

	Count Source	2014		
		Adult	Jack	Total
Adult Fish Counts	**McNary[1]**	410,786	76,110	486,896
	Wanapum[2]	52,424	7,240	59,664
	Priest Rapids[3]	120,099	12,321	132,420
	Fallback Adjustment[4]	40,584	4,164	44,748
	Ice Harbor[5]	61,389	17,944	79,333
	Prosser[6]	7,004	654	7,658
Hatcheries	Priest Rapids Hatchery	64,721	11,945	76,666
	Priest Rapids Hatchery Channel	78	0	78
	ABC	305	0	305
	Ringold Springs Hatchery	12,205	2,049	14,254
Harvest	Hanford Sport Harvest	28,689	3,738	32,427
	Yakima River Sport Harvest	1,568	66	1,634
	Wanapum Tribal Fishery	29	1	30
Escapement	Yakima River (Lower)[5]	2,897	271	3,168
	Hanford Reach + Priest Pool	179,555	32,202	211,679
	Priest Pool Return	27,091	917	27,930
	Hanford Reach Escapement	**152,464**	**31,285**	**183,749**

[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. GCPUD 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 (33.8%) based on 119 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	2014		
	Adult	Jack	Total
Wanapum Adult Passage[1]	52,424	7,240	59,664
Wanapum Dam Fallback Adjustment	Unknown	Unknown	Unknown
Priest Rapids Fallback Adjustment[2]	40,584	4,164	44,748
Wanapum Tribal Fishery Above PRD	238		238
OLAFT	951	0	951
Priest Rapids Pool Sport Fishery	1,361	279	1,640
Total	95,558	11,683	107,241
Priest Rapids Adult Passage[3]	120,099	12,321	132,420
Priest Rapids Dam Pool Escapement	**24,541**	**638**	**25,179**

[1] No adult fish passage counts at Wanapum Dam during 2014. Wanapum Dam passage for fall Chinook based on estimated passage at Rock Island adjusted by historical conversion rates between Wanapum and Rock Island for years 2010 - 2013

[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.

Appendix H

Carcass Drift Pilot Study

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December 30th, 2014

Introduction

A common objective of hatchery monitoring and evaluation programs is to identify the spawning distribution of both hatchery and natural origin fish. As part of the Priest Rapids Hatchery (PRH) and Ringold Springs Hatchery (RSH) fall Chinook salmon monitoring and evaluation (M&E) activities, the Hanford Reach is split into five main reaches and two very small reaches to define carcass recovery efforts and spawner distributions. Initially, we believed that the proportion of hatchery origin spawners (pHOS) could be calculated for each reach. However, a previous carcass bias assessment within the Hanford Reach showed a substantial amount of downstream carcass drift into lower reaches (Richards & Pearsons, 2013). Hence, we cannot assume that the carcass recovery locations directly represent spawner distributions.

A likely contributing factor to the carcass drift phenomenon observed in the bias assessment is the frequent fluctuation in river levels, but unnatural carcass drift may have been introduced by the tagging process where carcasses were moved and not replaced in the same location (Richards & Pearsons, 2013) (Hoffarth & Pearsons, 2012) (Hoffarth & Pearsons, 2011). Murdoch et al (2009) suggested that spring Chinook carcass bias in a relatively small and shallow unregulated river is attributed to post spawning behavior. In that study, female spring Chinook salmon were found on average 150 m from their redd location. If hydro operations produce daily fluctuations in discharge large enough to displace carcasses, the initial recovery location of all female fall Chinook salmon carcasses may not represent their spawning location. Hence, methodologies in the M & E Plan for assessing spawning distribution may not be applicable in regulated rivers. Given the spatially distinct redd locations observed in the Hanford Reach it will be important to determine if the Reach 1 spawning area is comprised primarily of hatchery fish from PRH.

In order to gain a better understanding of natural carcass drift, we tagged 994 carcasses in-place with no handling. Long tagging poles and Floy dart tags were used to limit artificial carcass disturbance. Tagging efforts occurred throughout the spawning period (late October through late November) to increase the chances of tagging fish near their redds. Historic spawning locations within the Hanford Reach are well documented (Lindsey & Nugent, 2014). Special emphasis was placed proximate to Vernita Bar (Reach 1) due to the significant spawning population and close proximity to Priest Rapids Hatchery. Tag recovery efforts occurred from early November through mid-December in conjunction with the ongoing Hanford Reach stream surveys associated with fall Chinook salmon coded-wire tag recovery. Ultimately, 289 tagged carcasses were recovered and provided the data for spatial analysis of movement patterns.

Methods

Adult fall Chinook were tagged in reaches 1 through 4 of the Hanford Reach (Table 64). Tagging generally occurred four days a week (Sunday through Wednesday). Each reach was given at least one day to accumulate carcasses prior to tagging within the reach. Carcass recovery crews surveyed reaches the day following tagging. The reach immediately below the tagging reach was surveyed for carcasses the second following day. The carcass recovery program utilizes three boat crews working daily from October 28 to December 19. The survey effort is designed to maximize carcass recoveries while attempting a systematic approach to distribute effort among the five main reaches. Seldom does a particular reach go more than one consecutive day without being surveyed.

Selected fish were tagged with up to two dart tags (FT-1-94, Floy Mfg.) (Caption 1), typically between the lateral line and the dorsal fin as well as in the opercular region. Whenever possible, two tags were applied per carcass to evaluate tag retention. GPS waypoints (± 5m) were taken for all tagged fish and compiled into a geodatabase for later analysis. Tagging efforts were concentrated in the areas immediately downstream of established spawning areas (Lindsey & Nugent, 2014) and on recently deceased fish which exhibited a low degree of decomposition. Carcasses were tagged in place to limit artificial movement, and those entangled in riparian vegetation were not tagged. Jacks were also omitted from selection due to presumed reduction in spawning success (Berejikian, et al., 2010) and reduced likelihood of recovery by the survey team (Zhou, 2002).

Upon recovery, sex and post orbital/hypural length (POHL) were collected from each tagged fish. The number of tags on the recovered fish was noted, and a recipient GPS waypoint was taken and appended to the geodatabase. Associated data were linked and used to track carcass movement through the Hanford Reach. An iterative model using Esri's CostPath algorithm was used to estimate minimum river distance (rkm) between donor and recipient points. The input raster was generated from the NHD hydrological area layer (National Hydrology Dataset, 2014) using a binary method to denote passable/unpassable terrain. This allowed us to generate routes between each donor/recipient point pair while restricting travel to the river channel and avoiding static obstacles such as islands.

Results

Between October 26th and November 23rd, 994 carcasses were tagged at an average density of 12.9 fish/river km. 973 were tagged twice to evaluate tag loss and 21 tagged once. The bulk of the tagging occurred in Reach 1 (486 fish), followed by Reach 3 (225), Reach 4 (175), and finally Reach 2 (107) (Table 1). Of these, 289 were recovered and provided data for spatial analysis. Sixty-four (22.4%) traveled over 100 m between donor and recipient points, though the bulk of found fish were discovered within the same reach they were tagged (270, 93.4%). The only two reaches with >10% non-local recoveries were Reach 4 and Reach 5 (Table 2).

Length distribution of the 246 recovered fish with associated length data is given in Figure 1. Overall mean length was 81.8 cm with a standard deviation of 9.1 cm; mean length for males was 83.5 cm and mean length for females was 80.1 cm.

Incidence of tag loss appears to be low: of the 283 recovered fish that were initially double-tagged, only 18 (6.3%) were recovered with one tag. We cannot account for tag loss of fish not recovered, or fish which may have lost both tags.

Daily minimum and maximum flow fluctuation during the study was 29.6 KCFS and 179.0 KCFS, respectively. Average daily fluctuation was 120 KCFS (Table 3). Distances traveled ranged from 0 to 87,099 meters, and average distance traveled was 3,073 m, however, the median distance traveled was much less at 32 m.. The carcasses soaked between 1 and 31 days before being recovered, with an average time of 8.2 days – median 4 days. Carcasses drifted between 0 and 16,780 meters per day, with an average of 410.2 meters per day – median 8 m (Table 4). We found no correlation between "soak time" and average distance traveled (linear regression, $R^2 = 0.0303$) (Figure 12).

Discussion

The primary objectives of this pilot study were to determine the feasibility of locating and tagging fresh carcasses in-place while minimizing disturbance, as well as to gain a better understanding of the degree of drift from donor to recipient sections. We also identified several points on the river which feed larger downstream collection sites, such as those located in reaches 4 and 5.

The results of this study suggest that a low proportion of the recovered tagged fish drifted out of the donor reach (Table 1), though a number of fish were recovered considerably further downstream from their donor sites in “carcass sinks” located throughout the Hanford Reach. The largest of these collection points are found in Reach 3 (“Puss Bay”) and Reach 4 (“The Fur Patch”). Since the primary limiting factor in sampling is time spent searching for carcasses, crews in these location are able to sample fish at a quicker rate than average (up to 600/day). This results in carcasses recovered from these two locations being disproportionately represented in the dataset.

“Puss Bay” and “The Fur Patch” both contained at least one tagged carcass from upstream reaches. While the numbers were low relative to the total tagging effort (4 tagged carcasses in Puss Bay and 7 tagged carcasses in the Fur Patch) (Figure 14 and Figure 15), this suggests that these collection points gather carcasses from multiple upstream reaches and do not strictly represent their proximal spawning populations. Additional studies are required to determine whether the influences from other reaches are statistically significant.

As evidenced by the enormous variances associated with distance of drift, the results were primarily driven by a number of outliers (Table 4). The majority of carcasses drifted a relatively small distance, if at all. Part of this may be attributable to the recovery methods; tag recovery was a secondary objective. Many fish appear to have beached relatively soon after tagging, only to remain there for a considerable period of time (up to 31 days) before being recovered. Another consideration is the spatial bias inherent to tagging dead, post-spawn fish: carcasses are unlikely to remain in the faster water where spawning occurs. The result of this is our tagging crews only having access to fish which have already drifted an unknown distance from their redds, in addition to being deposited in an area where they are less likely to leave.

Works Cited

Berejikian, B. A., Van Doornik, D. M., Endicott, R. C., Hoffnagle, T. L., Tezak, E. P., Moore, M. E., & Atkins, J. (2010). Mating success of alternative male phenotypes and evidence for frequency-dependent selection in Chinook salmon, Oncorhynchus tshawytscha. *Canadian Journal of Fisheries and Aquatic Sciences, 67*(12), 1933-1941.

Hoffarth, P., & Pearsons, T. (2011). *Priest Rapids Hatchery Monitoring and Evaluation: Annual Report for 2010*. Ephrata, Washington: Grant County Public Uility District.

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

Lindsey, C., & Nugent, J. (2014, December 09). *Hanford Reach Fall Chinook Redd Monitoring Report for Calendar Year 2013*. Richland: Mission Support Alliance. Retrieved December 09, 2014, from Hanford Site: http://www.hanford.gov/files.cfm/HNF-56707_-_Rev_00.pdf

Murdoch, A., Pearsons, T., & Maitland, T. (2009). Use of Carcass Recovery Data in Evaluating the Spawning Distribution and Timing of Spring Chinook Salmon in the Chiwawa River, WA. *North American Journal of Fisheries Management, 29*(5).

National Hydrology Dataset. (2014, December 18). Retrieved from U.S. Geological Survey: http://nhd.usgs.gov/

Richards, S., & Pearsons, T. (2013). *Priest Rapids Monitoring and Evaluation Annual Report for 2013*. Ephrata, Washington: Grant County Public Utility District.

Zhou, S. (2002). Size-dependent recovery of Chinook salmon in carcass surveys. *Transactions of the American Fisheries Society, 131*(6), 1194-1202.

Captions, Tables, and Figures

Caption 1. Picture of the pink dart tag (FT-1-94, Floy Mfg) and the aluminum application tool (Pink tube) attached to a short aluminum pole (metallic tub). The application tool was attached to a 12.5 meter aluminum pole while tagging from the boat. When possible, one tag was injected into the fish between the lateral line and dorsal fin. A second tag was injected in the opercular region of the head.

Table 1. Matrix of recovered fish by donor and recipient reach. Shaded cells show fish which did not stray from their donor reaches. The majority (93%) of fish were recovered in the same reach they were tagged. Numbers in parenthesis are the percent of fish from donor reach which are represented by the cell.

		Donor				
	Reach	1	2	3	4	Total Recovered
Recipient	1	143 (94%)				143 (49%)
	2	1 (1%)	32 (94%)			33 (11%)
	3	3 (2%)	1 (3%)	35 (90%)		39 (14%)
	4	4 (3%)	0 (0%)	4 (10%)	60 (94%)	68 (24%)
	5	1 (1%)	1 (3%)	0 (0%)	4 (6%)	6 (2%)
Total Donor		152	34	39	64	289

Reach 1. Priest Rapids Dam to Vernita Bridge (14 km)
Reach 2. Vernita Bridge to Island 2 (19 km)
Reach 3. Island 2 to Power line Towers at Hanford town site (21 km)
Reach 4. Power line Towers to Wooded Island (21 km)
Reach 5. Wooded Island to Interstate 182 Bridge (19 km)

Table 2. Proportion of carcass drift from each donor reach into recipient reaches. All recipient reaches were mostly populated by their own donated carcasses, with the exception of Reach 5.

		Donor				
	Reach	1	2	3	4	Total
Recipient	1	1.00				1.00
	2	0.01	0.99			1.00
	3	0.02	0.03	0.95		1.00
	4	0.02	0.00	0.10	0.88	1.00
	5	0.07	0.30	0.00	0.63	1.00

Table 3. River flows for days spent on tagging operations. Measurements were taken just below the Priest Rapids Dam, at USGS Site 12472800. Number of fish tagged per day is also shown.

Date	Min. flow (KCFS)	Max flow (KCFS)	Difference (KCFS)	Tagged
10/23/14	51.9	150.3	98.4	1
10/24/14	40.6	70.2	29.6	0
10/25/14	52.9	134.3	81.4	0
10/26/14	37.8	110.7	72.9	1
10/27/14	51.5	142.8	91.3	0
10/28/14	44.4	151.9	107.5	0
10/29/14	44.5	135.8	91.3	0
10/30/14	48.5	153.1	104.6	11
10/31/14	44.6	151.2	106.6	8
11/04/14	51.7	152.6	100.9	9
11/05/14	53.7	151.5	97.8	13
11/06/14	50.8	153.3	102.5	0
11/07/14	42.0	153.1	111.1	0
11/08/14	55.8	154.0	98.2	0
11/09/14	51.3	154.1	102.8	54
11/10/14	56.4	152.9	96.5	108
11/11/14	52.4	154.3	101.9	53
11/12/14	43.7	195.6	151.9	57
11/13/14	40.5	212.6	172.1	178
11/14/14	41.0	214.8	173.8	0
11/15/14	36.3	192.5	156.2	0
11/16/14	36.7	210.8	174.1	211
11/17/14	30.7	209.7	179.0	60
11/18/14	37.2	209.8	172.6	108
11/19/14	37.9	210.5	172.6	92
11/20/14	47.3	203.7	156.4	0
11/21/14	49.5	175.7	126.2	0
11/22/14	45.3	184.5	139.2	0
11/23/14	40.9	149.1	108.2	30
Average	45.4	165.4	119.9	34

Table 4. Summary statistics for recovered fish. Distances are measured in river distance, taking the shortest possible path without crossing unpassable land barriers.

	Fork Length (cm)	*Distance(m)*	*Soak Time (days)*	*Meters/day*
Mean	81.8	3073	8.2	410
Standard Error	0.6	695	0.5	96
Median	81	32	4	8
Standard Deviation	9.1	11,820	8.3	1,625
Sample Variance	82	139,705,361	69	2,641,856
Minimum	59	0	1	0
Maximum	108	87,099	31	16,781
Count	246	289	289	289

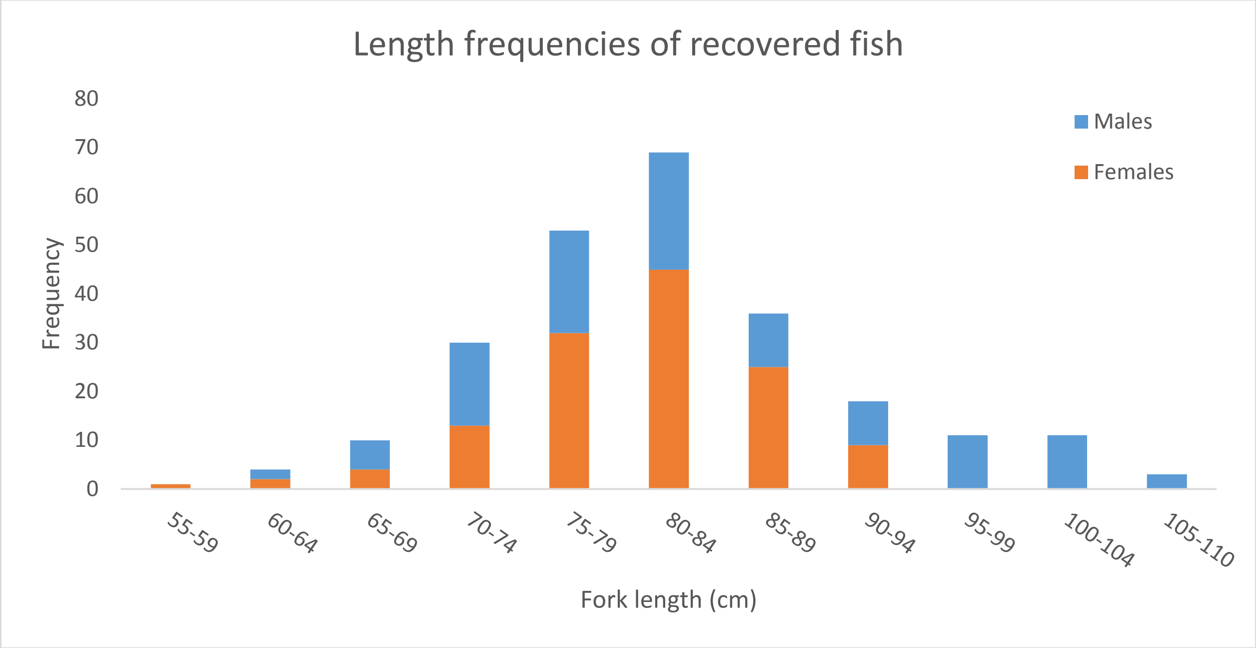

Figure 1. Length distribution of the 246 recovered fish with associated length data. Overall mean length was 81.8 cm with a standard deviation of 9.1 cm; mean length for males was 83.5 cm and mean length for females was 80.1 cm.

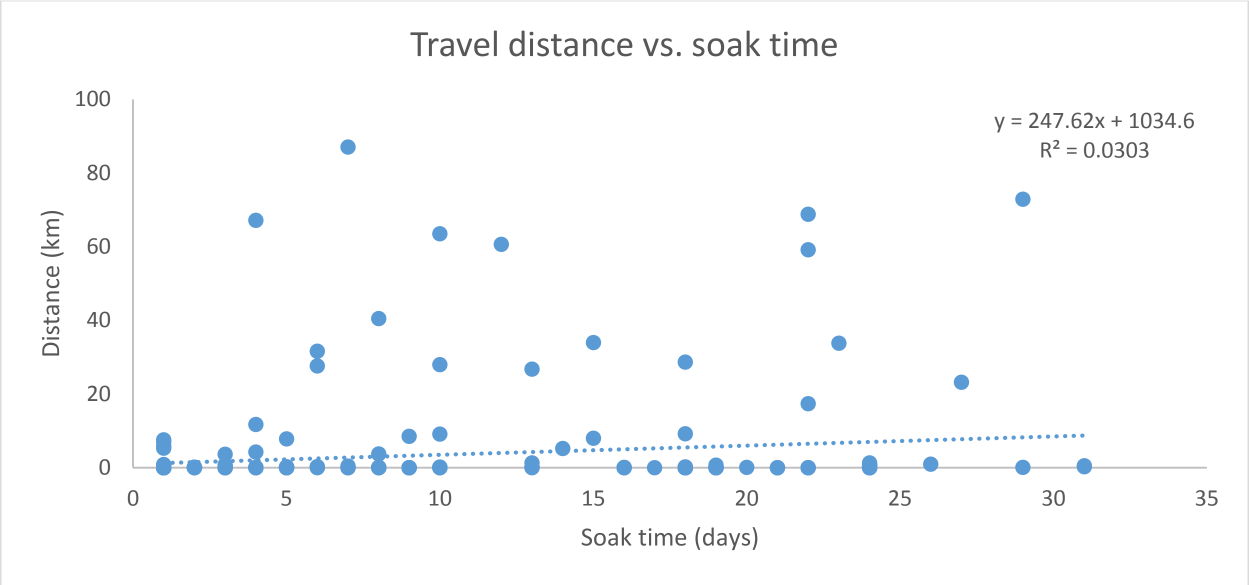

Figure 2. Graph showing relationship between "soak time" and distance traveled. 22% of the fish traveled over 100m, but there is no correlation between soak time and distance traveled (R2 = 0.0303).

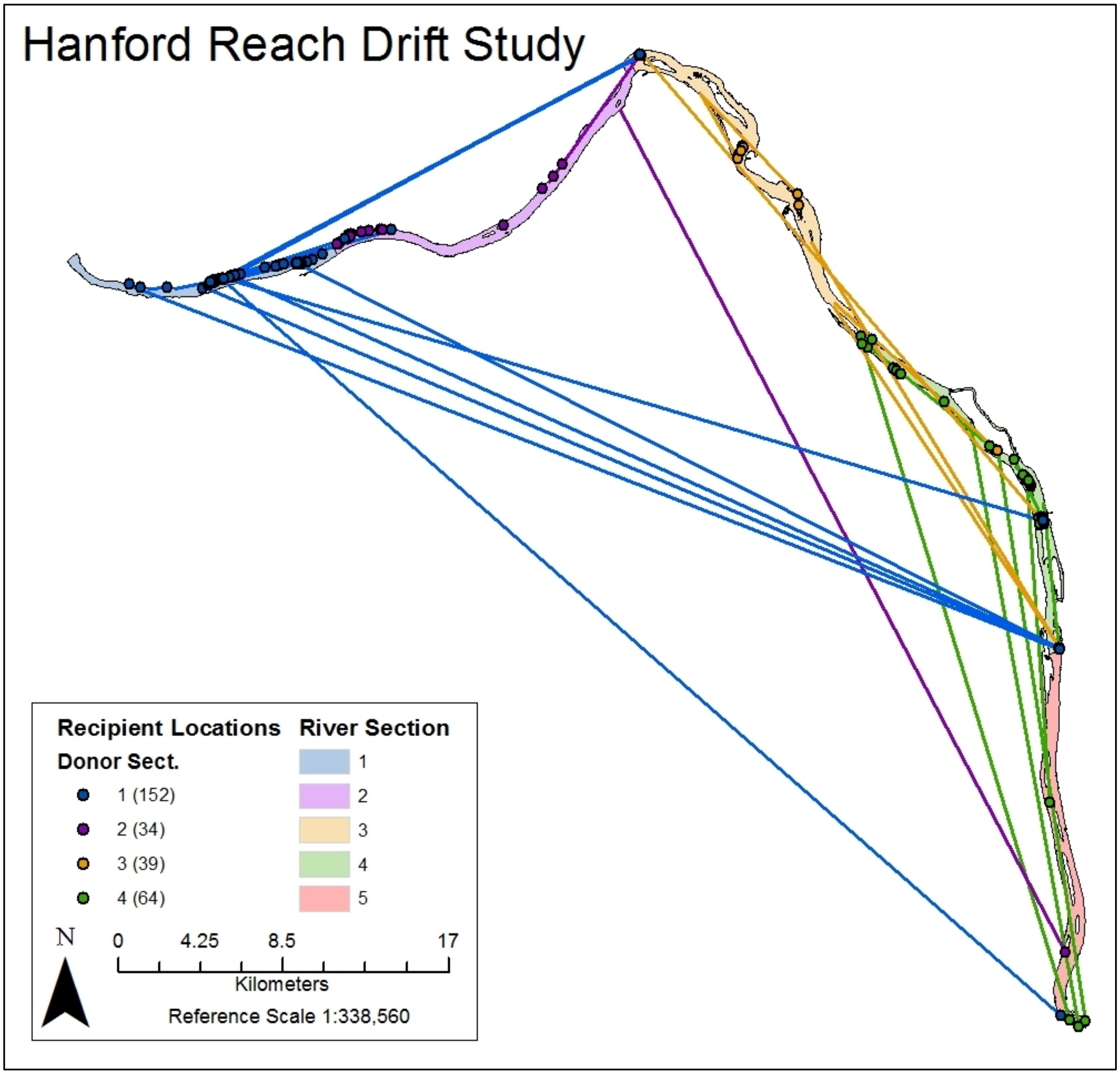

Figure 3. Recipient locations for all recovered fish, colorized by donor reach. Lines are drawn between donor and recipient locations.

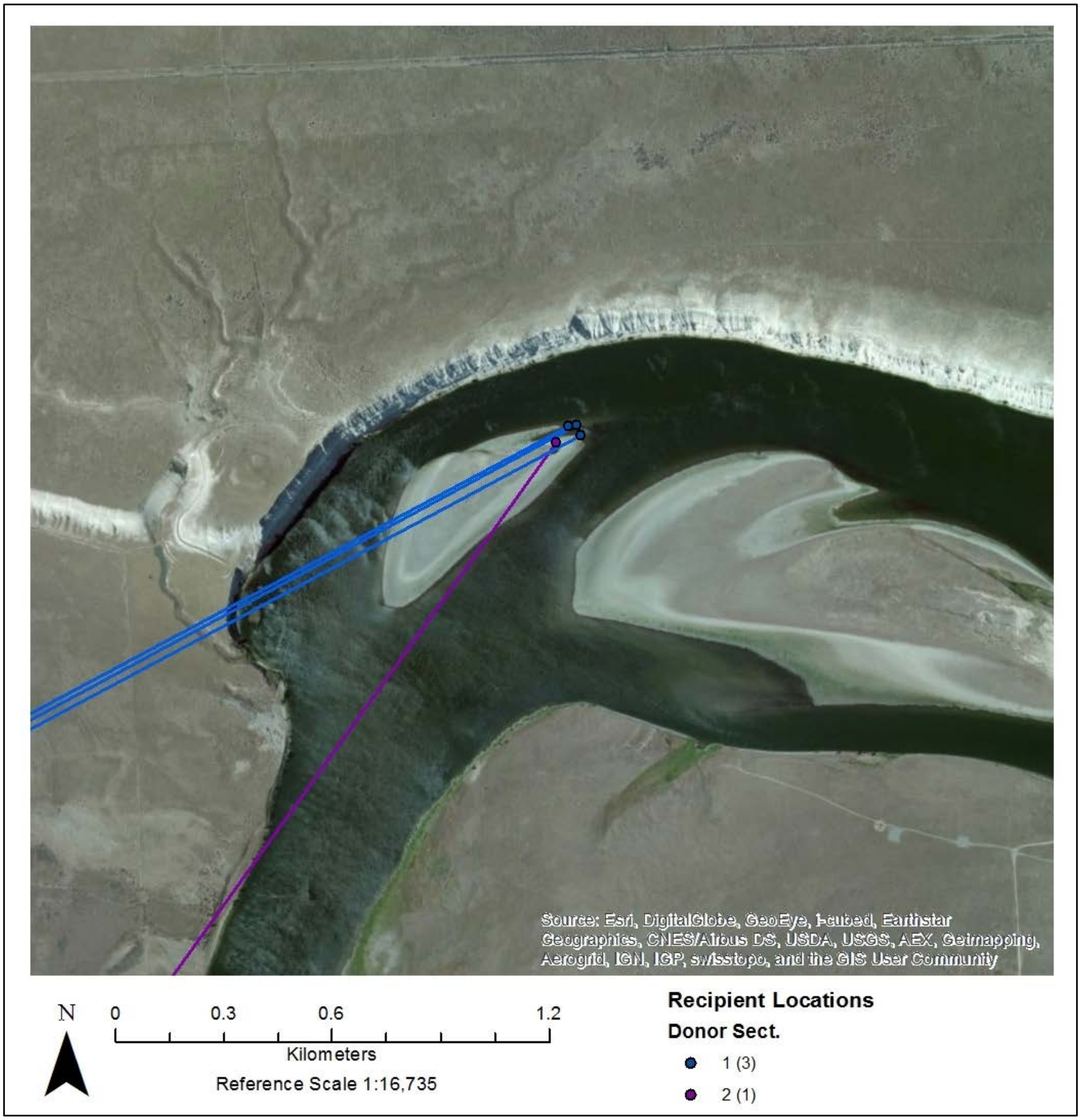

Figure 4 Close up of Puss Bay, the local collection point in reach 3. Recipient locations are colorized by donor reach, and lines are drawn between donor and recipient points. A number of carcasses were tagged within the bay, but were omitted from this figure for ease of viewing.

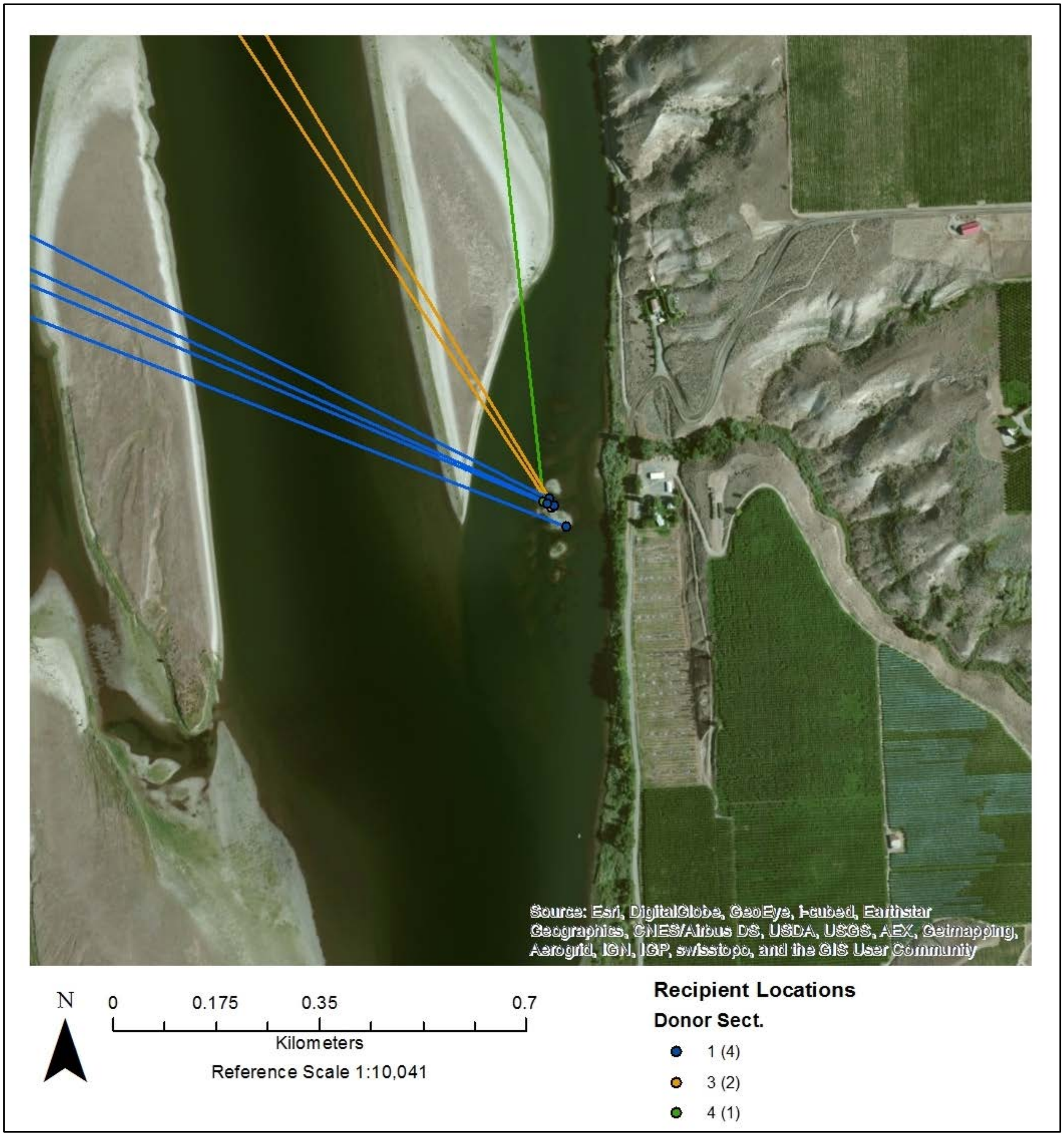

Figure 5. Close up of the Fur Patch, the local collection point in reach 4. Recipient locations are colorized by donor reach, and lines are drawn between donor and recipient points.

Appendix I

Explanation of methods for calculating adult-to-adult expansions based on coded-wire tag recoveries at Priest Rapids Hatchery.

Expanding adult coded-wire tag recoveries of either PRH or RSH origin fish by the corresponding brood's juvenile coded-wire tag rates has historically resulted in an under estimate of adult returns to locations within the Hanford Reach for each brood. Over the last fifteen years juvenile code-wire tag rates ranged from roughly 3% to 25% for PRH and roughly 6% for RSH. The relatively low tag rates combined with low proportions (<1%) of smolt to adult returns to the Hanford Reach may preclude the use of juvenile coded-wire tag rates in PNI calculations. For many years, WDFW fish management staff has used adult-to-adult coded wire tag expansions for the PRH origin returns to PRH for run-reconstruction associated with their annual fall Chinook Salmon forecast. We used similar methods to expand PRH and RSH origin adult coded wire tag recoveries in the vicinity of Hanford Reach to calculate PNI. An example of the calculations for the adult-to-adult expansion for the 2010 brood during return year 2014 is provided below. We make the assumption that the total number of PRH origin returns to PRH can be determined by removing other hatchery fish from the return: this is done by expanding few other hatchery coded-wire recoveries by their corresponding juvenile coded-wire tag rates. Other hatchery coded-wire tag groups often have tag rates exceeding 50%; therefore, we assume juvenile tag rate expansions are representative for these groups. In addition, we make the assumption that very few natural origin fish return to PRH.

$$\text{Adult-to-Adult Expansion}_{BY2010} = \frac{\text{Total}_{BY2010}\text{ CWT Recoveries at PRH}}{\text{Total}_{BY2010}\text{ PRH Origin Returns to PRH}}$$

$$\text{Adult-to-Adult Expansion}_{BY2010} = \frac{8719}{41{,}348} = 0.211$$

We then use the Adult-to-Adult Expansion $_{BY2010}$ to expand all recoveries of PRH $_{BY2010}$ in the Hanford Reach stream survey for return year 2014. This method is duplicated for each brood present in the given return year for both PRH and RSH to determine the total number of PRH and RSH origin fish in the escapement. The estimated number of PRH origin fish in the RY2014 Hanford Reach escapement based on the adult-to-adult expansion is higher than the number calculated using the conventional juvenile tag rate (Table 1).

Table 1 The number of PRH origin fish in the RY 2014 Hanford Reach escapement calculated form Adult-to-Adult Expansions versus Juvenile Tag Rates.

BY	CWT Recovered	Adult-to-Adult Exp	Expanded CWT	Survey Sample Rate	Total PRH origin in Escapement
2009	5	0.216	23	0.1063	218
2010	139	0.211	659	0.1063	6,197
2011	18	0.127	142	0.1063	1,333
2012	5	0.160	31	0.019	1,645
Adult-to-Adult Exp estimate for PRH origin fish in the Hanford Reach Escapement					9,393
Juvenile Tag Rate estimate for PRH origin fish in the Hanford Reach Escapement					7,934